Shaping Energy for a Sustainable Future

Annual Report 2020

IREC, a centre of excellence in applied energy research

Energy & Environment

Energy Storage

Smart Energy Management

INDEX

1. LETTER FROM THE DIRECTOR

"Our centre's main objective is to develop disruptive energy solutions and bring them to society"

Prof. Dr. Joan Ramon Morante

Director of IREC

Welcome to our 2020 Annual Report, which summarizes the institutional research and development activities, and the financial status of our Institute during the year.

In this report you will find information about our organization focused on the field of energy with special attention to the energy transition, our lines of research, our priority strategic actions and the main scientific and technological facts and results of the year, as well as the main participations of our institute in projects, demonstrators and pilot plants.

The Catalonia Energy Research Institute Foundation, IREC, is a public and multidisciplinary research center dedicated to cutting-edge research in the field of energy, pursuing excellence in the generation and transfer of knowledge, and in the development of tools and methodologies. scientific and technically necessary to advance in all and every one of the aspect of the energy transition in our society.

Considering the energy issues and their role in the ecological transition as one of the greatest and most complex challenges facing our society today, our main objective is to create new knowledge and innovative solutions to have and manage sustainable energy, from advanced functional materials to the production of digitized systems for smarter energy management.

During 2020, IREC has focused its actions mainly on the electrification and decarbonization of our society with special attention to the industrial sector and transportation:

- deployment of renewable energies, essentially floating marine wind energy and self-consumption in photovoltaic adapted and/or integrated into buildings,
- introduction of technologies related to the use of hydrogen from the manufacture of innovative options in electrolyzers and fuel cells to the problems of its transport and uses in industrial sector as well as in the transport and the tertiary sector's.
- implementation of CO2 capture and uses to produce value-added chemicals or "green" synthetic fuels on the base of electroconversion, thermoconversion, bioconversion or artificial photosynthesis inspired procedures.
- development of sustainable land, sea, river and air mobility.

- improvement of energy storage technologies with attention to electrochemical low cost batteries from materials for high energy density cells to complete systems, as well as chemical and thermal storage.
- Promotion of positive energy communities including aggregation of demand
- use of advanced energy management methods based on smart grids.

These activities have consolidated the institute's role as one of the reference in the energy field, corroborating its ascending evolution on the base of the different parameters and descriptive figures that are presented and described in this report.

On 2020, more than 50 R&D projects were being developed in the IREC's research groups. This activity has led to a total income of 6 M€ in 2020 from competitive and industrial projects. With income from European and national competitive projects of 4.6 million euros, income from projects providing services to industry of 1.1 M€, and grants received for the recruitment of distinguished research personnel of 0.3 M€.

About 65% of the income from competitive projects comes from European competitive calls.

IREC is lead coordinator of seven European projects in the European Commission's Horizon 2020 programme. It also participates as a beneficiary in sixteen more. Compared to the previous year, in 2020 IREC has increased its income from competitive projects by 13%.

Finally, we wish to highlight our commitment to society, reflected in the organisation of online scientific dissemination activities aimed at bringing science closer to the public and thus strengthening our relationship with them, despite of the social distance by the 2020 pandemic.

In short, IREC finds itself in an ideal position to tackle the challenges that will come in future years, and it will continue to Shaping Energy for a Sustainable Future.

J.R. Morante
Director of IREC

2. ORGANIZATION

HISTORICAL BACKGROUND

The Catalonia Institute for Energy Research, IREC (Institut de Recerca en Energia de Catalunya), was funded in July 2008, and began its R+D activities in January 2009.

After finishing the organization of the laboratories and infraestuctures in 2011-2012, in 2013 the Catalan Institute for Energy Research could achieve consolidation in both European and industrial projects. Since 2011 IREC has built a stable team of valuable individuals who are committed to the scientific and technological growth of the centre, resulting in cuttingedge research and a constantly increasing flow of income.
This was the result of the policy of the Generalitat de Catalunya -Ministry of Enterprise and Knowledge of the Government of Catalonia- to promote research of quality in the energy sector and to strengthen the positive impact of technological developments on energy in the society through the creation of a center in its CERCA network of research institutes coordinanting its research, industrial and energy policy.

In its first stage, the trustee board of IREC had also the support from the CIEMAT (Research Centre for Energy, Environment and Technology) within Ministry of Science and Innovation-, from the IDAE (Institute for the Diversification and Saving of Energy) within Ministry for the Ecological Transition and the Demographic Challenge. Also with the support of the University of Barcelona, Universitat Politècnica de Catalunya · BarcelonaTech (UPC) and Universitat Rovira i Virgili (URV), and from the private sector with the contribution from LCH, Alstom wind, Repsol, ENDESA, ENAGAS and NATURGY, to launch together the reasearch and development activities of this specialized center on energy and its impacts on the economy, society and productive sector besides to enhance the disruptive creation in this area.
Just this year, the bylaws of the foundation have been modified and IREC is now fully a public entity dependent on the Generalitat de Catalunya with a new trustee boards.

MISSION

Our mission is to contribute to the sustainable development of society with greater industrial competitiveness, by generating research of excellence, building new technologies to address current and future energy-related issues, and ensuring universal access to abundant, inexpensive and sustainable energy.

VISION

Our vision is to become a center of excellence and an international point of reference in the field of energy through research, development and innovation, and to work in a coordinated way with administration, industry and universities.

ORIENTATION

The Institute is developing its activities launching energy topics at short, medium and large term covering different approximations considering the time to market assessment:

» Technological researches which are focused on collaboration with Industry and Administration to create, in the short and medium-term, new products, solutions and services.

» Applied and technological researches which is aimed at generating novel flashing and exciting knowledges within groups of the Institute, with a medium or long-term application in mind for opening new transfer paths from science and technology to end users.

The Institute's orientation is defined by the balance and interaction between these two approaches.

ESTRATEGIC GOALS

» To spearhead the generation of disruptive scientific and technological knowledge aimed at providing industry and society with innovative and sustainable medium- and long-term energy solutions.

» To promote the continuous transfer of knowledge to the market and society, by collaborating directly with companies, and providing an environment that empowers spin-offs and supports the generation and licensing of patents.

» To expand our network in the field of energy, both at a local and international level, and to become a leading voice that inspires innovative, scientific and sustainable thinking across the sector.

ORGANIZATION CHART

BOARD OF TRUSTEES

As a public research institute, is part of the consolidated budget of the Government of Catalonia. The IREC Board of Trustees, chaired by the Minister of Enterprise and Knowledge of the Government of Catalonia. And leaded by the Director-General of Energy and Industrial and Mining Safety and the Director-General for Research of the Catalan Government.

THE IREC BOARD OF TRUSTEES HAS THE FOLLOWING MEMBERS

CATALAN MINISTRY OF BUSINESS AND KNOWLEDGE, Catalonian Government
(Generalitat de Catalunya)
From Generalitat de Catalunya, Departament d'Empresa i Coneixement

Ramon Tremosa i Balcells
Catalonian Minister of Business and Knowledge

Joaquim Ferrer Tamayo
Secretary for Business and Competitiveness of the Catalonian Ministry of Business and Knowledge.

Francesc Xavier Grau
Secretary for Universities and Research of the Catalonian Ministry of Business and Knowledge.

Manel Torrent Aixa
Secretari of the Board
General Director of Energy, Mines and Industrial Safety of the Catalonian Ministry of Business and Knowledge.

Joan Gómez Pallarés
General Director for Research of the Catalonian Ministry of Business and Knowledge.

Manel Torrent Aixa
Director of the Catalan Institute of Energy (ICAEN) of the Ministry of Business and Knowledge.

MINISTRY OF SCIENCE AND INNOVATION (MICINN), Government of Spain

Rafael Rodrigo Montero
Secretary-General for Research

CIEMAT - Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas - (Research Centre for Energy, Environment and Technology)
Organization of the Spanish Ministry of Science and Innovation

Carlos Alejaldre Losilla
Director of CIEMAT

José Ignacio Cruz
Head of Wind Energy Unit

MINISTRY FOR THE ECOLOGICAL TRANSITION AND THE DEMOGRAPHIC CHALLENGE (MITECO), Government of Spain
Sara Aagesen
Secretary of State for Energy

IDAE - Instituto Diversificación Ahorro Energético - (Institute for the Diversification and Saving of Energy)
Organization of the Spanish Ministry for the Ecological Transition and the Demographic Challenge

Joan Groizard Payeras
Director of IDAE

Consuelo Lozano

Area Director of Companies and Participated Companies

UB - Universitat de Barcelona - (University of Barcelona)
Joan Guàrdia Garcia
Chancellor

UPC - Universitat Politècnica de Catalunya- (Polytechnic University of Catalonia)
Francesc Torres Torres
Chancellor

URV - Universitat Rovira i Virgili - (Rovira i Virgili University)
María José Figueras Salvat
Chancellor

ENDESA Servicios S.L.
Isabel Buesa Gumbau
Director of Innovation and Technology of ENDESA SA in Catalonia

NATURGY, S.A.
Silvia Sanjoaquín Vives
Director of Gas Network, Energy Efficiency & Renewables

ENAGÁS, S.A.
Juan Andrés Díez de Ulzurrun Moreno
Engineering, Technology and Purchasing General Manager

IREC is one of the 42 research centres of Catalonia, especifically focused on energy research at Catalonia. IREC is a CERCA center, the Catalan institution created by the Catalan Government to supervise, support and facilitate research to the Catalan research centres:

IREC is one the research Institutes with the TECNIO accreditation, awarded in 2016 by ACCIÓ, the agency from the Generalitat of Catalonia responsible for competitiveness and internationalization:

IREC is one of the 30 research centres of Catalonia, which were awarded by the European Comission with the acreditation “Human Resources Excellence in Research”, to the R+D entities that implement the strategy “Human Resources Strategy for Researchers:

HR EXCELLENCE IN RESEARCH

3. FINANCES - IREC IN NUMBERS

BREAKDOWN OF ACCOUNTS

Year 2020 has been a year of financial stability regarding the ordinary operating R+D income, largely due to the strength of IREC's research initiatives.

Income from R+D activities increased 10.5% in competitive projects and increased 17% in industrial projects.

The increase of 6% in basal funding from Generalitat de Catalunya as trustee of the foundation, affected positively the financial closing of the year 2020.

This activity in competitive and industrial projects has led to a multiplier effect of more than three times over basal income from the Generalitat de Catalunya.

In 2020, the Institute achieved a positive exploitation balance, with an EBIT near to 0.5 million euros due to the positive effects of the significant increase in income from R+D activities, and with a Net Profit of 1,756 million euros, due to the extraordinary financial profit generated by the sale of our Innoenergy European Society share.

The tax contingency with respect to deductibility of the incurred value added taxes, which affected significantly both the economic results and equity from 2014 to 2019, has seen the positive resolution from the Regional Economic-Administrative Court, since the claim made by the IREC in front of the Court has been estimated. The resolution state that the activity of scientific and technological research should be considered a subject activity to the value added taxes and not exempt from them, with full right to the refund of input value added taxes.

AUDITED PROFIT & LOSSES ('000 EUROS)

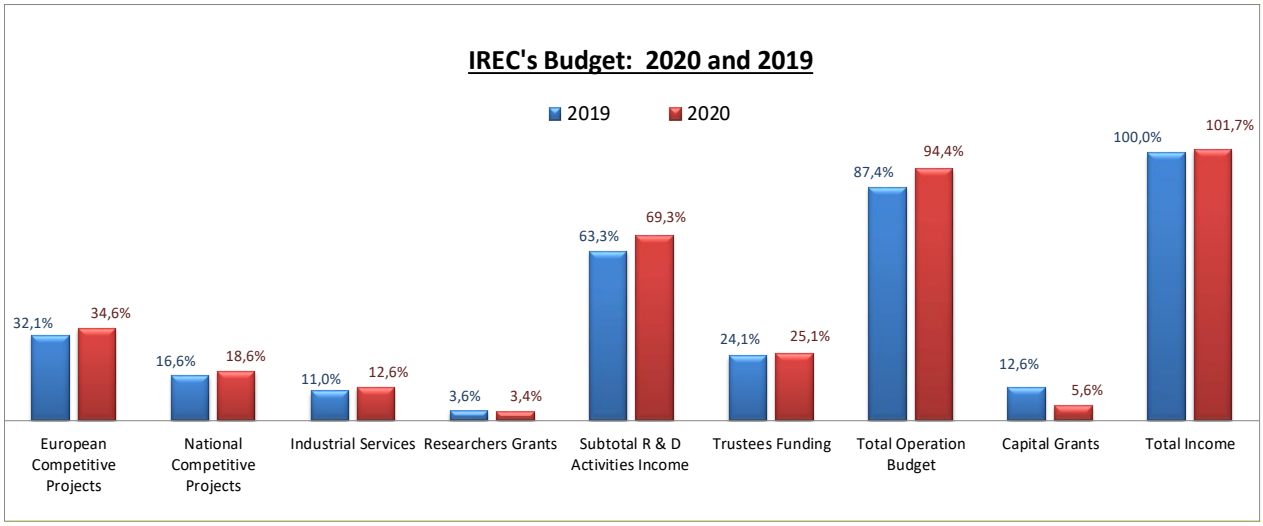
	Audited P&L	Audited P&L	Pre-Audited P&L
PROFIT AND LOSS ACCOUNT ('000)	2018	2019	2020
TOTAL REVENUE	**7.842**	**8.307**	**8.434**
INCOME FROM R+D ACTIVITIES	4.272	5.218	5.774
TRUSTEES FUNDING	2.000	2.000	2.120
GRANT ASSETS ASSIGNED	1.552	1.044	511
OTHER INCOME	18	45	29
TOTAL OPERATING EXPENSES	**5.736**	**6.705**	**7.213**
PERSONNEL EXPENSES	3.743	4.364	4.930
OTHER OPERATING EXPENSES	1.993	2.342	2.283
EBITDA	2.106	1.602	1.221
AMORTIZATIONS	1.642	1.231	786
EBIT	464	371	435
FINANCIAL RESULT	- 343	- 326	1.331
EXCEPTIONAL RESULT	- 0,5	9,5	- 10,2
PROFITS	**120**	**55**	**1.756**

IREC'S 2020 BUDGET

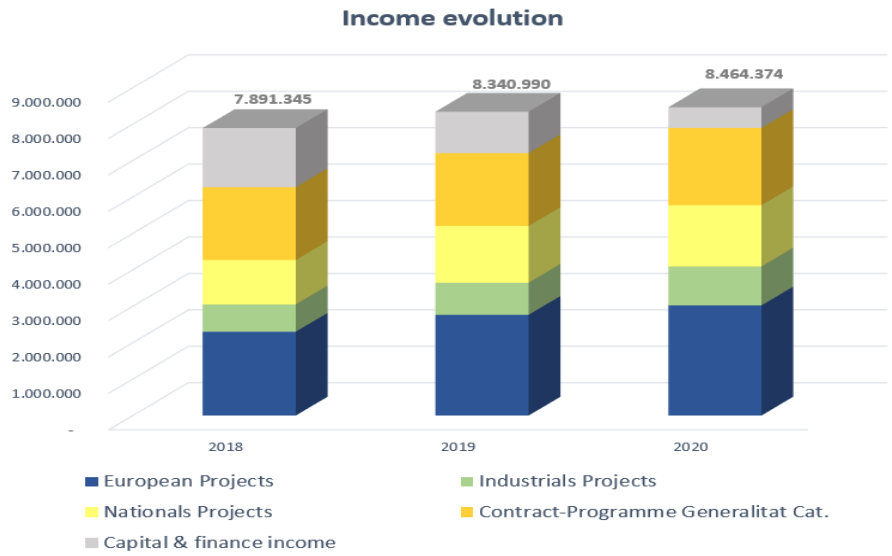
2020 has been a year of stability in the R+D activities, with consolidation in income from European competitive projects. Income from industrial projects increased too.

Overall total income budget increases 2%, due to an increase in basal contributions from trustees and due to the consolidation in income from competitive projects.

	European Competitive Projects	National Competitive Projects	Industrial Services	Researchers Grants	Subtotal R & D Activities Income	Trustees Funding	Total Operation Budget	Capital Grants	Total Income
2019	2.662.528	1.372.471	910.743	297.532	5.243.274	2.000.000	7.243.274	1.044.400	8.287.674
2020	2.920.785	1.569.886	1.063.674	285.025	5.839.370	2.120.000	7.959.370	471.961	8.431.331
Variation 2020/2019	9,7%	14,4%	16,8%	-4,2%	11,4%	6,0%	9,9%	-54,8%	1,7%



Income evolution from 2018 to 2020 shows the growth in the different lines of income.



INFRASTRUCTURE FUNDING

The IREC's scientific and technological infrastructures have been funded by the following public administrations through the annual calls for tender listed below:

» ERDF funding within the "Programa Operatiu Catalunya 2007-2013"; € 4,202,998.15 granted to finance the IREC's Barcelona infrastructures, and € 1,853,449.83 granted to finance the IREC's Tarragona infrastructures.

» ERDF funding within the "Fondo Tecnológico Ministerio de Ciencia e Innovación"; € 304,490 awarded to finance the infrastructures of the IREC's offshore wind energy test station in Tarragona, advanced through the program Innplanta 2010-2012 from "Parques Científicos y Tecnológicos del Ministerio de Ciencia e Innovación".

» "Infraestructuras Científico-Tecnológicas", from the Spanish Ministry of Science and Innovation, funded with loan and ERDF funding, within the "Fondo Tecnológico Ministerio de Ciencia e Innovación", with a € 402,425.78 grant to finance laboratory equipment in Barcelona.

» Funding of 2 million euros for IREC infrastructures in the 2009-2011 period from the 2009 Spanish State budget, pursuant to section 32 in the third additional ruling of the Statute of Autonomy, through the call made by the Spanish Ministry of Science and Innovation, with the support of the Ministry of Innovation, Universities and Enterprise of the Government of Catalonia.

» Funding of 3.1 million euros for IREC infrastructures in the 2010-2012 period from the 2010 Spanish State budget, pursuant to section 32 in the third additional ruling of the Statute of Autonomy, through the call made by the Spanish Ministry of Science and Innovation, with the support of the Catalan Ministry of Economy and Finance.

» Funding of 1 million euros for the IREC's offshore wind energy test station in Tarragona in the 2010-2012 period, from the 2010 Spanish State budget, pursuant to section 32 in the third additional ruling of the Statute of Autonomy, through the call made by the Spanish Ministry of Industry, Tourism and Commerce.

» Pluriannual funding of 7 million euros awarded by the Generalitat de Catalunya to fund 5 million € of the IREC's infrastructures in the period 2010-2014, plus interests.

» Nominal subsidy of € 100,000 from 2010 within a programme for cooperation between the state administration and the autonomous communities, awarded by the Spanish Ministry of Science and Innovation.

» Loans totalling € 13,963,966 through the calls Acteparq 2009 and Innplanta 2010-2012, both funding schemes from "Parques Científicos y Tecnológicos del Ministerio de Ciencia e Innovación", for the financing of the IREC's scientific and technological infrastructures at its Barcelona and Tarragona headquarters.

IREC PERSONNEL

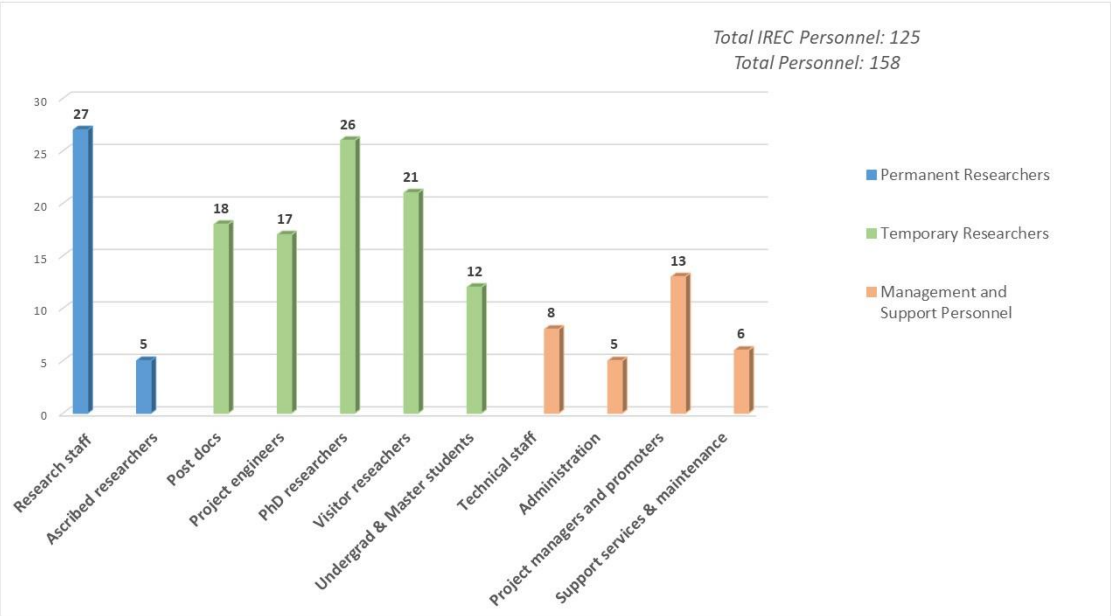
The Institute currently has 125 members from all over the world, including 7 research groups organised around two research areas -Advanced Materials and Systems for Energy Area and Energy Efficiency in Systems, Buildings and Communities Area- and one research programme -Program for Fusion Technology Development-. This IREC research is underpinned, protected and promoted by a comprehensive set of management and support services. All of them form the IREC Team.

IREC strives to provide a supportive and international working environment. The institute recognises the power of a diverse community and encourages applications from individuals with varied experiences, perspectives and backgrounds, and it is committed to promoting gender diversity among faculty. With this aim, IREC adopts family-friendly policies, adheres to state-of-the-art guidelines for advancing gender equality and women´s leadership in science.

IREC endorses the Requirements and Principles of the European Charter for Researchers, the Code of Conduct for the Recruitment of Researchers, and Open, Transparent, Merit-based recruitment promoted by the European Commission and follows Equal Opportunities policies.

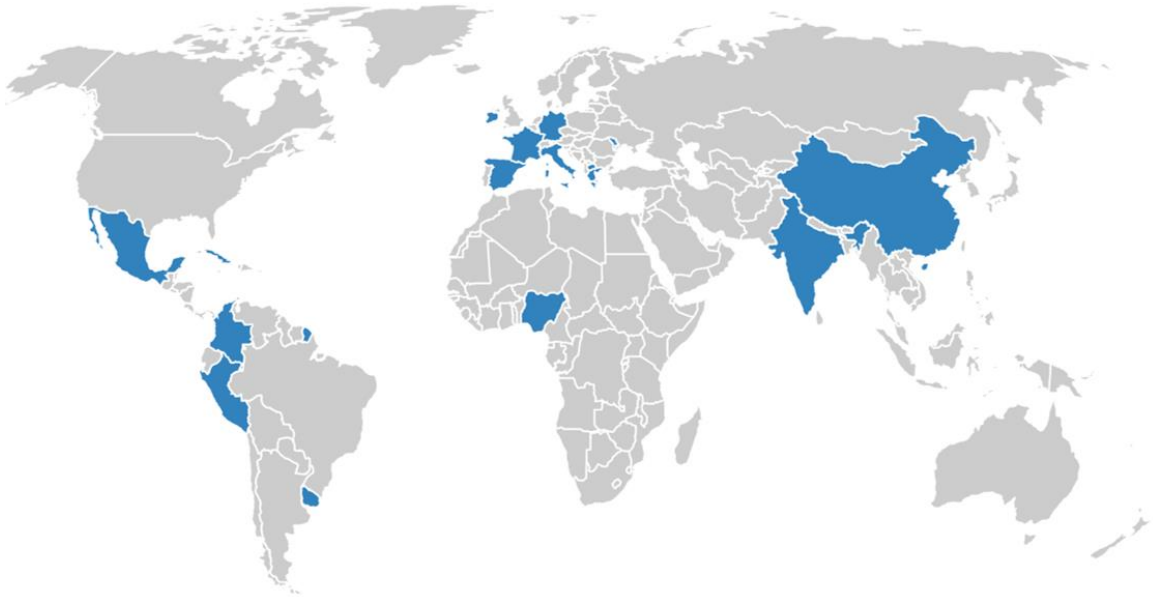
Since December 2017, IREC is awarded with the 'HR Excellence in Research' title. This recognition reflects the commitment of the Institute to the continuous improvement of its human resources policies.

Following, a distribution of IREC's personnel by permanent and temporary, identifying research, technician and management team:

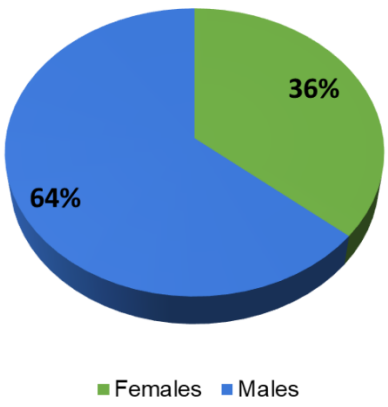


INTERNATIONALITY

In 2020 IREC had staff and researchers from different nationalities: Andorra, China, Colombia, Cuba, England, France, Germany, Greece, India, Ireland, Italy, Luxembourg, Macedonia, Mexico, Moldova, Nigeria, Peru, Spain, Ucraine and Uruguay.



BREAKDOWN OF IREC PERSONNEL BY GENDER



TECHNICAL STAFF

Research at IREC is supported by specific laboratory technicians and scientific and technological platforms and facilities running by specialized personnel that provide shared access to specialized and cross cutting equipment, services and expertise for the advanced technological preparation, characterization and assessments for all kinds of materials and energetic systems at different levels. These are open to external uses either from academia and industry, with precise conditions tailored to meet customer technology demands via our knowledge&technology transfer unit.

The IREC community in Barcelona headquarters

4. FACILITIES AND EQUIPMENT

The IREC facilities are located in Barcelona and Tarragona. Our laboratories are equipped with state-of-the-art tools to conduct research of excellence in the two areas of the institute:

1) Advanced Materials and Systems for Energy
2) Energy Efficiency in Systems, Buildings and Communities

Both IREC laboratories are equipped with cutting-edge technology comprising systems for the generation, storage and smart management of the energy.

IREC hosts:
- 7 research laboratories
- 1 general research support laboratory
- 1 general common facilities lab for characterization and analysis of materials, components and energy systems.
- 2 simulations and testing facilities that can operate jointly

5. RESEARCH LINES

IREC research activities are aligned with **three pillars** fully oriented to achieve the European objectives for 2050 reducing the contribution of the fossil energy sources and increasing the electrification as well as the decarbonisation of the society as active actions against the climatic change.

1) Energy and environment

With an increased demand for energy comes an increased responsibility to protect the natural environment. At IREC, we are innovating towards a cleaner energy future on the base of the deployment of renewal energy sources and developing technologies concerning the processes concerning C

2) Energy storage

To ensure that future energy needs are met, the transition towards renewable technologies must be accompanied by effective methods for large-scale energy storage as well as those addressed to the electrical mobility

3) Smart energy management

We are committed to making the energy efficient cities of tomorrow a reality. This requires a holistic approach that considers the economy, the environment, and the people who live in it.

IREC research lines are aligned with the European policy targets as well as with the energy industry aims of the energy strategy approved by the industrial and governmental members of the IREC Trustees Board.

In this framework, the European Strategic Energy Technology Plan (SET-Plan) as well as the forensen objectives included in the preparation of the Pacte Nacional per la Transició Energètica a Catalunya (PNTE), establishes a first references about the strategic energy technology policy for Europe and its adaptation to Catalunya. It is addressed to accelerate the development and the deployment of cost-effective low, even zero, carbon technologies and new energy generation, specially renewal ones, transport, distribution and end-user's models as well as the smart energy management systems and related services considering the contributions from novel options as energy storage, internet of thing and big data alternatives.

The proposed strategic map emphasizes the importance of promoting the quality of basic and applied science as a way of making progress for deployment emerging emerging technologies and their set-ups. The action plan also includes measures related to planning, implementation, resources and international cooperation in the field of energy technology, innovation and services as key elements for new energy business models and their acceptance and interaction with the society.

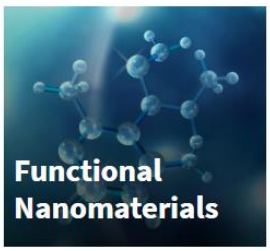
Under these boundaries, the most interesting topics, where European research should be the most effective for improving the industrial competitiveness, are about basic materials science for developing new functional sytems and device components, physical chemistry of processes,

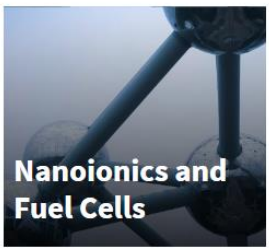
heat and mass transfer phenomena, advanced electronic and electrical power, dedicated powerful tools to assess energy set-up, especially, on large scale facilities. Likewise, emphasis must be addressed on engineering capabilities for transferring knowledge and understanding to disruptive innovations, smart energy management and intelligent services increasing efficiency of the used energy.

6. RESEARCH UNITS

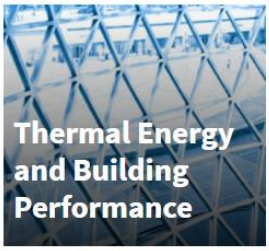
IREC comprises seven research groups. Within each of our research groups there are talented and dedicated teams striving to feed the world of tomorrow in an equally sustainable, affordable and accessible way.

Advanced Materials and Systems for Energy Area





Energy Efficiency in Systems, Buildings and Communities Area



6.1. ADVANCED MATERIALS AND SYSTEMS FOR ENERGY AREA

The area of Advanced Materials and Systems for Energy is a unit of research and technological development focused on materials and devices for implementing system for energy conversion and storage. Its activities involve the understanding, development and implementation of elements suitable for scientific and technological knowledge transfer to industry and offers, at the same time, technological support for addressing innovations in this field. These activities are strongly related with activities of research and technology development performed in other areas of the Institute, where projects are boosted through collaboration.

Regarding energy conversion, the work of the Advanced Materials and Devices for Energy area addresses major effort on solar energy and fuel cells, including also different options for the direct conversion of solar energy into electrical and/or chemical energy, in the context of artificial photosynthesis processes.

In this context, activities are centered on thin layer II-VI technology and the use of new concepts in nanomaterials to increase efficiency and or reduce cost considering its potential as building integration photovoltaic element. At the same time, our capacity to synthesize and or grow new nanostructured materials as well as new catalysts is addressed to new concepts of photoelectrochemical systems for the direct conversion of solar energy into chemical energy. Objectives are to obtain hydrogen and reduce CO2 to develop a C1 economy with special attention on the storage of chemical energy and the development of solar refinery. These activities are also guided by new results in the field of nanoionics for the advancement of electrochemical systems such as fuel cells and their reversible use as electrolyzers.

Nanoionic properties are being studied for developing advanced new electrochemical systems such as; integrated and intermediate temperature fuel cell and electrolyzers, while nanocatalyts are being implemented for new energy conversion systems.

Relevant advances in nanoelectrochemistry are being used for improved energy storage cells implementing new energy storage cells and systems as components of a pilote line. New 3D electrodes based on advanced nanomaterials and the use of catalysts, membranes and new formulations of liquid electrolytes are being applied to the development of new technologies for electrical storage beyond the present battery technology. This also includes new

methodologies for the diagnosis and prognosis of energy storage systems needed for smart energy management. Special attention is being laid on flow redox based batteries as an alternative to contemporary lithium ion cells. The above activities are converged for the development of integrated systems, their control, and development of testing tools and performance assessment procedures. Their control by means of sensors and the use of harvesting tools allows us to guarantee sustainable autonomy and potential effects on energy management criteria.

The Advanced Materials and Devices for Energy sector is organized in four interrelated laboratories and a general laboratory of common services and facilities. These laboratories are respectively focused on the following activities:

6.1.1. ENERGY STORAGE, HARVESTING AND CATALYSIS

6.1.2. FUNCTIONAL NANOMATERIALS

6.1.3. NANOIONIC AND FUEL CELLS

6.1.4. SOLAR ENERGY MATERIALS AND SYSTEMS

6.1.1. ENERGY STORAGE, HARVESTING AND CATALYSIS

The Team

(permanent and temporary positions, tenure tracks and fellowships)

Prof. Dr. Joan Ramón Morante, Group Leader of Energy Storage, Harvesting and Catalysis
Dr. Teresa Andreu, Deputy Group Leader of Energy Storage, Harvesting and Catalysis
Dr. Sebastián Murcia, Staff Scientist (Joan de la Cierva)
Dr. Jordi Jacas, Staff Scientist
Dr. Nina Carretero, Staff Scientist
Dr. Jordi Guilera, Postdoctoral Researcher
Dr. Zahilia Caban Postdoctoral Researcher (Tecniosping program)
Dr. Elias Martinez, Postdoctoral Researcher
Mr. Martí Biset, Laboratory Support
Dr. Carles Ros, Laboratory Support
Dr. Hemesh Avireddy, Postdoctoral Researcher
Mr. Arturo Javier Pajares, Predoctoral Student
Ms. Andreina Alarcón, Visiting Predoctoral Student
Mr. José Miguel Delgado, Visiting Predoctoral Student
Ms. Monalisa Chakraborty, Predoctoral Student
Ms. Viktoriia Holovanova, Predoctoral Student
Ms. Ting Zhang, Visiting Predoctoral Student
Mr. Venkata Siva Rama Krishma Tandava, Predoctoral Student
Mr. Marcelo Eduardo Chavez, Predoctoral Student
Mr. Paolo Lamagni, Postdoctoral Researcher (DFF grant)
Prof. Dr. Narcis Homs. Associated Professor, UB

The Energy Storage, Harvesting and Catalysis Group investigates, establishes and assesses new processes, mechanisms and systems for storing energy, as well as develop high performance catalysts to enhance the involved energy conversion processes for storing energy. Likewise, we investigate new methods in harvesting and energy storage for fully autonomous systems.

They cover a diverse range of multidisciplinary activities, including:

- The physics and chemistry of materials for their synthesis, processing and characterization.
- Electro (photo) chemistry
- Catalysis
- Thermoconversion, electroconverssion, bioconversion and artificial photosynthesis.
- CO_2 valorizationand Power to Gas or to Liquids
- Renewable gases (hydrogen methane…), synthetic fuels, e-fuels and added value chemical's
- The development of knowledge and technology in lithium ion, redox flow, metal air batteries as well as in capacitor's. Harvesting and storage for autonomous systems.

The activities of the group have led to the development of new technological approaches that have allowed us to obtain competitive prototypes of flow systems based on vanadium or organic electrolytes with very high performance with high values of energy efficiency and applied current density that demonstrate its feasibility at the industrial level. Likewise, we have obtained significant records in high density energy prototypes such as the achieved performances in LiS batteries working in regimes from 0.1C to 5C and in the use of new catalysts for new outstanding releases of metal air batteries, photobatteries and lithium ion based batteries avoiding non friendly elements. The latter have become a disruptive alternative for electrical energy storage combined with self-consumption.

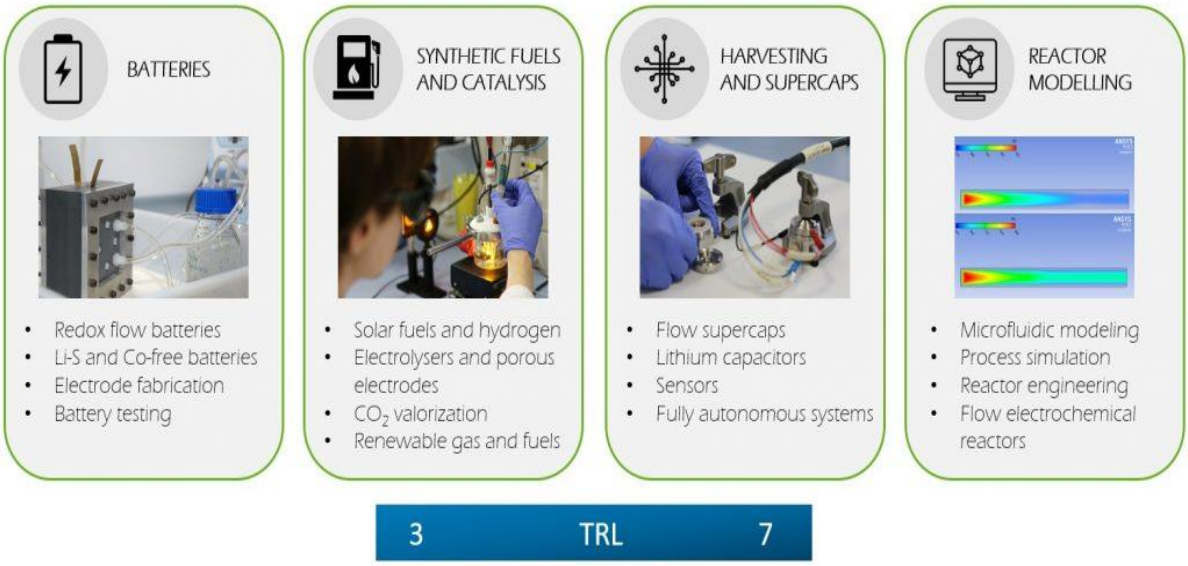
On the other hand, with the goal of building a decarbonized society based on a feasible energy transition in the industrial sectors, we are investigating the chemical storage of energy, the production of renewable fuels and the obtaining high value-added chemical products through sustainable procedures. So, based on the research carried out, new technological routes have been proposed for the efficient production of synthetic fuels in a high degree of efficiency, especially based on solar energy., The proposed technology route allow to achieve values of solar efficiency to hydrogen higher than 18% and solar to fuels greater than 15%. Likewise, activities are driven to the production of renewable gases (hydrogen, methane) at pilot plan level considering different sources of the required feedstock's. Complementary work is being performed using thermoconversion processes based on the use of plasmas and new catalysts.

Their research activities are distributed across three major axes:

- Electrochemical batteries, with a focus on redox flow batteries – vanadium, organics, supercaps, lithium sulphur, advanced lithium ion and metal air batteries.
- Thermoconversion, electroconversion, bioconversion and photoconversion (artificial photosynthesis) technologies as new alternatives for the sustainable fuel production.

- Fully autonomous systems with reliable capacity for energy storage, essential for achieving smart energy management systems.

The Energy Storage, Harvesting and Catalysis group conducts cutting edge research in emergent technologies to facilitate the energy transition: from materials to reactors of disruptive electrochemical and chemical energy storage devices contributing to the society descarbonization by reducing CO2 emissions or reusing CO2.



CAPABILITIES

- Battery fabrication, assembly and testing (ageing, degradation, climate tests...)
- Electrochemical testing (potentiostats, electrochemical impedance spectroscopy, rotating disk electrode, photoelectrochemistry, solar simulators, IPCE)
- Thermo-, photo- and plasma-catalytic reactors
- Heterogeneous catalyst characterization (BET, chemisorption-MS, TG-DSC, DRIFTS-MS)
- Electrode/catalyst fabrication and thin film deposition (ALD, electrospinning, hydrothermal, electro-deposition, wet impregnation, mesoporous materials, doctor Blade deposition, spin coating...)
- Reactor modelling (CFD)

HIGHLIGHTS

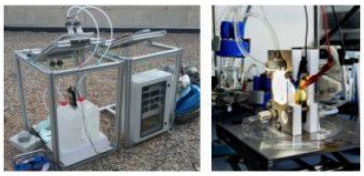
COSIN — **PILOT PLANT**

Methanation unit at the water treatment plant EDAR Riu-Sec, Sabadell

REDOX 2015 — **PILOT PLANT**

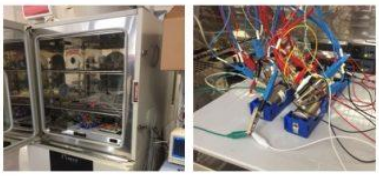
Collaboration in the Project for a Vanadium Redox Flow Battery pilot plant in EDP Energía (Gijón, Spain)

SOLAR FUELS — **PILOT PLANT**



Solar hydrogen demonstrator plant for an industrial project

HELIS — **DEMONSTRATOR**



New pouch cell based on LiS battery implemented

PROJECTS

Title: Interfacial engineering of nano-catalysts on gas diffusion electrodes for continuous CO2 photoelectroconversion to methanol,
Acronym: DFF-International Postdoctoral Grant
Description: Conversion of CO2 may be a key-player in defining new resources to produce chemical commodities and advanced materials, and to store chemical energy, especially when combined with renewable energy sources like wind and solar.
This project aims at the development of efficient catalytic systems for the realisation of scalable photo-assisted flow-reactors for CO2-to-MeOH photoelectroconversion. MeOH is of large industrial interest, being a key component in hundreds of chemicals and an attractive emerging fuel.
The first goal is designing novel catalysts merging together metal-organic frameworks and porous matrices, to form finely tailored gas diffusion electrodes. MOF nano-particles will be synthesised in situ within the pores of conductive templating layers, thus maximising the contact area with CO2 permeating through the hierarchical pores of the composite MOF catalyst-loaded layer. On top of this, a porous photocatalyst driving OER will provide extra electrons and protons for CO2RR.
Funding: DFF-IPD
Project ID: 9059-00008B
Type: Competitive Nationals
IREC Role: Beneficiary
Date: 2019 - 2021
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Prof. Joan Ramón Morante
More info at the following link

Title: 3d anodes in full pec Device for h2 generation,
Acronym: AnoDHyGen
Descripction: The preparation of single and modified Bi2WO6-based materials was carried out, as alternative to TiO2 in photocatalytic processes under visible light. Initially, the Bi2WO6 synthesis was optimized and 3D-hierarchical superstructures were obtained. Besides, given the inherent limitations of this material, several modification alternatives were proposed. Thus, Bi2WO6/TiO2 heterostructures and activated carbon- or metal-Bi2WO6/TiO2 systems were studied. This way, the improved charge separation mechanisms led to better photocatalytic responses in several reactions. Besides photodegradation of organic compounds, other ""green chemistry"" processes were studied with these materials, including selective oxidation of alcohols, propylene epoxidation and CO2 photoreduction.
Funding: Tecnio Spring - Acció
Project ID: TECSPR16-1-0084
Type: Competitive Nationals
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC), Universidad De Barcelona (UB), Universidad Autonoma de Madrid (UAM), Universitat Jaume I (UJI).
IREC Role: Beneficiary
Date: 2018 - 2020
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Dr.Sebastián Murcia López.
More info at the following link

Title: Design of catalysts based on transition metal carbides efficient for H2 production processes and for selective CO2 activation.
Acronym: CD&HYCATS
Description: In this project new catalysts based on transition metal carbides (TMC of 5 and 6 groups) will be developed. Two processes are contemplated, the alternative H2 production using biomass derived resources and the chemical recycling of CO2 through its conversion to methanol. Different preparation methods including the use of microwaves and ultrasounds will be used for the preparation of the catalytic materials based on CMT (M= Mo, W, V, Nb, Ta). Catalysts based on CMT/ZnO-CeO2, CMT/CeO2-ZrO2 and M/CMT (M= Cu, Co, Ni) will be prepared and studied in the catalytic steam reforming of C1-C3 oxygenates, methanol, ethanol and acetone. The photocatalytic H2 production using methanol as sacrificial agent will be also carried out. For this end, nanostructured-CMT/TiO2 and CMT/ZnO will be prepared and characterized. For the CO2 hydrogenation to methanol new systems based on CMT/ZnOGa2O3ZrO2 and M/CMT (M= Cu, Ni) will be developed. In all cases, catalytic materials will be deeply characterized before and after reaction. The stability of representative systems will be analyzed. Appropriate relationships between the catalytic behavior and the characteristics of the catalysts will be stablished. It is expected the determination of the fundamental characteristics of this type of materials, which are necessary for carry out the catalytic processes studied.
Funding: Proyectos I+D Excelencia 2017
Project ID: MAT2017-87500-P
Type: Competitive Nationals

IREC Role: Beneficiary
Date: 2018 - 2020
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Prof. Narcís Homs
Other groups:
More info at the following link

Title: CObalt-free Batteries for FutuRe Automotive Applications
Acronym: COBRA
Description: COBRA aims to develop a novel Co-free Li-ion battery technology that overcomes many of the current shortcomings faced by Electrical Vehicle (EV) batteries via the enhancement of each component in the battery system in a holistic manner. The project will result in a unique battery system that merges several sought after features, including superior energy density, low cost, increased cycles and reduced critical materials. To achieve these ambitious targets we will: upgrade the electrochemical performance by focusing on Co-free cathode, advanced Si composite as anode and electrolyte/separator; cell manufacturing and testing for electrical and electrochemical performance; leverage the use of smart sensors and advanced communication to optimise the system control; battery-pack manufacturing that deliver cost-effective and environmentally sustainable battery over its lifetime. The proposed Li-ion battery technology will be demonstrated at TRL6 (battery pack) and validated it on an automotive EV testbed. The involvement of several leading organisation for battery manufacturing ensure easy adaptation to production lines and scale up to contribute to a higher market adoption while helping to strengthen Europe's position in the field. Overall, the project includes the participation of 3 universities, 7 RTOs, 4 SMEs and 5 enterprises covering the entire value chain and strongly engaging EU battery industry.
Funding: H2020
Project ID: 875568
Type: Competitive EU
IREC Role: Coordinator
Partners: STOCKHOLMS UNIVERSITET, INTERUNIVERSITAIR MICRO-ELECTRONICA CENTRUM, CERAMIC POWDER TECHNOLOGY AS, UPPSALA UNIVERSITET, FUNDACION CIDETEC, SOLVIONIC, FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, LIACON GMBH, TECHNISCHE HOCHSCHULE INGOLSTADT, COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES, AENTRON GMBH, INFINEON TECHNOLOGIES AG, NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO, FUNDACIO EURECAT, AVL ARASTIRMA VE MUHENDISLIK SANAYI VE TICARET LIMITED SIRKETI, IDIADA AUTOMOTIVE TECHNOLOGY SA, RESITEC AS, BAX INNOVATION CONSULTING SL,
Date: 2020 - 2023
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Dr. Jordi Jacas
Other groups: Power Systems, Energy System Analytics.
More info at the following link

Title: AutoGraph – Electrodos basados en grafeno para dispositivos de almacenamiento de energía para sistemas totalmente autónomos
Acronym: Autograph-GRAPHCAT
Description: The AutoGraph project focuses on the development of an electrode fabrication technology based on the properties of graphene and its preparation suitable for the device requirements. on the properties of graphene and its preparation suitable for the requirements of the electrochemical electrochemical energy storage device for self-contained vehicles. Its objectives are: (i) to achieve an operational graphene-based energy storage system and its fabrication technology, and its manufacturing technology, (ii) developing a fully autonomous modular system having at least a nanogenerator, an energy storage, a sensor and a data communication system. energy storage, energy storage, sensor and data communication system.
The integration of a graphene-based supercapacitor (or a hybrid) in the prototype will allow to demonstrate that the in-house technology is robust enough to be used commercially in the near future considering the wide field of applications.
future considering the wide field of applications of these systems.
Funding: Emergents 2018
Project ID: IU16-011569
Type: Competitive Nationals
IREC Role: Coordinator
Partners: Fundació Institut Català de Nanociència i Nanotecnologia (ICN2), Institut de Ciència Fotònica (ICFO), Fundació Institut de Recerca en Energia de Catalunya (IREC),
Institut de Física d'Altes Energies (IFAE), Universitat Autònoma de Barcelona/ Ingeniería Electrónica/Instituto de Neurociencias (UAB), Consorci Institut d'Investigacions Biomèdiques August Pi i Sunyer / Systems Neuroscience Group (IDIBAPS), Fundació EURECAT (EURECAT), Institut de Microelectrònica de Barcelona de la Agencia Estatal Consejo Superior de Investigaciones Científicas (IMB-CNM-CSIC), Instituto Hospital del Mar de Investigaciones Médicas (IMIM), Barcelona Institute of Science and Technology (BIST)
Date: 2019-2021
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Prof. Joan Ramón Morante
More info at the following link

Title: Integro- CombIned Perovskite Solar Cell – Graphene Electrode for CO2 Reduction
Acronym: Integro-GRAPHCAT
Description: INTEGRO aims to develop an artificial photosynthesis device, combining a low-cost, high-voltage and efficient photovoltaic (PV) cell based on perovskite technology, with a metal-free electro-catalyst (EC) made of graphene. nitrogen doped, in order to create an integrated PV-EC system. Said PV-EC set, powered by solar energy, will be able to operate at low voltages (<2.4V) and high faradaic efficiencies (> 80%) and will be able to supply enough energy to initiate the CO2 reduction reaction, reaching a solar efficiency at fuel> 10%.
The GraphCAT group aims to group and stimulate collaborative actions between all technological development actors, including Technology Centers, industrial Clusters, other RIS3CAT communities, investors, companies (both SMEs and large companies), hospitals and healthcare personnel, and entrepreneurs. It is for this reason that the GraphCAT Action Plan

dedicates an action to the organization and participation in activities for the dissemination and valorization of technology, promoting the creation of forums shared by the community and at the same time exposing the technologies in development to an industrial audience. to facilitate your transfer.
Funding: Emergents 2018
Project ID: IU16-011569
Type: Competitive Nationals
IREC Role: Coordinator
Partners: Fundació Institut Català de Nanociència i Nanotecnologia (ICN2), Institut de Ciència Fotònica(ICFO), Fundació Institut de Recerca en Energia de Catalunya (IREC), Institut de Física d'Altes Energies (IFAE),Universitat Autònoma de Barcelona/ Ingeniería Electrónica/Instituto de Neurociencias (UAB), Consorci Institut d'Investigacions Biomèdiques August Pi i Sunyer / Systems Neuroscience Group (IDIBAPS), Fundació EURECAT (EURECAT), Institut de Microelectrònica de Barcelona de la Agencia Estatal Consejo Superior de Investigaciones Científicas (IMB-CNM-CSIC), Instituto Hospital del Mar de Investigaciones Médicas (IMIM), Barcelona Institute of Science and Technology (BIST)
Date: 2019 - 2022
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Nina Carretero
Other groups:
More info at the following link

Title: Biorefinery combining HTL and FT to convert wet and solid organic, industrial wastes into 2nd generation biofuels with highest efficiency
Acronym: Heat-to-Fuel
Description: Heat-to-Fuel will deliver the next generation of biofuel production technologies towards the de-carbonisation of the transportation sector. Heat-to-fuel will achieve competitive prices for biofuel technologies (<1€/l) while delivering higher fuel qualities and significantly reduced life-cycle GHG reductions. Heat-to-fuel will result in increased Energy production savings (>20%) and enhanced EU's energy security by the use of local feedstocks which in turn ensured local jobs are preserved and increased. The benefit of combining technologies like in Heat-to-Fuel is, that the drawbacks of the single technologies are balanced. FT and APR are promising technologies for the efficient production of 2nd generation fuels. But currently the economic border conditions don't allow the implementation, similar to many other biofuel technologies. The radical innovation of combining an APR with a FT reactor is the basis to overcome this barrier. The large organic wastes (from HTL or other streams) can be conveniently treated with APR to produce H2. Both dry and wet organic wastes can be integrated, with mutual advantages, i.e. steam production for gasification, HTL and APR preheating; FT heat cooling without external utilities. Using the synergies between these technologies maximizes the total process efficiency. Heat-to-fuel aims will be met thanks to the diversification of the feedstock for biofuels production, reducing the supply costs and upgrading the efficiencies of promising and flexible conversion.
Funding: H2020
Project ID: 764675
Type: Competitive EU (partner)

IREC Role: Beneficiary
Partners: GUSSING ENERGY TECHNOLOGIES GMBH (coordinator), FUNDACIO INSTITUT DE RECERCA DE L'ENERGIA DE CATALUNYA, CONSORZIO PER LA RICERCA E LA DIMOSTRAZIONE SULLE ENERGIE RINNOVABILI, COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES, JOHNSON MATTHEY PLC, SKUPINA FABRIKA RAZISKAVE IN RAZVOJ DOO, POLITECNICO DI TORINO, TECHNISCHE UNIVERSITAET WIEN, BEST - BIOENERGY AND SUSTAINABLE TECHNOLOGIES GMBH, INSTYTUT CHEMICZNEJ PRZEROBKI WEGLA, TECNOL SRL, ATMOSTAT, CENTRO RICERCHE FIAT SCPA, R2M SOLUTION SPAIN SL.
Date: 2017 - 2021
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Prof. Joan Ramón Morante
More info at the following link

Title: Light to Store chemical Energy in reduced Graphene Oxide for electricity generation
Acronym: LESGO
Description: Hydrogen is being pursued as a promising route to store energy, potentially mitigating the unpredictability of electricity generation based on renewables. Provided that more than 95% of H2 produced comes from breaking the C-H bond in hydrocarbons, it is natural to think that storing H bound to C may provide a long-term solution to this challenge. However, liquid hydrocarbons are not an optimal solution given that the process of extracting H from them involves CO2 emissions. LESGO proposes to store energy in the C-H bond of reduced graphene oxide (rGO-H). rGO-H can be stored safely, exhibits an energy density more than 100 times larger than that of H2 gas, and can be easily transported wherever the electricity generation is needed. LESGO will demonstrate that rGO-H can become an ideal energy stock at an affordable cost and used to supply electrical power on demand where it is required. In the complete cycle from sun light to electrical power the raw material for storage evolves from graphite back to graphite with no CO2 emissions in any intermediate step. LESGO's consortium has been structured to bring together a highly interdisciplinary community that will enable the emergence of an ecosystem around a circular economy relying on the use of: widely available raw materials, storing energy in chemical bonds, using it in applications that require electrical power, and finally recovering the materials for a second or multiple lives. Industrial (GRAPHENEA, HST, GENCELL and CRF), academic (UDE and AALTO) or research center (IREC and ICFO) activities are completely interwoven throughout the entire implementation of LESGO. Within the duration of LESGO, CRF will develop an application in the transport sector where rGO-H will be tested as the fuel in a support battery providing a fast charging for current electric vehicles. When looking ahead beyond the consortium, DBT will foster the engagement of a wider stakeholder/public community to consolidate the ecosystem around rGO-H.
Funding: H2020
Project ID: 952068
Type: Competitive EU (partner)
IREC Role: Beneficiary
Partners: FUNDACIO INSTITUT DE CIENCIES FOTONIQUES (coordinator), GRAPHENEA SA, UNIVERSITAET DUISBURG-ESSEN, AALTO KORKEAKOULUSAATIO SR, FUNDACIO INSTITUT DE

RECERCA DE L'ENERGIA DE CATALUNYA, HYSYTECH SRL, CONSIGLIO NAZIONALE DELLE RICERCHE, GENCELL LTD, CENTRO RICERCHE FIAT SCPA, FONDEN TEKNOLOGIRADET,
Date: 2020-2023
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Prof. Joan Ramón Morante
Other groups: Solar Energy Materials and Systems, Energy Storage, Harvesting and Catalysis
More info at the following link

Title: M2E SGR 2017-2019
Acronym: M2E SGR 2017-2019
Description: Electronic materials and M2E power. This consolidated research group carries out activities related to electronic materials and power.
Funding: SGR
Project ID: 2017 SGR 1246
Type: Competitive Nationals
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC), Universidad De Barcelona (UB), Universidad Autonoma de Madrid (UAM), Universitat Jaume I (UJI).
IREC Role: Coordinator
Date: 2018 - 2021
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Prof. Joan Ramón Morante
Other groups: Functional Nanomaterials.
More info at the following link

Title: Manufacture of catalyst for synthetic natural gas production of renewable origin
Acronym: Prod_Cat
Description: The goal of the present project is to expand the portfolio of our optimized catalysts to be able to fit in to a wider range of potential customer's reactors (from 100-µm microreactors to 5-mm conventional reactors). To accomplish this goal, it is necessary to synthesize the material onto which our catalyst is supported. Thus, new equipment is needed and understanding the role of new components (active material, binder, promoter, porous support) will become crucial. An iterative process of catalyst preparation and testing at the potential customer lab/pilot setups will be performed, at least with two customers (Tecnalia and Ineratec). Finally, implementation of the catalyst prototype in a real demonstration plant will be the main milestone of the project.
Funding: AGAUR
Project ID: 2019 PROD 00091
Type: Competitive nationals
IREC Role: Beneficiary
Date: 2020 - 2022
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Prof. Joan Ramón Morante
More info at the following link

Title: Materials, processes and components for a solar refinery
Acronym: RESOL
Description: The direct conversion of solar energy into a chemical, hydrogen or reduced products from CO2, is a difficult challenge, as it must exceed the range of efficiencies in the order of 8-10% (STF, Solar-To-Fuel) just to be energy-efficient compared to other indirect pathways. In addition, it should offer lifetimes, scalability and costs that make this option feasible as a preferred technology. For this, it is necessary to delve into the knowledge of the energy transfer processes of the photon to the charge carriers and from these ones to the chemical species via suitable catalysts to be able to design and to implement fotoelectrochemical cells with low cell voltages allowing configurations bias free. On the other hand, the development of these photoelectrochemical cells without bias, only with the contribution of solar energy, opens numerous capacities to implement oxidation treatments and / or reduction of components in industrial, agricultural or even urban residual liquids for their treatment with excellent energy balances which constitutes a real disruptive challenge. RESOL, is aimed at the study, knowledge, modeling and implementation of the different constituents of the photoelectrochemical system to construct prototypes that allow to evaluate both water oxidation processes and CO2 reduction processes with their transformation to added value chemicals as well as processes of oxidation of organic molecules. To this end, appropriate catalysts will be synthesized for each application, the procedures for their application being developed with the electrodes and photoelectrodes used in each of the PEC cell configurations that will be proposed for each of the objectives. Photoactive structures based on photovoltaic devices will also be used, combining junctions or developing tandem structures, in silicon or thin layer technology of chalcogenides or photoactive materials on transparent substrates or other emerging technologies implemented in the consortium to have enough photogenerated voltage to ensure bias free systems (artificial leaves). It will work in configurations of two compartments, anode and cathode, separated by selected membrane to minimize cell voltages. The catalysts will be explored based on their use in 3D structures to increase their specific surface active, trying to minimize voltage drops, maximizing their catalytic activity and minimizing their degradation. For this, their behavior will be studied at nano scale. Finally, RESOL will address the issues of stability, scalability and, based on the prototypes implemented, the potential uses for both the production of solar fuels based on a circular CO2 economy and for the decontamination of fluids at low costs will be evaluated.
Funding: Proyectos I+D Retos 2017
Project ID: ENE2017-85087-C3-2-R
Type: Competitive Nationals
IREC Role: Beneficiary
Partners: Universitat Jaume I (UJI), Fundacio Institut de Recerca en Energia de Catalunya (IREC), Fundació Institut Català de Nanociència i Nanotecnologia (ICN2)
Date: 2018 - 2020
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Prof. Dr.Joan Ramón Morante.
More info at the following link

Title: Towards High Energy All Solid State Lithium Batteries,
Acronym: SOLBAT
Description: All-solid-state Li-ion batteries in thin-film format are currently the most promising concept for the energy storage needs of miniature electronic devices. Using 3D substrates, the effective surface area and thus the energy density could be increased. Atomic layer deposition (ALD) is one of the few methods capable in producing conformal layers on such complex structures. The basic research on new ALD processes for Li-containing thin films is only in early stage. The aim of this project was to advance the field with the introduction of novel deposition processes for each of the active components of a thin-film Li-ion battery. An ultimate goal was to manufacture a fully functional all-solid-state thin-film battery.
Funding: Tecnio Spring - Accio
Project ID: TECSPR18-1-0049
Type: Competitive Nationals
IREC Role: Beneficiary
Date: 2019 - 2021
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Zahilia Caban Huertas.
More info at the following link

Title: Wide band gap Chalcogenide Technologies for cost efficient solar energy applications
Acronym: Wincost
Description: WINCOST proposes a breakthrough in the development of high efficiency and low cost energy systems based on wide band gap chalcogenide technologies. The project includes both electricity generation via advanced photovoltaic devices and the development of new concepts for energy storage, considering the implementation of specific solutions that meet the different needs in these applications, based on the use of semiconductors with different band gaps (Eg):
1.- Eg =1.4-1.5 eV, for the development of high efficiency photovoltaic devices with Voc >0.9 V and low current, in order to reduce potential
efficiency losses related to window layer. This will allow resolving one of the current problems for the up-scaling of these technologies at
module level, minimizing the effects related to the window layer inhomogeneities which are one of the main origins of the efficiency loss in
the industrial photovoltaic modules;
2.- Eg = 1.6-1.8 eV, for the development of cells suitable for their integration as top cell in tandem structures of very high efficiency (>
25%), and for the development of high efficiency photoelectrochemical devices for solar energy storage. The optimization of these devices
that involve the integration of both the solar energy conversion and the storage in the same system, requires for devices configurations
compatible with working voltages V > 1.3 V;
3.- Eg = 2.0-2.5 eV for the development of new semitransparent photovoltaic devices suitable for building integration (BIPV), with the aim
to answer to the increasing demand in this sector for semitransparent devices with higher efficiencies and different colors with the

requirements of both high aesthetic quality and high uniformity together with high stability and good durability.
The project involves the development of solutions based on the use of Cu(In,Ga)(S,Se)2 chalcopyrites that are compatible with processes already established at an industrial production level, and includes also the development of solutions based on emergent technologies with kesterites based Cu2ZnSn(S,Se)4 compounds and related alloys. Kesterites have potential interest as future replacement of chalcopyrites, being more compatible with a sustainable upscaling of the production to industrial mass production levels, avoiding the use of critical raw
materials (Ga, In). In all the cases, the viability of different technological strategies for the development of competitive solutions compatible with their implementation at industrial level will be evaluated.
WINCOST is based in the strong experience and background of the groups participating in the proposal in these technologies. This has been acquired within the development of different research projects that included both national and European relevant projects on these topics. Most of the European projects where coordinated by the groups participating in this proposal (SCALENANO, KESTCELLS, PVICOKEST, INDUCIS). These projects involve the main world leading groups and reference centers in these technologies, and have allowed the groups involved in WINCOST to achieve a deep knowledge on the fundamental properties of these materials and on the development of processes for high efficiency devices fabrication, positioning the WINCOST groups among the reference ones in these technologies in Europe.
Funding: Proyectos I+D Retos 2016
Project ID: ENE2016-80788-C5-1-R
Type: Competitive Nationals (coordinator)
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC), Universidad de Barcelona (UB), Universidad Autonoma de Madrid (UAM), Universitat Jaume I (UJI)
Date: 2016 - 2020
Group: Energy Storage, Energy Harvesting and Catalysis
P.I: Prof. Joan Ramón Morante
More info at the following link

PUBLICATIONS

Articles and Journals from ISI Database

Bigiani, L., Gasparotto, A., Maccato, C., Sada, C., Verbeeck, J., Andreu, T., Morante, J.R., Barreca, D. "Dual Improvement of β-MnO2 Oxygen Evolution Electrocatalysts via Combined Substrate Control and Surface Engineering" *ChemCatChem* 12, 23, pp. 5984 - 5992. 2020 DOI: 10.1002/cctc.202000999

Biset-Peiró, M., Mey, R., Guilera, J., Andreu, T. "Adiabatic plasma-catalytic reactor configuration: Energy efficiency enhancement by plasma and thermal synergies on CO2 methanation" *Chemical Engineering Journal* 393, pp. 124786 - 2020 DOI: 10.1016/j.cej.2020.124786

Casu, A., Dalmases, M., Lin, M., Wang, Y., Homs, N., Ramírez de la Piscina, P., Llorca, J., Figuerola, A., Falqui, A. "Monitoring the insertion of Pt into Cu2-xSe nanocrystals: a combined structural and chemical approach for the analysis of new ternary phases" *Nanoscale* 12, 31, pp. 16627 - 16638. 2020 DOI: 10.1039/d0nr02726j

Maccato, C., Bigiani, L., Andreu, T., Gasparotto, A., Sada, C., Modin, E., Lebedev, O.I., Morante, J.R., Barreca, D. "Quasi-1D Mn2O3 nanostructures functionalized with first-row transition-metal oxides as oxygen evolution catalysts" *ACS Applied Nano Materials* 3, 10, pp. 9889 - 9898. 2020 DOI: 10.1021/acsanm.0c01951

Yang, D., Zhang, C., Biendicho, J.J., Han, X., Liang, Z., Du, R., Li, M., Li, J., Arbiol, J., Llorca, J., Zhou, Y., Morante, J.R., Cabot, A. "ZnSe/N-Doped Carbon Nanoreactor with Multiple Adsorption Sites for Stable Lithium-Sulfur Batteries" *ACS Nano* 14, 11, pp. 15492 - 15504. 2020 DOI: 10.1021/acsnano.0c06112

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DOCTORAL THESES

Ongoing theses:

PhD student: Venkata Siva Rama Krishma Tandava (H2020-MSCA-COFUND-2016)
PhD supervisor: Dr. Joan Ramon Morante, Dr. Sebastián Murcia López
Title: Advanced Catalyst Materials and Systems for Electro-Conversion of CO2

PhD student: Marcelo Eduardo Chavez
PhD supervisor: Dr. Joan Ramon Morante, Dr. Sebastián Murcia López
Title: Synthesis of Value-Added Products through Advanced Photo-Electrocatalytic Systems

PhD student: Monalisa Chakraborty (H2020-MSCA-COFUND-2016)
PhD supervisor: Dr. Teresa Andreu Arbella, Dr. Sebastian Murcia-López
Title: Advanced photoelectrodes for next generation of solar energy storage: Photobatteries

PhD student: Monalisa Chakraborty (H2020-MSCA-COFUND-2016)
PhD supervisor: Dr. Teresa Andreu Arbella, Dr. Sebastian Murcia-López
Title: Advanced photoelectrodes for next generation of solar energy storage: Photobatteries

PhD student: Viktoria Holovanova (H2020-MSCA-COFUND-2016)
PhD supervisor: Dr. Joan R. Morante Lleonart, Dr. Teresa Andreu Arbella
Title: Development of catalysts for solar based fuels

PhD student: Andreina Alarcón (visiting researcher ESPOL)
PhD supervisor: Dr. Teresa Andreu Arbella, Dr. Jordi Guilera Sala
Title: Synthetic fuels production for the chemical energy storage and the carbon dioxide circular economy

PhD student: Miguel Angel Delgado
PhD supervisor: Dr. Joan Ramon Morante
Title: Degradation studies in electrochemical storage systems without lithium

PhD student: Martí Biset Peiró
PhD supervisor: Dr. Teresa Andreu Arbella
Title: Plasma-catalytic conversion of carbon dioxide

OUTREACH

- Menció especial als Premis PIONER 2020 (CERCA): December 22, 2020

- La revolución del hidrógeno verde: December 20, 2020

- European Research Night: November 27, 2020

- Biocombustibles: frío en barcos, tibio en coches y caliente para aviones: November 26, 2020

- Hidrógeno para descarbonizar el futuro: November 11, 2020

- Hidrogeno: vector energético de una economía descarbonizada- Fundación Naturgy - El hidrogeno como vector energético sostenible: November 5, 2020

  - Vídeo:https://youtu.be/vNNIe7etnyk

  - Llibre: https://www.fundacionnaturgy.org/publicacion/hidrogeno-vector-energetico-de-una-economia-descarbonizada/

  - NdP: https://www.irec.cat/wp-content/uploads/2020/11/NdP-Libro-hidrogeno-Fundacion-Naturgy.pdf

  - El español: La producción de hidrógeno verde podría ser 11 veces el consumo de gas en España: https://www.elespanol.com/invertia/empresas/energia/20201105/produccion-hidrogeno-verde-podria-veces-consumo-natural/533697381_0.html

  - EuropaPress: El hidrógeno renovable podría ser competitivo a partir de 2030, según un estudio del IREC y Fundación Naturgy:https://www.europapress.es/epsocial/responsables/noticia-hidrogeno-renovable-podria-ser-competitivo-partir-2030-estudio-irec-fundacion-naturgy-20201105134049.html

  - Energías renovables: España es el país europeo con mayor potencial de producción de hidrógeno verde según Naturgy:https://www.energias-renovables.com/almacenamiento/espana-es-el-pais-europeo-con-mayor-20201105

  - Catalunya press: La Fundación Naturgy apuesta por el uso del hidrógeno como energía renovable:https://www.catalunyapress.es/texto-diario/mostrar/2151809/fundacion-naturgy-apuesta-hidrogeno-como-energia-renovable

  - Climatización y confort: El hidrógeno renovable, ¿competitivo en España a partir de 2030? https://climatizacion-y-confort.cdecomunicacion.es/noticias/sectoriales/41228/hidrogeno-renovable-competitivo-en-espana-partir-2030

  - El boletín: El hidrógeno renovable puede ser competitivo a partir de 2030

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○ El periódico de la energía: El hidrógeno renovable puede ser competitivo a partir de 2030 https://elperiodicodelaenergia.com/el-hidrogeno-renovable-puede-ser-competitivo-a-partir-de-2030/

○ El Confidencial Digital: El hidrógeno renovable puede ser competitivo a partir de 2030, según un estudio https://www.elconfidencialdigital.com/articulo/ultima-hora/hidrogeno-renovable-puede-ser-competitivo-partir-2030-estudio/20201105121126182040.amp.html

○ El economista: El hidrógeno renovable será competitivo a partir de 2030 https://www.eleconomista.es/empresas-finanzas/noticias/10875603/11/20/El-hidrogeno-renovable-sera-competitivo-a-partir-de-2030.html

○ Diario Abierto: 5/11/2020 El hidrógeno renovable puede ser competitivo a partir de 2030 https://www.diarioabierto.es/527828/el-hidrogeno-renovable-puede-ser-competitivo-a-partir-de-2030

○ Merca2: 13/11/2020 El hidrógeno verde será competitivo a partir de 2030 https://www.merca2.es/hidrogeno-verde-competitivo-2030/

○ Diario Siglo XXI: 5/11/2020 El hidrógeno renovable podría ser competitivo a partir de 2030, según un estudio del IREC y Fundación Naturgy http://www.diariosigloxxi.com/texto-ep/mostrar/20201105134055/hidrogeno-renovable-podria-competitivo-partir-2030-segun-estudio-irec-fundacion-naturgy

○ Press digital: 5/11/2020 El hidrógeno renovable puede ser competitivo a partir de 2030, según un estudio https://www.pressdigital.es/texto-diario/mostrar/2151426/hidrogeno-renovable-puede-competitivo-partir-2030-segun-estudio

○ El correo: 19/11/2020 Así serán los negocios verdes más rentables de la próxima década https://www.elcorreo.com/economia/negocios-verdes-rentables-proxima-decada-20201115160811-ntrc.html

○ El Diario Vasco: 19/11/2020 Así serán los negocios verdes más rentables de la próxima década https://www.diariovasco.com/economia/negocios-verdes-rentables-proxima-decada-20201115160811-ntrc.html

○ El Norte de Castilla: 19/11/2020 Así serán los negocios verdes más rentables de la próxima década https://www.elnortedecastilla.es/economia/negocios-verdes-rentables-proxima-decada-20201115160811-ntrc.html

○ El nuevo lunes: 11/12/2020 El 'boom' del hidrógeno, la nueva promesa energética https://elnuevolunes.es/portada/el-boom-del-hidrogeno-la-nueva-promesa-energetica/

- The luxonomist: 27/11/2020 Hidrógeno renovable, el futuro del cambio climático https://theluxonomist.es/2020/11/27/hidrogeno-renovable-el-futuro-del-cambio-climatico/the-luxonomist

- Heraldo: 6/12/2020 Dónde, cuándo y cómo estará el hidrógeno verde en España https://www.heraldo.es/noticias/economia/2020/12/06/donde-cuando-y-como-estara-el-hidrogeno-verde-en-espana-1408904.html
- Burgos conecta: 6/12/2020 Dónde, cuándo y cómo estará el hidrógeno verde en España https://www.burgosconecta.es/economia/hidrogeno-verde-espana-20201206122023-ntrc.html

- Ethic: 10/12/2020 LA HOJA DE RUTA DEL HIDRÓGENO EN ESPAÑA: ¿PODEMOS CUMPLIR LOS OBJETIVOS? https://ethic.es/2020/12/hoja-ruta-hidrogeno-espana-objetivos/

- La razón: 18/12/2020 Renovables e Hidrógeno, las claves del futuro energético español https://www.larazon.es/medio-ambiente/20201218/euzjo256njea7nmah4gavpm4hu.html

- Interempresas: 21/12/2020 La AEQT expone el potencial de Tarragona para ser "el hub de hidrógeno más importante del sur de Europa" https://www.interempresas.net/Quimica/Articulos/321811-AEQT-expone-potencial-Tarragona-ser-hub-hidrogeno-mas-importante-sur-Europa.html

- El COVID-19 desacelera la transición energética: October 14, 2020

- An expert view on the electric vehicle batteries of tomorrow: October 14, 2020

- Materias orgánicas para almacenar energía: June 28, 2020

- Cap a una societat descarbonitzada: June 17, 2020

- Associació d'Enginyers Industrials de Catalunya i Col·legi Oficial d'Enginyers Industriuals de Catalunya AEIC/COEIC- Comissió d'Energia del Col·legi d'Enginyers**.** Tecnologies per a la Descarbonització i l'electrificació d'una societat sostenible davant dels reptes del 2050: Juny 16th 2020

- Comisión Nacional para el Uso Eficiente de la Energía CONUEE Secretaría de Energía, México en colaboración con la Alianza de Electromovilidad. Webinar "Implementación de Movilidad Eléctrica como opción para una sociedad sostenible descarbonizada": June 10th 2020

- Webinar "Nanoscience, climate change and energy": May 20, 2020

- Vermut Nanociencia "Tratamiento de aguas por medios electroquímicos": May 8, 2020

- Vermut de Nanociencia "Redox flow batteries- promising choice for stationary energy storage": May 6, 2020.

- Webinar "Movilidad Eléctrica": Ciclo de Webinars Movilidad Eléctrica OLADE Organización Latino Americanas de Energía - Quito, Ecuador.:

- Estrategias nacionales para movilidad eléctrica: April 29 th 2020
- Medidas e incentivos para fomentar la movilidad eléctrica: April 30th 2020
- Principales barreras para impulsar la movilidad eléctrica: May 1st 2020

- European project COBRA developing sustainable battery for electric vehicles: March 18,2020

- Cambios en los combustibles: ¿Ha llegado la hora de los biocarburantes: March 10, 2020

- In-forma't – «Explora» l'IREC: February 18, 2020

- Catalan researchers lead search for sustainable electric vehicle batteries: February 10,
- 2020.

- Workshop intern Lego Serious Play: February 7, 2020

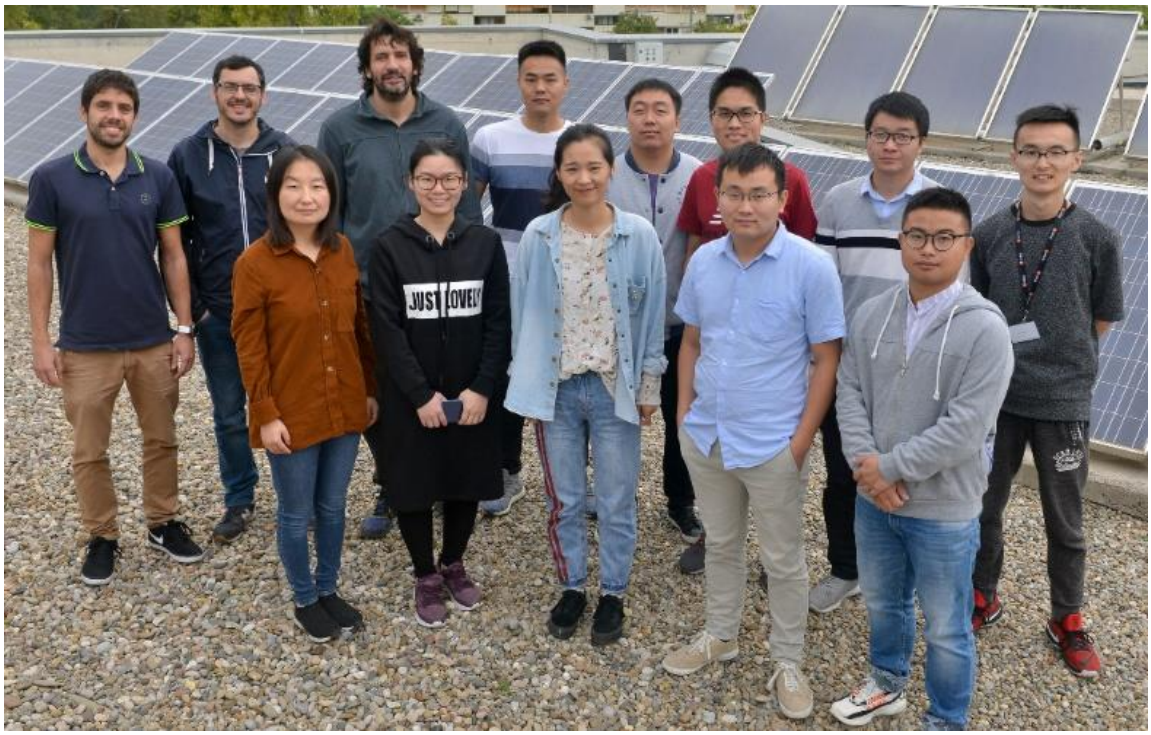
- L'IREC coordinarà un nou projecte europeu per desenvolupar bateries de liti February 3, 2020

6.1.2. FUNCTIONAL NANOMATERIALS

The Team

(permanent and temporary positions, tenure tracks and fellowships)

Prof. Andreu Cabot, ICREA research professor and Group Leader
Dr. Pablo Guardia, Postdoctoral Researcher
Ievgenii Liashenko, Predoctoral Student
Alberto Ramon, Predoctoral Student
Yu Zhang, Predoctoral Student
Yong Zuo, Predoctoral Student
Ruifeng Du, Predoctoral Student
Xiaoting Yu, Predoctoral Student
Chaoqi Zhang, Predoctoral Student
Concong Xing, Predoctoral Student
Xiang Wang, Predoctoral Student
Yang Dawei, Predoctoral Student
Mengyao Li, Predoctoral Student ent
Zhifu Liang, Predoctoral Student
Marcos Batista, Predoctoral Student
Ke Xiao, Predoctoral Student



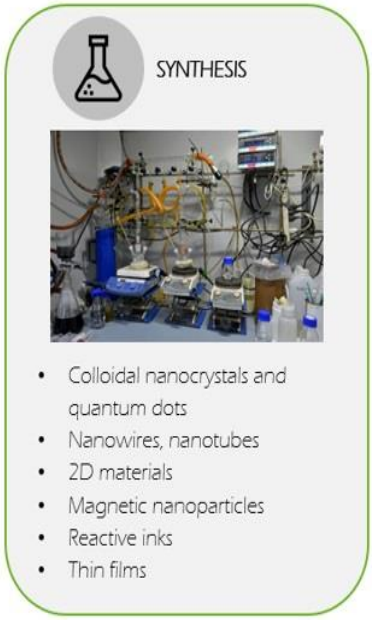
The Functional Nanomaterials group (FNG) designs and engineers nanomaterials to be applied in energy technologies, particularly in the fields of thermoelectrics, batteries and fuel cells.

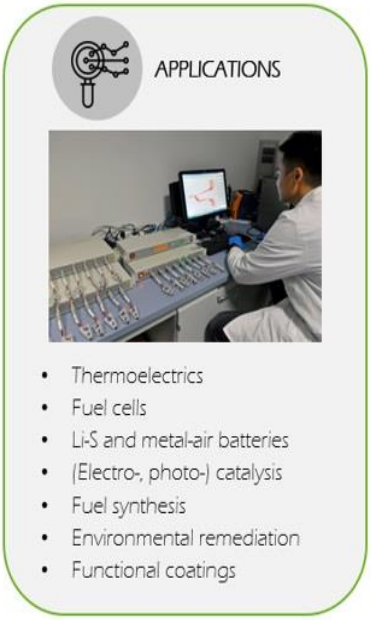
Their efforts are mainly focused on the synthesis of colloidal nanoparticles, and their assembly and use in different energy conversion technologies. In particular, we have pioneered strategies to produce complex multinary chalcogenides, phosphides and oxides and on their application in thermoelectric energy conversion, Li-S batteries and electrocatalysis.

A major outcome of their work has been the production of bulk materials with world record ZT values, which would allow up to 60% higher energy conversion efficiencies than current commercial devices. They have also developed innovative techniques to manipulate the surface chemistry of colloidal nanocrystals and assemble them into clusters, thin films, gels and bulk nanocomposites.

Their laboratories are equipped with the all the necessary set-ups to undertake every stage in the development of nanomaterial-based energy conversion devices, including nanomaterials synthesis, manipulation and fabrication of macroscopic structures and devices, material functional characterization and device test.

The Functional Nanomaterials Group designs and engineers' nanomaterials with optimized functionalities and applies them in energy conversion, energy storage and environmental remediation technologies.

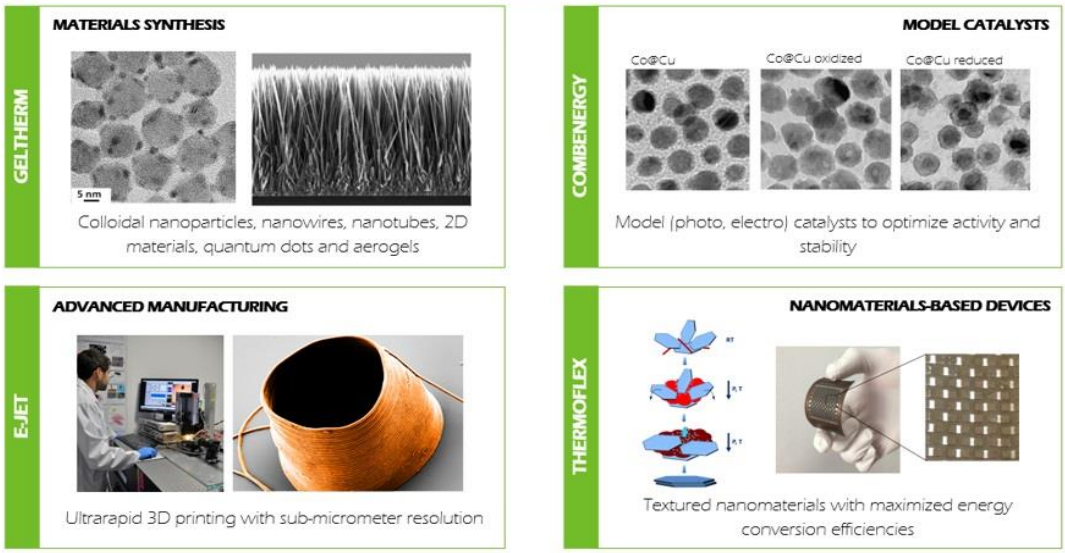




CAPABILITIES

- Nanoparticle synthesis (2-glove glovebox, 8 fume hoods for colloidal synthesis, hydrothermal synthesis, ball milling, etc.)
- Nanomaterial/nanocomposite preparation (16-glove gloveboxes, rapid hot press, induction ovens, vacuum infusion)
- Nanomaterial growth (dip coating, sputtering, chemical vapor deposition, evaporation, etc.)
- Surface functionalization (plasma cleaner, UV-vis spectroscopy, dynamic light scattering, zeta potential)
- (Hydro)gel and aerogel preparation (freeze drier, CO_2 and high temperature supercritical point driers)
- Ink-based high resolution 3D printing system
- Battery / fuel cell / (photo-, electro-) catalytic test (gas chromatography, potentiostats, solar-simulator, reactors, etc.)
- Thermoelectric characterization (thermal conductivity, Seebeck coefficient and electrical conductivity up to 600 °C)

HIGHLIGHTS



PROJECTS

Title: Solar Energy Harvesting with Two-Photon Processes: Nanoparticle-based light sensitizers
Acronym: Sehtop-NP
Description: This project, joining effort from four groups, will apply to photovoltaic, photoelectrochemical, photocatalytic and photoluminescent systems a novel scheme of solar energy utilization which makes use of a wider interval of the solar spectrum than in usual systems by combining two electronic excitations produced by photons of relatively low energy to achieve the excitation of one electron by an energy larger than that of each of the two photons absorbed. This two-photon process (TPP) is similar to the one behind natural photosynthesis (the Z-scheme), but adds the possibility of achieving the complete excitation as well with only one photon having enough energy. In this way one obtains an important electric or chemical potential with a larger number of excited electrons than could be achieved with a traditionalsemiconductor. To this aim the project will use different materials, focussing in perovskites and composite sulphide/oxide systems, with partial substitution of their cations by transition elements which according to quantum calculations can produce an in-gap band allowing a TPP. These systems will be tested as thin film photovoltaic or photoelectrochemical cells, as powders in photocatalytic generation of hydrogen or as luminescent up-converters,

their efficiency measured by rigorous methods and interpreted by a combined theoretical/experimental approach. The project aims at translating its results not only to scientific outputs but also to technologically oriented solutions advantageous for society using the already made connection with several companies interested in our approach. Within this joint project, the subproject SEHTOP-NP will address the synthesis of TPPenabled perovskites and sulphides in the form of nanoparticles and nanostructured layers in combination with high surface area titania. The synthesis of this materials and its application will be at all times guided by the theoretical work developed in SEHTOP-QC and coordinated with the subprojects SEHTOP-HRM and SEHTOP-TF. Besides their use in photocatalysis in the SEHTOP-HRM subproject, TPP-enabled materials in nanoparticle form will be used in SEHTOP-NP to produce up-conversion luminescent solar concentrators. The advantage of TPP will be also demonstrated here with materials in the form of supported films in the fields of photoelectrochemical water splitting and semiconductor sensitized solar cells.
We foresee the results of this sub-project to have not only a significant scientific impact but also an economic and subsequently a social one, based on the development of more efficient technologies for the conversion of solar energy into electricity or readily usable chemical energy.
The research team that will carry out this subproject has extensive experience in the preparation of nanostructured materials and its application in various energy conversion technologies, including photovoltaics, photoelectrochemistry and luminescent conversion filters.
At the same time, IREC is equipped with state of the art laboratories enabling pursuing with the appropriate tools the project goals.
Funding: Retos Investigació
Project ID: ENE2016-77798-C4-3-R
Type: Competitive Nationals
Partners: Agencia Estatal Consejo Superior De Investigaciones Cientificas (CSIC), Universitat Politècnica De València (UPV), Universidad Politecnica De Madrid (UPM), Fundacio Institut de Recerca en Energia de Catalunya (IREC)
Date: 2016 - 2020
Gorup: Funtional Nanomaterials
P.I: Andreu Cabot.
More info at the following link

Title: Gel-Nanocomposites for Magnetic-Mediated Heating Assited Water Purification
Acronym: GELTHERM
Description: The project GELTHERM addresses one of the greatest challenges of the 21st century defined in the Plan estatal de investigación científica y técnica y de innovación 2017-2020 (Reto 5): Providing water universally in a safe, reliable and affordable manner. This challenge is also included in the EU Horizon 2020 Work Program 2018-2020 Climate action, environment, resource efficiency and raw materials CE-SC5-04-2019. GELTHERM solution to this challenge is based on the development of novel materials and the application of novel strategies and technologies for water remediation. In particular, the project aims to develop magnetic-activated multifunctional nanocomposite gels as a platform for multiple activated water treatments: ion removal, dye degradation, oil spill clean-up and pathogen inactivation.

As such, a unique absorbent material can be exploited to eliminate a range of pollutants, thus reducing the complexity and costs associated to traditional water purification systems. To achieve this ambitious goal, the project will exploit gelation processes to combine different nanoscaled building blocks (several types of nanoparticles and graphene oxide nanosheets) into highly porous structures (gels or aerogels). Multifunctionality will be provided by combining nanoparticles having photocatalytic activity, magnetic response, biocidal activity and selective adsorption capability. Embedding magnetic nanoparticles into gels will allow for magnetic mediated heating (MMH) and the use of hyperthermia for purification (i.e. pathogen inactivation or foulant degradation). MMH combined in standard purification procedures will boost the performances: Ion-absorption and desorption capacities, photocatalytic dye degradation and pathogen inactivation, absorption and desorption of oil spills and molecules, and biocidal release can be boosted well beyond the current-state-of-the-art through local increase of the temperature by MMH. Moreover, since MMH is a contactless process, it can be exploited for triggering each process thus providing both selectivity and remote control over the purification treatment. Finally, the magnetic response will provide magnetic extraction, improving the reuse of the absorbent material and limiting unintended release to the environment. The nanocomposite gels developed will be also exploited as sensing platforms for water pollutants in collaboration with external groups.
The technology developed during the project will be directly applied in a gravity filter prototype to be further implemented in a cartridge filter for a water purification pitcher. The final goal of the project is to provide a point-of-use water purification system for areas in which water security is scarce or water-supplying systems are inefficient. Outcomes of the project will find further applications in industrial, agriculture and urban wastewater management. As such, the project have a huge potential impact in society by: i) decreasing diseases and deaths related with contaminated water, ii) decreasing wastewater management costs through faster and efficient purification processes, iii) the restoration of aquatic ecosystems and iv) providing point-of-use water purification systems for undeveloped areas.
Funding: Retos Investigació
Project ID: RTI2018-102006-J-I00
Type: Competitive Nationals
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC)
Date: 2019 - 2022
Group: Funtional Nanomaterials
P.I: Pablo Guardia Giros.
More info at the following link

Title: Fabricació additiva d'alta velocitat i resolució mitjançant un nou sistema de control del posicionament del material addicional
Acronym: Fabricació additiva d'alta velocitat i resolució mitjançant un nou sistema de control del posicionament del material addicional.
Description: There is an ample consensus that the main challenges of 3D printing technologies is to increase their production speed, to improve their resolution and to increase the palette ofprinted materials, ideally making possible the fabrication of multi-material products. Amongthe different current and under development additive manufacturing technologies, thematerial injection in an ink form is the only one providing a true material versatility,

makingpossible the fabrication of structures with any composition that can be formulated as ink, thus virtually any composition. However, the current 3D printing technologies based onmaterial jetting are severely limited both in terms of fabrication speed and in resolution, withthe intrinsic problem that when trying to improve resolution, fabrication speed is furtherreduced. At the basis of this limitation, there is the combination of a slow material injectionand a slow translation of the printing head. More specifically, the moderate acceleration thatmechanical stages are able to reach, due to their relatively high mass, strongly constrainsthe translation speed of the injector or support in the non-linear movement required tocreate predefined 3D structures. Best motorized stages move with maximum accelerationsclose to 20 m/s2 and are able to reach speeds close to 0.2 m/s. To overcome this intrinsiclimitation of additive manufacturing technologies based on material jetting, a revolutionarynew strategy to control the position of addition of material need to be developed. In the Nanomaterials Group, at the Catalonia Institute for Energy Research ¿ IREC, wehave demonstrated the possibility to move a jet with accelerations above 500,000 m/s2 andspeeds close to 10 m/s using electrostatic fields. We plan to use this concept to develop anew 3D printing technology that makes use of electrostatic fields to deflect the material jetand to control in this way the positioning of the added material. The use of a fast positioningwill further allow increasing the jet generation speed to 1-10 m/s. In the present project, wewill validate this new and revolutionary technological concept, which will allow printingspeeds over 100 times faster than current technologies based on material jetting. At thesame time, the use of charged jets potentially allows creating filaments with a thicknessdown to 100 nm, thus potentially providing sub-micrometer resolution. This technology willbe initially based on inks, which will allow creating 3D structures with any composition,including metals, semiconductors, oxides, and even proteins and biological material.The possibility of fabricating 3D structures with submicron resolution at high speed and withan unlimited material versatility, will allow to advantageously compete in a number of fieldswhere conventional additive technologies has been already entered and opening new blueocean markets for 3D printing strategies.To translate the formulated technological concept into a commercially exploitabletechnology, several challenges are yet to be overcome. The main 3 challenges are thecontrol of the jet start/stop, the improvement in the resolution of the initial positioning of thematerial addition and the probe of the concept with inorganic materials through developinginorganic inks, printing protocols and postdeposition treatments, since the basic concepthas been just probed with polymer-based inks. Additionally, a compact electronics and asoftware able to control the different system components need to be developed. These tasks will be carried out during this Llavor project. Along with this experimental work, we will define applications, follow the competing technologies and market, define acommercialization route and a business model, study the commercial viability of ourtechnology, and partner with key players and end potential users of our new technology.
Funding: AGAUR
Project ID: 2018 LLAV 00044
Type: Competitive Nationals
Partners: FUNDACIO INSTITUT DE RECERCA DE L'ENERGIA DE CATALUNYA (IREC)
Date: 2019 - 2020
Group: Funtional Nanomaterials
P.I: Andreu Cabot.
More info at the following link

Title: Solid-liquid thermoelectric sytems with uncorrelated properties
Acronym: UncorrelaTEd
Description: More than 60% of the global power is lost as waste heat. Thermoelectric (TE) materials can convert vast amounts of this waste heat into electricity and significantly contribute to the current energy challenge. Despite large efforts to identify better TE materials, still, the TE technology is limited by low efficiency. One of the two performance improvement routes, thermal conductivity reduction, has already reached its limit, which makes the other route, power factor (PF) improvements, crucial. Current strategies targeting PF enhancement have only reached modest improvements, mainly due to the adverse interdependence of the Seebeck coefficient (S) and the electrical conductivity, which produces a decrease in one of these properties if the other is increased. This is a serious obstacle to achieve the widespread application of the TE technology, since PF=S^2. UncorrelaTEd will come true the dream of breaking the S-? correlation by introducing a new paradigm in thermoelectricity that comes from the connection of TEs and electrochemistry, using a properly designed hybrid system, formed by a porous TE solid permeated by a liquid electrolyte. The porous solid provides a low thermal conductivity, whereas the electrolyte tactically interacts with the solid to enlarge the PF. Unprecedented PF improvements (above 35 times) have already been observed by UncorrelaTEd members in this system using a material with modest TE properties. UncorrelaTEd aims at extending these improvements to different materials (bismuth telluride alloys, oxides, and polymers) with state-of-the-art TE properties, potentially leading to an extraordinarily powerful technology able to provide more than 4 times larger PF than state-of-the-art low-mid temperature (<150 ºC) materials and ZTs>3. This will enable the TE technology to be implemented in many areas, such as self-powered sensors, empowering the elimination of batteries, textiles, factories, power plants, and combustion engines.
Funding: H2020
Project ID: 863222
Type: Competitive EU
Partners: Universitat Jaume I De Castellon (UJI), Fundacio Institut de Recerca en Energia de Catalunya (IREC), Kungliga Tekniska Hoegskolan (KTH), The University of Warwick (Warwick), Solvionic, Intenanomat SL.
Date: 2020 - 2023
Group: Funtional Nanomaterials
P.I: Andreu Cabot
More info at the following link

Title: Combining energy sources to enhance catalytic processes in the energy area: thermo-electro catalytic
Acronym: COMBENERGY
Funding: Proyectos I+D+i 2019
Project ID: PID2019-105490RB-C32
Date: 2020 - 2022
Gorup: Funtional Nanomaterials

P.I: Andreu Cabot.
More info at the following link

Title: High quality magnetic particles
Acronym: HiQ-Mag
Description: HiQ-Mag will validate in a relevant environment our process to transform poor magnetic nanocrystals (MNCs) into high quality ones. The process is based on an annealing step at mild temperatures in the presence of additives in solution. It allows to significantly improve the crystallinity of the NCs and hence their saturation magnetization. This process can be suitable implemented to any hydrophilic or hydrophobic colloidal dispersion of MNCs. Noteworthy, it does not significant affect the size and shape distribution of the MNCs, nor compromises the stability of the shell (i.e. molecular functionalization and organic or inorganic coatings). In few words, HiQ-Mag recycles MNCs.
The synthesis and commercialization of colloids is an ever-growing market with a rather strict demand depending on the target applications. Most nanocrystals (NCs) colloidal formulations successfully address most market needs. However, MNCs colloids do not fulfil the expectations. Magnetism does strongly depend over the crystallographic quality and most synthesis procedures provide poor crystallinity NCs. As such, MNCs show low saturation magnetization values and hence performances. This drawback can be partially overcome by increasing either the amount of MNCs or the magnetic field strength. Yet, for most appealing and relevant application of MNCs (e.g. nanomedicine or catalysis) these strategies are simply not affordable. The paradigm of this issue are iron oxide NCs (IONCs) and its use for hyperthermia cancer therapies or MRI imaging. Both applications require for IONCS produced in a rather narrow size range (18-22 nm) having the highest saturation magnetization values. Fulfilling these requirements is mandatory to reduce dose, side effects as well as treatment costs.
Currently, most of the large-scale synthesis routes reported for IONCs do not provide high-quality NCs neither control precisely the size. There are few lab-scale approaches that do successfully provide high quality MNCs but with poor reproducibility, rather low yield (40 mg per synthesis) and require for high-trained operators. As such, there is a clear need to find an operator-friendly process meeting high quality MNCs and mass production.
HiQ-Mag addresses the current needs and provides a flexible, yet efficient, solution to be applied to any established industrial process, transforming mass-produced IONCs into a high quality product.
Funding: AGAUR
Project ID: 2019 LLAV 00051
Type: Competitive Nationals
Date: 2020 - 2021
Gorup: Funtional Nanomaterials
P.I: Pablo Guardia.
More info at the following link

Title: Electrostatic control of the jet positioning for ultrafast high resolution 3D printing
Acronym: Innov_3DPrint
Description: 3D printing technologies are foreseen to change the way we design and produce almost everything. Soon, all industries, mechanical workshops, designers, architects, builders, electrical technicians, plumbers, dentists, etc. will make use of 3D printing systems to produce customized components and models. However, there is an ample consensus that current 3D printing technologies need to increase their production speed, improve resolution, and increase the range of printable materials. Among the different additive manufacturing technologies currently on the market or under development, only nozzle-based material injection strategies that make use of precursor materials in the form of inks provide a true material versatility. However, current 3D printing technologies based on material jetting are severely limited both in terms of fabrication speed and resolution. At the basis of this limitation, there is the combination of a slow material injection and a slow translation of the printing nozzle. More specifically, the low accelerations that mechanical stages are able to reach, due to their relatively high mass, strongly constrain the translation speed of the nozzle in the non-linear movement required to create predefined 3D structures. To overcome this intrinsic limitation, we have developed a revolutionary new strategy to control the jet contact point with the substrate, thus the method of realization of predefined object. We have demonstrated the possibility to move a jet with accelerations above 500,000 m/s2 and speeds close to 10 m/s using electrostatic fields. We have further developed this new strategy within a novel 3D printing technology that makes use of electrostatic fields to deflect material jets as narrow as 100 nm, controlling their positioning on the substrate with printing speeds over 100 times faster than current technologies. This technology has been recently protected in two European patents. In the present project, we will develop a compact prototype of this new and revolutionary 3D printer, incorporating the electronics and software required for a user-friendly interface. In parallel, we will develop a business plan to commercialize this technology through the creation of a spin-off.
Funding: Innovadors 2019 (AGAUR)
Project ID: 2019 INNOV 00054
Type: Competitive Nationals
Date: 2020 - 2021
Gorup: Funtional Nanomaterials
P.I: Andreu Cabot.
More info at the following link

Title: Combining energy sources to enhance catalytic processes in the energy area: thermo-electro catalytic
Acronym: COMBENERGY
Funding: Proyectos I+D+i 2019
Project ID: PID2019-105490RB-C32
Type: Competitive Nationals
Date: 2020 - 2022
Gorup: Funtional Nanomaterials
P.I: Andreu Cabot.
More info at the following link

PUBLICATIONS

Articles and Journals from ISI Database

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Morais, F., Carvalhaes-Dias, P., Duarte, L., Spengler, A., De Paiva, K., Martins, T., Cabot, A., Dias, J.S. "Optimization of the TEGs configuration (series/parallel) in energy harvesting systems with low-voltage thermoelectric generators connected to ultra-low voltage DC-DC converters" *Energies* 13, 9, pp. 2297 - 2020 DOI: 10.3390/en13092297

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DOCTORAL THESES

Presented Theses:

PhD graduate: Ievgenii Liashenko
PhD supervisor: Dr. Andreu Cabot, Dr. J. Rosell.
Title: Ultrafast electrohydrodynamic 3D printing with submicrometer resolution
Presented date: 07/16/2020

Ongoing theses:

PhD student: Xiaoting Yu
PhD supervisor: Dr. Andreu Cabot
Title: Colloidal nanoparticles for electrocatalytic energy conversion

PhD student: Yong Zuo
PhD supervisor: Dr. Andreu Cabot
Title: Precise Engineering of Interband Photocatalysts for Solar Fuels

PhD student: Chaoqi Zhang
PhD supervisor: Dr. Andreu Cabot
Title: New nanomaterials for Li-S batteries

PhD student: Ruifeng Du
PhD supervisor: Dr. Andreu Cabot
Title: 2-photon processes to improve photovoltaic and photocatalytic efficiency

PhD student: Congcong Xing
PhD supervisor: Dr. Andreu Cabot
Title: Metal doping in graphene for electrocatalytic applications

PhD student: Mengyao Li
PhD supervisor: Dr. Andreu Cabot
Title: Electronic doping in bottom-up engineered nanomaterials

PhD student: Yang Dawei
PhD supervisor: Dr. Andreu Cabot
Title: Optimization of catalytic properties of metal chalcogenides toward polysulfides

PhD student: Alberto Ramon
PhD supervisor: Dr. Andreu Cabot
Title: High electric fields to control jet deflection

PhD student: Yu Zhang
PhD supervisor: Dr. Andreu Cabot
Title: Molecular precursors towards high performance inorganic functional materials

PhD student: Xiang Wang

PhD supervisor: Dr. Andreu Cabot
Title: Single atom catalysts for electrocatalytic fuel production

PhD student: Zhifu Liang
PhD supervisor: Dr. Andreu Cabot
Title: Single atom catalysts for CO2 conversion

PhD student: Marcos Batista
PhD supervisor: Dr. Andreu Cabot
Title: Complex oxide nanostructures for photocatalytic applications

PhD student: Guillem Montaña
PhD supervisor: Dr. Andreu Cabot
Title: Influence of external electric fields on thermocatalytic processes for the generation of solar fuels

OUTREACH

- New cover in Small: Efficient and selective conversion of methanol
- New cover in Advanced Energy Materials: Catalysts for efficient Li–S batteries
- IREC earns 3 new Knowledge Industry Grants
- A new European project on thermoelectrics started
- The graphene association "GRAPHCAT" sets its goals

6.1.3. NANOIONIC AND FUEL CELLS

The Team

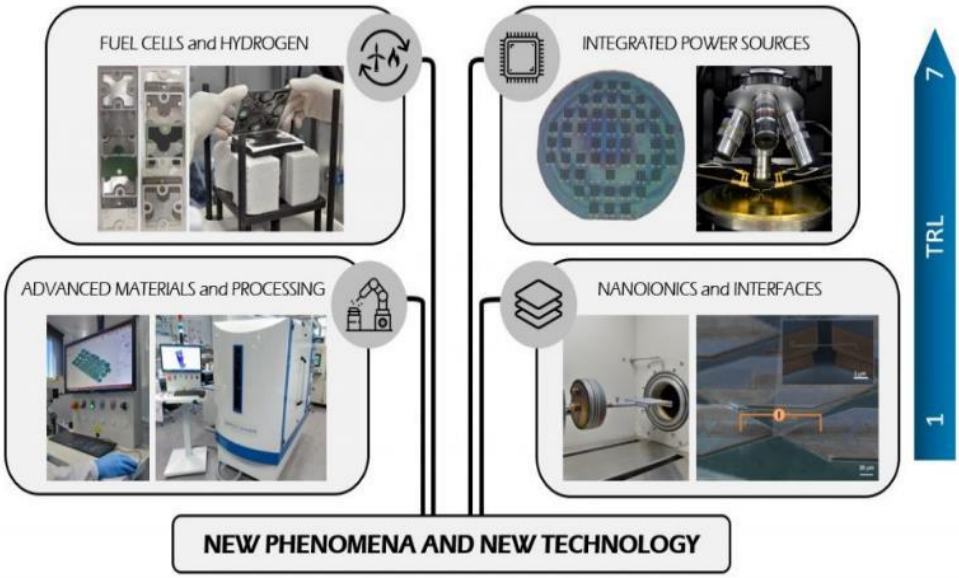
(permanent and temporary positions, tenure tracks and fellowships)

Prof. Albert Tarancón, ICREA Professor and Head of Group
Dr. Alex Morata, Senior Researcher
Dr. Marc Torrell, Senior Researcher
Dr. Nerea Alayo, Staff Scientist
Dr. Federico Baiutti, Staff Scientist
Dr. Marc Núñez, Head of Laboratory
Dr. Mercè Pacios, Postdoctoral researcher - Beatriu de Pinós Fellow)
Dr. Gianfranco Sabato, Postdoctoral researcher (Marie Curie Fellow)
Dr. Julian Atilio Puszkiel, Postdoctoral Researcher (TecnioSpring Fellow)
Dr. Juan Carlos González Rosillo, Postdoctoral Researcher (TecnioSpring Fellow)
Dr. Aitor Hornes, Postdoctoral researcher
Dr. Lucile Bernadet, Postdoctoral researcher
Dr. Francesco Chiabrera, Postdoctoral Researcher
Mr. Gotzon Garcia, Project Engineer
Ms. Maritta Meyrella Dos Santos, Predoctoral Student (Marie Curie Fellow)
Mr. Jose Sojo, Predoctoral Student (FPU Fellow)
Ms. Arianna Pesce, Predoctoral Student
Mr. Simone Anellli, Predoctoral Student
Ms. Valerie Siller, Predoctoral Student
Mr. Marco Bianchini, Predoctoral Student
Ms. Yunqing Tang, Predoctoral Student
Ms. Natalia Kostretsova, Predoctoral Student
Mr. Juan De Dios Sirvent, Predoctoral Student
Ms. Carolina Duque Sierra, Predoctoral Student

The Nanoionics and Fuel Cells Group addresses the challenge of developing highly efficient and clean solid state energy conversion technologies to power a sustainable society. The group use their knowledge in ionic, electronic and thermal transport combined with expertise in advanced manufacturing to develop new energy concepts from the microwatt to the kilowatt range.

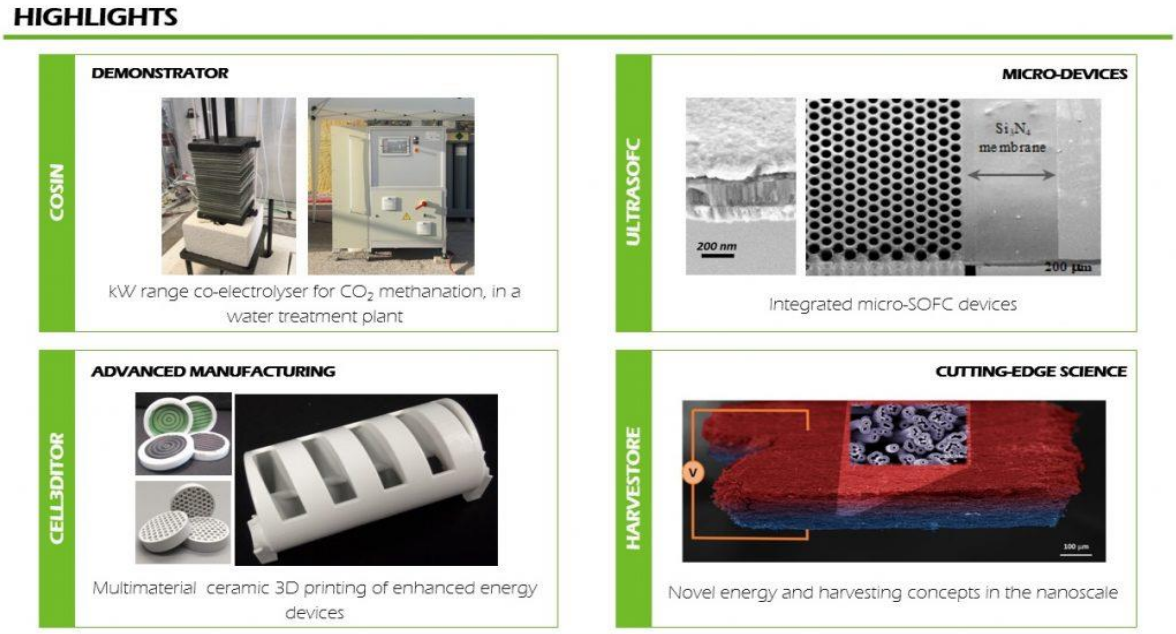
In the microwatt range, we develop miniaturized energy sources for powering the Internet of Things (IoT). Using disruptive ideas from the emerging Nanoionics and Iontronics disciplines, which deal with the complex interplay between electrons and ions in the nanoscale, we develop new families of all-solid state micro-energy sources able to harvest and store energy at the same time. Together with ambitious high-tech companies, we look for the viability of a new paradigm of embedded energy.

In the kilowatt range, we develop advanced solid oxide fuel cells and electrolysers that will enable a hydrogen-based zero-emissions energy system. Through the innovative ceramic 3D printing of ionic conductors, we are working towards fabricating a new generation of enhanced solid oxide cells that will bring us closer to novel functionalities and improved performance by design. In our lab, we push for joint development of original concepts and more conventional technologies with the current leading industry.



CAPABILITIES

- Nanostructures and thin films fabrication (large area PLD, CVD) and characterisation (operando ellypsometry/Raman, quantum efficiency, electroemission)
- Advanced materials fabrication (multimaterial ceramic 3D printer, Screen printing, 3D-controlled airbrush, Inkjet printing, DLP and FDM plastic printers) and characterisation (in-situ Raman, TGA)
- Electrochemistry and performance (micro-devices automatized electrochemical test stations, button cells and kW-stack scale test benches)



PROJECTS

Title: Breaking the temperature limits of Solid Oxide Fuel Cells: towards a new family of ultra-thin portablepower sources
Acronym: Ultra Sofc
Description: Solid Oxide Fuel Cells (SOFCs) are one of the most efficient and fuel flexible power generators. However, a greatlimitation on their applicability arises from temperature restrictions. Operation approaching room temperature (RT) isforbidden by the limited performance of known electrolytes and cathodes while typical high temperatures (HT) avoidtheir implementation in portable applications where quick start ups with low energy consumption are required.The ULTRASOFC project aims breaking these historical limits by taking advantage of the tremendous opportunitiesarising from novel fields in the domain of the nanoscale (nanoionics or nano photochemistry) and recent advances inthe marriage between micro and nanotechnologies. From the required interdisciplinary approach, the ULTRASOFCproject addresses materials challenges to (i) reduce the operation to RT and (ii) technological gaps to develop ultra-low-thermal mass structures able to reach high T with extremely low consumption and immediate start up. A unique SOFC technology fully integrated in ultrathin silicon will be developed to allow operation with hydrogenat room temperature and based on hydrocarbons at high temperature. Stacking these SOFCs will bring a new familyof ultrathin power sources able to provide 100 mW at RT and 5W at high T in a size of a one-cent coin. A stand-alonedevice fuelled with methane at HT will be fabricated in the size of a dice. Apart from breaking the state-of-the-art of power portable generation, the ULTRASOFC project will cover the gapof knowledge existing for the migration of high T electrochemical devices to room temperature and MEMS to highT. Therefore, one should expect that ULTRASOFC will open up new horizons and opportunities for research inadjacent fields like electrochemical transducers or chemical sensors. Furthermore, new technological

perspectives ofintegration of unconventional materials will allow exploring unknown devices and practical applications
Funding: ERC
Project ID: 681146
Type: Competitive EU (coordinator)
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC)
Date: 2016 - 2021
Group: Nanoionic and Fuel Cells
P.I: Albert Tarancón Rubio
More info at the following link

Title: Cost-effective and flexible 3D printed SOFC stacks for commercial applications
Acronym: Cell3ditor
Description: A Solid Oxide Fuel Cell (SOFC) is a ceramic-based multilayer device that involves expensive and time-consuming multi-step manufacturing processes including tape casting, screen printing, firing, shaping and several hightemperature thermal treatments. In addition, these cells are manually assembled into stacks resulting in extra steps for joining and sealing that difficult the standardization and quality control of the final product while introducing weak parts likely to fail. Since current ceramics processing presents strong limitations in shape and extremely complex design for manufacturing (more than 100 steps), industrially fabricated SOFC cells and stacks are expensive and present low flexibility and long time to market. This is particularly relevant for the commercial segment of
the stationary fuel cells market (5-400kW) that is highly heterogeneous in terms of the overall power and heat requirements and requires customization of the final product. The main goal of the Cell3Ditor project is to develop a 3D printing technology for the industrial production of SOFC stacks by covering research and innovation in all the stages of the industrial value chain (inks formulation, 3D printer development, ceramics consolidation and system integration). All-ceramic joint-free SOFC stacks with embedded fluidics and current collection will be fabricated in a two-step process (single-step printing and sintering) to reduce in energy, materials and assembly costs while simplifying the design for manufacturing and time to market. Compared to traditional ceramic processing, the Cell3Ditor manufacturing process presents a significantly shorter time to market (from years to months) and a cost reduction estimated in 63% with an initial investment below one third of an equivalent conventional manufacturing plant (production of 1000 units per year). The project is product-driven and involves SMEs (with proved technologies) in the entire value chain to ensure reaching TRL>6.
Funding: H2020
Project ID: 700266
Type: Competitive EU (coordinator)
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC), Danmarks Tekniske Universitet (DTU), Francisco Albero SA (FAE), 3DCERAM (3DCERAM), Promethean Particles LTD (PROM), Universidad de la Laguna (ULL), SAAN Energi AB (SAAN), HyGear Fuel Cell Systems B.V. (HFCS)
Date: 2016 - 2020
Group: Nanoionic and Fuel Cells

P.I: Dr. Albert Tarancón Rubio
Other group: Energy Systems Analitics-Dr. Cristina Corchero García
More info at the following link

Title: 3D- Printing MAterials and Devices for Energy Storage and Biofuels
Acronym: 3D Made
Descripction: The main goal of the 3D-MADE project is the optimization of different advanced ceramic 3D printing technologies for a cost-effective and time efficient fabrication of highly complex devices for energy conversion technologies. The focus of the proposal is put on i) development and optimization of 3D printing technologies for advanced ceramics and ii) the design, fabrication and performance evaluation of 3D printed devices and reactors for the energy market. In particular, the project will address major concepts in syngas production by high temperature electrolysis (Power-to-Fuel, P2F) and production of Solar Fuels and Biofuels. The development of these energy technologies contributes to reach the goal of Secure, clean and efficient energy production, defined in the Spanish and European Strategic Programmes, by implementing and deploying. The first major aim of the 3D-MADE project is to carry out a product-driven optimization of different ceramic 3D printing techniques, i.e. to optimize the printing parameters and ceramic precursor slurries/inks/filaments to reach the specific requirements (printable materials, accuracy, surface finishing, microstructure control, size, speed and cost) of each particular device or reactor. While the second major aim refers to the implementation of unique functionalities and unfair advantages of 3D printing in sustainable energy conversion devices for: i) improving their efficiency by surface maximization or increasing their specific power by designing complex geometries and ii) reducing the cost, energy consumption, environmental impact and waste material during fabrication. The 3D-MADE project represents a natural extension of the former R3DES project (ENE2013-47826-C4-4-1, 2013 RETOS Call). All the partners involved in the current proposal already participated in the previous project and, therefore, the whole set of results obtained
there are considered specific background and the initial set of hypotheses for facing the new challenges pursued here.
Funding: Retos Investigació
Project ID: ENE2016-74889-C4-1-R
Type: Competitive Nationals (coordinator)
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC)
Date: 2016 - 2020
Group: Nanoionic and Fuel Cells
P.I: Albert Tarancón Rubio.
More info at the following link

Title: 2017 SGR NANOEN
Acronym: NANOEN
Funding: SGR
Project ID: 2017 SGR 1421
Type: Competitive Nationals
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC), Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC), Universidad de Castilla-La Mancha (UCLM), Universidad de la Laguna (ULL)
Date: 2018 - 2021
Group: Nanoionic and Fuel Cells
P.I: Albert Tarancón Rubio.
More info at the following link

Title: 3D-printed u-reactors for green chemistry
Acronym: 3D4GREEN
Description: The 3D4GREEN project represents a cutting edge multidisciplinary approach aiming to convert emitted CO2 into valuable chemicals using electricity from renewable sources. Applying innovative 3D-printing of ceramics, a Micro-Structured Catalytic Reactor coupled to a Solid Oxide Electrolyser will be fabricated as a reliable CO2 re-use technology, directly impacting the RIS3CAT strategy on energy storage lead by IREC. Moreover, the future career of the candidate will be reinforced by complementing his background with expertise in a relevant Key Enabling Technology (KET), such as 3D-printing, applied to the crucial field of Energy Storage together and with new skills in technology transfer gained in the industrial secondment and the active participation in the KIC InnoEnergy initiative.
Funding: Accio
Project ID: TECSPR18-1-0046
Type: Competitive Nationals
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC), Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC), Universidad de Castilla-La Mancha (UCLM), Universidad de la Laguna (ULL)
Date: 2019 - 2021
Group: Nanoionic and Fuel Cells,
P.I: Julián Puszkiel.
More info at the following link

Title: Energy HarceStorers for Powering the Internet of Things
Acronym: HARVESTORE
Description: A breakthrough in micro-energy harvesting and storage technologies is required to cover the increasing demand of autonomous wireless sensor nodes (WSN) for the future Internet of Things (IoT), which is considered one of the five technologies that will change the world by connecting 27 billion devices and generating €2 trillion market by 2025. The HARVESTORE project aims to power these IoT nodes from ubiquitous heat and light sources by

using nano-enabled micro-energy systems with a footprint below 1cm3. Using disruptive concepts from the emerging Nanoionics and Iontronics disciplines, which deal with the complex interplay between electrons and ions in the nanoscale, a radically new family of all-solid state micro-energy sources able to harvest and store energy at the same time will be developed. This new device will be called “harvestorers” (HS). In order to enable this science-totechnology breakthrough, our nano-enabled -HSs will be integrated in silicon technology. This will allow reaching the highly dense features and scalability required for a real miniaturization and massive deployment that will show their viability as a new technological paradigm of embedded energy. The HARVESTORE project addresses this challenging objective by building an interdisciplinary research consortium that includes consolidated and emergent leading researchers in modelling, microfabrication, materials science and energy together with high-tech pioneer SMEs with unique capabilities to develop and deploy IoT nodes for real applications. Moreover, the structure and communication strategy have been designed to make HARVESTORE a lighthouse project for boosting this novel micro-energy paradigm and building around an innovation ecosystem founded on emerging Nanoionics and Iontronics applied to energy.
Funding: H2020
Project ID: 824072
Type: Competitive EU (coordinator)
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC), Danmarks Tekniske Universitet (DTU), Interuniversitair Micro-Electronica Centrum (IMEC), Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC), Technische Universitaet Wien (TU WIEN), Imperial College of Science Technology and Medicine (Imperial), Centre National de la Recherche Scientifique CNRS (CNRS), Coventry University (COVU), Worldsensing SL (WSE), Horiba France SAS (HORIBA), Alternative Energy Innovations SL (AEInnova).
Date: 2018 - 2023
Group: Nanoionic and Fuel Cells
P.I: Albert Tarancón Rubio
More info at the following link

Title: 3D-PRintable glass-based Electrolytes for all-Solid-State lithium batteries
Acronym: 3D-PRESS
Description: The main goal of the 3D-PRESS project is to advance in the 3D printing concepts for safer, cheaper andcustomizable all-solid state Li-ion batteries (LIB). More specifically, the project is focused on the design, production, characterization and testing of 3D printed NASICON-type glass-based electrolytes for 3D printed batteries. In 3D-PRESS, glass-based compositions will be designed and synthesized in order to obtain printable glass-basedelectrolytes with superior conductivity and functional properties. The produced glasses will be thermally andelectrochemically characterized in order to investigate their sinter-crystallization behaviour (tailoring suitable sinteringtreatments) and electrochemical performances. The most promising electrolyte compositions will be selected to beprinted in free-form robust self-standing structures in order to obtain 3D batteries with high active area (allowing highspecific energy and power per unit volume).3D-PRESS represents a cutting edge multidisciplinary approach for the development of reliable and customizableall-solid state 3D

LIBs, especially interesting for micro-power applications such as the ones for Internet of Things(IoT). The project will provide a new family of printable materials increasing the short list of available compositions, especially solid electrolytes, opening the door to the development of a new generation of fully printable all-solid state3D LIBs.A high impact on the future career of the candidate is expected by complementing his current background with newskills in one of the more relevant Key Enabling Technologies (KETs), 3D-printing, applied to the crucial field of theEnergy Storage. Moreover, the host institute will offer unique opportunities to re-enforce the technology transfercompetences of the candidate by carrying out an industrial secondment and by the involvement in the KIC Innoenergycommunity.
Funding: H2020
Project ID: 841937
Type: Competitive EU (coordinator)
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC)
Date: 2020 - 2022
Group: Nanoionic and Fuel Cells
P.I: Albert Tarancón Rubio
More info at the following link

Title: Tecnologies de Làser i altra Llum
Acronym: LIGHT3D
Description: The final objective of Base3D is to accompany additive manufacturing technologies during a technological maturation process and to press as much as possible to achieve its tangible implantation in the industry, the operating theaters, companies and the Catalan classrooms. To achieve this goal, the different subprojects that are part of Base3D will be developed. This base will be generated through research and development in materials, simulation, design and development of prototypes, and testing and evaluation in laboratory and industrial environments.
First, Project1, Light3D and laser technologies and other light will develop systems for the formation of material for stimulation through the application of energy from radiated emission of light. This will be applicable to plastic and / or metal materials.
Secondly, Project2, Fus3D, which will consist of generating and improving parts forming systems for the deposition of hot materials in a semi-cast or pasty (plastic, metal or hybrid) to acquire pieces with new mechanical properties and / or Making it viable is processed through more efficient and sustainable methods. The fields of application are Bio-Health and Pharmaceutical, Food, Construction, Energy and Traditional.
The third project will be the Ink3D that will consist of the development of materials, the design of machinery and the simulation of processes that allow to respond in the short, medium and long term to the great technological challenges of the printing by deposition of continuous inks at room temperature.
Finally, the fourth project will be the Hybri3D which will consist of the development, optimization and integration of different manufacturing technologies in order to obtain a multimaterial hybrid manufacturing process.
Funding: Emergents
Project ID: IU16-011596

Type: Competitive Nationals
Partners: Centre d'innovació i tecnologia especialitzat en Tecnologies Avançades de la Producció i Fabricació Additiva/Impressió 3D.(CIM-UPC), Innovació en Materials i Enginyeria Molecular (IMEM), Institute of Chemical Research of Catalonia (ICIQ), Institut de Bioenginyeria de Catalunya (IBEC), Fundació EURECAT (EURECAT), Fundacio LEITAT (LEITAT), Fundacio Institut de Recerca en Energia de Catalunya (IREC), Centre d'innovació tecnològica de la UPC (CD6), Plàstics i Compòsits Ecològics (e-PLASCOM UPC), Centro Internacional de Métodos Numéricos en Ingeniería (CIMNE), Fundació Sant Joan de Déu (FSJD), Hospital Sant Joan de Déu (HSJD), Grupo de investigación en ingeniería de materiales (GEMAT), Grup de Recerca en Enginyeria de Producte, Procés i Producció (GREP), Centro de Diseño y Optimización de Procesos y Materiales (DIOPMA UB)
Grup de Recerca de Biomaterials, Biomecànica i Enginyeria de Teixits (BBT) UPC, Centro de Diseño de Aleaciones Ligeras y Tratamientos de Superficie (CDAL) UPC, Centre de Prototips i Solucions Hardware-Software (CEPHIS UAB), Centro de Integridad Estructural, Fiabilidad y Micromecànica de los Materiales (CIEFMA UPC), Centre Tecnològic de Transferència de Calor (CTTC), UPC, IMEM UPC, NEMEN UPC, POLTEPO UPC, REMM UPC, TECNOFAB UPC, PROCOMAME.
Date: 2019 - 2021
Group: Nanoionic and Fuel Cells
P.I: Marc Torrell Faro.

Title: Infraestructures del Carrer Connectat
Acronym: FEM IoT P1
Description: Analitzant l'estat de l'art actual de les Ciutats Intel·ligents s'observa una notable fragmentació de les solucions existents en quant a infraestructura, ja que la majoria de proveïdors de serveis acaben desplegant nous equips i recursos (sensors, xarxa, gestió i emmagatzematge de dades) de manera aïllada i independent de la resta. S'han portat a terme algunes iniciatives, tals com City-OS o FIWARE, per trencar aquesta estructura basada en sitges ('Smart City silos') a nivell de plataforma de dades, però no existeix una solució consolidada per a integrar tota la infraestructura necessària en la ciutat del futur. Sumat a això, les futures infraestructures plantegen alguns reptes. Per una banda, s'hauran d'incorporar una gran quantitat de noves antenes i equips de la futura xarxa 5G que proporcionarà comunicacions d'ultra alta velocitat (eMBB), ultra fiables (URLLC) i tecnologies per a la comunicació massiva de dispositius (mMTC). Per altra banda, s'haurà de veure com el model de la infraestructura dona cabuda als requeriments de mobilitat i latència de nous casos d'ús de IoT relacionats amb els vehicles connectats i, més endavant, amb els cotxes autònoms i drones. Així, el projecte té l'objectiu de contribuir a la definició, implementació i desenvolupament de les infraestructures de carrer a la ciutat intel·ligent del futur. Per tal de dissenyar una arquitectura global que pugui donar resposta a totes les necessitats de connectivitat i serveis d'un entorn urbà, la originalitat del projecte es centrarà en tres elements tecnològics: Una infraestructura ICT integrada, multi-tecnologia i flexible, que suporti el desplegament dinàmic de diferents serveis de ciutat intel·ligent de manera àgil i eficient. Les tecnologies IoT de baix consum, que son la base per connectar els milions de dispositius sensors que es desplegaran a les ciutats, i generaran les dades que permetran extreure decisions intel·ligents. Les comunicacions vehiculars, que son imprescindibles per tal d'integrar en la ciutat del futur un element tant disruptiu com és el

futur cotxe autònom i connectat. Aquest projecte és singular en la mesura que posa de relleu diverses iniciatives de la ciutat de Barcelona com a capital del mòbil, l'existència d'interessos reals en la indústria de la mobilitat (Seat) i el consorci 5GBarcelona.
Funding: Emergents
Project ID: IU16-011655
Type: Competitive Nationals
Partners: Fundació Internet i Innovació Digital a Catalunya (i2CAT), Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Universitat Politècnica de Catalunya (UPC), Universitat Oberta de Catalunya (UOC), Universitat Rovira i Virgili (URV), Centre de Visió per Computador (CVC), Universitat Pompeu Fabra (UPF), Centre Tecnològic de Catalunya (Eurecat), condicionamiento Tarrassense (Leitat), Fundacio Institut de Recerca en Energia de Catalunya (IREC)
Date: 2019 - 2022
Group: Nanoionic and Fuel Cells
P.I: Alex Morata García.
More info at the following link

Title: 3D processing of advanced solid state ionics energy devices
Acronym: 3DPASSION
Description: The 3DPASSION project addresses the development of a new generation of energy production and storage devices manufactured by 3D ceramic
energy production and storage devices manufactured using 3D ceramic processing techniques. 3DPASSION combines emerging 3D fabrication technologies with advanced materials to develop high power density solid-state energy high power density solid-state energy devices (solid oxide fuel cells and electrolysers and lithium metal batteries) oxide fuel cells and electrolysers and lithium metal batteries). In line with the RIS3 (Research and Innovation Strategies for Smart Specialisation) strategy of Strategies for Smart Specialisation) specialisation strategy of the regions involved in the project (Catalonia, Aragon and the Basque Country), these energy technologies (fuel cells, hydrogen and batteries) are considered necessary for the batteries) are considered necessary for a full deployment of renewables in a future fully decarbonised system.
Funding: Proyectos I+D+i 2019
Project ID: PID2019-107106RB-C31
Type: Competitive Nationals
Partners: IREC (coordinador), INMA and CIC Energigune.
Date: 2020 - 2023
Group: Nanoionic and Fuel Cells
P.I: Albert Tarancón Rubio
More info at the following link

Title: Hydrogen lab for the modernisation and technological transformation of the city of Barcelona
Acronym: Hy-BCN
Description: The main objective of the Hy-BCN project is to design a fully-integrated reversible and highly efficient solid oxide cell system for energy conversion, storage and production based on hydrogen fuel technologies, to demonstrate its potential application in local and sustainable energy use from renewable power sources.
The aim of the project is to build a 1kW system based on a Solid Oxide Electrolyser Cell (SOEC) stack to generate hydrogen using the surplus of local intermittent renewable energy sources and subsequently store it. Similarly, the stored hydrogen will be utilised to generate power by the same system operating as fuel cell achieving a complete energy management cycle.
Funding: Pla Barcelona Ciència- Ajuntament de Barcelona
Project ID: 19S01452-006
Type: Competitive Nationals
Date: 2020 - 2021
Group: Nanoionic and Fuel Cells
P.I: Marc Torrell Faro.
More info at the following link

Title: Next Generation solid oxide fuel cell and electrolysis technology
Acronym: NewSOC
Description: The NewSOC project aims at significantly improving performance, durability, and cost competitiveness of solid oxide cells & stacks compared to state-of-the-art (SoA). In order to achieve these goals, NewSOC proposes twelve innovative concepts in the following areas: (i) structural optimisation and innovative architectures based on SoA materials, (ii) alternative materials, which allow for overcoming inherent challenges of SoA, (iii) innovative manufacturing to reduce critical raw materials and reduction of environmental footprint at improved performance & lifetime. The NewSOC project will validate the new cells & stacks at the level of large cells with > 50 cm2 active area and short-stacks in close collaboration with industry thereby moving the technology readiness level from 2 to 4. Six major European SOC manufacturers are part of the consortium, representing a large range of SOC concepts and product & market strategies. Industry partners will take the lead for providing a path how to increase the TRL level beyond the project period towards TRL of 6. The NewSOC project will evaluate the new SOC materials and fabrication processes according to life cycle impact and cost assessment.
Funding: H2020
Project ID: 874577
Type: Competitive EU
Partners: DTU, CEA, UNISA, IREC, IEN, TNO, FORTH, CERTH, VTT, EPFL, POLITO, SolidPower, Elcogen, Sunfire, CeresPower, Hexis
Date: 2020 - 2023
Group: Nanoionic and Fuel Cells
P.I: Alex Morata García.
More info at the following link

Title: Nanostructured fabrics for high performing flexible thermoelectric power Generator
Acronym: POWERCOAT
Description: The combination of a broad presence of heat-waste with a major necessity of controlling the instruments and processes, makes thermoelectric energy generators (TEG) highly attractive for "place-and-forget" industrial IoT nodes. Thermoelectric effects enable direct conversion between thermal and electrical energy, thus heat harvesting will provide an alternative power generation. Unfortunately, commercial TEG present some limitations that prevent them from success, main limitations are the toxicity and high cost of the materials used for their production. POWERCOAT technology presented in this proposal is a revolutionary new high-performing cost-effective and environmentally friendly TE material. The POWERCOAT approach centers around nano-enabled easy-to-handle flexible fabrics made of thin-walled silicon microtubes. POWERCOAT fabric-like thermoelectrics adapt to any hot surfaces (usually round chimneys, unlike conventional flat batteries or TEGs), leading to a high performance and mechanical properties. The ongoing extension of POWERCOAT technology to room temperature will open the door to a large number of new markets. Agriculture, food industry and packaging are some of the highly interesting industrial IoT sectors that would benefit. Moreover, the biocompatibility of the silicon material, added to the flexibility of the fibers and the appropriate fluidics to allow transpiration will make them an excellent harmless everlasting power source for body wearables and implants.
Funding: Fons de Patents GÍNJOL (CERCA)
Type: Competitive Nationals
Date: 2019 - 2020
Group: Nanoionic and Fuel Cells
P.I: Nerea Alayo.
More info at the following link

Title: Thin Film Reversible Solid Oxide Cells for Ultracompact Electrical Energy Storage
Acronym: EPISTORE
Description: In the last decades, advanced thin film technology has enabled a wide range of technological breakthroughs that have transformed entire sectors such as electronics and lighting by the implementation of outstanding nanoscale phenomena in reliable products that involve ultralow contents of critical raw materials (CRMs). EPISTORE aims to revolutionize the energy storage sector by developing pocket-sized kW-range stacks based on thin film reversible Solid Oxide Cells (TF-rSOCs) that will be able to efficiently store renewable electricity for applications where the use of batteries is inefficient due to size constraints or long term storage requirements, e.g. off-shore power generation or transportation. Nanoscale breakthroughs and never explored materials will be combined in revolutionary TF-rSOCs giving rise to radically new ultracompact and fast response Power-to-Gas and Power-to-Power storage solutions with superior performance (hydrogen production of 10kg/l per hour and specific power of 2.5kW/kg) and negligible use of CRMs (50mg/kW). In order to enable this science-to-technology step forward, our nano-enabled TF-rSOCs will be integrated in scalable silicon technology to show their viability as a potentially low-cost new paradigm of large-scale energy storage. The EPISTORE project addresses this challenging objective by building an interdisciplinary research consortium that includes consolidated and emergent leading researchers in modelling, micro- and nano-technologies, materials science and energy together

with high-tech pioneer SMEs that cover the whole value chain and possess unique capabilities to develop kW-range modular stacks for real applications. Moreover, the structure and communication strategy have been designed to make EPISTORE a lighthouse project for boosting this novel storage paradigm and building an innovation ecosystem founded on advanced thin films applied to energy technology.
Funding: H2020- FET Proactive
Project ID: 101017709
Type: Competitive EU (coordinator)
Partners: FUNDACIO INSTITUT DE RECERCA DE L'ENERGIA DE CATALUNYA (coordinator), THE CHANCELLOR MASTERS AND SCHOLARS OF THE UNIVERSITY OF CAMBRIDGE, KARLSRUHER INSTITUT FUER TECHNOLOGIE, AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS, THE UNIVERSITY COURT OF THE UNIVERSITY OF ST ANDREWS, IMPERIAL COLLEGE OF SCIENCE TECHNOLOGY AND MEDICINE, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS, RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE AACHEN, JOHNSON MATTHEY PLC, SOLMATES BV, SOLIDPOWER SA, HYGEAR BV.
Date: 2020 - 2024
Group: Nanoionic and Fuel Cells
P.I: Albert Tarancón Rubio.
More info at the following link

Title: Nanoscience Foundries and Fine Analysis – Europe|PILOT
Acronym: NFFA-EUROPE PILOT
Description: NFFA-EUROPE PILOT (NEP) aims at expanding and consolidating the operation of an Interoperable Distributed Research Infrastructure for Nanoscience (IDRIN) supporting research on materials and functional systems at the nanoscale and at the microscale. NEP provides a unique overarching offer of experimental and theoretical facilities to be combined to suit user needs ranging from materials synthesis, growth, nanofabrication to nanocharacterization, microscopy and spectroscopies also with fine analysis methods at large scale X and neutron radiation sources, and to numerical simulation. The model IDRIN fostered by NEP builds on the four-year experience of transnational access provision of NFFA-Europe that delivered combined scientific services to over one thousand European users.
Funding: H2020-INFRAIA
Project ID: 101007417
Type: Competitive EU (Third party)
Date: 2021 - 2026
Group: Nanoionic and Fuel Cells
P.I: Alex Morata García.
More info at the following link

PUBLICATIONS

Journals and articles, Peer review System

Anelli, S., Hernández, E., Bernadet, L., Sun, X., Hagen, A., Baiutti, F., Torrell, M., Tarancón, A. "Co-electrolysis of steam and carbon dioxide in large area solid oxide cells based on infiltrated mesoporous oxygen electrodes" *Journal of Power Sources* 478, pp. 228774 - 2020 DOI: 10.1016/j.jpowsour.2020.228774

Bernadet, L., Moncasi, C., Torrell, M., Tarancón, A. "High-performing electrolyte-supported symmetrical solid oxide electrolysis cells operating under steam electrolysis and co-electrolysis modes" *International Journal of Hydrogen Energy* 45, 28, pp. 14208 - 14217. 2020 DOI: 10.1016/j.ijhydene.2020.03.144

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Erinmwingbovo C., Siller V., Nuñez M., Trócoli R., Brogioli D., Morata A., La Mantia F. "Dynamic impedance spectroscopy of LiMn2O4 thin films made by multi-layer pulsed laser deposition" *Electrochimica Acta* 331, pp. 135385 - 2020 DOI: 10.1016/j.electacta.2019.135385

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Gadea Díez G., Sojo Gordillo J.M., Pacios Pujadó M., Salleras M., Fonseca L., Morata A., Tarancón Rubio A. "Enhanced thermoelectric figure of merit of individual Si nanowires with ultralow contact resistances" *Nano Energy* 67, pp. 104191 - 2020 DOI: 10.1016/j.nanoen.2019.104191

Gadea Díez G., Sojo Gordillo J.M., Pacios Pujadó M., Salleras M., Fonseca L., Morata A., Tarancón Rubio A. "Enhanced thermoelectric figure of merit of individual Si nanowires with ultralow contact resistances" *Nano Energy* 67, pp. 104191 - 2020 DOI: 10.1016/j.nanoen.2019.104191

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ultralow contact resistances" *Nano Energy* 67, pp. 104191 - 2020 DOI: 10.1016/j.nanoen.2019.104191

Gamba, N.S., Puszkiel, J., Arneodo Larochette, P., Gennari, F.C. "Dual application of Ti-catalyzed Li-RHC composite for H2 purification and CO methanation" *International Journal of Hydrogen Energy* 45, 38, pp. 19493 - 19504. 2020 DOI: 10.1016/j.ijhydene.2020.05.023

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Pesce, A., Hornes, A., Nuñez, M., Morata, A., Torrell, M., Tarancon, A. "3D printing the next generation of enhanced solid oxide fuel and electrolysis cells" *Journal of Materials Chemistry A* 8, pp. 16926 - 16932. 2020 DOI: 10.1039/D0TA02803G

Puszkiel, J., Bellosta von Colbe, J.M., Jepsen, J., Mitrokhin, S.V., Movlaev, E., Verbetsky, V., Klassen, T. "Designing an AB2-Type Alloy (TiZr-CrMnMo) for the Hybrid Hydrogen Storage Concept" *Energies* 13, 11, pp. 2751 - 2020 DOI: 10.3390/en13112751

DOCTORAL THESES

Ongoing theses:

Doctorate: Valerie Siller
Title: Thin film based all-solid-state lithium-ion batteries and operando characterization methods
Directors: Dr. Albert Tarancon, Dr. Alex Morata

Doctorate: Yunqing Tang
Title: Mixed ionic and electronic conduction in nanostructured materials for energy applications
Directors: Francesco Maria Chiabrera, Alex Morata, Albert Tarancón

Doctorate: Simone Anelli
Title: Advanced strategies for Solid Oxide Electrolysis Cells
Directors: Albert Tarancón Rubio, Marc Torrell Faro, Federico Baiutti

Doctorate: Arianna Pesce
Title: 3d printing of ceramic based energy conversion devices.
Directors: Alex Morata, Albert Tarancón

Doctorate: Marco Bianchini
Title: Development of large area Micro Solid Oxide Fuel Cells and stacks
Directors: Nerea Alayo, Albert Tarancón

Doctorate: Jose Manuel Sojo
Title: Si and Si-Ge thermoelectric materials and devices
Directors: Alex Morata, Albert Tarancón

Doctorate: Maritta Lira dos Santos
Title: 3D printed large area Solid Oxide Cells
Directors: Marc Torrell, Albert Tarancón

Doctorate: Natalia Kostretsova
Title: 3D printing of complex ceramics for energy applications
Directors: Marc Torrell, Albert Tarancón

Doctorate: Carolina Duque
Title: Silicon-based thermoelectric materials for energy applications
Directors: Alex Morata, Albert Tarancón

OUTREACH

- 3D printing technologies for enhanced energy devices
- IREC endorses the acceleration of European electrolyzers
- Solid state micro-batteries as a miniature energy source
- The 3DPASSION project kicks-off
- "µ-harvestorers": A revolution in IoT
- National projects tackle diverse energy-related challenges
- The Hydrogen Table from ICAEN promotes hydrogen tecnologies in Catalonia
- 3D printing boosts the development of hydrogen technologies
- Printing safer, cheaper lithium batteries
- IREC participates in the BASE3D association
- IREC participates in the emerging IoT association as an expert in energy
- Barcelona bets for hydrogen as a green energy vector
- New Solid Oxide Cell concepts based on 3D printing developed at IREC
- IREC participates in 6 sub-projects of 4 Emerging Technologies Associations
- 3D printing technologies for enhanced energy devices
- https://www.irec.cat/event/100tifiques-dia-internacional-de-les-dones-i-les-nenes-en-la-ciencia/
- https://www.irec.cat/event/in-format-explora-lirec/
- https://www.irec.cat/event/webinar-hydrogen-for-emission-free-mobility/
- https://www.irec.cat/event/webinar-hidrogen-una-solucio-immediata-pel-medi-ambient/
- https://www.irec.cat/event/hidrogeno-vector-energetico-de-una-economia-descarbonizada/

- https://www.irec.cat/event/european-research-night/
- Hydrogen: Energy vector of a decarbonised economy
- https://www.lavanguardia.com/economia/20200611/481706664731/hidrogeno-verde-combustible-futuro-energia-coches-renovables.html
- https://www.radioillaformentera.cat/lhidrogen-verd-el-combustible-del-futur/
- https://www.lavanguardia.com/economia/20201202/49782634947/hidrogeno-energia-futuro-transporte-espana.html

6.1.4. SOLAR ENERGY MATERIALS AND SYSTEMS

The Team

(permanent and temporary positions, tenure tracks and fellowships)

Prof. Dr. Alejandro Pérez-Rodríguez, Group Leader
Dr. Edgardo Saucedo, Researcher, Deputy Head
Dr. Víctor Izquierdo-Roca, Researcher
Dr. Marcel Placidi, Researcher
Dr. Yudania Sánchez, Researcher
Dr. Maxim Guc, Researcher
Dr. Sergio Giraldo, Researcher
Dr. Zacharie Jehl Li Kao, Researcher
Dr. Kunal Jogendra Tiwari, Researcher
Dr. Ignacio Becerril, Researcher
Dr. Josep Oriol Blazquez Gomez, Researcher
Dr. Angelica Thomere, Researcher
Rafael Meyer, Optical Engineer
Jacob Andrade-Arvizu, PhD student
Pedro Vidal, PhD student
Mohamed Salem, PhD student
Alex López-García, PhD student
Robert Fonoll-Rubio, PhD student
Enric Grau, PhD student
Fabien Atlan, PhD student
Alex Jiménez, PhD student
Axel Gon Medaille, PhD student

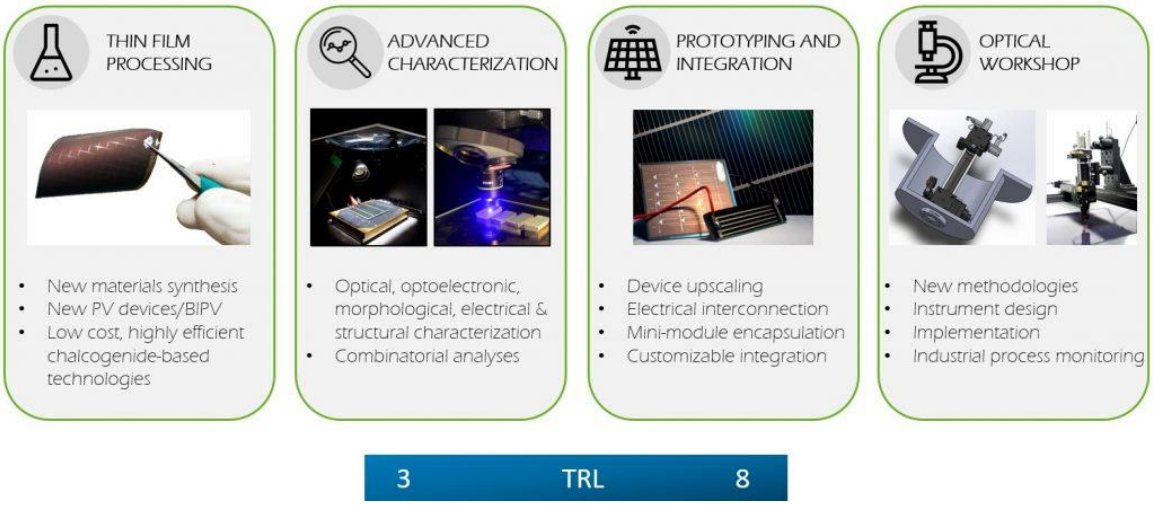
Solar Materials and Systems group aims to design new materials and processes for advanced thin-film photovoltaic (PV) technologies. We investigate and develop novel solutions for industrial mass-production that are more affordable, efficient and sustainable.

One of our major outcomes has been the development of new earth abundant PV baseline technologies scalable up to 10×10 cm2 substrates with efficiency values that are among the highest achieved in the world avoiding the use of scarce critical elements or toxic compounds, and the demonstration of their technological flexibility for advanced PV integration concepts.

Their research is about pushing innovative emerging technologies based on inorganic chalcogenide compounds to industry, with a focus on kesterites, chalcopyrites and low dimensional compounds. Our aim is to exploit the flexibility of these technologies for next generation PV integrated components and systems, to enable their use in all scenarios of human activity.

Their state-of-the-art laboratory is a global point of reference in the field and one of the few facilities in Spain that enables both the production and advanced characterisation of solar cell prototypes.

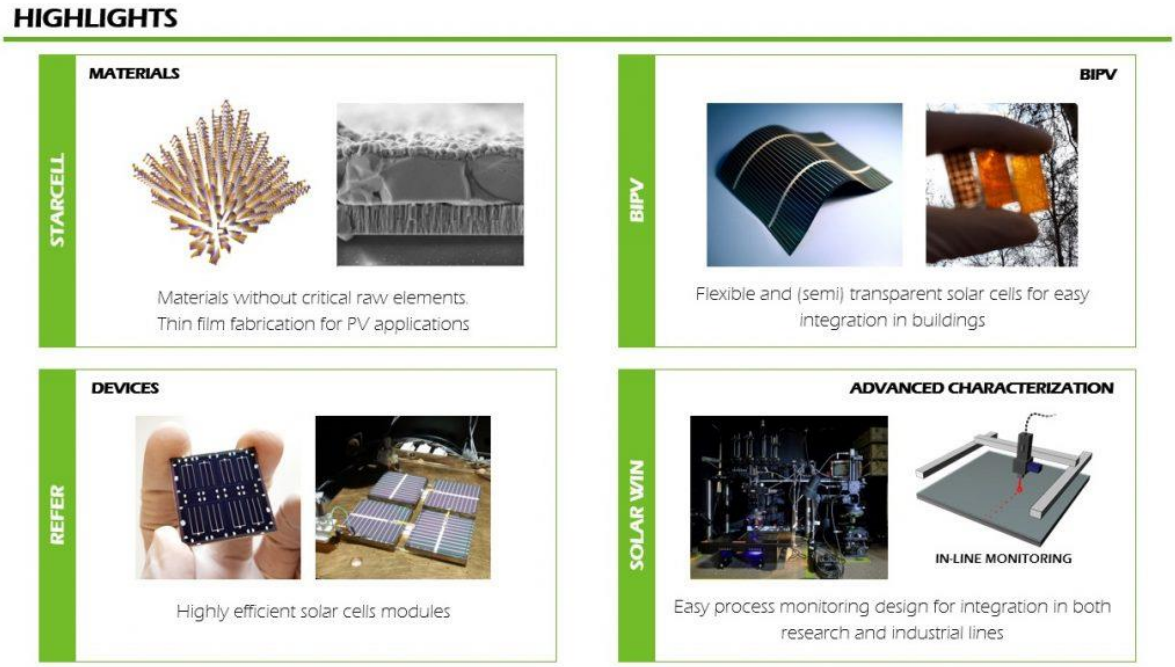
They work closely both with pioneer research groups from institutions across Europe and multinational companies in advanced characterization methodologies for quality control and process monitoring applications.



CAPABILITIES

- *Synthesis:* DC, DC pulse & RF sputtering, thermal & e-beam evaporator, ALD, chemical bath deposition, electrochemical workshop, spray pyrolysis, spin coating, screen printing, advanced chemical workshops, substrate washing machine, UV ozone cleaner, reactive CTP & RTP furnaces, mechanical scribing, ball-milling, electrical & module prototyping workshop.

- *Characterization:* solar simulator, EQE/IQE, XRF, 4-point probe, XRD, multi-wavelength Raman, industrial integrable & portable Raman, PL, EL, AFM, UV-Vis-IR, confocal-interferometric microscope, impedance system, helium cryostat, optical workshop, 3D prototyping platform, XY platform for optical characterization, industrial process monitoring workshop.



PROJECTS

Title: SEMS SGR 2017-2019
Acronym: SEMS SGR 2017-2019
Description: SEMS group research activities are centred in the development and advanced characterisation of thin film chalcogenide devices and processes for next generation cost-efficient sustainable photovoltaic technologies, including chalcopyrite technologies (based on Cu(In,Ga)(S,Se)2 (CIGS) compounds) that have already started their transition to industrial production, as well as emerging technologies based on kesterites (Cu2ZnS(S,Se)4 (CZTS) compounds) that avoid the use of critical raw materials and highly toxic compounds. In these technologies, the group has developed an intense activity in the development of methodologies based on Raman Spectroscopy for advanced characterization of devices and their extension to Quality Control and Process Monitoring applications, being one of the reference groups at world level in this field. At technological level, the SEMS group is one of the pioneers in Europe in the development of kesterite technologies, having obtained a photovoltaic conversion efficiency of 11.8% which is among the best values reported at world level using processes free of hazardous or explosive compounds (as hydrazine). The SEMS group has also been a pioneering group in the extension of these technologies to alternative substrates with relevant added value for building and product integration applications, as ceramic architectural substrates and poliyimide/steel foils for light weight and flexible modules.
Funding: SGR
Project ID: 2017 SGR 862
Type: Competitive Nationals

Partner: Fundacio Institut de Recerca en Energia de Catalunya (IREC), Universidad De Barcelona (UB), Universidad Autonoma de Madrid (UAM), Universitat Jaume I (UJI)
Date: 2018 - 2020
Group: Solar Energy Materials and Systems
P.I: Alejandro Pérez-Rodríguez.
More info at the following link

Title: International cooperation for the development of cost-efficient kesterite/c-Si thin film next
Acronym: Infinite-Cell
Description: Photovoltaic (PV) is recognized as one of the main renewable energy solutions for fulfilling the targets defined bythe EU Energy Roadmap 2050 and the SET Plan. Most of the current commercial PV devices are formed by singlejunctions, and more complex device concepts allowing a significant increase in device efficiency (well beyond thetheoretical limit in the 30%-33% range) are still mostly limited to expensive III-V technologies. INFINITE-CELL proposes extending the very high efficiency tandem device concepts to emerging thin film PVtechnologies with high potential for reduction of costs and avoiding the use of critical raw materials. Within thiscontext, the aim is to establish and consolidate an International and Intersectoral Cooperation between 6 EC/ACAcademic Institutions (IREC, SINTEF, CNRS, UAM, IAP-ASM, HZB), 2 European Companies (SUNGA, MET), and 4 non EC/AC Academic Institutions (MASCIR, BSUIR, UM5, UWC), for the development of cost-efficientphotovoltaic tandem devices based in the combination of wide band-gap kesterite absorbers (Cu2Zn(Si,Ge,Sn)(S,Se)4)as top cell, and low cost c-Si thin film as bottom cell. Thanks to the combination of the know-how generated inprevious and successful FP7 projects (PVICOKEST (269167) and EUROSUNMED (608593)), INFINITE-CELLtargets to develop stacked and monolithically integrated kesterite/c-Si thin film devices with efficiencies of 15% and20% respectively, using only fully sustainable materials and processes.This will be possible through de definition of a very impacting Research Plan and a very ambitious Plan ofSecondments, where 293 PMs will be exchanged among the partners. The seconded researchers will be immersed inan International and Intersectoral environment for the development and improvement of their networking, scientific,writing, effective communication, and time management skills, warranting the consolidation of a high level scientificcommunity in Advanced Tandem Solar Cell.
Funding: H2020
Project ID: 777968
Type: Competitive EU, Coordinator
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC), Stiftelsen Sintef (SINTEF), Centre National de la Recherches Cientifique CNRS (CNRS), Universidad Autonoma de Madrid (UAM), Institute of Applied Physics of the Academy of Sciences of Moldova (IAP ASM), Helmholtz-Zentrum Berlin fur materialien und Energie GMBH (HZB), Societatea cu Raspundere Limitata Sunga S.R.L. (SunGa), UAB Modernios E-Technologijos (MET)
Date: 2017 - 2021
Group: Solar Energy Materials and Systems
P.I: Edgardo Ademar Saucedo Silva
More info at the following link

Title: Soluciones avanzadas de encapsulado de muy alta estabilidad para tecnologias
Acronym: Duracis
Description: Flexible photovoltaics based in thin film Cu(In,Ga)Se2 (CIGS) technologies can largely contribute to the fast penetration of solar energy production inresidential and low weight infrastructures applications. These flexible devices can reduce the weight of a conventional glass-glass solar panel in almostone order of magnitude, representing a clear advantage for their application in building integrated concepts. Nevertheless, for a cost-competitive fullmarket entry, flexible CIGS photovoltaic (PV) technologies require the availability of innovative encapsulation solutions with both, very low costs andexcellent barrier properties guaranteeing a long operating time of the devices, while keeping the lightweight characteristics. Even if there are alreadyexisting solutions with acceptable performance levels, costs remain a relevant issue that needs to be solved in order to keep the stringent cost reductiontargets established for these technologies. To solve these problems, DURACIS will explore new alternative encapsulation and optical glue materials andconcepts, compatible with their implementation into already existing industrial CIGS pilot lines and allowing a significant extension of the lifetime whilesubstantially reducing costs. To achieve this goal, transfer of concepts previously developed for organic technologies (with very stringent encapsulationrequirements) will be investigated. In particular, three innovative approaches will be fully developed and tested, including: i. Liquid encapsulant basedstrategies that have been previously developed and applied in OLED technologies; ii. Self-stratifying polymers concepts that have been developed forencapsulation of organic PV (OPV) devices; and iii. Alternative front sheet and Polyolefin embedding encapsulant concepts. The final goal of DURACIS is the development of a novel encapsulation technology with costs below 15 Euros/m2 and ensuring a durability higher than25 years for flexible CIGS devices. The project will adopt a global strategy including solutions for the main industrial substrate technologies that havebeen developed for flexible CIGS (polyimide, steel substrates) and will also include the analysis of their transfer into industrial pilot lines available in theconsortium. The implications of the different kinds of substrates on these new encapsulation concepts will be specifically addressed aiming at thedevelopment of optimized cost efficient solutions compatible with very long term stability.The project will also include the development of advanced methodologies for the non-destructive monitoring of the encapsulation processes and layers.In particular, IREC will work in the development of optical methodologies (Raman scattering, photoluminescence, reflection based methodologies), toassess and provide fast and reliable tools for control and monitoring of the degradation of the different encapsulant solutions proposed in DURACIS. Thisinvolves both monitoring of the deposition processes as well as the definition of fast methodologies for detection of potential degradation effects affectingthe encapsulation and device lifetime.
Funding: APCIN
Project ID: PCIN-2017-041
Type: Competitive Nationals
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC)
Date: 2017 - 2020
Group: Solar Energy Materials and Systems
P.I: Alejandro Pérez-Rodríguez.
More info at the following link

Title: Soluciones innovadoras de bajo coste y alta eficiencia para la produccion de bipv semitransparente
Acronym: MASTER PV
Description: MasterPV proposes the development and demonstration of low cost innovative processes for cost efficient semi-transparent Cu(In,Ga)(S,Se)2 (CIGS)BIPV solutions. The project involves the replacement of the Mo back contact in the traditional CIGS device architecture by chemical vacuum-free basedTCO (Transparent Conductive Oxide) electrodes. This will allow achieving a significant improvement in the aesthetic quality of the semi-transparentdevices, with the elimination of the back mirror effect that is determined by the remaining Mo regions in the semi-transparent modules. Improvement of the aesthetic quality of CIGS ST devices is strongly relevant to ensure a higher level of acceptance of these solutions in the BIPVmarket. The proposed solutions will contribute to a more efficient exploitation of the potential of CIGS technologies for lowering of manufacturing costs,with the replacement of the vacuum-based Mo sputtering deposition processes by lower cost approaches that are based in low CAPEX vacuum-freechemical strategies.The main scientific challenge of the project is related to the development of optimal transparent contacts allowing for device efficiencies comparable tothe high efficiency values that have already been achieved with standard Mo based back contacts. This will imply a special effort in the optimization ofTCO based contacts suitable for high efficiency devices, which will be based in the development of surface contact configurations including nanometrictransition metal oxides (TMO) that have already been demonstrated as efficient hole transport layers in organic based technologies and are verypromising for optimization of the valence band alignment at the back contact/CIGS interface. The main technological challenge is related to theimplementation of low cost vacuum-free processes for the growth of the optimal transparent back contact configurations and to the adaptation of theseprocesses for the fabrication of efficient semi-transparent CIGS modules. At commercial level, the improvement of the aesthetic quality of the STmodules and the decrease of their cost will contribute to the consolidation of CIGS as one of the main commercial technologies able to answer to theincreasing demand of cost-efficient and reliable semi-transparent products in the BIPV market. The project will contribute in a relevant way to theenhancement of the innovation capacity and integration of new knowledge in the European PV industry, with the development of innovative processesthat are also relevant for other advanced PV applications as bifacial solar cells and very high efficiency thin film tandem devices
Funding: APCIN
Project ID: PCI2018-092945
Type: Competitive Nationals
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC)
Date: 2018 - 2021
Group: Solar Energy Materials and Systems
P.I: Víctor Izquierdo Roca.
More info at the following link

Title: Dispositivos hibridos de silicio/calcogenuro de capa delgada para tecnologias fotovoltaicos sostenibles de bajo coste y muy alta eficiencia
Acronym: IGNITE
Description: IGNITE will explore a new concept in the development of high efficiency tandem photovoltaic technologies, based in the combination of c-Si and thin film technologies using earth abundant materials with excelent stability, low toxicity and proved sustainability. This will bepossible by combining for the first time, c-Si technology with interdigitated back contacts (IBC c-Si) prepared at low temperature (< 250 ºC)as bottom cell in a tandem configuration, and wide band-gap kesterite absorbers deposited onto semi-transparent substrates as top solarcell. The project proposes to introduce a fully new tandem concept, taking advantage of the intrinsic characteristics of the devices basedon IBC c-Si with the low cost potential of thin film technologies, allowing for the integration of the kesterite device in a monolithicconfiguration, and with the possiblitiy to fully and independently optimize the different electrical contacts. In the last years, the fastimprovement of new photovoltaic materials such as perovskites and kesterites, has open the posibility to develop for the first time highefficiency tandem solar cells using exclusivelly cost-efficient and earth abundant materials, by combining them with already stablished c-Sitechnologies. Nevertheless, the toxicity and stability issues related to perovskites, and the necesity of relatively high temperatureprocesses in kesterites for obtaining good efficiencies, has limited in a large extent this development. In this sense, and thanks to the fast improvements on the IBC c-Si technoloy, IGNITE will explore for the first time the possibility tointegrate these devices, with wide band-gap sustainable solar cells besed on kesterites. The most relevant idea behind IGNITE issupported by the fact that in the interdigitated technology, the electrical contacts of c-Si are placed in the same side of the waffer, makingpossible the compatibility with the independent development and optimization of the kesterite device in the other side of the wafer. This willallow to have monolithically integrated tandem devices, in 4 terminal connection configuration, in which for the first time each of the 4electrical contacts can be independently optimized. This will suppose a clear technological advantage, reducing production costs, andallowing for the independent optimization of the fabrication processes for the two different devices.For solving the proposed challenges, IGNITE is formed by a multidisciplinary and complementary consortium, joining leading groups atSpanish and European level in the development of c-Si technologies (UPC), in thin film photovoltaic chalcogenides (IREC), and inchemical routes for synthesis of functionalized oxides (UJI), positioning these technologies towards a possiblie future industrialization. Atthe end of the project, IGNITE will demonstrate c-Si photovoltaic devices with interdigitated contacts fabricated at low temperature withefficiencies higher than 20%, wide-band gap and semi-transparent kesterite devices with efficiencies exceeding 14%, and combining both,a monolithic integrated tandem device with conversion efficiency > 25%, allowing to push the efficiency in IBC c-Si devices to valuescomparable with the current Si world record efficiency by the implementation of low cost thin film processes.
Funding: Retos Investigació
Project ID: ENE2017-87671-C3-1-R
Type: Competitive Nationals, Coordinator
Partners: Fundació Institut de Recerca en Energia de Catalunya (IREC), Universitat Politècnica de Catalunya (UPC), Universidad Jaume I de Castelló
Date: 2018 - 2020

Group: Solar Energy Materials and Systems
P.I: Edgardo Ademar Saucedo Silva.
More info at the following link

Title: Semi-transparent back contacts for solar cells
Acronym: Semi-transparent back contacts for solar cells
Description: It was proposed to use the high aspect ratio of electrodeposited Zinc Oxide (ZnO) nanowires as a super hydrophobe surface for self-cleaning glass application. In collaboration with the leading glass French company Saint-Gobain, electrodeposited films with various nanowire geometries were developed. These films were coated with stearic acid to lower surface energy, and characterized by sessile drop wettability. It was found that the density of the nanowires was a critical aspect for optimization, while their verticality had very little influence on the surface wettability; however, verticality was still needed to obtain specular films in terms of optical transmission. By using a ZnO seed layer, electrodeposited at lower temperature and with a difference Zn concentration, it was possible to significantly increase the nanowires' density hence leading to an improvement of the super hydrophobicity of the films. Water drop contact angles showed a near perfect super hydrophobicity, and values above 175° were obtained in the course of this project.
Funding: Accio
Project ID: TECSPR17-1-0052
Type: Competitive Nationals
Partners: Fundació Institut de Recerca en Energia de Catalunya (IREC), Universidad de Barcelona (UB), Universidad Autonoma de Madrid (UAM), Universitat Jaume I (UJI)
Date: 2018 - 2020
Group: Solar Energy Materials and Systems
P.I: Zacharie Jehl.
More info at the following link

Title: Nuevos procesos industriales sostenibles para la producción de dispositivos fotovoltaicos competitivos integrables en sensores y sistemas autónomos (FOTOSENS)
Acronym: FOTOSENS
Description: El objetivo principal del proyecto FOTOSENS es el desarrollo y demostración de nuevos procesos industriales para la fabricación de dispositivos fotovoltaicos avanzados para la alimentación de sistemas autónomos basados en la implementación de procesos sostenibles y de bajo impacto medio-ambiental que se caracterizan por presentar una elevada flexibilidad tecnológica, una relación coste-eficiencia adecuada y que son compatibles con su escalado para etapas de producción industrial en masa.
El proyecto propone un nuevo concepto basado en la integración de los dispositivos fotovoltaicos en los sistemas autónomos, para lo que se propone el desarrollo y demostración de tecnologías basadas en procesos de impresión y tratamiento térmico con láser que presentan un potencial muy elevado de reducción de costes y que son compatibles con el uso

de diferentes tipos de sustratos, y con la realización de forma sencilla de diseños complejos sin la necesidad de integrar etapas costosas adicionales de ataque selectivo y/o grabados.
Funding: Retos Col·laboració
Project ID: RTC-2017-5857-3-P02
Type: Competitive Nationals
Partners: Francisco Albero SA (FAE), Fundació Institut de Recerca en Energia de Catalunya (IREC), Universidad De Zaragoza
Date: 2018 - 2021
Group: Solar Energy Materials and Systems
P.I: Marcel Placidi.
More info at the following link

Title: Disruptive sustainable TECHnologies FOR next generation pvWINdows
Acronym: Tech4Win
Description: Tech4win proposes a very innovative transparent photovoltaic (PV) window concept that is based on the adoption of a tandem inspired structure combining an inorganic UV selective multifunctional coating (including UV filtering and UV selective PV functionalities), with an organic IR selective PV device. This will allow fully exploiting the IR efficiency and transparency potential of organic based solutions together with the robustness and stability of inorganic thin film concepts, combining sustainable and industrial compatible technologies with demonstrated potential for cost reduction, and avoiding the use of critical raw materials to ensure sustainable mass deployment. This “tandem inspired structure” will be able to generate on-site renewable energy (PCE 10%, with a long term goal 12%) guaranteeing a high-transparency degree (AVT 60% with a long term goal 70%, and CRI 70) and all by a competitive manufacturing costs. This novelty lies precisely in the capacity to protect the most active PV layer (IR selective organic solar cell) through the filtering of UV radiation, extending the lifetime of the PV hybrid device to 10 years (with a long term goal 25 years). To fulfil these objectives, a very well balanced multi-sectorial consortium comprising reference Research Centers in the different PV technologies involved in the window concept, together with high-tech European Companies from different sectors including relevant stakeholders involved in the value chain (Organic materials, Industrial Equipment developers, PV module producers and BIPV system manufacturers). This scenario constitutes an excellent business opportunity to satisfy the growing BIPV market to commercialize a unique cost-effective solar window solution, fully feasible as an active product capable to reach a challenging combination of efficiency, transparency and lifetime, with the design of a “Tech4Win” roadmap to place on the market a robust solar window in approximately 10 years.
Funding: H2020
Project ID: 826002
Type: Competitive EU, Coordinator
Partners: Fundació Institut de Recerca en Energia de Catalunya (IREC), Onyx Solar Energy S.L (ONYX), Commissariat a l’Energie Atomique et aux Energies Alternatives (CEA), Interuniversitair Microelectronica Centrum (IMEC), Fundacion Tekniker (IK4-TEKNIKER), Armor SA, Advanced Energy Technologies (AE), Ereunas & Anaptyxis Ylikon, Proiontonananeosimon, Pigon Energeias & Synafon Symvouleftikon Y Piresion ADVEN, Kenosistec S.R.L.

Date: 2019 - 2022
Group: Solar Energy Materials and Systems
P.I: Alejandro Pérez-Rodríguez
Other group: Thermal Energy & Building Performance-Dr. Jaume Salom Tormo
More info at the following link

Title: New in-line process monitoring in advanced PV
Acronym: MONICIS
Description: MONICIS aims to develop and demonstrate (at module level) new optical methodologies for the in-line monitoring of cost-efficient encapsulation processes in CIGS industrial flexible photovoltaic (PV) technologies. The project proposes the design of an optical multifunctional probe based in Raman, PL and trans-reflectance techniques for the non-destructive assessment of innovative cost-efficient encapsulant and barrier layers that are being developed in these technologies, in order to ensure a successful transfer of these highly innovative encapsulation concepts from the cell (lab) level to the module (industrial) level. This implies the need for high sensitivity methodologies for the advanced assessment at in-line monitoring levelof the uniformity of the processes.
Funding: Accio
Project ID: TECSPR18-1-0048
Type: Competitive Nationals
Partners: Fundació Institut de Recerca en Energia de Catalunya (IREC)
Date: 2019 - 2021
Group: Solar Energy Materials and Systems
P.I: Maxim Guc.
More info at the following link

Title: Next generation transparent solar windows based on customised integrated photovoltaics
Acronym: SOLAR-WIN
Description: The main goal of Solar-Win is the industrial scale-up, validation under real-world operation conditions (TRL8) and commercialisation of next generation transparent and non-intrusive photovoltaic (PV) windows. The project will result in a unique transparent and electricity-generating window that merges the functionality of a PV module and a window in one, allowing a strong increase in the surface available in the building for generation of PV electricity. Solar-Win will revolutionize the Building Integrated PV (BIPV) and the architectural sectors, by providing a PV window solution featuring a unique set of characteristics, namely: (1) transparent and visually non-intrusive windows (with controlled visible transparency from 40% to 75%) able to generate up to 60 W/m2 of green electricity; (2) full compatibility with existing window manufacturing technologies; (3) lifespan equivalent to standard windows (20 years); and (4) cost effectiveness (cost increase of just 30% with respect to a standard window). To achieve these goals, Solar-Win involves two Technology-based SMEs (PHYSEE and SUNPLUGGED from the Smart Window and PV sectors, respectively) coordinated by a flagship RTD organisation with a strong experience and background in technology transfer and

optimisation of advanced PV technologies (IREC) and a leader constrution company (ACCIONA) which is the main costumer segment. The Project concept relies on the solar window patented technology developed by PHYSEE at TRL6, and on the highly flexible PV technology of SUNPLUGGED, which will be further optimised and customised for Solar-Win application. Solar-Win will overcome a major barrier that presently limits a further deployment of BIPV solutions, which relates to its intrusive character. Moreover, Solar-Win will allow achieving a disruptive advance extending drastically the possibilities for integration of PV solutions to virtually any kind of buildings, just by installing and/or replacing building windows.
Funding: H2020
Project ID: 870004
Type: Competitive EU, Coordinator
Partners: Fundació Institut de Recerca en Energia de Catalunya (IREC), Physee Group BV, Sunplugged – Solare Energiesysteme GMBH, ACCIONA Construccion SA,
Date: 2019 - 2021
Group: Solar Energy Materials and Systems
P.I: Víctor Izquierdo Roca
More info at the following link

Title: Thin film PV Technologies for (semi)transparent solar cells: Towards non-intrusive solar Windows
Acronym: CELL2WIN
Funding: Proyectos I+D+i 2019
Project ID: PID2019-104372RB-C31
Type: Competitive Nationals
Date: 2020 - 2022
Group: Solar Energy Materials and Systems
P.I: Alejandro Pérez-Rodríguez.
More info at the following link

Title: Disruptive kesterites-based thin film technologies customised for challenging architectural and active urban furniture applications
Acronym: Custom-ART
Description: CUSTOM-ART aims at developing the next generation of building and product integrated photovoltaic modules (BIPV and PIVP respectively), based on earth-abundant and fully sustainable thin film technologies. Nowadays, BIPV and PIPV are identified as key enabling technologies to make “near Zero Energy Buildings” and “net Zero Energy Districts” more realistic, through the integration of a new generation of photovoltaic modules capable of entirely replacing architectural/mobility/urban-furniture passive elements. This promising scenario of mass realisation of BIPV and PIPV solutions can only be achieved by developing cost-efficient and sustainable thin film technologies with unbeatable aesthetic functionalities, including mechanical flexibility and optical tuneability. Unfortunately, mature materials

already available at the market such as Cu(In,Ga)Se2 or CdTe are formed by scarce and expensive elements (In, Ga and Te), or toxic ones (Cd).
Considering this, CUSTOM-ART will join for the first time a leading group of companies and academic partners all around Europe, to develop advanced BIPV and PIPV products (flexible and semi-transparent solar modules), based on earth abundant kesterite materials, which have been demonstrated in two previous European projects to be at the forefront of emerging inorganic thin film technologies. By combining advanced strategies for materials properties management, with customized modules design in a circular economy approach, two types of products will be developed including flexible PV modules (polymer and steel supports) and semi-transparent (polymer). CUSTOM-ART will bring these technologies from TRL4-5 up to TRL7, demonstrating very competitive conversion efficiencies (20% at cell and 16% at module level) and durability (over 35 years), at a reduced production cost (< 75 €/m2), using exclusively abundant elements and contributing to ensure the full sustainability and competitiveness of the European BIPV and PIPV Industry.
Funding: H2020
Project ID: 952982
Type: Competitive EU (coordinator)
Partners: FUNDACIO INSTITUT DE RECERCA DE L'ENERGIA DE CATALUNYA (coordinator), INTERUNIVERSITAIR MICRO-ELECTRONICA CENTRUM, EIDGENOSSISCHE MATERIALPRUFUNGS-UND FORSCHUNGSANSTALT, TALLINNA TEHNIKAÜLIKOOL, CARL VON OSSIETZKY UNIVERSITAET OLDENBURG, HELMHOLTZ-ZENTRUM BERLIN FUR MATERIALIEN UND ENERGIE GMBH, OXFORD BROOKES UNIVERSITY, AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE, CENTRE TECHNIQUE INDUSTRIEL DE LA PLASTURGIE ET DES COMPOSITES, UPPSALA UNIVERSITET, CRYSTALSOL OU, IMRA EUROPE SAS, AYESA ADVANCED TECHNOLOGIES SA, ECO RECYCLING SOCIETA A RESPONSABILITA LIMITATA, SUNPLUGGED - SOLARE ENERGIESYSTEME, MBH, RESCOLL, KWS KUNSTSTOFFVERARBEITUNG SCHIESTLGESELLSCHAFT MBH.
Date: 2020 - 2023
Group: Solar Energy Materials and Systems
P.I: Alejandro Pérez-Rodríguez.
More info at the following link

Title: International cooperation for the development of cost-efficient kesterite/c-Si thin film next
Acronym: Infinite-Cell
Description: Photovoltaic (PV) is recognized as one of the main renewable energy solutions for fulfilling the targets defined by the EU Energy Roadmap 2050 and the SET Plan. Most of the current commercial PV devices are formed by single junctions, and more complex device concepts allowing a significant increase in device efficiency (well beyond the theoretical limit in the 30%-33% range) are still mostly limited to expensive III-V technologies. INFINITE-CELL proposes extending the very high efficiency tandem device concepts to emerging thin film PV technologies with high potential for reduction of costs and avoiding the use of critical raw materials. Within this context, the aim is to establish and consolidate an International and Intersectoral Cooperation between 6 EC/AC Academic Institutions (IREC, SINTEF AS, CNRS,

UAM, IAP-ASM, HZB), 2 European Companies (SUNGA, MET), and 4 non EC/AC Academic Institutions (MASCIR, BSUIR, UM5, UWC), for the development of cost-efficient photovoltaic tandem devices based in the combination of wide band-gap kesterite absorbers (Cu2Zn(Si,Ge,Sn)(S,Se)4) as top cell, and low cost c-Si thin film as bottom cell. Thanks to the combination of the know-how generated in previous and successful FP7 projects (PVICOKEST (269167) and EUROSUNMED (608593)), INFINITE-CELL targets to develop stacked and monolithically integrated kesterite/c-Si thin film devices with efficiencies of 15% and 20% respectively, using only fully sustainable materials and processes. This will be possible through de definition of a very impacting Research Plan and a very ambitious Plan of Secondments, where 293 PMs will be exchanged among the partners. The seconded researchers will be immersed in an International and Intersectoral environment for the development and improvement of their networking, scientific, writing, effective communication, and time management skills, warranting the consolidation of a high level scientific community in Advanced Tandem Solar Cell.
Funding: H2020
Project ID: 777968
Type: Competitive EU (coordinator)
Partners: Fundacio Institut de Recerca de l'Energia de Catalunya (IREC), Stiftelsen for industriell og teknisk forskning (SINTEF), Centre National de la Recherche Scientifique (CNRS), Universidad Autónoma de Madrid (UAM), Institute of Applied Physics of the Academy of Sciences of Moldova (IAP-ASM), Helmholtz-Zentrum Berlin (HZB), Moroccan Foundation for Advanced Science, Innovation and Research (MASCIR), Belarusian State University of Informatics and Radioelectronics (BSUIR), University Mohammed V of Rabat (UM5), SunGa Srl (SUNGA), Modern E-Technologies (MET), University of Western Cape (UWC).
Date: 2017 - 2021
Group: Solar Energy Materials and Systems
P.I: Sergio Giraldo
More info at the following link

Title: New in-line methodology for advanced evaluation of highly efficient industrial CIGS processes
Acronym: In4CIS
Description: In4CIS propone el desarrollo y demostración a nivel pre-industrial de metodologías ópticas avanzadas para la monitorización en línea de los procesos de fabricación de módulos fotovoltaicos CIGS de alta eficiencia. Estas metodologías se aplicarán para la monitorización de nuevos procesos postdeposition (PDT) que se
basan en tratamientos de dopado con impurezas alcalinas y que han permitido el desarrollo de células solares con valores reproducibles de eficiencia > 20% (con un valor record certificado de 22.6% en ZSW). El escalado de estos procesos para la producción de módulos a nivel pre-industrial requiere de la disponibilidad de metodologías que permitan asegurar la uniformidad de los procesos a escala de módulo, lo que implica la necesidad de disponer de técnicas no destructivas de muy alta sensibilidad y que sean adecuadas para su implementación como técnicas de monitorización in-line.
Funding: MICINN-AEI

Project ID: PCI2019-111837-2
Type: Competitive National
Partners: IREC (coordinador), Universidad de Barcelona, Lenz instruments, ZSW y MANZ AG
Date: 2019 - 2022
Group: Solar Energy Materials and Systems
P.I: Alejandro Pérez-Rodríguez.
More info at the following link

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Ritzer M., Schönherr S., Schöppe P., Wisniewski W., Giraldo S., Gurieva G., Johannes A., Plass C.T., Ritter K., Martínez-Criado G., Schorr S., Saucedo E., Ronning C., Schnohr C.S. "On the Germanium Incorporation in Cu2ZnSnSe4 Kesterite Solar Cells Boosting Their Efficiency" *ACS Applied Energy Materials* 3, 1, pp. 558 - 564. 2020 DOI: 10.1021/acsaem.9b01784

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Ruiz-Perona, A., Sánchez, Y., Guc, M., Khelifi, S., Kodalle, T., Placidi, M., Merino, J.M., León, M., Caballero, R. "Effect of Na and the back contact on Cu2Zn(Sn,Ge)Se4 thin-film solar cells: Towards semi-transparent solar cells" *Solar Energy* 206, pp. 555 - 563. 2020 DOI: 10.1016/j.solener.2020.06.044

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photovoltaic" *Journal of Alloys and Compounds* 839, pp. 155679 - 2020 DOI: 10.1016/j.jallcom.2020.155679

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DOCTORAL THESES

Ongoing theses:

PhD student: Jacob Andrade Arvizu
PhD supervisor: Dr. Edgardo Saucedo, Dr. Osvaldo Vigil-Galan
Title: Band gap grading strategies for high efficiency kesterite based thin film solar cells

PhD student: Pedro Vidal
PhD supervisor: Dr. Edgardo Saucedo, Dr. Victor Izquierdo-Rocar
Title: Sb-based thin film chalcogenide materials for innovative photovoltaic applications

PhD student: Mohammed Salem
PhD supervisor: Dr. Edgardo Saucedo, Dr. Marcel Placidi
Title: Wide band-gap Cu(In,Ga)(S,Se)2 for innovative thin film photovoltaic applications

PhD student: Alex López-Garcia
PhD supervisor: Dr. Edgardo Saucedo, Dr. Alejandro Pérez-Rodríguez
Title: Synthesis and Characterization of UV-selective oxide-based transparent solar cells

PhD student: Robert Fonoll
PhD supervisor: Dr. Victor Izquierdo-Roca, Prof. Alejandro Pérez-Rodríguez
Title: Advanced characterization of interfaces in thin film absorber materials for innovative photovoltaic technologies

PhD student: Enric Grau Luque
PhD supervisor: Dr. Victor Izquierdo-Roca, Dr. Maxim Guc
Title: n-D combinatorial analysis techniques for a deeper understanding and improvement of complex thin film photovoltaic devices

PhD student: Fabien Atlan
PhD supervisor: Dr. Victor Izquierdo-Roca, Prof. Alejandro Pérez-Rodríguez
Title: Advanced optical characterisation of advanced chalcogenide thin film PV technologies

OUTREACH

- Solar refineries: On the development of (photo)electrochemical systems
- LESGO aims at generating electricity from graphene oxide
- Recent implementation of Solar-Win experimental system
- A photovoltaic fabric for umbrellas and awnings
- IN4CIS selected as a granted project in the SOLAR-ERA.NET call
- Tech4Win will develop transparent smart solar windows
- BIPV – Building Integrated Photovoltaics Thematic Session

6.2. ENERGY EFFICIENCY IN SYSTEMS, BUILDINGS AND COMMUNITIES AREA

The main objective of the technological research and technical development area focuses on the development of energy efficiency to buildings, systems and communities. Based on the Nearly Zero Energy concept applied to buildings, it expands the concept to communities such as districts, cities and rural areas as well as industrial systems.

This concept involves working on the design of the building or system as an active part of the de district, community or industrial system. The main energy efficient technologies considered are intelligent lighting, building design and modelling, integration of electricity and thermal energy (heating and cooling), renewable and decentralized energy resources, green IT, e-mobility, micro grids and smart grids and energy management and control systems. In addition, research economic analysis and regulation activities support the energy efficiency research lines.

6.2.1. ENERGY SYSTEMS ANALYTICS

6.2.2 POWER SYSTEMS

6.2.3 THERMAL ENERGY & BUILDING PERFORMANCE

6.2.1. ENERGY SYSTEMS ANALYTICS GROUP

The Team

(permanent and temporary positions, tenure tracks and fellowships)

Dr. Cristina Corchero, Energy Systems Analytics Group Leader Dr. Victor Jose Ferreira, Postdoctoral Researcher Dr. Lluc Canals, Postdoctoral Researcher Alba Colet, Staff Engineer Lucía Igualada, Staff Engineer Alaia Sola, Project Engineer David Cardoner, Project Engineer Jordi Farre, Staff Engineer Antoni Company, Project Engineer Mattia Barbero, Predoctoral Student Fernando Garcia, Visiting Predoctoral Student Daniel Ramon Lumbierres, Project Engineer

The Energy Systems Analytics group works to accelerate the energy transition through the economic and environmental optimal integration of complex energy systems. Energy systems integration aims to explore ways for energy systems to work more efficiently on their own and with each other. They recognize the evolving demands of the energy field as it moves away from individual energy devices and towards complex energy systems that require advanced management to guarantee optimal performance.

With expertise in the modelling, optimization and sustainability and economic assessment of energy systems, we can better understand how to increase reliability, reduce costs, and minimize environmental impacts of our energy systems.

The Energy Systems Analytics group uses advanced mathematical, statistical and engineering techniques to answer the new energy systems challenges. The group aims to develop and refine advanced techniques to progress towards the economically and environmentally sustainable energy systems of tomorrow.

Specifically, our research lines are:

- Smart Energy Management: optimal energy management systems, flexibility integration, hybrid systems management and integration
- New market agents' functionalities definition and evaluation
- Sustainable mobility integration: infrastructure optimization, V2X technologies, urban e-mobility solutions
- Sustainability and economic assessment: life cycle assessment and life cycle cost, levelized cost of energy, business model evaluation
- Novel energy system optimization methods and data management techniques
- Data science for energy systems: data forecasting based on machine learning algorithms, patterns recognition and stochastic modelling for optimization and simulation.

They work closely with industry to apply advanced data science and optimization techniques to allow optimal management of novel energy systems that integrate new technologies, new market schemes or regulation frameworks.

PROJECTS

Title: Re-usable and re-configurable parts for sustainable LED-based lighting systems (Repro-light)
Acronym: Repro-light
Description: The Repro-light project aspires to successfully initiate a transformation of the European LED lighting industry by the year 2020 since European lighting companies have been facing fierce competition from Asia while at the same time prices for LED luminaires are rapidly falling. By developing an intelligent LED-based luminaire with a modular, stackable architecture the project seeks to change the industry's view of the LED luminaire as a generic, disposable object into a customized, sustainable product with high functional value. Breaking the rules of traditional luminaire design by using innovative technologies and materials to completely forgo wiring and make luminaires completely stackable as in the Repro-light project has never been attempted before. Through the modular design and the development of a smart production scheme costs and time of luminaire manufacturing can be reduced substantially as well as

their environmental impact. Now is an extremely crucial moment for creating a sustainable solution for
LED luminaires since the LED market is in the middle of a massive transformation, changing the value proposition of LED-based lighting solutions from a focus on energy efficiency to functional values. The Repro-light luminaire will fulfil this value propositions by employing intelligence and having a positive impact on peoples' health. The Repro-light consortium is perfectly suited to be the spearhead of this lighting "revolution" as the entire value chain is represented and the consortium is structured around a sound industrial backbone. With representatives and driving forces of the European lighting industry as well as manufacturers of basic products, experts on lighting sustainability and the Social Sciences, the Repro-light consortium possesses the excellence and the influence to not only execute this project successfully but also invoke a sustainable change in the European lighting industry beyond the lifetime of the project.
Funding: H2020
Project ID: 768780
Type: Competitive EU
Partners: Bartenbach GMBH (BART), Fundacio Institut de Recerca en Energia de Catalunya (IREC), Itz Innovations- Und Technologiezentrum GMBH (ITZ), Trilux Gmbh & Co Kg (TXKG), Luger Siegfried (LUGER), Mondragon Goi Eskola Politeknikoa Jose Maria Arizmendiarrieta S COOP (MU-ENG), BJB GMBH & CO KG (BJB), Grado Zero Espace SRL (GZE), Daniel Rohner (ROHNER)
Date: 2017 - 2020
Group: Energy Systems Analitics
P.I: Cristina Corchero García
More info at the following link

Title: Empowering women to take action against energy poverty in the Mediterranean
Acronym: EmpowerMed
Description: In the Mediterranean countries, the coastal areas are facing several specific challenges when it comes to energy poverty, mainly connected with thermal comfort of dwellings. Buildings are scarcely isolated, often there are no heating systems in buildings, or those are highly inefficient, and the cooling component is more important than in other areas, calling for a diversity of energy services beyond heating. Women and women-led households are disproportionately affected by energy poverty, while women's agency is highlighted in acting against energy poverty. Although there is some knowledge on the health impacts of energy poverty, involving health practitioners in the energy poverty action is rare. This is why the main objective of the project is to contribute to energy poverty abatement in the Mediterranean through a) implementing a set of practical energy efficiency and RES measures, tailored to empower households' in
energy poverty and specifically focused on women and health, b) assessing their efficiency and impacts to formulate policy recommendations and c) promoting policy solutions among key actors for stimulating action against energy poverty at local and EU level. The project will first build networks with local actors in pilot regions (WP1) and transfer knowledge and experience to build capacity of all involved actors for implementing practical measures (WP2). The core of

the project is implementation of practical measures to tackle energy poverty, such as community approaches, household visits, doit-yourself approaches, support for small investments and health workshops (WP3). The impacts and success of the implemented measures will be assessed and analysed (WP4) to support formulation of policy recommendations, which
will be advocated among key actors to stimulate and support policies against energy poverty (WP5). Project results and outcomes will be disseminated among the target groups to ensure a wide reach out at local, national and EU level.
Funding: H2020
Project ID: 847052
Type: Competitive EU
Partners: Focus Drustvo Za Sonaraven Razvoj (FOCUS), Drustvo Za Oblikovanje Odrzivog Razvoja (DOOR), SOGESCA s.r.l., Universitat Autonoma de Barcelona (UAB), Fundacio Institut de Recerca en Energia de Catalunya (IREC), Geres Groupes Energies Renouvables (GERES), Associacio Catalana d'Enginyeria Sense Fronteres (ESF), Women Engage for a Common Future Ev (WECF), Milieukontakt Shqiperi (MiA)
Date: 2019 - 2023
Group: Energy Systems Analitics
P.I: Lluc Canals Casals
Other group: Thermal Energy & Building Performance-Dr. Jaume Salom Tormo
More info at the following link

Title: Electro-depuració d'aigües residuals industrials: viabilitat tècnica, ambiental i econòmica
Acronym: ELDE
DescriptionThe ELDE project aims to improve the results obtained with conventional wastewater treatment processes in three industrial sectors: paper, chemical and tannery, which are generally characterised by high pollution, mainly in terms of colour, high organic matter content and high salinity. The name "electro-purification" reflects the general objective of the project, which consists of using electricity-based technologies to eliminate the various pollutants present in wastewater by taking advantage of the salts they contain. The ELDE project is aimed at transforming the serious problem of salinity into an advantage, either by separating the salts and organic matter for reuse, or by using the salts to generate oxidants capable of destroying organic pollutants. The generation of oxidants in situ would avoid the transport, handling and overdosing of chemical products.
Funding: Ris3Cat
Project ID: COMRDI16-1-0066-05
Type: Competitive Nationals
Partners: Universitat Politècnica de Catalunya (UPC), Fundació CTM Centre Tecnològic (CTM), Fundacio Institut de Recerca en Energia de Catalunya (IREC), Técnica y proyectos S.A (TYPSA), Waterologies S.A., Lavola 1981 S.A, Pere Valls S.A.
Date: 2018 - 2021
Group: Energy Systems Analitics
P.I.: Cristina Corchero García

Other groups: Power Systems- Dr. José Luis Domínguez, Solar Energy Materials and Systems- Dr. Alejandro Pérez-Rodríguez
More info at the following link

Title: Valorització de les dades de la IoT.
Acronym: FEM IoT P2
Description: Many cities and territories have been making a significant investment of resources since a few years ago in order to have their own smart city IoT platforms, many of these platforms have been funded by public initiatives, which have served to boost the implementation of IoT platforms. As stated in the SMARTCAT strategy, in order to achieve its objectives, it is essential that these platforms integrate a set of external and internal elements and intelligence algorithms that have an impact on public services without being part of them. Internal objects are understood as buildings, roads and other infrastructures, such as ports, airports, metro stations, public buildings, etc., which have a set of data that must be transferred to the city so that it can better plan its services. Moreover, cities are in permanent contact with other cities and metropolitan areas that are influenced by the same climate, and are also connected to supply networks that go beyond the city level. All these interrelationships and dependencies influence the problems to be solved and the services provided, which is what is understood as external objects. The great value of the IOT will also come from the sharing and exploitation of data in different applications and models. However, the global interoperability of hardware and software infrastructures is generally based on standards, but as the IoT world is constantly evolving without specific centralised technical coordination and control, many solutions and pseudo-standards will be developed and proposed in the coming years. This will lead to greater heterogeneity and, therefore, difficulty in connecting data. In fact, there are currently many different (de facto) standards in the IoT field aimed at: communications, hardware, software and data. Therefore, it is essential to provide approaches capable of integrating, interconnecting, merging, heterogeneous data analysis platforms to build large-scale interoperable ecosystems, and thus be able to build new services on these platforms. Two use cases will be worked on: one for controlling energy flows in the streets and another case of an intelligent system for controlling mobility and traffic intensity, which is related to P1. The developments will follow the philosophy of defined networks based on the Software Defined Networks (SDN) concept, i.e. (i) centralised management; (ii) complete separation of components; (iii) open standard interfaces for communication based on Application Programming Interfaces (API), open flow protocols and cloud-computing to achieve flexibility. Advanced data analysis algorithms will focus on indicator extraction methods for multi-variate time series and on the classification and prediction of complex events based on artificial intelligence techniques.
Funding: Emergents
Project ID: IU16-011655
Type: Competitive Nationals
Partners: Centre Internacional de Mètodes Numèrics en Enginyeria (CIMNE), Barcelona Supercomputing Center-Centro Nacional de Supercomputación (BSC-CNS), Fundació Internet i Innovació Digital a Catalunya (i2CAT), Universitat Politècnica de Catalunya (UPC), Institut de

Recerca en Energia de Catalunya (IREC), Universitat Rovira i Virgili (URV) Centre de Visió per Computador (CVC), Centre Tecnològic de Catalunya (Eurecat), Universitat Pompeu Fabra (UPF)
Date: 5/2/2019-4/30/2021
Group: Energy Systems Analitics
P.I: Cristina Corchero García.
More info at the following link

Title: Market uptake of citizen energy communities enabLing a hIGH peneTratioN of renewable EnergySourceS
Acronym: Lightness
Description: LIGHTNESS will increase the Renewable Energy hosting capacity, to securely achieve the EU target for 2030, by supporting the market uptake of Citizen Energy Communities through a turnkey social engagement, regulatory roadmap, low-cost technological package and innovative business models to unlock the full flexibility potential, reduce the final energy consumption and CO2 emissions and bring economic, social and environmental benefits to the communities and across the energy value chain. LIGHTNESS solution will elaborate and execute ambitious end users engagement plans for the involved sites with continuous iterations and solution adaptation to achieve a direct engagement of +500 households and +30 tertiary buildings and an immediate replication potential to over 70.000 persons. LIGHTNESS solution will create digital twins for holistic assessment of 5 CECs case studies across 5 countries to be then deployed and monitored. Case studies consist in an energy cooperative (ES), a social housing building (PL), a private multi-apartment building (IT), a business park (FR) and 2 CECs to uphold the interaction among them (NL). The different regulatory and policy frameworks will allow to exchange best practices and providing road maps for the authorities. Overall, LIGHTNESS will engage +3000 end users, professionals, policy makers in EU, will consent a minimum 25% increase of renewable hosting capacity by making available up to 20% of flexibility in peak times from residential and tertiary buildings, will reduce up to 30% the Prosumers and CECs energy cost and up to 30% of CAPEX and OPEX costs for DSOs. LIGHTNESS has received the support from 59 organisations from which we can highlight EPEX-Spot, STEDIN, LIANDER, ACCIONA, VEOLIA, BAM, 10 EU cities, 9 energy agencies, 9 energy cooperatives, and 3 extra EU replicators from India, Turkey and Africa/America.The project management structure is gender balanced with two women and two men serving in the positions of responsibility.
Funding: H2020
Project ID: 953020
Type: Competitive EU
Partner: R2M SOLUTION SPAIN SL (coordinator), AXPO ENERGY SOLUTIONS ITALIA-SOCIETA PER AZIONI, IES R&D, DUNEWORKS BV, I. LECO, FUNDACIO INSTITUT DE RECERCA DE L'ENERGIA DE CATALUNYA, CIVIESCO SRL, ENER2CROWD SRL, AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE, SOFIA ENERGY AGENCY ASSOCIATION, TRAZA TERRITORIO, S.L.L., ALBEDO ENERGIE, UNION DE COOPERATIVAS DE PERSONAS CONSUMIDORAS Y USUARIAS DE ENERGIAS RENOVABLES.
Date: 2020- 2023
Group: Energy Systems Analitics

P.I: Cristina Corchero García.
More info at the following link

Title: Vehicle/Grid Integration (IEA-HEV, task 43)
Acronym: IEA-HEV (task 43)
Description: Task 43 analyses the challenges identified on the integration of the electric vehicles into our electricity and transport system in order to improve economic and environmental performance. Our specific objectives are to explore, identify and give answers to the gaps preventing the electric vehicles to be fully integrated in the electrical grid to improve the joint work between electric sector and mobility sector, which is a key point for the real energy transition. Task 43 will focus on the challenges identified on the following categories: infrastructure planning, electricity markets, technology development and user engagement.
Funding: Agreement
Type: Competitive EU (coordinator)
Date: 2018 - 2021
Group: Energy Systems Analitics
P.I: Cristina Corchero García.
More info at the following link

Title: Advanced Light-weight BATteRy systems Optimized for fast charging, Safety, and Second-life applications
Acronym: ALBATROSS
Description: ALBATROSS addresses the needs of European Electric and Hybrid-Electric passenger vehicle market by overcoming driver concerns relating to battery range and anxiety, cost, long-term reliability and excessive charging times. ALBATROSS will develop an integrated approach based on smart batteries combined with lightweight designs. Using innovative cooling technologies, we will achieve pack temperature range 5-40°C (30-40°C under ultra-fast charging), with <3°C variation between battery cells and optimal operating temperature 20-23°C. The light weighting solutions, based on modular multi-material systems for battery modules and trays, will be fabricated and joined using cutting edge, fast and cost-effective processes, with disassembly, recycling and reuse designed in as a part of an eco-design approach. The modular approach provides solutions for BEVs and PHEVs. The scalability to delivery vans and heavy-duty vehicles will be assessed.
Using a BMW i3 passenger vehicle to base the developments on, ALBATROSS will achieve a Peak Energy Density >200Wh/kg, increase driving range to 480km and reduce charging times by 25%. Advanced sensing and control, as a part of a flexible advanced Battery Management System, will be utilised on-vehicle and using the cloud to conduct remote maintenance and troubleshooting ensuring safety even at these high energy densities. Using advanced analytics will enable the State of Health and State of Safety to be continuously and accurately measured. The system will be validated on-vehicle under real world, extreme environmental conditions.

ALBATROSS represents a pan-European EU consortium of world leading organisations that are looking to commercialise these technologies of European origin. The coordinator (Yesilova) has a global presence in the automotive market and the consortium is strengthened by organisations that are part of the global Fiat-Chrysler, Ford and Mercedes-Benz groups as well as European SMEs with world leading technologies.
Funding: H2020
Project ID: 963580
Partner: YESILOVA HOLDING AS, INND BATTERIES BV, MERCEDES-BENZ TURK AS, ALGOLION LTD, EUROPEAN THERMODYNAMICS LIMITED, ZEMISSION AB, PST SENSORS EUROPE LTD, EUROPEAN FEDERATION FOR WELDING JOINING AND CUTTING, CENTRO RICERCHE FIAT SCPA, FEV TR OTOMOTIV VE ENERJI ARASTIRMAVE MUHENDISLIK LIMITED SIRKETI, TWI LIMITED, FUNDACIO INSTITUT DE RECERCA DE L'ENERGIA DE CATALUNYA, TECHNOVATIVE SOLUTIONS LTD, NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU, FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V., CENTRE FOR PROCESS INNOVATION LIMITED LBG, ASOCIACION DE INVESTIGACION METALURGICA DEL NOROESTE, THE UNIVERSITY OF NOTTINGHAM, ACONDICIONAMIENTO TARRASENSE ASSOCIACION, FORD OTOMOTIV SANAYI ANONIM SIRKETI, FUNDACION CIDETEC.
Date: 2020 - 2024
Group: Energy Systems Analitics
P.I: Cristina Corchero García.
More info at the following link

Title: Reenvisioning the potential of energy communities
Acronym:
Description: The RECOMMIT project stands for “Reenvisioning the potential of energy awdsdawcommunities “. This project proposes to develop novel strategies for the market layer and integration of the market layer with the other system layers. Some of the key characteristics of novel energy community markets and market structures include the ability to reduce costs and improve efficiency while also maintaining sufficient capacity without favoring any resource, providing a contingency reserve in the event of a failure in the energy system, and avoiding manipulation by other market participants. There is also a need to better define and demonstrate interactions between market participants including interactions between members of the same community, trade between communities and interactions between the community and the Transmission System Operator (TSO) or Distribution System Operator (DSO). In addition, this project will explore the methods by which energy transactions can occur — considering features like transaction cost, speed and volume.
IREC hosts Josh Eichman as a Tecniospring Industry researcher. Josh will work in the Energy Systems Analytics group at IREC and he will develop a professional career within the energy field and benefit from top training in technology transfer.

Tecniospring is ACCIÓ’s international talent programme, which boosts technology transfer processes by offering R&D companies and TECNIO centres 2-year employment contracts to host a researcher.
Funding: Tecniospring Industry - Acció

Type: Competitive Nationals
Date: 2021 - 2023
Group: Energy System Analytics
P.I: Josh Eichman
More info at the following link

PUBLICATIONS

Articles and Journals from ISI Database

Taddeo, P., Colet, A., Carrillo, R.E., Casal Canals, L., Schubnel, B., Stauffer, Y., Bellanco, I., Corchero Garcia, C., Salom, J. "Management and activation of energy flexibility at building and market level: A residential case study" *Energies* 13, 5, pp. 1188 - 2020 DOI: 10.3390/en13051188

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DOCTORAL THESES

Ongoing theses:

PhD student: Alaia Sola
PhD supervisor: Dra. Cristina Corchero, Dr. Pau Fonseca (UPC)
Title: Urban-scale energy modelling

PhD student: Mattia Barbero
PhD supervisor: Dra. Cristina Corchero, Dr. F. Javier Heredia (UPC)
Title: Demand Aggregator Optimal Strategies: from the Bidding to the Execution

PhD student: Anzhelika Ivanova
PhD supervisor: Cristina Corchero, Pau Fonseca
Title: Optimal Sensor Placement for Accurate State Estimation in Active Distribution Networks

PhD student: Markus Lerch
PhD supervisor: Dr. Mikel de Prada, Dr. Climent Molins (UPC)
Title: Techno-economic assessment, modelling and optimization for floating offshore wind farms

PhD student: Fernando Garcia
PhD supervisor: Dra. Cristina Corchero, Dr. Francisco Diaz (UPC)
Title: Optimal location of storage systems in the distribution network

PhD student: Gabriela Benveniste
PhD supervisor: Dra. Cristina Corchero, Dra. Beatriz Amante (UPC)
Title: LCA y análisis económico de sistemas innovadores de almacenaje eléctrico en Litio-azufre (Li-S)

OUTREACH

- Market uptake of citizen energy communities
- The Energy Hub concept: green local energy communities
- SABINA attains two connected laboratories and a spin-off
- PLURAL aims to renovate buildings to reach nZEB status

- Repro-light concludes with guidelines for a sustainable lighting industry
- Empowering over 10,000 people to tackle energy poverty in the Mediterranean
- Energueia, a software platform for demand aggregation: new IREC spin-off
- Second life battery work at IREC
- Self-consumption systems for smart buildings in Barcelona
- IREC wins IDAE's tender to simulate local electricity markets
- COP25 UN Climate Change Conference 2019
- IREC participates in the emerging IoT association as an expert in energy
- IREC participates in 6 sub-projects of 4 Emerging Technologies Associations
- 100tífiques – Jornada Internacional de les Dones i les Nenes en la Ciència
- Webinar "Electric vehicle: Grid and market integration"
- European Research Night
- "De camí a cap a la transició energètica"
- IREC actively participates in the European Researchers' night
- Así puedes ahorrar energía con ayuda de la inteligencia artificial
- Crean un grupo de investigación para impulsar el internet de las cosas
- Volem combatre la pobresa energètica a casa nostra, també des de la ciència i la recerca"
- Cataluña afronta el reto de los enchufes para el coche eléctrico
- ICTA-UAB actúa contra la pobreza energética de 1500 hogares de Barcelona
- El proyecto Repro-Light desarrolla la iluminación inteligente y sostenible centrada en las personas

6.2.2. POWER SYSTEMS

The Team

(permanent and temporary positions, tenure tracks and fellowships)

Dr. Jose Luis Dominguez García; Power System Group Leader
Dr. Lluis Trilla Romero, Senior Research Staff
Dr. Hugues Renaudineau, Postdoctoral Researcher (until February 2020)
Dr. Adedotun J. Agbemuko, Postdoctoral Researcher (until April 2020)
Dr. Àlber Filbà, Postdoctoral Researcher (From April 2020)
Dr. Alexandra Ciuriuc, Postdoctoral Researcher (From August 2020)
Alba Colet, Head of Laboratory
Pol Paradell, Staff Project Engineer
Toni Cantero, Project Engineer
Daniel Sanchez Muñoz, Project Engineer
Paschalia Stefanidou-Voziki, Project Engineer
Jose Ignacio Rapha Juan, Project Engineer
Anzhelika Ivanova, Project Engineer
Didac Bofill Izquierdo, Research Technician
Juan Alberto Romero, Industrial PhD Student
Jorge Alejandro Torres, Project Engineer
Claudia Cabré

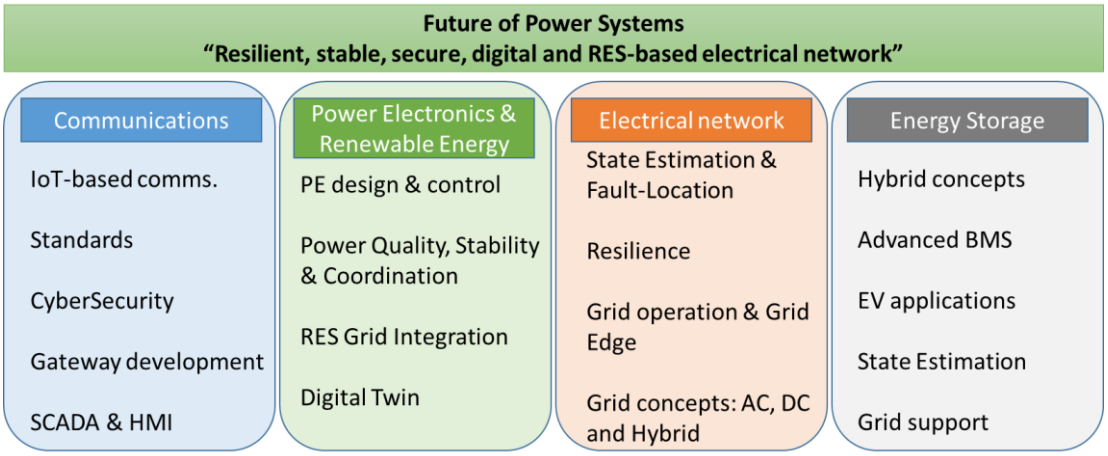
Power Systems Group Strategy aims to provide solutions for the challenges of the future power systems in order to ensure the proper advent and implementation of the Digital Grid.

The global objective for the group is to set the path of future electrical network by the development of innovative solutions for the challenging task of ensuring resilient, stable, secure, digital and RES-based electrical network as the future of Power Systems.

In order to achieve this challenging goal, the group strategy has been organized into 4 research pillars namely:

1. Communications,
2. Power Electronics and Renewable Energies
3. Distribution network
4. Energy Storage

On such fields and activities, the group aims to be an attracting pole of knowledge and a recognized and reference group of excellence. Such activities include a variety of hardware and software actions which are required for the power systems implementation and to bring such innovations into reality.



PROJECTS

Title: Resilience to cope with climate change in urban areas - a multisectorial approach focusing on water
Acronym: RESCCUE
Description: RESCCUE aims to deliver a framework enabling city resilience assessment, planning and management by integrating into software tools new knowledge related to the detailed water-centred modelling of trategic urban services performance into a comprehensive resilience platform. These tools will assess urban resilience from a multisectorial approach, for current and future climate change scenarios and including multiple hazards. The project will review and integrate in the general framework existing options to assess climate change impacts and urban systems vulnerabilities allowing to assess multisectorial dependencies under multiple climate change scenarios. An adaptation strategies portfolio, including climate services, ecosystem-based approaches and resource efficiency measures will be incorporated as key components of the deployment strategy. The possible approaches will be ranked by

their costefficiency in terms of CAPEX and OPEX to evaluate their benefits potential. This will enable city managers and urban system operators deciding the optimal investments to cope with future situations. The validation platform is formed by 3 EU cities (Barcelona, Lisboa and Bristol) that will allow testing the innovative tools developed in the project and disseminating their results among other cities belonging to major international networks. In terms of market potential, RESCCUE will generate large potential benefits, in terms of avoided costs during and after emergencies, that will contribute to their large-scale deployment. The structure of the consortium will guarantee the market uptake of the results, as the complete value chain needed is already represented. The project is coordinated by Aquatec, a large consultancy firm part of a multinational company focused on securing and recovering resources, and includes partners from the research domain, operation of critical urban systems, city managers and international organisations devoted to urban resilience.
Funding: H2020
Project ID: 700174
Type: Competitive EU
Partners: Aquatec Proyectos para el Sector del Agua SA (AQUA), Centro Tecnologico del Agua, Fundacion Privada (CETAQUA), Fundacion para la Investigacion del Clima (FIC), Opticits Ingenieria Urbana SL (Opticits), The University Of Exeter (UNEXE), Laboratorio Nacional de Engenharia Civil (LNEC), Ajuntament de Barcelona (BARCELONA CC), Fundacio Institut de Recerca en Energia de Catalunya (IREC), United Nations Human Settlements Programme (UN Habitat), Edistribucion Redes Digitales SL (ENDESA), Camara Municipal de Lisboa (CML), EDP Distribuicao Energia SA (EDP DISTR), Hidra - Hidraulica e Ambiente LDA (HIDRA), Bristol City Council, Suez Advanced Solutions UK Limited (SASUK), Urban Dna Solutions LLP (UrbanDNA), ADP - Aguas de Portugal,SGPS SA (AdP SGPS), Ecole des Ingenieurs de la Ville Deparis (EIVP), Aguas do Tejo Atlantico SA (AdTA), Wessex Water Services Limited (WESSEX)
Date: 2016 - 2020
Group: Power Systems
P.I: José Luis Domínguez García
More info at the following link

Title: CoSt redUction and enhanced PERformance of PV systems
Acronym: SUPER PV
Description: SUPER PV is pursuing an ambitious bus realistic goal for innovative PV system cost reduction and consequentlysignificant LCOE reduction (26%-37%) by adopting hybrid approach combining technological innovations and DataManagement methods along the PV value chain. To achieve that, key actions will be implemented at three main levelswithin the PV value chain: PV module innovation level, power electronics innovation level and system integrationlevel. To ensure fast uptake of the project results by industry, state of the art modules (c-Si and flexible CIGS) andpower electronics products were utilised for adopting innovations developed by research centres. For cost reduction insystem integration and operation, Digitalization and Data Management solutions based on Industry 4.0 approach willbe adopted following successful utilization of Building Information Modelling approach in the construction sector.Selected for uptake innovations will be compatible with existing manufacturing technological processes thus reducingimpact on Cost of Ownership and ensuring attractiveness

of proposed technologies for PV manufacturers.Prototype SUPER PV systems will be produced in industrial environments and tested in different (including harsh)climate conditions to evaluate cost efficiency and demonstrate competitiveness of the proposed solutions. On the basisof test results, business cases for technologies under consideration will be performed, plans for production and marketreplication will be prepared. Project activities will be complemented by wide training and dissemination campaignensuring highest visibility and social impact of the project activities. By delivering to the market SUPERior PV products, the project will have twofold impact on EU PV sector:1. Will create conditions for accelerated large scale deployment of PV in Europe for both utility (non-urban) andresidential (urban) scenarios and2. Will help EU PV businesses to regain leadership on world market.
Funding: H2020
Project ID: 792245
Type: Competitive EU
Partners: Uab Soli Tek R&D (SOLITEK), Perspektyviniu Technologiju Taikomuju Tyrimu Institutas (PROTECH), Institut fur Solarenergieforschung GMBH (ISFH), Apollon Solar (APOLLON), Loser Chemie GMBH (LCH), Flisom AG (FLISOM), Tecnologia Navarra De Nanoproductos SL (TECNAN), Moroccan Foundation For Advanced Science Innovation And Research Fondation Mascir (MAScIR), Nederland Se Organisatie Voor Toegepast Natuurwetenschappelijkonderzoek TNO (TNO), SINTEF AS, Fundacion Para El Desarrollo Tecnologico Y Social (LUREDERRA), Eolane Combree , Cosylab Laboratorij Za Kontrolne Sisteme Dd (COSYLAB), Fundacio Institut de Recerca en Energia de Catalunya (IREC), Commissariat a l'Energie Atomique et aux Energies Alternatives (CEA), Cadcamation Kmr SA (CADCAMation), Ayesa Advanced Technologies SA (AYESA), Scuola Universitaria Professionale della Svizzera ITALIANA (SUPSI), Moroccan Agency for Solar Energy SA (MASEN), BNW-ENERGY, Icares Consulting (BI), Wirtschaft Und Infrastruktur GMBH & CO Planungs KG (WIP), Agence Nationale pour la Maitrise de l'Energie (ANME), Universitat Konstanz (UKON), Universite Mohammed V de Rabat (UMV), Univerza V Ljubljani (UL)
Date: 2018 - 2022
Group: Power Systems
P.I: José Luis Domínguez García
Other group: Solar Energy Materials and Systems, Energy Systems Analitics.
More info at the following link

Title: SDN - microgrid reSilient Electrical eNergy SystEm
Acronym: SDN-microSENSE
Description: The smart energy ecosystem constitutes the next technological leap of the conventional electrical grid, providingmultiple benefits such as increased reliability, better service quality and efficient utilization of the existinginfrastructures. However, despite the fact that it brings beneficial environmental, economic and social changes, italso generates significant security and privacy challenges, as it includes a combination of heterogeneous, co-existingsmart and legacy technologies. Based on this reality, the SDN-microSENSE project intends to provide a set of secure, privacy-enabled and resilient to cyberattacks tools, thus ensuring the normal operation of EPES as well as the integrityand the confidentiality of communications. In particular, adopting an SDN-based technology, SDN-microSENSEwill

develop a three-layer security architecture, by deploying and implementing risk assessment processes, self-healing capabilities, large-scale distributed detection and prevention mechanisms, as well as an overlay privacyprotection framework. Firstly, the risk assessment framework will identify the risk level of each component of EPES, identifying the possible threats and vulnerabilities. Accordingly, in the context of self-healing, islanding schemes andenergy management processes will be deployed, isolating the critical parts of the network in the case of emergency. Furthermore, collaborative intrusion detection tools will be capable of detecting and preventing possible threatsand anomalies timely. Finally, the overlay privacy protection framework will focus on the privacy issues, includinghomomorphic encryption and anonymity processes.
Funding: H2020
Project ID: 833955
Type: Competitive EU
Partners: Ayesa Advanced Technologies Sa (AYE), Panepistimio Dytikis Makedonias (UOWM), Ethniko Kentro Erevnas Kaitechnologikis Anaptyxis (CERTH), Preduzece Zatelekomunikacijske Uslugerealaiz doo Beograd (SAVSKIVENAC) (REAL), Atos Spain SA (ATOS), Schneider Electric France SAS (SEF), Public Power Corporation S.A. (PPC), Fundacion Tecnalia Research & Innovation (TECN), Dimos Avdiron (MOA), Innovative Energy and Information Technologies LTD (IEIT), Elektroenergien Sistemenoperator EAD (ESO), Cez Distribution Bulgaria AD (CEZ), Ubitech Ltd (UBITECH), Cyberlens Ltd (CLS), Sidroco Holdings Ltd (SID), Infinity Limited (0INF), Eight Bells Ltd (8BELLS), Incites Consulting SARL (INC), Energynautics GMBH (ENERGYNAUTICS), Norges Teknisk-Naturvitenskapelige Universitetntnu (NTNU), Siaxampanis E.E. (ALKYONIS), Gottfried Wilhelm Leibnizuniversitaet Hannover (LUH), Ravna Hydro Ltd (VETS), Fundacio Institut de Recerca en Energia de Catalunya (IREC), Estabanell Y Pahisa Energia SA, (EPESA)
Date: 2019 - 2022
Group: Power Systems
P.I: José Luis Domínguez García
More info at the following link

Title: COst REduction and increase performance of floating WIND technology
Acronym: COREWIND
Description: Floating offshore wind is still a nascent technology and its LCOE is substantially higher than onshore and bottomfixed offshore wind, and thus requires to be drastically reduced. The COREWIND project aims to achieve significant cost reductions and enhance performance of floating wind technology through the research and optimization of mooring and anchoring systems and dynamic cables. These enhancements arisen within the project will be validated by means of simulations and experimental testing both in the wave basin tanks and the wind tunnel by taking as reference two concrete-based floater concepts (semi-submersible and spar) supporting large wind turbines (15 MW), installed at water depths greater than 40 m and 90 m for the semisubmersible and spar concept, respectively. Special focus is given to develop and validate innovative solutions to improve installation techniques and operation and maintenance (O&M) activities. They will prove the benefits of concrete structures to substantially reduce the LCOE by at least15% compared to the baseline case of bottom-fixed offshore wind, both in terms of CAPEX and OPEX. Additionally, the project will

provide guidelines and best design practices, as well as open data models to accelerate the further development of concrete-based semi-submersible and spar FOWTs, based on findings from innovative cost-effective and reliable solutions for the aforementioned key aspects. It is aimed that the resulting recommendations will facilitate the cost-competitiveness of floating offshore wind energy, reducing risks and uncertainties and contributing to lower LCOE estimates.
COREWIND aims to strength the European Leadership on wind power technology (and specially floating). To do so, the project consortium has been designed to ensure proper collaboration between all stakeholders (users, developers, suppliers, academia, etc.) which is essential to accelerate commercialization of the innovations carried out in the project.
Funding: H2020
Project ID: 815083
Type: Competitive EU (coordinator)
Partners: Fundacio Institut de Recerca en Energia de Catalunya
(IREC), Danmarks Tekniske Universitet (DTU), INNOSEA , JDR Cable Systems Ltd (JDR), Ramboll Ims Ingenieurgesellschaft MBH (RAMBOLL), Fundacion Instituto de Hidraulica Ambiental de Cantabria (FIHAC), UL International GMBH (UL INT), WindEurope (WindEurope), Politecnico di Milano (POLIMI), Universitat Politecnica de Catalunya (UPC), Equinor ASA, Cobra Instalaciones Y Servicios S.A (COBRA), Universitaet Stuttgart (USTUTT).
Date: 2019 - 2023
Group: Power Systems
P.I: José Luis Domínguez García
Other group: Energy Systems Analitics- Dr. Cristina Corchero García
More info at the following link

Title: Desenvolupament experimental de noves tecnologias d'automatització de la xarxa de mt a catalunya
Acronym: NaENCAT
Description: El proyecto NAenCAT, pretende ser un referente de las nuevas Smart Grid, dotando de innovadores sistemas de sensorización, telemando y automatización distribuidaa la red eléctrica de Cataluña. Pare ello, empresas punteras del sector como son Ormazabal, ZIV, iGRid, IREC, Comercial Vallesanay Electra Caldensehan unido esfuerzos para poder desarrollar y probar estas tecnologías en NAenCAT.
Por un lado, en el proyecto se desarrollarán nuevos sensores adaptados a las características técnicas de la red eléctrica de Cataluña, lo que permitirá aumentar el conocimiento de lo que está pasando en la red. El desarrollo del sistema de sensorización se basará en criterios de bajo coste y adaptación al sistema de automatización distribuida de la red que también se propone en este proyecto. En este sentido, se desarrollarán algoritmos para localizar de forma eficiente los sensores en la red.
Por otro lado, se ampliarán las capacidades de los sistemas de telemando actuales, que serán más robustos y de menor coste, lo que permitirá flexibilizar la operación de red y un despliegue más rápido. Fruto del mayor conocimiento que se tendrá de la red gracias al sistema de sensorización, el telemando dispondrá de información más fiable, precisa y actualizada para gestionar de forma centralizada la red y anticipar posibles congestiones en la

misma o solventar incidencias existentes de forma eficaz. En este sentido, también se estudiarán los potenciales beneficios para la operación de la red de los sistemas de almacenamiento de energía y su integración en el telemando.
A otro nivel de operación de la red, se incorporará una solución innovadora para la automatización inteligente distribuida que complemente la solución de telemando centralizado actual, lo que permitirá que la red se auto-cicatrice sola en caso de avería. La automatización distribuida de las redes de distribución requerirá de las tecnologías de vanguardia en el sistema de sensorización que se desarrollarán en este proyecto.
Los tres sistemas mencionados sobre los que se basará NAenCAT dispondrán de equipos de comunicación que permitirán el envío de información entre cada sensor y los centros de control (telemando) por un lado, y entre un sensor y otro (automatización distribuida) por otro.
Finalmente, se desarrollarán algoritmos avanzados para la correcta coordinación de los sistemas y tecnologías anteriormente descritos, así como para convertir en información útil los datos generados por los sistemas. En este sentido, se combinarán modelos de red con datos sensorizados para obtener de forma económicamente eficiente estimaciones del estado de la red.
Todas estas tecnologías se instalarán y validarán en la red, para poder estudiar su impacto y beneficio respecto a los sistemas actuales y así poder planificar su instalación masiva a medio plazo, convirtiendo la red eléctrica de Cataluña en una red todavía más inteligente.
Funding: Ris3Cat
Project ID: COMRDI15-1-0039-01
Type: Competitive Nationals
Partners: Electra Caldense, S.A, Institut de Recerca en Energia de Catalunya (IREC), iGrid, S.L., Ormazabal Media Tensión S.L., ZIV Aplicaciones y Tecnologóa S.L.U., Comercial Vallesana de Suministros SA
Date: 2017 - 2020
Group: Power Systems
P.I: José Luis Domínguez García.
More info at the following link

Title: COnvertidor Resilient i Versàtil
Acronym: CORV
Description: Nowadays, power converters are essential for the energy transition towards a system based on renewable electric energy generation, the electric power storage and the electrification and integration of the new vehicles. In particular, many of these systems operate with DC voltage at one side and AC voltage at the other in a way that allow the interaction between these two electric system. This is necessary, for instance, for the integration of PV power or battery-based storage into the AC power network. In this sense, to ensure the correct operation of the power converter there must be a certain ratio of DC voltage with respect of the AC voltage if a one-stage power converter (DC/AC) is to be used. This input DC voltage range can be enhanced if a two-stage conversion system (DC/DC – DC/AC) is applied. However, these two-stage systems increase costs and reduce the global efficiency of the system since they require two devices interconnected.

In this project it is proposed to use a new internal configuration of the converter active parts (the semiconductor-based solid-state switches) that allows to operate in one or two stages in an independent manner. The proposed strategy offers a compact and efficient configuration that provides the versatility of enhancing the acceptable DC voltage input range where the power converter can operate safely.
Moreover, in case of an internal failure of the switches that compose the converter the device stops its operation resulting in economic losses and potential problems in the local electric network that can affect other subsystems. The proposed internal configuration is fault-tolerant meaning that the power converter is internally reconfigurable to remain in operation after the fault while the maintenance and reparation tasks are expected to happen. The fault-tolerant strategy intends to minimize the number of redundant components with the objective of reducing the costs while the capacities of the power converter, its resilience and versatility are improved.
Furthermore, it is the aim of the project to put into test the novel configuration of the converter that provides the versatility and fault-tolerant functionalities developing a cost-effective device. To facilitate the energy transition the proposed design can be easily used by the industry and integrated into existing facilities since it is compatible with current technologies.
Funding: AGAUR
Project ID: 2019 LLAV 00045
Type: Competitive Nationals (coordinator)
Date: 2020 - 2021
Group: Power Systems
P.I: José Luis Domínguez García
More info at the following link

Title: greEN Energy hUbs for local integRated energy cOmmunities optimizatioN
Acronym: E-NEURON
Description: The main goal of the eNeuron project is to develop innovative tools for the optimal design and operation of local energy communities (LECs) integrating distributed energy resources and multiple energy carriers at different scales. This goal will be achieved, by having in mind all the potential benefits achievable for the different actors involved and by promoting the Energy Hub concept, as a conceptual model for controlling and managing multi-carrier and integrated energy systems in order to optimize their architecture and operation. In order to ensure both the short-term and the long-term sustainability of this new energy paradigm and thus support an effective implementation and deployment, economic and environmental aspects will be taken into account in the optimization tools through a multi-objective approach. eNeuron's proposed tools enable tangible sustainability and energy security benefits for all the stakeholders in the LEC. Local prosumers (households, commercial and industrial actors) stand to benefit through the reduction of energy costs while leveraging local, low carbon energy. Developers and solution providers will find new opportunities for technologies as part of an integrated, replicable operational business model. Distribution system operators (DSOs) benefit from avoiding grid congestion and deferring network investments. Policy makers benefit from increasingly sustainable and secure energy supply

systems. eNeuron is a high TRL project in line with the Work Programme, by developing innovative approaches and methodologies to optimally plan and operate integrated LECs through the optimal selection and use of multiple energy carriers and by considering both short- and long-run priorities. Through optimally coordinating all energy carriers and vectors, cost-effective and low-carbon solutions will be provided for fostering the deployment and implementation of this new energy paradigm at European level.
Funding: H2020
Project ID: 957779
Partners: AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE (coordinator), UNIVERSITY OF CYPRUS, INSTYTUT ENERGETYKI, FUNDACIO INSTITUT DE RECERCA DE L'ENERGIA DE CATALUNYA, SINTEF ENERGI AS, FUNDACION TECNALIA RESEARCH & INNOVATION, European Distributed Energy Resources Laboratories e.V., EPRI EUROPE DAC, UNIVERSITA POLITECNICA DELLE MARCHE, UNIVERSIDAD POLITECNICA DE MADRID, ENEA OPERATOR SP ZOO, LEDE AS, LABELEC - ESTUDOS, DESENVOLVIMENTO E ACTIVIDADES LABORATORIALS SA, FONDAZIONE ICONS, ENEIDA WIRELESS & SENSORS SA, MINISTERIO DA DEFESA NACIONAL, MIASTO BYDGOSZCZ.
Date: 2020 - 2024
Group: Power Systems
P.I: José Luis Domínguez García
Other IREC Groups: Energy System Analytics
More info at the following link

PUBLICATIONS

Articles and Journals from ISI Database

Sánchez-Muñoz, D., Domínguez-García, J.L., Martínez-Gomariz, E., Russo, B., Stevens, J., Pardo, M. "Electrical grid risk assessment against flooding in Barcelona and Bristol cities" *Sustainability (Switzerland)* 12, 4, pp. 1527 - 2020 DOI: 10.3390/su12041527

Agbemuko A.J., Domínguez-García J.L., Gomis-Bellmunt O. "Impedance-Based Modelling of Hybrid AC/DC Grids With Synchronous Generator for Interaction Study and Dynamic Improvement" *Electric Power Systems Research* 179, pp. 106086 - 2020 DOI: 10.1016/j.epsr.2019.106086

Agbemuko A.J., Domínguez-García J.L., Prieto-Araujo E., Gomis-Bellmunt O. "Advanced Impedance-based Control Design for Decoupling Multi-Vendor Converter HVDC Grids" *IEEE Transactions on Power Delivery* 35, 5, pp. 2459 - 2470. 2020 DOI: 10.1109/TPWRD.2020.2968761

Attya A.B.T., Domínguez-García J.L. "A Novel Method to Valorize Frequency Support Procurement by Wind Power Plants" *IEEE Transactions on Sustainable Energy* 11, 1, pp. 239 - 249. 2020 DOI: 10.1109/TSTE.2018.2889803

B. Russo, M. Velasco, R. Monjo, E. Martínez-Gomariz, D. Sánchez, J. L. Domínguez, A. Gabàs, A. Gonzalez "Evaluación de la resiliencia de los servicios urbanos frente a episodios de inundación en Barcelona. El Proyecto RESCCUE" *Ingeniería del Agua* 24, 2, pp. 101 - 118. 2020 DOI: 10.4995/ia.2020.12179

Kotsalos K., Miranda I., Domínguez-Garcia J.L., Leite H., Silva N., Hatziargyriou "Exploiting OLTC and BESS Operation Coordinated with Active Network Management in LV Networks" *Sustainability (Switzerland)* 12, 8, pp. 3332 - 2020 DOI: 10.3390/su12083332

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DOCTORAL THESES

Presented theses:

PhD graduate: Markus Lerch
PhD supervisor: Dr. Mikel De Prada
Title: Techno-economic assessment, modelling and optimization for floating offshore wind farms
Presented date: 9/3/2020

Ongoing theses:

PhD student: Carlos Marchante
PhD supervisor: Dr. Lluís Trilla
Title: Behavior, modelling and aplicability of second life batteries: new perspectives

PhD student: Juan Alberto Romero
PhD supervisor: Dr. Lluís Trilla
Title: Contributions to advanced battery management systems for automotive applications

PhD student: Paschalia Stefanidou-Voziki
PhD supervisor: Dr. Jose Luis Domínguez-García
Title: Fault detection and identification tools for distribution networks

PhD student: Anzhelika Ivanova
PhD supervisor: Dr. Jose Luis Domínguez-García
Title: Optimal Sensor placement for accurate state estimation in active distribution networks

PATENTS:

Title: Fault-tolerant DC-AC electric power conversion device
Inventors: Ll. Trilla, P. Paradell, JL Dominguez, H Renandineau
Applicants: IREC
Application number: EP20382860
Application date: 29/09/2020

Title: Risk assessment evaluation tool. Methodology for electric systems.
Inventors: D. Sanchez Muñoz, JL Dominguez
Applicant: IREC
Registration Date: 14/04/2020
Registration number: i-depot 123033
Registry: Benelux Office for Intellectual Property

Title: Tool based on Binary Genetic Algorithm for Intentional Islanding after a Fault
Inventors: A. Ivanova, P. Paradell, A. Colet, JL Dominguez
Applicant: IREC
Registration Date: 30/07/2020
Registration number: i-depot 126954
Registry: Benelux Office for Intellectual Property

OUTREACH

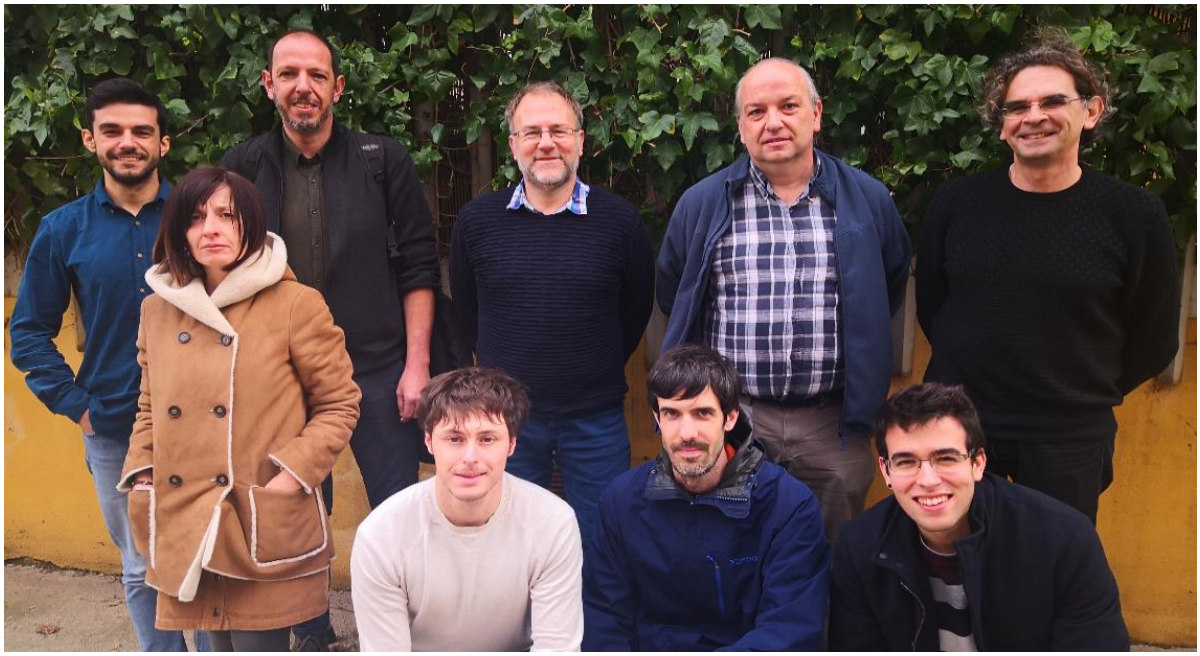
- PROENCAT 2050: towards the energy transition in Catalonia
- IREC earns 3 new Knowledge Industry Grants
- Protecting our cities against climate change
- The Energy Hub concept: green local energy communities
- Participation of IREC in the 25th Science Week
- IREC actively participates in the European Researchers' night
- Webinar – Sofa Talks "Floating offshore wind: innovations and cost-reduction trends"
- Urban Resilience in a Context of Climate Change
- The Future of Renewable Energy in Scotland and Spain

6.2.3. THERMAL ENERGY & BUILDING PERFORMANCE

The Team

(permanent and temporary positions, tenure tracks and fellowships)

Dr. Jaume Salom, Group Leader Dra. Elena Fuentes, Staff Scientist Dra. Joana Ortiz, Staff Scientist Dr. Joaquim Romaní, Postdoctoral Researcher Dr. Paolo Civero, Postdoctoral Researcher Dr. Jordi Pascual, Postdoctoral Researcher Juan Francisco Belio, Laboratory Support Paolo Taddeo, Project Engineer Thibault Pean, Predoctoral Student Ivan Bellanco, Predoctoral Student



Thermal Energy & Building Performance group aims to investigate and develop an integrated and systemic approach towards zero energy communities. Globally speaking, the building sector is responsible for 40% of primary energy consumption. Our vision is to investigate in solutions and strategies that accelerate the reduction of greenhouse gas emissions through human-centred design, energy efficiency measures, integration and management of energy systems, particularly distributed renewable sources in the built environment as part of urban communities.

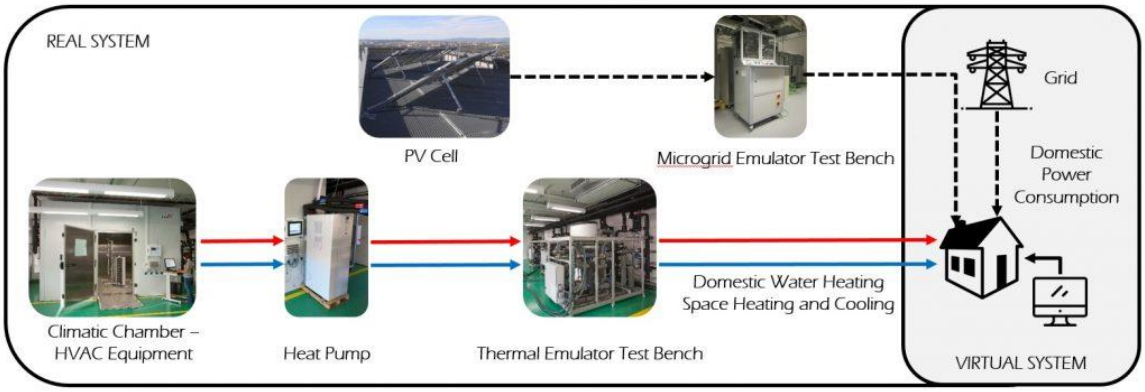
In order to develop solutions for reducing energy consumption, we take an approach that is not only technological, but also holistic in that it considers aspects that are crucial for

buildings, offices and cities, such as air quality, indoor environment and socio-economic impacts, including benefits on occupants' health. Buildings should be considered as nodes of the overall energy system that fight against climate change challenges, being so important to consider the integration with the energy infrastructures: the electrical grid or district heating and cooling networks.

The key research lines that define our activity are:

- Zero energy and flexible energy buildings and communities
- Energy infrastructures for low energy cities
- Green IT

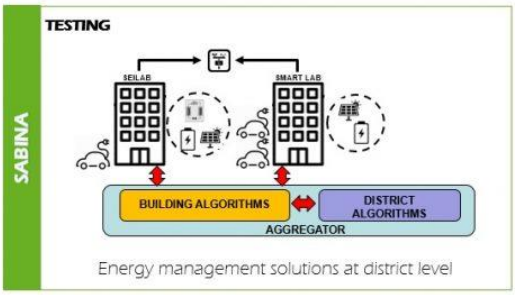
SEILAB provides advanced expertise to assess the development and integration of renewable energy solutions and innovative thermal and electrical equipment that are designed to improve energy efficiency in buildings and energy systems.

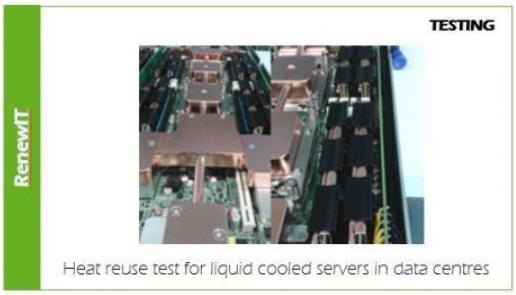


CAPABILITIES

- Semi-virtual testing approach: operation of real equipment as a function of dynamic virtual models
- Testing the performance of components or complex energy systems under defined building and environmental conditions
- Development and integration of innovative, sustainable and renewable building energy supply systems: thermal solar systems, photovoltaics, micro-cogeneration, energy storage, heat pumps and other HVAC equipment
- Analysis of equipment behaviour at particular transient phases
- SEILAB and Energy SmartLab are connected allowing to test aggregator policies and management strategies for districts

HIGHLIGHTS





PROJECTS

Title: SmArt BI-directional multi eNergy gAteway (SABINA)
Acronym: Sabina
Description: Flexibility needs to be added to Europe's power system to accommodate an increasing share of variable power generation from renewable sources. Indeed, service quality issues start to arise on the grid when this share in electricity consumption reaches 10%. To meet the EU's targets for reduction of greenhouse gas emissions this share should rise to 30% by 2030 and up to 50% by 2050. The cost of this transition and the necessary measures to guarantee stable and continuous supply are a major political concern. The SABINA project responds to it by targeting the cheapest possible source of flexibility: the existing thermal inertia in buildings and the coupling between heat and electricity networks it enables. This coupling requires accurately estimating the thermal inertia of many buildings. SABINA's partner the University of Navarra has created a breakthrough, automatic method for this estimation, which shall be scaled up, validated and integrated in a complete management system through this project. This system will operate on two complementary time horizons:
• One day: aggregation and management at the district level of the electric and thermal flexibilities, and conversion and storage of the excess electrical energy to thermal energy in the freely available building inertia.
• Seconds to minutes: local control of inverters feeding renewable electricity to the grid, with optimal parametersautomatically determined at the district level.
Research partners will develop novel control and optimization algorithms, and integrate and evaluate the system in lab and operational settings. The SABINA solution is compatible with

both new and existing buildings; it is planned to be deployed within five years of the end of the project. Lead users are present in the consortium: Telvent and SMS plc, the coordinator, for the architecture, and Insero for the business model it enables; compliance and contribution to relevant standards will be ensured by the European Digital SME Alliance.
Funding: H2020Project ID: 731211
Type: Competitive EU
Partners: SMS Energy Services Ltd (SMS), CSEM Centre Suisse
D'electronique et de Microtechnique SA - Recherche et
Developpement (CSEM), Universidad de Navarra (UNAV), Insero AS (INS), Fundacio Institut de Recerca en Energia de Catalunya (IREC), Schneider Electric Espana SA (SCHE), National Technical University of Athens - NTUA (NTUA), European Digital Sme Alliance (DSME), Amires Sro (AMI).
Date: 2016 - 2020
Group: Thermal Energy & Building Performance
P.I: Jaume Salom Tormo
Other group: Energy Systems Analitics- Dr. Cristina Corchero García
More info at the following link

Title: Trigeneration systems based on heat pumps with natural refrigerants and multiple renewable sources
Acronym: TRI-HP
Description: The overall goal of the TRI-HP project is the development and demonstration of flexible energy-efficient andaffordable trigeneration systems. The systems will be based on electrically driven natural refrigerant heat pumpscoupled with renewable electricity generators (PV), using cold (ice slurry), heat and electricity storages to provideheating, cooling and electricity to multi-family residential buildings with a self-consumed renewable share of 80%.TRI-HP systems will include advanced controls, managing electricity, heat and cold in a way that optimizes theperformance of the system and increases its reliability via failure self-detection. The flexibility will be achieved byallowing for three heat sources: solar (with ice/water as storage medium), ground and ambient air. The innovationsproposed will reduce the system cost by at least 10-15% compared to current heat pump technologies with equivalentenergetic performances. Two natural refrigerants with very low global warming potential, propane and carbon dioxide, will be used as working fluids for adapted system architectures that specifically target the different heating andcooling demands across Europe. The newly-developed systems will find application in both new and refurbishedmulti-family buildings, allowing to cover the major part of Europe's building stock. The new systems reduce GHGemissions by 75% compared to gas boilers and air chillers. The TRI-HP project will provide the most appropriateknowledge and technical solutions in order to cope with stakeholder's needs, building demand characteristics, localregulations and social barriers. Two system concepts will be developed for two different combinations of heat sources, i) dual ground/air source and ii) solar with ice-slurry as intermediate storage. These two concepts combined with thetwo heat pump types developed (CO_2 and propane) will lead to three complete systems (CO_2-ice, propane-ice andpropane-dual) that will be tested in the laboratory.
Funding: H2020

Project ID: 814888
Type: Competitive EU
Partners: HSR Hochschule Fur Technik Rapperswil (HSR), Fundacion Tecnalia Research & Innovation (TECNALIA), Cadena Systems AG (Cadena), Fundacio Institut de Recerca en Energia de Catalunya (IREC), Alfa Laval Lund AB (ALFA LAVAL), Industrielack AG (ILAG), ISOE GMBH , Norges Teknisk-Naturvitenskapelige Universitet NTNU (NTNU), Teknologisk Institut (DTI), Hochschule Karlsruhe-Technik und Wirtschaft (UASKA), Federatie Van Verenigingen Voor Verwarming Enluchtbehandeling In Europa Vereniging (REHVA), Grvefc SL (EFC).
Date: 2019 - 2023
Group: Thermal Energy & Building Performance
P.I: Jaume Salom Tormo
Other group: Energy Systems Analitics- Dr. Cristina Corchero García
More info at the following link

Title: PEDRERA. Positive Energy Districts renovation model
Acronym: PEDRERA
Description: PEDRERA project aims to provide an innovative energy renovation model able to accelerate the urban transition towards Positive Energy Districts (PEDs) in the new era of emerging smart technologies and to validate economic feasibility of the business models, guaranteeing interoperability and replicability at EU scale. The use of the SDL language will afford maximum flexibility to the model, integrating GIS, new processes and procedures to the system in a co-simulation scenario of energy efficiency measures at district scale. The impact of the competencies provided by the host institutions and achieved during the fellowship will shape an expert profile in Energy Efficiency for working in internationally recognized academic centers, research agencies or R&D companies.
Funding: Accio
Project ID: TECSPR18-1-0044
Type: Competitive Nationals
Partners: Fundacio Institut de Recerca en Energia de Catalunya (IREC)
Date: 2019 - 2021
Group: Thermal Energy & Building Performance
P.I: Paolo Civiero
More info at the following link

Title: Smart and local reneWable Energy DISTRICT heating and cooling solutions for sustainable living
Acronym: WEDISTRICT
Description: The overall objective of WEDISTRICT is to demonstrate DHC as an integrated solution that exploits the combination of RES, thermal storage and waste heat recycling technologies to satisfy 100% of the heating and cooling energy demand in new DHC and up to 60-100% in retrofitted DHC. For this purpose, the focus of WEDISTRICT is largescale replication of best practice: better valorisation of local resources, like renewable and waste heat by

making District Heating and Cooling networks more efficient in relation to the use of new resources. In parallel, systems will evolve to provide even more flexible solutions by the integration of innovative molten-salts based thermal storage, the interaction with other energy networks (electricity and gas) and the involvement of end-users (operators and consumers) through ICT-based control and decision making. Finally, to enable significant expansion, costeffectiveness will be enhanced by transitioning from handicraft to more industrialised solutions that integrate LEAN methodologies to optimise processes and lower costs.
Funding: H2020
Project ID: 57801
Type: Competitive EU
Partners: Ingenieria Especializada Obra Civil e Industrial SA (ACCING), District Heating Eco Energias SL (DHECO), Atos Spain SA, Ramboll Danmark A/S (RAM), Compania Espanola De Petroleos SA (CEPSA), Universitatea Politehnica din Bucuresti (UPB), Rise Research Institutes of Sweden AB (RISE), Fundacio Institut de Recerca en Energia de Catalunya (IREC), European Science Communication Institute GGMBH (ESCI), R2M Solution (R2M SOLUTION), Laterizi Gambettola SRL (SOLTIGUA), Fresnex GMBH (FRESNEX), Seenso Renoval SL (SEE), Cirkularni Energetski Resursi doo za Projektiranje i Izgradnju
Energetskih Postrojenja (CER), Fertiberia SA (FERTIBERIA), Universidad de Cordoba (UCO), ISPE Proiectare si Consultanta SA (ISPE), Aalborg CSP AS (ACSP), Universidad Politecnica de Madrid (UPM), PGNIG Termika Energetyka Rozproszona SP. Z O.O (PTER),
Krajowa Agencja Poszanowania Energii Spolka Akcyjna (KAPE), AAF SA.
Date: 2019 - 2023
Group: Thermal Energy & Building Performance
P.I: Jaume Salom Tormo
More info at the following link

Title: ECOS SGR 2017-2019
Acronym: ECOS SGR 2017-2019
Description: L'activitat científica del grup ECOS es focalitza en l'eficiència energètica i les energies renovables, especialment focalitzat en les energies renovables distribuïdes i les Smart Cities, amb una marcada orientació al desenvolupament tecnològic i de mercat en les següents línies:
- Edificis i Districtes d'Energia Neta nul·la
- Micro-xarxes i xarxes intel·ligents
- Integració de Renovables i emmagatzematge
- Green IT – Eficiència Energètica i renovables aplicada a les tecnologies de la informació
- Mobilitat Elèctrica
- Energia Eòlica Offshore
- Economia de l'Energia i Regulació

El grup ECOS disposa d'infraestructures i laboratoris concebuts com a plataformes flexibles i polivalents tant per al desenvolupament tecnològic amb industria com per a projectes competitius de recerca; entre d'altres: micro-xarxa, wind-lab, wind-pilot, SEILAB.
Funding: SGR

Project ID: 2017 SGR 1219
Type: Competitive Nationals
Partners: FUNDACIO INSTITUT DE RECERCA DE L'ENERGIA DE CATALUNYA
Date: 2018 - 2020
Group: Thermal Energy & Building Performance
P.I: Jaume Salom Tormo
Other group: Energy Systems Analitics- Dr. Cristina Corchero, Power Systems- Dr. José Luis Domínguez García
More info at the following link

Title: Efficient Buildings
Acronym: Efficient Buildings
Description: As a MED hub for Energy Efficiency (EE) innovative and shared solutions, the MEDNICE project will anchor a MED community around energy issues that public organisations face in order to promote modular projects' results and increase their impact on public policies. Indeed, in the MED area, the majority of public buildings is not adequately designed to reduce their energy consumption and improve their EE performance. This is partly due to a lack of awareness of owners and managers and knowledge gaps regarding common answers to this transnational challenge. Thus the overall objective of MEDNICE is to empower MED projects' partners through the establishment of a MED community and a joint transnational framework around energy efficiency in public buildings. By setting up training and peer learning mechanisms, MEDNICE will contribute to increase the capacity of owners and managers of public buildings to design and implement better energy efficiency practices. It will set up a knowledge platform that will allow for capitalizing and communicating results and outputs of the modular projects. It will serve as a cornerstone of a transnational peer network laying the ground for a MED identity. MEDNICE will also analyze and summarize EE practices through thematic and policy papers to be promoted and benefit the MED community. Relying on Ambassadors this will help disseminate and transfer messages in order to advocate for specific MED EE policies and mainstream them in relevant strategies.
Funding: Med Programme
Project ID: 7MED19_2.1_HP_008
Type: Competitive Nationals
Partners: City of Nice, Energy Cities, Fundacio Institut de Recerca en Energia de Catalunya (IREC), Euro-Mediterranean Centre on Climate Change Foundation, University of Patras-Department of Civil Engineering, Centre for Renewable Energy Sources and Saving (CRES), Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Portuguese Energy Agency.
Date: 2019 - 2023
Group: Thermal Energy & Building Performance
P.I: Jordi Pascual
More info at the following link

Title: Positive Energy Districts European Network
Acronym: Cost Action PED-EU-NET
Description: Europe is set to be a global role model in energy transition. It has made significant progress in building level innovations and is now stepping up efforts towards city-wide transformation with the pioneering concept of Positive Energy Districts (PEDs). The EU's Strategic Energy Technology Plan (SET-Plan) has set out a vision to create 100 PEDs in Europe by 2025. The concept of PEDs is emerging and the knowledge and skills needed for the planning and designing, implementation and monitoring, as well as replication and mainstreaming of PEDs are yet to be advanced. The challenge is cross sectors and domains, thus the solutions can only be found through collective innovation. This COST Action will drive the deployment of PEDs by harmonising, sharing and disseminating knowledge and breakthroughs on PEDs across different stakeholders, domains and sectors at the national and European level. It will establish a PED innovation eco-system to facilitate open sharing of knowledge, exchange of ideas, pooling of resources, experimentation of new methods and co-creation of novel solutions across Europe. Additionally, this COST Action will support the capacity building of new generation PED professionals, Early Career Investigators as well as experienced practitioners. It will mobilise the relevant actors from and across Europe to collectively contribute to the long-term climate neutral goal.
Funding: Cost Action
Project ID: CA19126
Type: Competitive EU
Date: 2020 - 2024
Group: Thermal Energy & Building Performance
P.I: Paolo Civiero
More info at the following link

Title: Plug-and-use renovation with adaptable lightweight systems
Acronym: PLURAL
Description: PLURAL aims to design validate and demonstrate a palette of versatile, adaptable, scalable, off-site prefabricated plug and play facades accounting for user needs ("Plug-and-Use" kits). Three different core systems are assessed, coupling heating-cooling, ventilation, heat harvesting systems with smart windows, 3D printing, low carbon footprint and nano-enabled coating materials to reduce the building total primary energy consumption to less than 60 kWh/m2 per year and ensure on-site renewable energy generation to more than 50 kWh/m2 reaching NZEB status for different European climates and different residential building typologies.
A BIM based big data management platform and a Decision Support Tool (DST) are coupled to enable the optimal component selection, and integration, best PnU kit design, speedy and low-cost manufacturing and installation. Renewable energy and smart control systems are coupled with low environmental footprint prefabricated façade components to create the integrated all-in-one PnU kits for post war residential building deep renovation. The project creates best practice renovation examples for the residential sector based on innovation and competitiveness, with benefits for the citizens and the environment. It develops business cases

and models for key stakeholders and improves the life cycle based performance standards applied in the building sector.
The solutions are implemented in three real and three virtual residential buildings to evaluate reduction in renovation time and costs, the PnU kit performance, carbon saving and users' acceptance. The selected buildings cover all European climatic zones and are representative residential typologies. PLURAL will achieve at least 50% reduction in the time required for deep renovation of e.g. multi-family blocks. 58% reduction in renovation costs will be achieved through off-site prefabrication lean manufacturing and construction, interactively supported by the BIM based platform and DST.
Funding: H2020
Project ID: 958218
Type:
Partners: National technical university of Athens (NTUA) (coordinator), Advanced Management Solutions (AMS), Municipality of Vari-Voula-Vouliagmeni (VVV), FENIX TNT s.r.o., Obec Kašava, Czech Technical University (CTU), BG Tec Bergamo Tecnologie Sp.z o.o., Daikin Airconditioning Hellas SA, INTRASOFT International S.A, Institute for Solar Technology SPF University of Applied Sciences HSR, The Catalonia Institute of Construction Technology (ITeC), Pich Architects, The Catalonia Institute for Energy Research (IREC), ZRS Architekten, RECUAIR s.r.o,, DENVELOPS TEXTILES S.L., RD Rymarov, Agència de l´Habitatge de Catalunya (AHC).
Date: 2020 - 2024
Group: Thermal Energy & Building Performance
P.I: Jaume Salom Tormo
Other IREC group: Energy System Analytics
More info at the following link

Title: Sustainable Plus Energy Neighbourhoods
Acronym: Syn.ikia
Description: Syn.ikia aims at achieving sustainable plus energy neighbourhoods with more than 100% energy savings, 90% renewable energy generation triggered, 100% GHG emission reduction, and 10% life cycle costs reduction, compared to nZEB levels. This will be achieved while ensuring high quality indoor environment and well-being.
Our main strategy for achieving these goals is to deliver a blueprint for sustainable plus energy buildings and neighbourhoods, leading the way to plus energy districts and cities, through:
I. Demonstrating new designs and efficient operation of sustainable plus energy neighbourhoods through the balanced application of integrated energy design, energy- and cost-efficiency measures, local renewables, local storage, energy flexibility, and energy sharing and trading. This will be demonstrated in four real-life development projects with plus energy apartment blocks located in four climatic zones and representing four different types of urban development strategies.
II. Delivering customized designs, innovative technologies, and decision support strategies and tools that enable informed decisions to be made by the key stakeholders in Europe.
III. Encouraging community engagement and empower user's control facilitated by digital platforms and driven by housing affordability, improved quality of life, and environmental consciousness to inform and enable behavioural change.

IV. Unlocking the potential of neighbourhoods as flexibility providers that enable more RES to enter the system and allow for flexible management of energy demand and RES generation in neighbourhoods, to avoid costly reinforcements of distribution grids while improving the quality and reliability of supply.
V. Providing big data based infrastructure management and smart networks that, together with new and validated construction technologies and materials, unlock the flexibility potential, enable community engagement, and provide well-managed housing for the citizens.
Funding: H2020
Project ID: 869918
Type: Competitive EU
Partners: NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU (coordinator), DANMARKS TEKNISKE UNIVERSITET, BUILDINGS PERFORMANCE INSTITUTE EUROPE ASBL, SINTEF AS, COMITE EUROPEEN DE COORDINATION DE L'HABITAT SOCIAL AISBL, FUNDACIO INSTITUT DE RECERCA DE L'ENERGIA DE CATALUNYA, OBOS BBL, STICHTING AREA, INSTITUT CATALA DEL SOL, NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO, ENFOR AS, ABUD MERNOKIRODA KFT, HEIMAT OSTERREICH GEMEINNUTZIGE WOHNUNGS- UND SI EDLUNGSGESELLSCHAFT MBH
Date: 2020 - 2024
Group: Thermal Energy & Building Performance
P.I: Jaume Salom Tormo
More info at the following link

Title: Som Comunitat Energètica
Acronym: Som Comunitat Energètica
Description: Som Comunitat Energètica is singular project for the socioeconomic reactivation due to COVID-19 for cooperative companies. The goal of the project is to dynamize the energy transition of the building stock towards decarbonization through the creation of energy communities from an inclusive and solidarity perspective.
IREC plans to develop algorithms for recognizing potential energy communities, given the association archetypes of buildings and floors for different uses. These algorithms will be implemented in the main software and in the derived services, to uncover potential energy communities throughout the territory.
Funding: Departament de Treball, Afers Socials i Famílies
Type: Competitive Nationals
Partners: Cíclica (leader), IREC, Electra Caldense and Dies d'Agost; Xarxa de Micropobles
Date: 2020 - 2021
Group: Thermal Energy & Building Performance
P.I: Jordi Pascual
More info at the following link

Title: Designing Resilient Communities to Mitigate Pandemic and Climate Change effects
Acronym: ComMit-20

Description: The ComMit-20 project aims to establish long and short term impacts of the COVID-19 pandemic situation regarding the energy consumption, changes in usage patterns and higher indoor environmental quality requirements in buildings. The project will propose oriented adaptive measures, policies and recommendations to increase resilience of buildings and urban communities by means of integrating new found requirements in design and energy planning tools, and energy management systems.
The project should emphasize which alternatives will improve resilience and robustness of the systems and help us (as society) to prevent not desired effects in this current and new epidemic situations. The project will derive design and operational recommendations to be applied in future epidemic times in different domains of the built environment and at different levels, with a special focus on residential and educational buildings.
Funding: AGAUR
Project ID: 2020PANDE00116
Type: Competitive Nationals
Date: 2021 - 2022
Group: Thermal Energy & Building Performance
P.I: Jaume Salom Tormo
Other IREC group: Power Systems, Energy System Analytics.
More info at the following link

PUBLICATIONS

Articles and Journals from ISI Database

Kathirgamanathan, A, Péan, T., Zhang, K., De Rosa, M., Salom, J., Kummert, M., Finn, D.P. "Towards standardising market-independent indicators for quantifying energy flexibility in buildings" *Energy and Buildings* 220, pp. 110027 - 2020 DOI: 10.1016/j.enbuild.2020.110027

Taddeo, P., Colet, A., Carrillo, R.E., Casal Canals, L., Schubnel, B., Stauffer, Y., Bellanco, I., Corchero Garcia, C., Salom, J. "Management and activation of energy flexibility at building and market level: A residential case study" *Energies* 13, 5, pp. 1188 - 2020 DOI: 10.3390/en13051188

Asim M., Saleem S., Imran M., Leung M.K.H., Hussain S.A., Miró L.S., Rodríguez I. "Thermo-economic and environmental analysis of integrating renewable energy sources in a district heating and cooling network" *Energy Efficiency* 13, 1, pp. 79 - 100. 2020 DOI: 10.1007/s12053-019-09832-9

Bandera C.F., Pachano J., Salom J., Peppas A., Ruiz G.R. "Photovoltaic plant optimization to leverage electric self consumption by harnessing building thermal mass" *Sustainability (Switzerland)* 12, 2, pp. 553 - 2020 DOI: 10.3390/su12020553

Clemente C., Civiero P., Cellurale M. "Positive Energy Districts (PEDs) for inclusive and sustainable urban development" *SMC- Sustainable Mediterranean Construction* 12, 1, pp. 112 - 118. 2020 DOI: ISSN 2420-8213

Foteinaki K., Li R., Péan T., Rode C., Salom J. "Evaluation of energy flexibility of low-energy residential buildings connected to district heating" *Energy and Buildings* 213, pp. 109804 - 2020 DOI: 10.1016/j.enbuild.2020.109804

Schubnel B., Carrillo R.E., Taddeo P., Canals Casals L., Salom J., Stauffer Y., Alet J.P. "State-space models for building control: how deep should you go?" *Journal of Building Performance Simulation* 13, 6, pp. 707 - 719. 2020 DOI: 10.1080/19401493.2020.1817149

Sola A., Corchero C., Salom J., Sanmarti M. "Multi-domain urban-scale energy modelling tools: A review" *Sustainable Cities and Society* 54, pp. 101872 - 2020 DOI: 10.1016/j.scs.2019.101872

DOCTORAL THESES

Presented theses:

Date: 21/01/2020
Doctorate: Thibault Q. Péan
Title: Heat pump controls to exploit the energy flexibility of building thermal loads
Director: Dr. Jaume Salom; Dr. Ramon Costa-Castelló

Ongoing Theses:

PhD student: Ivan Bellanco Bellanco
PhD supervisor: Dr. Jaume Salom, Dr. Joan Manel Vallès Rasquera
Title: Automatic fault detection in domestic heat pump

OUTREACH

- nZEB course 2020
- A new project will create inclusive energy communities in Catalonia
- SABINA attains two connected laboratories and a spin-off
- PLURAL aims to renovate buildings to reach nZEB status
- IREC leads an ITP on Positive Energy Districts
- PROENCAT 2050: towards the energy transition in Catalonia
- IREC researchers receive 3 Juan de la Cierva grants
- Efficient Buildings Community in the MED region kicks-off
- IREC contributes to sustainable plus energy neighbourhoods within syn.ikia
- "Hacia un sistema flexible, eficiente y sostenible"
- 7th edition of Barcelona Science Slam
- Jornada científico-técnica "Análisis térmico y calorímetría"
- "La salut del planeta Sostenibilitat ambiental: reptes i oportunitats després de la covid-19"
- Efficient public buildings: How will the Renovation Wave bend around the Mediterranean shore?
- 6a edició del curs sobre edificis de consum d'energia gairebé zero (nZEB) 2020
- VII Congreso Edificios Energía Casi Nula
- 6a edició del curs sobre edificis de consum d'energia gairebé zero (nZEB) 2020
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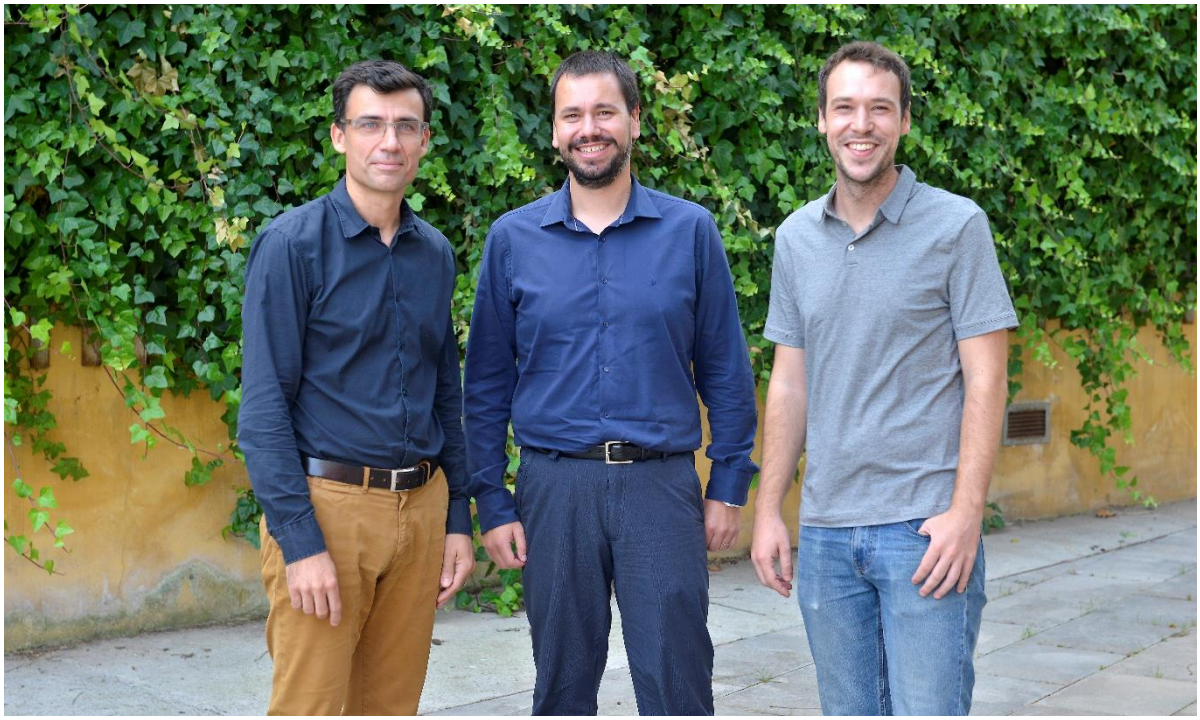
- "Barcelona prohibirà les estufes de combustió a les terrasses, però a partir del 2025".
- Barreres de gestió comunitària en instal·lacions d'autoconsum en blocs d'habitatges".
- ICTA-UAB actúa contra la pobreza energética de 1500 hogares de Barcelona

7. PROGRAMMES

7.1. PROGRAM FOR FUSION TECHNOLOGY DEVELOPMENT (bFUS)

The Team
(permanent and temporary positions, tenure tracks and fellowships)

Manel Sanmartí, Head of bFUS Program Oriol Nomen, Staff Engineer Daniel Sanchez, project engineer



Since 2010 IREC has been leading the "Barcelona Fusion Centre" (bFUS) programme with the aim of promoting and boosting research activities in the field of nuclear fusion technologies in Catalonia. This programme was developed within the framework of the international project ITER and the European Fusion Program by EUROfusion. IREC has been working on mechanical design of fusion components, energy storage systems, grid integration studies, cryogenics and cryodistribution, fuel cycle and superconductivity.

Since 2018, IREC has become the System Responsible of the High Energy Beam Transport Line (HEBT) and Beam Dump Subsystem of the Accelerator of the IFMIF DONES Facility. DONES is expected to be built in Granada, Spain and it will be the 1st facility to provide experimental data on the behavior of fusion reactor candidate materials under neutron irradiation levels of a fusion machine.

The bFUS Programme has also allowed IREC to establish technology transfer collaborations with Catalan industry. These collaborations have increased their technology capabilities allowing them to obtain industrial contracts in nuclear fusion and particle accelerators programs.

PROJECTS

Title: DONES
Acronym: DONES
Description: The International Fusion Materials Irradiation Facility – Demo Oriented NEutron Source (IFMIF-DONES) is a single-sited novel Research Infrastructure for testing, validation and qualification of the materials to be used in a fusion reactor. It is based on a unique neutron source with energy spectrum and flux tuned to those expected for the first wall containing future fusion reactors. Materials irradiation data under such conditions are of fundamental interest for the fusion community as those will feed and validate the modelling tools for materials radiation damage phenomena. The IFMIF-DONES will be a major step towards IFMIF as it will develop a unique high-current high-duty cycle accelerator technology, liquid metal target technology and advanced control systems.
Funding: H2020
Type: Competitive EU, Linked third party
Date: 2018 - 2020
Group: b_Fus
P.I: Oriol Nomen Escoda
More info at the following link

Title: Fusion in Catalonia
Acronym: FusionCAT
Description: The objective of FusionCAT is to establish an active fusion community in Catalonia. FusionCAT is formed by 7 partners that are leading institutions in Catalonia in their respective fields. Most of them have on-going involvement in fusion R&D through participation in the EU fusion research programme, contracts with ITER and Fusion for Energy (F4E), national fusion projects as well as collaborations with CIEMAT. FusionCAT consists of 11 original R&D projects, organized in 3 focused work packages building on the complementary fields of well-recognized expertise of the partners and the synergies between them, as well as a strong dissemination and technology transfer programme. It aims to establish technology transfer from the partners to industry in order to develop industrial competences in Catalonia for the realization of fusion energy. Transfer of relevant know-how is sought in particular. This is essential and timely because the development of fusion energy requires that the role of the industry changes from being a provider of high-technology components to being the driver of fusion development. The projects focus on numerical modelling, analysis and design of fusion reactor components and processes, fusion reactor software development (including high performance computing) and validation as well as diagnostic methods and instrumentation.

The key fusion technologies addressed are tritium breeding blankets, high temperature superconducting magnets and fusion reactor materials. Seven companies have already expressed their interest to participate in the Industrial Advisory Board of the project. It facilitates the exchange of ideas and contacts with industrial stakeholders. In addition, an Advisory Board is formed by invited world-leading experts in the field. The main key indicators will be the number of highly-skilled jobs created and the number of contracts and collaboration agreements with industry.
Funding: Emergents
Project ID: IU16-011702
Type: Competitive Nationals
Partners: Barcelona Supercomputing Center-Centro Nacional de Supercomputación (BSC-CNS), Fundació b_TEC Campus Diagonal-Besòs (BTEC), EURECAT Centre Tecnològic de Catalunya (EURECAT, Institut de Ciència de Materials de Barcelona (ICMAB-CSIC), Institut Químic de Sarrià (IQS), Institut de Recerca en Energia de Catalunya (IREC), Universitat Politècnica de Catalunya (UPC)
Date: 2019 - 2022
Group: b_Fus
P.I: Oriol Nomen Escoda
More info at the following link

Title:
Acronym: ITER-IPA
Description: ITER is one of the most ambitious energy projects in the world today. It is based in southern France, where 35 nations are collaborating to build the world's largest tokamak, a magnetic fusion device that has been designed to demonstrate the feasibility of fusion as a large-scale and carbon-free source of energy based on the same principle that powers our Sun and stars.
The experimental campaign that will be carried out at ITER is crucial to advance fusion science and pave the way for the fusion power plants of tomorrow. ITER will be the first fusion device to produce net energy, to maintain fusion for long periods of time and to test the integrated technologies, materials, and physics regimes necessary for the commercial production of fusion-based electricity.
The bFUS group at IREC has started a new collaboration with ITER in the field of Electron Cyclotron Resonance Heating (ECRH) with the nomination of Oriol Nomen as ITER Project Associate (IPA) within the Electron Cyclotron (EC) Section. IREC will provide mechanical and manufacturing engineering support for the next coming four years in the detailed development of the Upper Launcher and Ex-Vessel Waveguides Systems of the ECRH. The ECRH is one of the three sources of external heating that will provide the input heating of hydrogen gas in the ITER machine to a temperature about 10 times that of our Sun. The ECRH is based on high-frequency electromagnetic waves.
Funding: Agreement
Type: Competitive EU, Linked third party
Date: 2020 - 2024
Group: b_Fus
P.I: Oriol Nomen Escoda

More info at the following link

PUBLICATIONS

Articles and Journals from ISI Database

Arranz F., Micciche G., Coloma S., Sanchez-Herranz D., Nomen O., Ferre M., Ibarra A. "Remote Handling in the Accelerator Systems of DONES" *IEEE Transactions on Plasma Science* 48, 6, pp. 1743 - 1747. 2020 DOI: 10.1109/TPS.2020.2969262

Kondo K., Akagi T., Arranz F., Bazin N., Bellan L., Bolzon B., Brañas B., Cara P., Carin Y., Castellanos J., Chel S., Comunian M., Dzitko H., Ebisawa T., Facco A., Fagotti E., Gavela D., Gex D., Grespan F., Heidinger R., Hirata Y., Jimenez D., Jokinen A., Kasugai A., Knaster J., Kumagai K., Kwon S., Maebara S., Marchena A., Marqueta A., Marroncle J., Méndez P., Molla J., Moya I., Nomen O., Palmieri A., Phillips G., Pisent A., Podadera I., Pruneri G., Regidor D., Rodriguez A., Sakamoto K., Scantamburlo F., Shimosaki Y., Shinya T., Sugimoto M., Varela R., Weber M. "Validation of the Linear IFMIF Prototype Accelerator (LIPAc) in Rokkasho" *Fusion Engineering and Design* 153, pp. 111503 - 2020 DOI: 10.1016/j.fusengdes.2020.111503

Nomen O., Sanchez-Herranz D., Oliver C., Podadera I., Varela R., Ogando F., Hauer V., Arranz F., Coloma S., Heidinger R., Dzitko H. "Preliminary design of the HEBT of IFMIF DONES" *Fusion Engineering and Design* 153, pp. 111515 - 2020 DOI: 10.1016/j.fusengdes.2020.111515

Sánchez-Herranz D., Ortego P., Nomen O., Brañas B., Ogando F., Sauvan P., Arranz F., Coloma S. "Design and configurations for the Shielding of the Beam Dump of IFMIF DONES" *Fusion Engineering and Design* 153, pp. 111475 - 2020 DOI: 10.1016/j.fusengdes.2020.111475

DOCTORAL THESES

Ongoing theses:

PhD candidate: Oriol Nomen
Title: Beam transport and beam dump sections of facilities for qualification of fusion reactors materials
Director: Dr. Youri Koubychine (UPC), Dr. Fernando Arranz (Ciemat)

8. SCIENTIFICAL AND INSTITUTIONAL HIGHLIGHTS

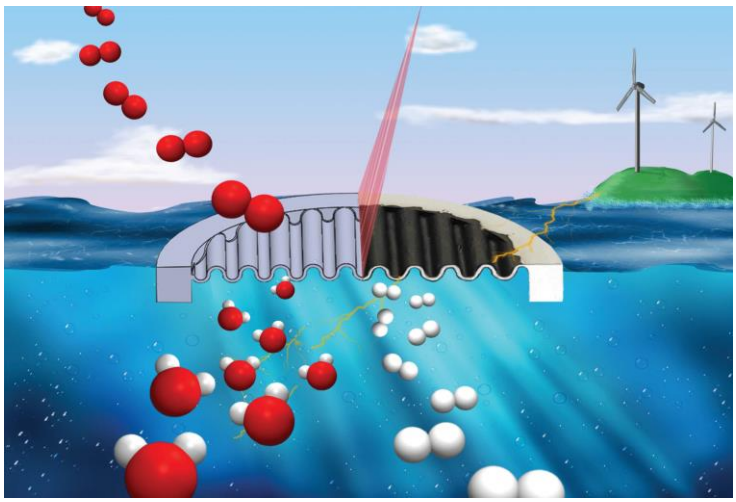
- 3D Printing the Next Generation of Energy Devices

  Three dimensional printing technologies represent a manufacturing revolution because of their unique capabilities for increasing shape complexity while reducing waste material, capital cost and design for manufacturing. However, the application of 3D printing technologies for the fabrication of devices remains an almost unexplored field due to their elevated complexity from the materials and functional points of view. The use of 3D printing technologies in energy and environmental applications is of special interest since the related devices usually involve expensive advanced materials such as ceramics or composites, which present strong limitations in shape and functionality when processed with classical manufacturing methods.

  Among other technologies, Solid Oxide Fuel and Electrolysis Cells (SOFC/SOECs) are one of the candidates to strongly benefit from 3D printing. SOFC/SOECs are ceramic-based multilayer complex devices able to efficiently generate electricity from clean fuels like hydrogen (fuel cell mode) as well as store renewable electricity in the form of transportable gases (electrolysis mode). In the last year, we have been developing an innovative 3D printing technology able to fabricate free-form SOCs with up to 60% of improved performance even using state-of-the-art materials.

  References:

  - Cell3Ditor EU project (***www.cell3ditor.eu***)
  - ***Solar Impulse Efficient Solution Label*** for the Cell3Ditor technology
  - A. Pesce, A. Hornes, M. Nunez, A. Morata, M. Torrell, A. Tarancón, '3D printing the next generation of enhanced solid oxide fuel and electrolysis cells', Journal of Materials Chemistry A, 8 (2020) 33, 16926 – 16932 (HOT paper and cover image of the issue)



Sketch of 3D printed Solid Oxide Cells able to store renewable electricity in the form of hydrogen and oxygen (starting from water)

- New PV technologies for advanced integration concepts: Transparent PV

SEMS achieves key advances in new PV technologies for (semi)transparent PV device concepts based on low dimensional earth abundant semiconductors

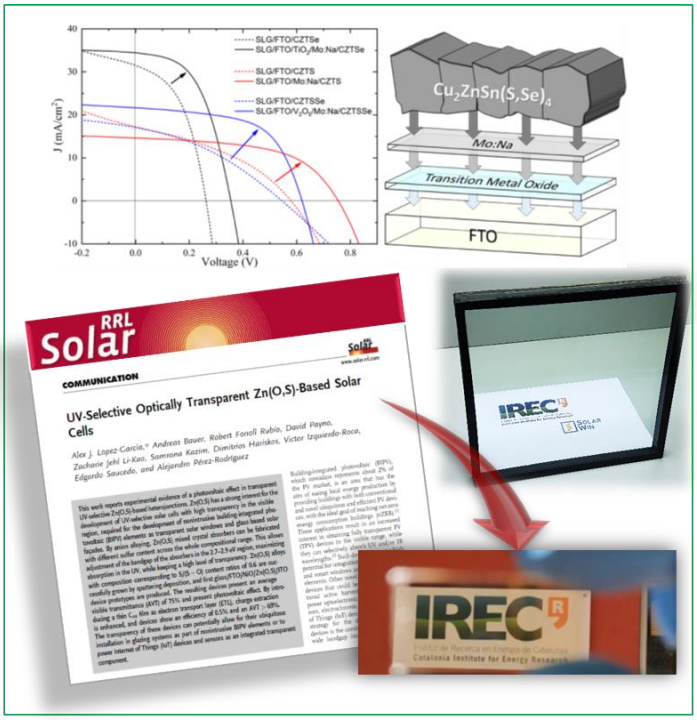
Next generation PV integration concepts require for the development and demonstration of devices with new and improved functionalities as (semi)transparent devices for BIPV applications (including glass based semitransparent façades and next generation smart solar windows). SEMS group relevant achievements in this field include:

Development and demonstration of (1) optimised transparent back contact configurations replacing standard Mo back contact and (2) wide band gap absorbers allowing efficient chalcogenide solar cells (relevant publications: ACS Applied Materials & Interfaces 2020, https://doi.org/10.1002/solr.202000470; Solar RRL 2020 https://doi.org/10.1002/solr.202000284)

Demonstration of first proof of concept of UV selective solar cells based on ZnOS alloys compatible with very high transparency (≥ 70%) (relevant publication: Solar RRL 2020, https://doi.org/10.1002/solr.202000470)

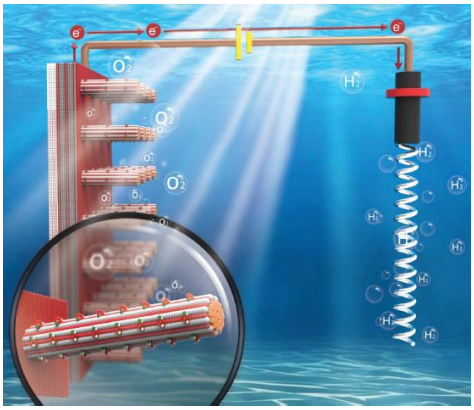
Characterization of optimized customized CIGS processes for smart solar windows based in luminescent concentration strategies: demonstration of first operative solar window prototypes with 60% transparency

Advanced in the understanding of main factors limiting the efficiency of innovative devices based in Quasi-1D chalcogenides (Sb2Se3) (relevant publication: Solar RRL 2020, https://doi.org/10.1002/solr.202000141



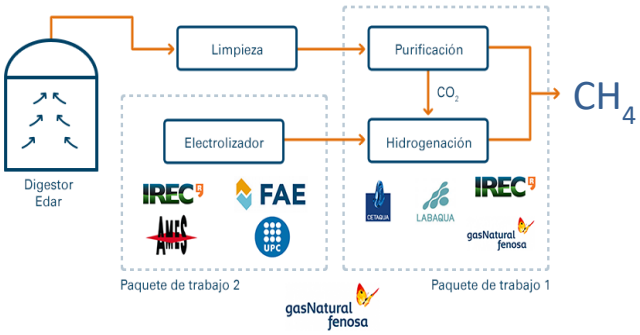
- <u>Solar Hydrogen Pilot Plant</u>

A two-year service provision contract with Repsol and Enagás, for the development of solar fuel generation technologies addressed to implement a pilot plant for the solar hydrogen production has been signed.



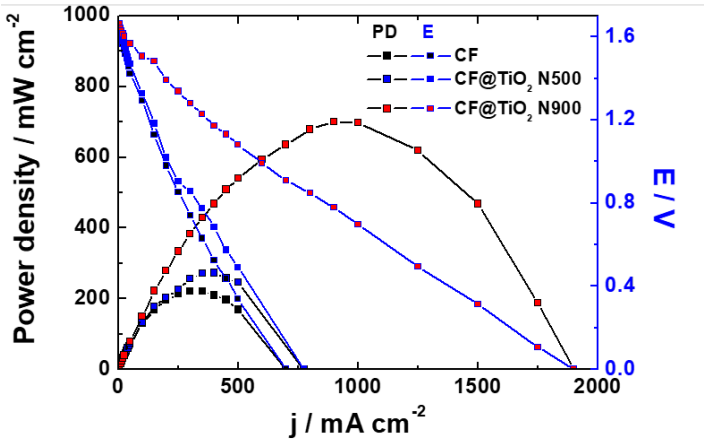
- <u>Methanation Pilot Plant</u>.

IREC has moved their advanced laboratory results to a field pilot plant in a waste water depuration plant located in Sabadell as example of new strategies for CO2 reduction on the base of power to gas technologies in new energy models for a sostenible society.



- <u>New applications of redox flow batteries.</u>

IREC is collaborating with the company HidraRedox for developing new prototypes of flow redox batteries.



- Recharging station for electrical vehicle

IREC has launched several new applications for enhancing electrical mobility. Based on the results of the Cofast project by IREC, a new recharging station has been implemented in Mataró.

- Advanced harvesting systems based on nanoionica.

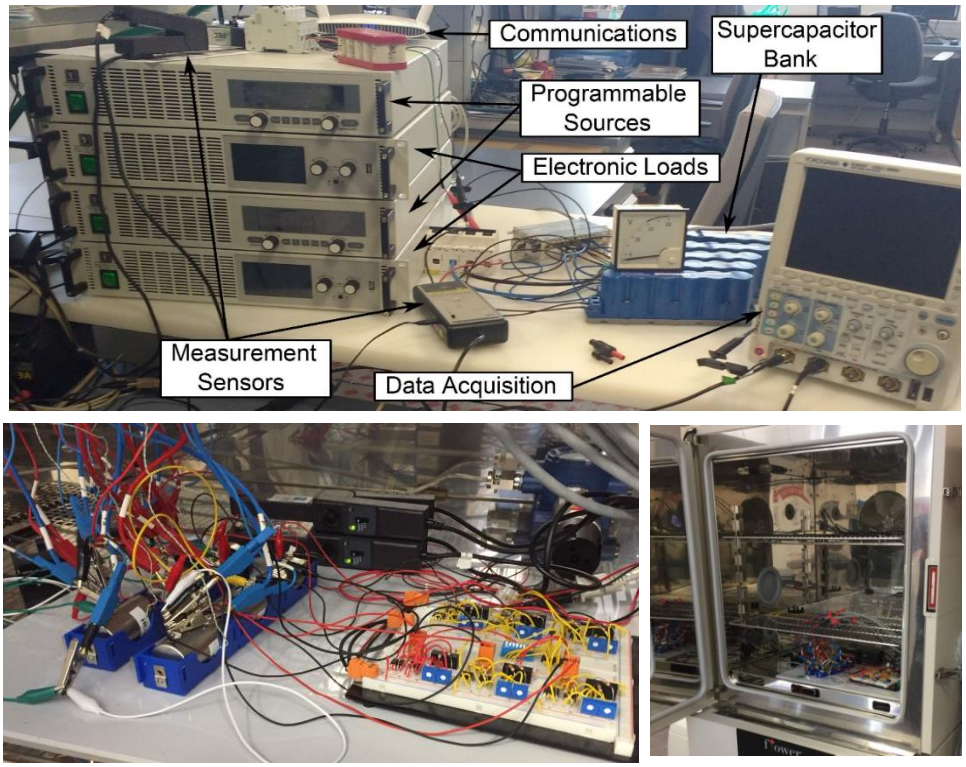
Recent approval of the European “Harvestore” project. It is a large coordinated project of the call “FET Proactive” of the nanoionics research line, focused on portable energy sources. The "µ-harvestorers" developed in this project will collect and store energy from heat and light at the same time, to serve for a new generation portable devices. They will be powerful, small and friendly to the environment

- IREC is collaborating with the Port Authority of Barcelona

Recent agreement with the Port Authority of Barcelona to enhance the collaboration of both institutions, and submit joint project proposals with the participation of APB, TMB, Air Liquide, Naturgy or Enagás, and promote the application of hydrogen technologies in the Port of Barcelona. First service provision agreement for the definition of the APB strategic plan.

- New battery management system for LiS battery has been implemented.

In the frame of the EU Helis project where high performant LiS cells have been developed by IREC, now a new management systems have been implemented to facilitate the application of these type of advanced and highly performant batteries for electrical mobility



- Wind offshore project

"Corewind" is a new project coordinated by IREC, focused on reducing the costs of offshore floating wind energy. Our technical tasks focus on the optimization of the wiring of the offshore wind farm.

- Stratgegy Cyber security program for new management of the energy

"SDN MicroSense" is a project focused on the analysis of cybersecurity in electrical networks, increasing your resilience. Our technical tasks include the development of new controls and network management algorithms.

- Smart grids applied at the Graciosa Island.

IREC smart management developments have been applied in the Graciosa Island project implemented for assessing the reability of the new energy models in a sostenible society based in the management of the smart grids.

- New strategy in the integration of renewable eneergies in buildings.

The European project "We District" has been aproved. Its objective is to demonstrate the integration of energies renewable, thermal accumulation systems and waste heat recovery systems in district heat networks and cold (District Heating and Cooling) to meet up to 100% of the demand for heating and cooling in networks.

Calculation and monitoring of the demonstrator associated with heat recovery of CPDs with DHC fuel cells.

In addition to other transversal projects, the objective of the project is to develop a masterplan for positive energy neighborhoods, considering technical, financial, legal and social aspects, in different European contexts, climates and markets, including its demonstration in pilot buildings / neighborhoods. IREC is leading the work package for the development of energy flexibility management technology in buildings and neighborhoods and the development of simulation tools at the urban level. Design and evaluation of the demonstration of “La Estrella” in the city of Badalona (2 buildings with 64 homes)

- IREC in the Nature Index database

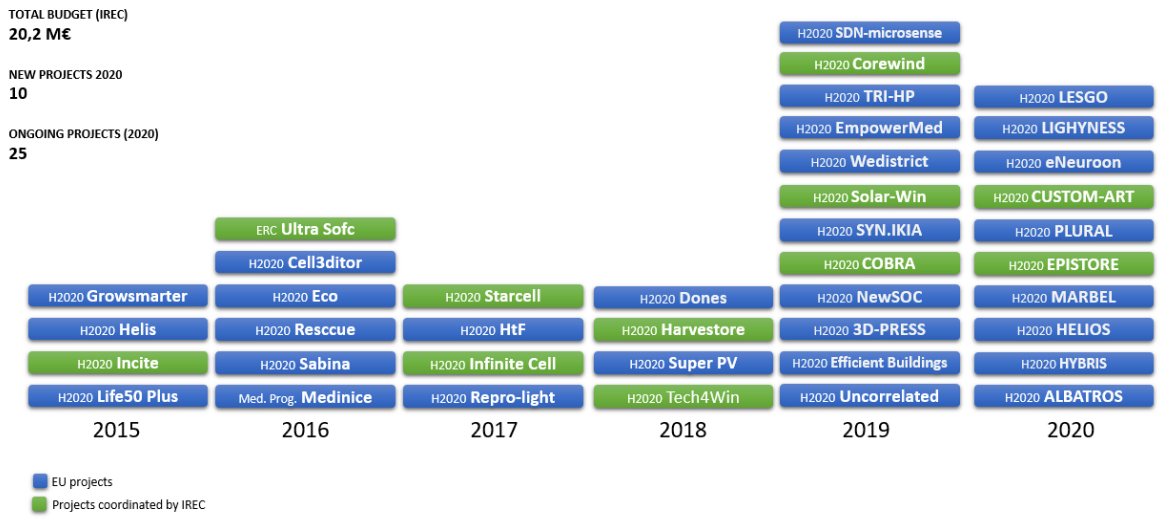
IREC, in spite of its small size in comparison to other institutions, has confirmed its excellence in science in the Nature Index 2018. According to it, IREC has been ranked in the top positions as Catalonian research centers or as Spanish center in comparison with other institutions working in the field of energy. The Nature Index database, which tracks the author affiliations collected from high quality scientific articles published in 68 high quality science journals independently selected by a panel of active scientists, is an indicator of an institution impact compared to other ones in the world.

9. SCIENTIFIC AND TECHNOLOGIC INPUTS SUMMARY

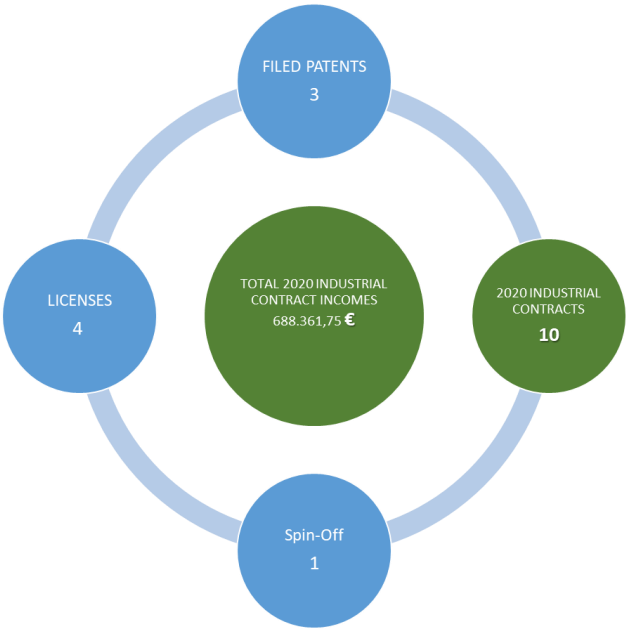
IREC's PROJECTS SUMMARY

The weighted average Technology Readyness Level of IREC ongoing projects is 4.5.

The following the picture shows a detail of the 25 European ongoing projects during 2020, identifying the year from the start of each project and also the role of IREC, as well as coordinating or participating in the projects. During 2020, 10 new European projects were funded by the European Comission. These 25 European projects in execution during 2020, involve a total amount of 20,2 million euros of European funding.



Following, the picture shows a detail of actions connecting industry with our knowledge and developments, as industrial projects and patents (filed and licensed):



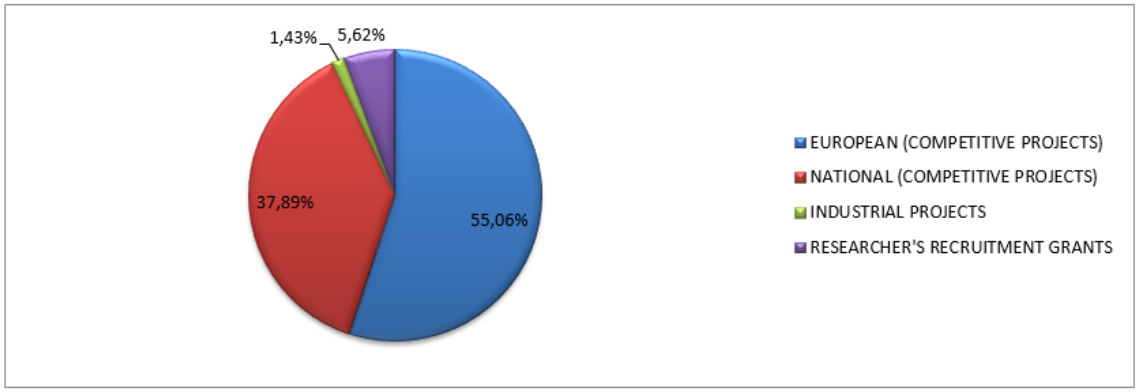
ONGOING PROJECTS

The implementation of competitive and industrial projects for a total income in 2020 of 5,5 million euros, with income from competitive projects of 4,6 million euros (81%) and income from industrial projects of 1,1 million euros (19%). Most of competitive projects come from European tenders.

Regarding current situation at the end of December 2020, we show the amount and share of the ongoing projects portfolio.

Figures below show the expected income for the next years from the ongoing projects at the end of 2020:

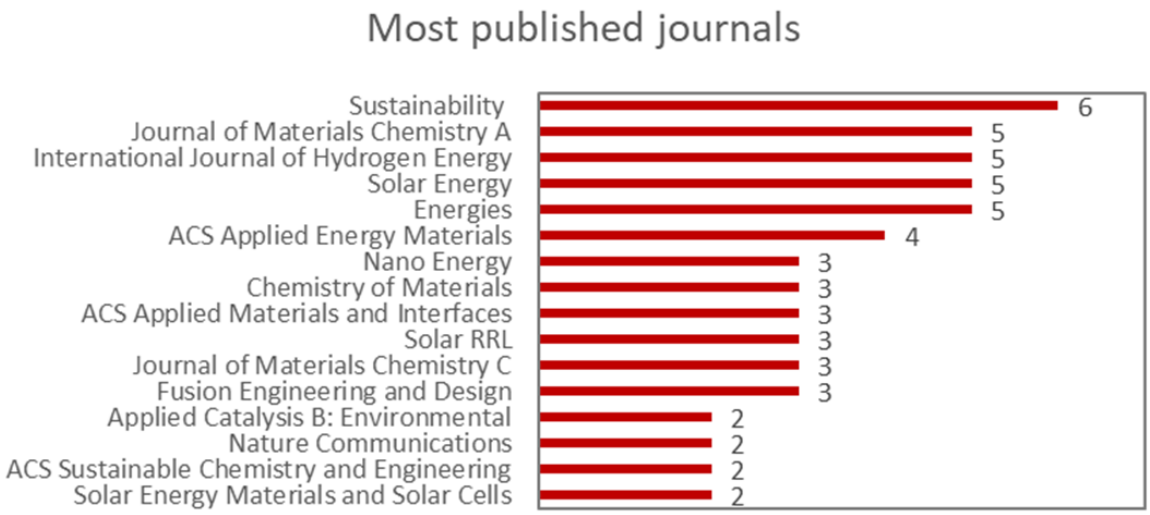
Origin	Income (€)	%	Nº Projects	€ / project
EUROPEAN (COMPETITIVE PROJECTS)	8.893.604	55,06%	23,00	386.678
NATIONAL (COMPETITIVE PROJECTS)	6.121.157	37,89%	37,00	165.437
INDUSTRIAL PROJECTS	230.833	1,43%	10,00	23.083
RESEARCHER'S RECRUITMENT GRANTS	907.979	5,62%	14,00	64.856
Total general	**16.153.573**	**100%**	**84,00**	**192.304**

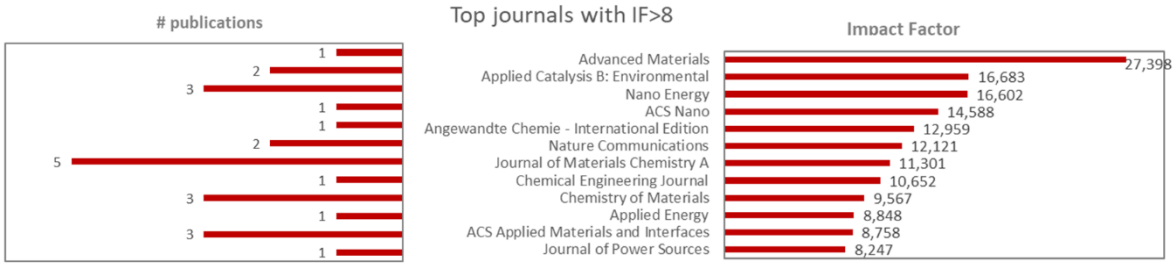


10. SCIENTIFIC AND TECHNOLOGIC OUTPUTS SUMMARY

The outputs of the performed activities reveal that the institute is characterized by excellent research outcomes. IREC at the end of 2020, after 7 years of having finished its laboratories in 2013, counted about 1200 publications and more than 32000 citations with an average ratio of about 25 citations per paper and a total h index of 83.

In 2020 IREC researchers published 96 articles in international scientific journals with impact factor, with an average impact factor of 6.7. 81% of the papers were in first quartile (Q1) journals, and 17% were published in journals with impact factor above 10 and 25% above IF=8.





THE 10 HIGHTLY CITED PAPERS

#	Authors	Title	Publication	Impact Factor	Q	Cited by
1	Giraldo S., Jehl Z., Placidi M., Izquierdo-Roca V., Pérez-Rodríguez A., Saucedo E.	Progress and Perspectives of Thin Film Kesterite Photovoltaic Technology: A Critical Review	Advanced Materials	25.809	Q1	47
2	Liu J., Luo Z., Li J., Yu X., Llorca J., Nasiou D., Arbiol J., Meyns M., Cabot A.	Graphene-supported palladium phosphide PdP 2 nanocrystals for ethanol electrooxidation	Applied Catalysis B: Environmental	14.229	Q1	21
3	Zhang X., Luo J., Wan K., Plessers D., Sels B., Song J., Chen L., Zhang T., Tang P., Morante J.R., Arbiol J., Fransaer J.	From rational design of a new bimetallic MOF family with tunable linkers to OER catalysts	Journal of Materials Chemistry A	10.733	Q1	21
4	Ibupoto Z.H., Tahira A., Tang P., Liu X., Morante J.R., Fahlman M., Arbiol J., Vagin M., Vomiero A.	MoS x @NiO Composite Nanostructures: An Advanced Nonprecious Catalyst for Hydrogen Evolution Reaction in Alkaline Media	Advanced Functional Materials	15.621	Q1	18
5	Zuo Y., Liu Y., Li J., Du R., Yu X., Xing C., Zhang T., Yao L., Arbiol J., Llorca J., Sivula K., Guijarro N., Cabot A.	Solution-Processed Ultrathin SnS 2 -Pt Nanoplates for Photoelectrochemical Water Oxidation	ACS Applied Materials and Interfaces	8.456	Q1	14
6	Péan T.Q., Salom J., Costa-Castelló R.	Review of control strategies for improving the energy flexibility provided by heat pump systems in buildings	Journal of Process Control	3.316	Q1	14
7	Canals Casals L., Barbero M., Corchero C.	Reused second life batteries for aggregated demand response services	Journal of Cleaner Production	6.395	Q1	13
8	Casals, L.C., Amante García, B., Canal, C.	Second life batteries lifespan: Rest of useful life and environmental analysis	Journal of Environmental Management	4.865	Q1	13
9	Masciandaro S., Torrell M., Leone P., Tarancón A.	Three-dimensional printed yttria-stabilized zirconia self-supported electrolytes for solid oxide fuel cell applications	Journal of the European Ceramic Society	4.029	Q1	13
10	Zhang C., Biendicho J.J., Zhang T., Du R., Li J., Yang X., Arbiol J., Zhou Y., Morante J.R., Cabot A.	Combined High Catalytic Activity and Efficient Polar Tubular Nanostructure in Urchin-Like Metallic NiCo2Se4 for High-Performance Lithium–Sulfur Batteries	Advanced Functional Materials	15.621	Q1	12
11	Guilera J., Del Valle J., Alarcón A., Díaz J.A., Andreu T.	Metal-oxide promoted Ni/Al 2 O 3 as CO 2 methanation micro-size catalysts	Journal of CO2 Utilization	5.189	Q1	12
12	Yi M., Zhang C., Cao C., Xu C., Sa B., Cai D., Zhan H.	MOF-Derived Hybrid Hollow Submicrospheres of Nitrogen-Doped Carbon-Encapsulated Bimetallic Ni-Co-S Nanoparticles for Supercapacitors and Lithium Ion Batteries	Inorganic Chemistry	4.85	Q1	12

IMPACT FACTOR & RANKING RESULTS OF THE TOP 10 PUBLICATIONS

#	Authors	Title	Publication	Impact Factor	Q
1	Giraldo S., Jehl Z., Placidi M., Izquierdo-Roca V., Pérez-Rodríguez A., Saucedo E.	Progress and Perspectives of Thin Film Kesterite Photovoltaic Technology: A Critical Review	Advanced Materials	25.809	Q1
2	Chiabrera F., Garbayo I., López-Conesa L., Martín G., Ruiz-Caridad A., Walls M., Ruiz-González L., Kordatos A., Núñez M., Morata A., Estradé S., Chroneos A., Peiró F., Tarancón A.	Engineering Transport in Manganites by Tuning Local Nonstoichiometry in Grain Boundaries	Advanced Materials	25.809	Q1
3	Hadke S., Levcenko S., Sai Gautam G., Hages C.J., Márquez J.A., Izquierdo-Roca V., Carter E.A., Unold T., Wong L.H.	Suppressed Deep Traps and Bandgap Fluctuations in Cu2CdSnS4 Solar Cells with ≈8% Efficiency	Advanced Energy Materials	24.884	Q1
4	Tang P.-Y., Han L.-J., Hegner F.S., Paciok P., Biset-Peiró M., Du H.-C., Wei X.-K., Jin L., Xie H.-B., Shi Q., Andreu T., Lira-Cantú M., Heggen M., Dunin-Borkowski R.E., López N., Galán-Mascarós J.R., Morante J.R., Arbiol J.	Boosting Photoelectrochemical Water Oxidation of Hematite in Acidic Electrolytes by Surface State Modification	Advanced Energy Materials	24.884	Q1
5	Hermans Y., Murcia-López S., Klein A., Jaegermann W.	BiVO4 Surface Reduction upon Water Exposure	ACS Energy Letters	16.331	Q1
6	Zhang C., Biendicho J.J., Zhang T., Du R., Li J., Yang X., Arbiol J., Zhou Y., Morante J.R., Cabot A.	Combined High Catalytic Activity and Efficient Polar Tubular Nanostructure in Urchin-Like Metallic NiCo2Se4 for High-Performance Lithium–Sulfur Batteries	Advanced Functional Materials	15.621	Q1
7	Ibupoto Z.H., Tahira A., Tang P., Liu X., Morante J.R., Fahlman M., Arbiol J., Vagin M., Vomiero A.	MoS x @NiO Composite Nanostructures: An Advanced Nonprecious Catalyst for Hydrogen Evolution Reaction in Alkaline Media	Advanced Functional Materials	15.621	Q1
8	Shi Y., Fluri A., Garbayo I., Schwiedrzik J.J., Michler J., Pergolesi D., Lippert T., Rupp J.L.M.	Zigzag or spiral-shaped nanostructures improve mechanical stability in yttria-stabilized zirconia membranes for micro-energy conversion devices	Nano Energy	15.548	Q1
9	Domnez Noyan I., Gadea G., Salleras M., Pacios M., Calaza C., Stranz A., Dolcet M., Morata A., Tarancon A., Fonseca L.	SiGe nanowire arrays based thermoelectric microgenerator	Nano Energy	15.548	Q1
10	Yu X., Zhang C., Luo Z., Zhang T., Liu J., Li J., Zuo Y., Biendicho J.J., Llorca J., Arbiol J., Morante J.R., Cabot A.	A low temperature solid state reaction to produce hollow MnxFe3-xO4 nanoparticles as anode for lithium-ion batteries	Nano Energy	15.548	Q1
11	Avireddy H., Byles B.W., Pinto D., Delgado Galindo J.M., Biendicho J.J., Wang X., Flox C., Crosnier O., Brousse T., Pomerantseva E., Morante J.R., Gogotsi Y.	Stable high-voltage aqueous pseudocapacitive energy storage device with slow self-discharge	Nano Energy	15.548	Q1

11. SPIN-OFFS

The institute's ongoing commitment is to making real contributions to industry and society. The resulting culture of innovation and entrepreneurship have the added benefit of preparing its researchers for the more diverse, more imaginative manifestations of public-private research collaborations of the future.

As a result of this commitment has provided two spin-offs:

» Ledmotive Technologies S.L.

» Eolos Floating Lidar Solutions

» Bamboo Energy Platform S.L.

11.1. LEDMOTIVE TECHNOLOGIES, S.L.

LEDMOTIVE is the first spin-off from IREC. Created in 2012.
It has gathered more than 3.5M€ in total funding and its selling its products in all the continents.
Leader: Dr. Josep Carreras
Promoting Institution: Fundació Institut de Recerca en Energia de Catalunaya (IREC)
Shareholders: Dr. Josep Carreras, Meritxell Carreras, IREC, IESE Investors, Private Investors and Victoria Capital Group.

LEDMOTIVE lighting technology allows users to recreate any light spectrum. Lighting can be adjusted at different times of day and in different situations to respond to natural circadian rhythms, with demonstrated positive effects on productivity and health. Founded in 2012, the company now has 15 employees and is selling its products across the globe.

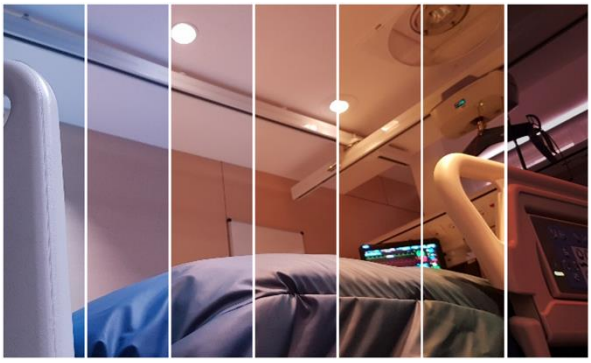
They are pioneers of light with our spectral control technology. The aim is to establish a reference point in the market where light represents a major value-added. We are committed to light as a means to improve people's quality of life. The fundamental pillars are innovation, development, protection of intellectual property related to spectral control, and integration through different technological platforms. Ledmotive believe in ideas argued under the strictest scientific principles and in the effort behind these ideas to make them a reality.

The natural evolution of leds: improving human well-being: Its multispectral lighting system allows the dynamism of natural light to be transferred to closed environments. In particular, this

technology has promising potential in the health sector, given that this system improves the mood and increases the well-being and quality of life of patients, providing an adequate atmosphere in harmony with circadian rhythms.

In 2019, the VEGA07 Module from Ledmotive Technologies was named the "most important Enabling Technology of the year" at the LUX Awards 2019, the most important award ceremony in the world for the Lighting industry.

LEDMOTIVE: light, a quality-of-life factor



According to the WHO, most people spend about 90% of their time indoors. However, exposure to natural light has many health benefits: it facilitates nocturnal rest, improves school performance, and even significantly reduces the likelihood of mental illness at certain ages (1). For this, it is essential that the circadian rhythm (the biological clock that regulates the hours of sleep and wakefulness) be altered as little as possible. Experts in the field insist that the lack of a certain type of light stimulates the body's production of melatonin. This hormone ensures that the biological clock is reset to zero every 24 hours and protects the body from inflammatory diseases and aging.

It is clear that the artificial lighting of interior spaces affects production of melatonin and ends up modifying the sleep patterns of people who spend a lot of time in closed spaces.

LEDMOTIVE: lighting technology for people's well-being

In 2012, aware that LED technology would represent the future of lighting and that there was still work to be done to develop light systems that could considerably improve well-being, Josep Carreras, founder and CTO of LEDMOTIVE and holder of a PhD in Physics, decided to develop a technology capable of adapting perfectly to people's circadian rhythm. This led to the launch of LEDMOTIVE spectral control technology (patented in 21 countries) that allows the reproduction of natural light, including its changes throughout the day, with the highest visual quality and without resorting to high luminous intensities.

This system combines the light of 7 differentiated colour channels to produce any spectrum of light within the visible range. This makes it possible to eliminate or modify the light that produces the most harmful effects (e.g. violet light) or to emphasize the light that provides the

greatest benefits, depending on each correct moment and application. The daily solar pattern is not a simple change in light tonality (Correlated Colour Temperature - CCT) but rather a complete and continuous evolution of the spectrum.

With LEDMOTIVE technology it is possible to programme a lighting sequence for circadian cycles, which oscillates between the light spectrum of a sunrise and a sunset, reproducing the hourly variations of sunlight. In this way, the biological clock can be synchronized by artificial light, when there are reasons that prevent access to natural exposure.

LEDMOTIVE: technology ready to make the leap in Europe

At the end of 2020, the board of directors of the company, headquartered in Barcelona, closed a round of financing that had begun some 12 months earlier. This enabled the company -the leading lighting company in spectral control with LED technology- to obtain a total of €1,850,000, of which €850,000 comes from the "SME Instrument - Horizon 2020" European research and innovation programme. According to Meritxell Carreras, CEO of the company, "LEDMOTIVE wants to expand and above all seeks to reach international markets such as England, France, Belgium, Germany and Sweden". Meritxell Carreras points out that the high degree of technology acceptance in Spain, especially in the hospital sector, leads them to believe that they can achieve a major market share in this area. LEDMOTIVE has installed its technology in the new smart Intensive Care Unit of the Vall d'Hebron Hospital in Barcelona, one of the biggest in Europe and the largest in Spain, to encourage better orientation and to help patients to recover. For this purpose, 21 March has been established as the light-model day, so thanks to LEDMOTIVE technology it is always spring in the ICU.

The applications of this lighting system are innumerable. For example, in schools, to improve student performance and in offices to improve employee well-being and productivity; or in Nordic countries, to reduce seasonal depression due to the absence of sunlight.

11.2. EOLOS FLOATING LIDAR SOLUTIONS

Spin-off of IREC's Offshore Wind department, created on March 2014.
Leader**:** Rajai Aghabi Rivas
Promoting Institution: Fundació Institut de Recerca ene Energia de Catalunaya (IREC)
Shareholders: Rajai Aghabi, EiT InnoEnergy.

As a result of the 3-year innovation project "Neptune", the Offshore Wind Group of IREC, jointly with 5 other partners (Naturgy, UPC, CIEMAT, University of Stuttgart, and SIMO), developed back in 2014 a technology with high market potential that consists of an energy autonomous system capable of taking accurate and reliable wind measurements at height of up to 200 meters at any offshore locations, independent of water depth.

The spin-off company EOLOS FLOATING LIDAR SOLUTIONS, S.L. was set up in March 2014, with the objective of commercializing the resulting product of the "Neptune" project, through a license agreement signed with all the "Neptune" partners.

Five years later, in 2020, EOLOS is a 17-people company with operations in three continents (Europe, Asia and the USA) and a 600m2 workshop plus offices in Montcada i Reixac (Barcelona), from where it assembles its technology and coordinates its world operations.

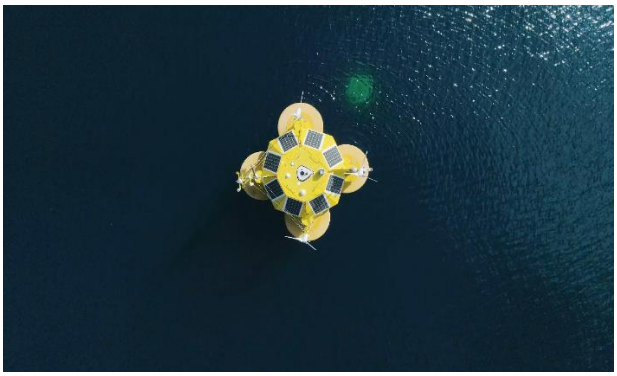
The EOLOS technology helps to:

Significantly reduce capital costs (up to 10x less than bottom fixed met masts) during the development phase, when the final investment decision (FID) has not yet been reached.

Pre-FID cost of money for developers is high as it involves a significant risk since only a portfolio approach hedges against failure.

EOLOS can be installed earlier in the development phase, potentially reducing the wind speed measurement uncertainty and therefore the financial risks.

In addition, it offers positional flexibility and can be reused in other areas within a wind farm site (or on other sites), potentially reducing the wind speed measurement uncertainty.



11.3. BAMBOO ENERGY

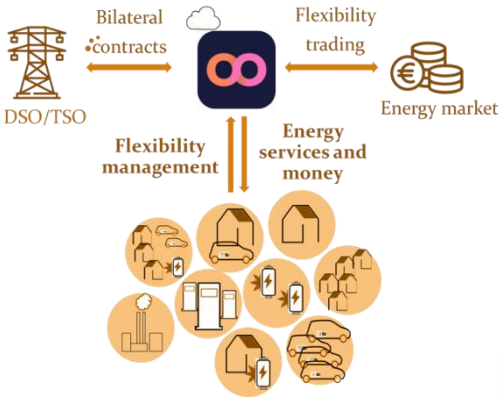
Spin-off of IREC's Energy System Analytics group, created on July 2020.
Leader**:** Dr. Cristina Corchero
Promoting Institution: Fundació Institut de Recerca ene Energia de Catalunaya (IREC)
Shareholders: Dr. Cristina Corchero, IREC, EiT InnoEnergy,

Bamboo Energy is a spin-off company from IREC, created on July 2020 under the name Energueia, and renamed afterwards as Bamboo Energy. It aims to accelerate the energy transition, democratize the access to cleaner and cheaper energy by providing ways to monetize the flexibility of energy assets and the integration of renewable energy sources.

The energy transition in response to climate change and the challenges of our society must be an effective, efficient and just transition. The energy sector is evolving towards a decentralized, decarbonized, digitized and democratized model, where energy flexibility will be a key element

in meeting the challenges in this transition. In this context, the role of demand aggregators is key to enabling and providing demand flexibility to the system.

Bamboo was born to be the software platform of choice for demand aggregation offering a modular architecture and versatile platform. The software is able to adapt customer requirements and regulations whilst minimizing customization efforts. The technology has an artificial intelligence core that allows customised and tailored solutions whilst reducing operating costs. It has the capability to manage all type of demand flexibility, which avoids asset discrimination and offers an easy integration platform, providing aggregation management to the energy market agents.



The technology is the result of the extensive work performed by the Energy System Analytics group at IREC, led by Cristina Corchero. The group accounts for more than 10 years of experience working at the intersection of technology and energy analytics. This know-how has been transferred to Bamboo Energy through a licensing and technology transfer agreement granting full commercial rights.

12. CORPORATE DEVELOPMENT AND TECHNOLOGY TRANSFER (CD&KTT)

The Team

(permanent and temporary positions, tenure tracks and fellowships)

Manel Sanmartí, Head of the Unit Federico Noris, Business Developer Marta Fonrodona, Technology Transfer and Business Intelligence Anna Magrasó, RIS3CAT Energy Community Manager Joana Tarrés, Energy for Society (XRE4S) Research Network Manager

The main objective of the Corporate Development and technology Transfer (CD&KTT) unit is to provide support to the research groups in competitive programs and relationship with industry. It manages IREC's Intellectual Property assets and strategies in close collaboration with the research groups and proposes valorization strategies in order to maximize the impact of the Institute. In addition, it represents IREC in many national and European committees, associations and industrial organizations like Innoenergy, EMIRI, EERA, CEEC, PTE-ee and others fostering international recognition and positioning for the Institute. The CD&KTT unit also manages IREC's transverse projects like the RIS3CAT Energy Community, the "Energy for Society" (XRE4S) research network, the IREC's contribution to the PROENCAT and the strategic alliance with Eurecat.

The main activities have focused on the above mentioned programs and projects. In addition, preparation activities in the field of IP portfolio management, competitive projects and industrial commercial plan have been started and will be consolidated during 2019.

The Energy for Society (XRE4S) Research Network

The Energy for Society (XRE4S) research network proposal was created in 2018 as an expansion and continuation of the Advanced Materials for Energy Network (XaRMAE) which has been operating since 2004. The objective of the network is to boost the success of technology transfer activities and increase the industrial and social impact of energy research activities in Catalonia. The XRE4S is currently composed of 35 research groups from universities (UB, UPC, UdL, UdG, URL-La Salle, UVic), research institutions (BSC, CIMNE, CSIC, ICN2, ICIQ, IREC) and technological centers (Eurecat). In total, the network is made up of more than 400 researchers and 20 FTE working in low carbon technologies, energy efficiency and smart grids. Strategic alliances have been set up with the Catalonia Energy Cluster (industry relationship), InnoEnergy (innovation and entrepreneurship), DEMETER Capital (investors) and Barcelona ACTIVA (training).

The five years' work programme of the XRE4S focuses on technology transfer actions, valorization programmes, networking, capacity building and training activities for researchers.

The RIS3CAT Energy Community

IREC has led the RIS3CAT Energy Community since 2016 as part of the Catalan regional smart specialization strategy (RIS3CAT) developed in the framework the European Research Innovation Strategy for Smart Specialization (RIS3). The RIS3CAT Energy Community aims at improving competitiveness and specialization of the Catalan energy sector with the participation of the most relevant Catalan energy stakeholders (the so called quadruple helix: industry, research and academia, public sector, end users and consumers). The RIS3CAT Energy Community is a €9M action plan (2015-2019) focused on developing 3 large R&D and 4 innovation projects with more than 35 partners and 80 associates around 3 priority lines: low carbon technologies (LCT), Energy Efficiency (EE) and Smart Grids (SG).

The RIS3CAT Energy Community projects are:

- Refer (COMSA EMTE, R&D): Flexibility and energy reduction in buildings rehabilitation to get near zero energy emission buildings.
- NaenCat (Electra Caldense, R6D): New Technologies to increase observability, security and flexibility of the electric grid in Catalonia.
- Cosin (Naturgy, R6D): Development of new fuels, through fuel synthesis and electrolysis.
- Flexedinet (iEnergy, Innovation): Information system for energy saving, flexibility and optimization of the use and demand of energy in buildings.
- MicroIT (ARC BCN, Innovation): Creation of new products and business models to offer energy efficiency solutions to SMEs.
- Estorelot (iGRID, Innovation): Integration of distributed energy resources (DER) and energy storage to improve the management of renewable energy power plants.
- LCA Enerboost: Development of a new tool to boost the energy sector sustainability.

KIC Innoenergy

KIC Innoenergy is a European-wide company created to help promoting a sustainable future through innovation in the energy field. It was in its origin one of the first Knowledge and Innovation Communities (KICs) fostered by the European Institute of Innovation and Technology (EIT). Although the headquarters are in the Netherlands, activities take place thanks to a network of offices located in Belgium, France, Germany, the Netherlands, Spain, Portugal, Poland and Sweden. The project has nowadays 27 shareholders, including top ranking industries, research centers and universities. All of them are key players in the energy field. But beyond this, there are 160 associate and project partners forming a strong network for sustainable energy innovation throughout Europe; working simultaneously in education, innovation projects and business creation.

EIT InnoEnergy

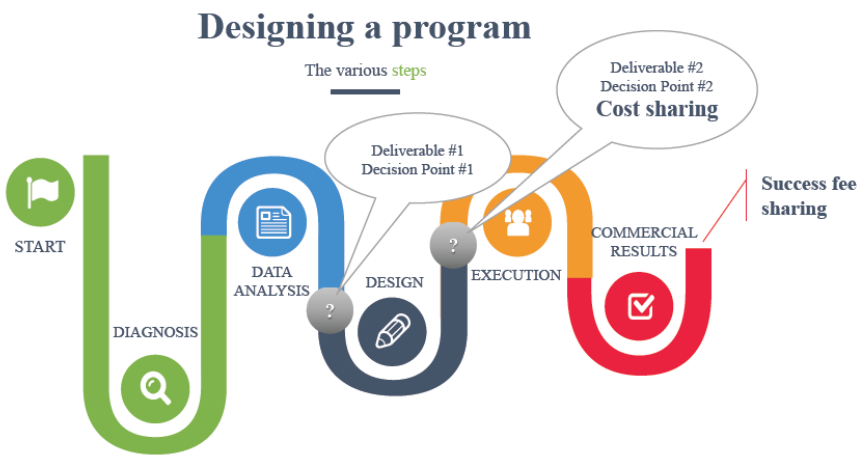
IREC is founder and shareholder of the KIC InnoEnergy, a Europe-wide company created to help promote a sustainable future through innovation in the energy field. Created in 2011, it is one of the first Knowledge and Innovation Communities (KICs) fostered by the European Institute of Innovation and Technology. In recent years, IREC has been actively participating in several InnoEnergy activities and programmes:

- more than 15 IREC's PhD candidates have participated in the InnoEnergy PhD school, each receiving specific entrepreneurship training and completing a 6 month internship in an industrial companies.
- and enhancing innovation in sustainable energy in Europe. One of these projects has concluded with the creation of the EOLOS spin-off which is currently in the market. Another project (COFAST) has concluded in a licencing agreement with an industrial partner who is commercializing the product developed in the project.

The "Lab to Market (L2M)" program

IREC has developed during the last years several innovative projects, as a partner or as a leader, thus contributing to achieve the objectives of promoting and enhancing innovation in sustainable energy in Europe. IREC and InnoEnergy have developed a joint program in order to increase the technology transfer of IREC's research results to market, the so called "Lab to Market" (L2M) programme.

This programme has the objective to analyse several IREC technologies including their technological maturity, the level and strategy of IP protection, and market potential in order to assess their potential for future commercialization. The following figure shows the program phases.



The L2M programme has analysed 20 technologies developed (or being developed) by IREC research groups (Diagnosis phase), selecting the top 5 most promising technologies.

In the Data Analysis phase, these 5 technologies were deeply analysed in collaboration with external experts (canvas analysis, market assessment, deep IP assessments). Finally, 2 technologies were selected for the Design Phase including a commercialization strategy proposition (spin-off creation). These technologies are:

- 3D printed SOFC: IREC and the research team decided to continue the technology development, extend IP protection and internally redefine the exploitation strategy.
- Energy aggregator (CASE): Energy Aggregator (CASE): IREC and researchers participated in The Collider program, and also in negotiations with InnoEnergy and as a result a spin-off (Bamboo Energy) based on this technology has been created. Bamboo Energy has created a software platform of choice for demand aggregation that offers a modular architecture and a versatile platform. The software is capable of adapting customer requirements and regulations while minimizing customization efforts. The technology has a core of artificial intelligence that enables customized and tailored solutions while reducing operating costs. It has the ability to manage all kinds of demand flexibility, which avoids asset discrimination and offers a platform for easy integration, providing aggregation management to energy market agents.

As a result of the programme, IREC has:

- Evaluated 20 technologies for potential market exploitation including recommendations for future development.
- Performed deep analysis on 5 of those technologies related to market potential, IP protection and technology maturity including specific recommendations for future commercialization.
- Provided final recommendations and commercialization strategies for the 2 selected technologies, one of which is currently in the process of creating a spin-off.
- Extended knowledge of valorisation, IP protection and exploitation analysis and strategies for the KTT team.
- Provided training and practice of technology and market assessment for researchers.

IREC-Eurecat Energy Joint Unit

In 2017, IREC and EURECAT (the Technology Centre of Catalonia) signed a strategic agreement with the support of the Generalitat of Catalonia in order to implement a joint unit for technological and business development in the energy field.

The joint unit aims at promoting joint actions by sharing technical and human resources to maximize competitive and industrial funding opportunities and synergies between the institutions and their research groups.

PROJECTS

Title: Coordinación de la Comunidad RIs3CAT Energía
Acronym: Ris3Cat
Description: El Proyecto de Coordinación de la Comunidad Energía tiene por objetivo garantizar el correcto desarrollo del Plan de Actuaciones 2016-2018, la consecución de los objetivos e impacto de los proyectos, así como de la Comunidad, consolidar el Plan de Actuaciones con actividades complementarias y definir una estrategia de consolidación más allá de 2019. La Comunidad RIS3CAT Energía ha desarrollado 3 proyectos de R+D+I y 4 proyectos de Innovación dentro del sector energético en Cataluña. Estos proyectos cubren los tres ejes estratégicos definidos en el plan de actuaciones: eficiencia energética (EE), redes inteligentes (SG) y tecnologías bajas en carbono (LCT).
Funding: Ris3Cat
Project ID: COM15-1-0008
Type: Competitive Nationals, Coordinator
Partners: Fundacio Institut de Recerca de l'Energia de Catalunya (IREC)
Date: 2016 - 2020
Group: Corporate Development and Technology Transfer
P.I: Manel Sanmartí Cardona
More info at the following link

Title: Xarxa d'R+D+I Energy for Society
Acronym: XRE4S
Description: L'objectiu inicial de la XRE4S és la consolidació com a xarxa de referència en energia que evoluciona de la XaRMAE, per tal d'englobar tot l'espectre energètic i promoure la transició energètica a nivell català i internacional donada la seva rellevància en els plans estratègics europeus i nacionals en matèria d'energia. La XRE4S promourà la valorització i transferència tecnològica de l'àmbit Energia cap al sector productiu i social, tot fomentant la interacció recerca-empresa per transferir coneixement i crear productes innovadors en el sector de l'Energia, augmentant alhora, l'impacte de les innovacions energètiques a la societat. La Xarxa R+D+I Energy for Society (XRE4S) integra 35 grups de recerca de 14 universitats, centres de recerca i centres tecnològics catalans i és coordinada per l'IREC. A la XRE4S s'hi han adherit tres entitats: el Clúster d'Energia Eficient de Catalunya (CEEC), el fons d'inversió DEMETER i l'Institut Català del Sòl (INCASÒL). En la Figura 1 es pot veure la presentació esquemàtica de l'organigrama de la XRE4S.
La Xarxa d'R+D+I Energy for Society (XR4ES) ha dissenyat un programa per impulsar la valorització i transferència tecnològica en l'àmbit de l'Energia a Catalunya. L'objectiu és augmentar l'impacte d'aquesta transferència en el sector productiu i social a Catalunya i convertir Catalunya en un pol d'innovació energètica a nivell internacional. Per aquest motiu, el Programa de Valorització i Transferència s'anomena "Catalunya, pol d'innovació energètica internacional".
Funding: AGAUR + FEDER
Type: Competitive Nationals, Coordinator
Partners: Fundacio Institut de Recerca de l'Energia de Catalunya (IREC)
Date: 2018 - 2022
Group: Corporate Development and Technology Transfer
P.I: Manel Sanmartí Cardona
More info at the following link

13. OUTREACH & SOCIETY

The future of our planet and a more sustainable and equitable society depend on our use of energy, one of the important pillars of society's progress. Nowadays, the role of the energy system is one of the priorities of the scientific, political, economic and social agenda, given the wide repercussions it has on the planet.

The foreseeable depletion of fossil resources and climate change as a result of greenhouse emissions have generated a series of challenges that transcend individual actors and national spheres, and thus require global research efforts towards common solutions.

We have to rethink how we manage energy, and find new and better sources. In this sense, IREC's experience in collaborating with society allows us to Shape Energy for a Sustainable Future. This interaction allows us to channel expectations and social demands, as well as make progress in aspects such as citizen awareness, responsible energy consumption and contribute to the promotion of open dialogue between different actors (society, industry and public sector).

At IREC, we aim to have an impact and boost the energy transition our planet needs, in collaboration with society that allows a mutually beneficial relationship.

We work with leading researchers around the world, as well as with industry and public administration. Therefore, we understand that it's crucial to engage in fruitful discussions with communities that represent the needs and opportunities of our society: learners of all ages, and people that as individuals or in their roles as entrepreneurs or managers, are confronting decisions about energy in their daily lives.

This is why we foster open dialogue and mutual learning between our team and society. Together, we have a better chance of overcoming the challenges before us.

In this regard, IREC encourages public participation and collaboration to raise new questions and co-create a new scientific culture. Some of the outreach activities that IREC takes part are:

- IREC Open Days and Mapping
- European Researchers' Nights
- International Day of Energy Efficiency
- Workshops in the frame of the International Day of Women and the Girls in Science
- Gonano Innovation and co-creation workshop (add link to EU initiative)

In the local and national area, we participate in initiatives such as:

- Fotciencia
- 100tífiques
- Promotion of scientific vocations (Espai Jove – Ajuntament de Barcelona)
- 10alamenos9 Festival

- Collaborations with some artists in the framework of the Nanocaedre activity.

Our researchers are also frequently sharing their expertise via round table discussions and public talks at third-party events, as well as through publications and interviews in the media.

In addition to these institutionally led activities, our groups actively participate in the dissemination of the publicly funded projects that they are involved in, including the

organization of events for the general public, dissemination in national and international conferences, and training sessions, among others.

Committed to public engagement

IREC is firmly committed to the promotion of an informed public that can then engage in decision-making for the future of energy. In this sense, we've increased the number and scope of activities in recent years and, as a result, citizen participation is now an integral component of our program.

This outreach strategy falls in line with policies set out by the relevant governing bodies of Spain and the EU. It is through these open, trans-disciplinary conversations that we are fostering more democratic science policies and building a more evidence-informed society.

14. THE TEAM

INDEX OF THE IREC STAFF AND RESEARCHERS AT 31.12.2020

NAME		POSITION
Morante Lleonart, Joan Ramon	(8)	Director

AREAS

Management and Administration

Chulilla Corral, Elisabeth	Corporate Communications Manager and Director Assistant
Collado Borrull, Miguel Angel	Maintenance
Colomina Martinez, Montserrat	Administrative Staff
Fontana Vinelli, Raquel	Administrative Staff
González Villanueva, Emilio	Administrative Staff
Lara Bejar, Yolanda	Head of Accounting
Marfà Sánchez, Jaume	Director of Finance and Management Area
Mediano Valiente, Begoña	Health and Safety Technician
Ramírez Galaso, Eduardo	Administrative Staff
Torregrosa Mora, Francesc	Head of Human Resources
Valls Mariscal, Francesc	Head of Maintenance

Research Management Services

Francisco García, Inés	Researcher Manager
Hernández Rodríguez, Elba Maria	Researcher Manager
Herrera Rodríguez, Josep M.	Researcher Manager

Baboim Vall, Vanessa	Head of Researcher Management
Viaplana Rueda, Rita	Researcher Manager

Corporate Development and Technology Transfer

Fonrodona Turón, Marta	Project Developer
Magrasó Sola, Anna	Project Developer
Noris, Federico	Project Developer
Sanmarti Cardona, Manel	Head of Technology Transfer
Tarres Font, Joana	Project Developer

Advanced Materials and Systems For Energy Area

Morante Lleonart, Joan Ramon	(8)	Head of Area
Sylla, Dioulde		Laboratories Technician

Functional Nanomaterials Research Group

Cabot, Andreu	(9)	Group Leader
Guardia Giros, Pablo	(3)	Researcher
Liashenko, Ievgenii	(4)	Phd Fellowship
Ramon Ferrer, Alberto	(5)	Phd Fellowship

Solar Energy Materials and Systems Research Group

Andrade Arvizu, Jacob Antonio	Phd Fellowship
Becerril Romero, Ignacio	Phd Fellowship
Fonoll Rubio, Robert	Phd Fellowship

Giraldo Muñoz, Sergio		Phd Fellowship
Guc, Maxim		Researcher
Hernández Martinez, Alejandro	(5)	Phd Fellowship
Izquierdo Roca, Victor		Researcher
Jehl, Zacharie Victor Samuel N	(9)	Researcher
Lopez Garcia, Alejandro Jose		Phd Fellowship
Perez Rodriguez, Alejandro	(8)	Group Leader
Placidi, Marcel Jose		Researcher
Sanchez Gonzalez, Yudania		Laboratory Technician
Saucedo Silva, Edgar Ademar		Researcher
Vidal Fuentes, Pedro		Phd Fellowship

Nanoionic and Fuel Cells Research Group

Alayo Bueno, Nerea		Researcher
Anelli, Simone		Phd Fellowship
Baiutti, Federico		Researcher
Bernadet, Lucile		Researcher
Bianchini, Marco		Researcher
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