imdea energy institute

research for a **sustainable energy development**

institute
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energy

annual report 2014

foreword

foreword

David Serrano
Director of the IMDEA Energy Foundation

Móstoles, September 2015

annual report
2014

I am glad to introduce the Annual Report of the IMDEA Energy Institute, which highlights the main outcomes and achievements corresponding to 2014. IMDEA Energy is aimed to the development of novel, efficient and clean energy technologies for contributing to the transition towards a low-carbon energy system. Created by the Regional Government of "Comunidad de Madrid", IMDEA Energy is featured by having a modern and flexible management system, whereas scientific excellence, international impact and cooperation with industry are the key drivers of its activities.

The Scientific Programme of IMDEA Energy addresses a number of topics of high industrial and social relevance: concentrating solar thermal power, production of sustainable fuels, energy storage materials and devices, smart management of electricity demand, energy systems with enhanced efficiency and valorization of CO_2 emissions.

The headquarters of IMDEA Energy are located in a new building in the Technological Park of Móstoles (Madrid), provided with high efficiency energy systems, having been awarded with the Gold LEED certificate, which is a highly reputed international recognition for buildings with a minimum environmental impact. Likewise, the availability of sophisticated lab equipment, as well as of singular pilot plant infrastructures, allows the research activities to be performed on a very high level.

IMDEA Energy is organized in six research units including scientists with a great variety of backgrounds and specializations like mechanical, electrical and chemical engineering, physics, biology, chemistry, biochemistry and environmental science, among others. This provides the Institute with a high qualified and multidisciplinary team of researchers to undertake the study of complex energy systems. By the end of 2014, the staff working in IMDEA Energy reached a total of 70 persons. About two third of the researchers hold a Ph.D degree, with up to 16 different nationalities being represented in agreement with the international profile of the IMDEA Energy Institute. In addition, about 43 B.Sc. and M.Sc. students have been trained by participating in the different research topics of the Institute.

During 2014, IMDEA Energy had 42 ongoing research projects funded by public administrations and private companies, with a strong contribution of international projects. The external funding executed by the Institute in 2014 reached 1.8 M€ which represents a 10% increase compared to 2013. The collaboration with private companies has also grown in 2014, which is a fact of special relevance since one of the main goals of the IMDEA Energy Institute is to stablish strong alliances with the industrial sector and to promote technology transfer.

Remarkable scientific results have been also obtained in 2014, as denoted by the 66 scientific works published in indexed journals and the 77 communications presented in scientific congresses. Likewise, IMDEA Energy researchers have participated in a wide variety of science dissemination actions, such as invited lectures, masters and technical seminars.

These excellent results have been possible thanks to the commitment and strong dedication of the IMDEA Energy staff, as well as to the continuous support received from the Regional Government of "Comunidad de Madrid".

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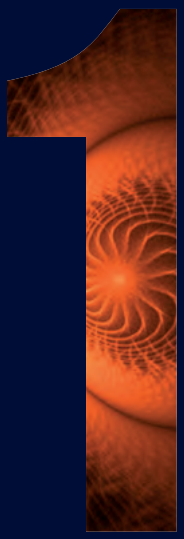

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The IMDEA Energy Institute is a Research Centre funded by the Regional Government of Comunidad de Madrid and operates as a not-for-profit foundation. The Scientific Programme of the IMDEA Energy Institute aims at contributing to the future establishment of a sustainable energy system. Thereby, two main objectives are guiding the work-programme:

- R&D activities focused on fostering the development of renewable energies.
- R&D activities aimed at developing clean energy technologies that have none or minimal environmental impact.

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

Research topics addressed at the IMDEA Energy Institute are concentrated within the following areas:

- Solar energy systems and technologies.
- Production of sustainable fuels for the transport sector.
- Energy storage coupled to renewable energies.
- Smart management of electricity demand.
- Energy systems with enhanced efficiency.
- Confinement and valorization of CO_2 emissions.

The strategic framework guiding the R&D priorities of IMDEA Energy is based on goals and priorities established by energy plans and research programmes at regional, national and European levels; such as the new European Strategic Energy Technology (SET) Plan; the European Research Framework HORIZON 2020; technology roadmaps of recognized international institutions and associations and implementation agreements of the International Energy Agency.

governing bodies and functional structure

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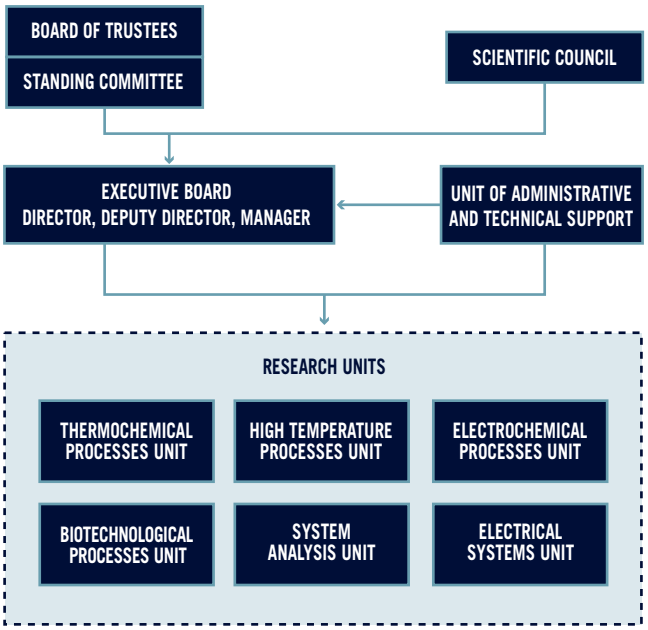
The organization and functional structure of the IMDEA Energy Institute is summarized in the following diagram with indication of its main bodies and units:



2.1. Board of Trustees

The Board of Trustees is the highest decision-making body of IMDEA Energy. It is responsible for its government, representation and administration, aiming to ensure the achievement of the objectives purposed by the institution. It is composed by scientists with international prestige, energy experts, and representatives of the regional administration, universities, public research centres, and industry sectors. The meetings of the Board of Trustees are held twice per year since its creation.

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Director of Institute of Environmental Technology and Energy, Hamburg University of Technology, Germany

Excma. Sra. Lucía Figar de Lacalle
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General Director of "Fundación para el conocimiento madri+d"
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Spain

SECRETARY

Mr. Alejandro Blázquez Lidoy
Consultalia
Spain

Standing Committee

The Standing Committee holds a large fraction of delegated powers of the Trust, to support the day-to-day operation of the Foundation. The composition of the Standing Committee as of December 31st, 2014 is listed below:

- Ilma. Sra. Lorena Heras Sedano
- Mr. Juan Angel Botas Echevarria
- Mr. Jose de la Sota Rius
- Mr. Rafael van Grieken Salvador
- Mr. Julian Garcia Pareja, Secretary

2.2. Scientific Council

This Council is aimed to advise and to help the Director of the Institute in elaborating the scientific programme and in establishing the goals to be achieved by periods of four years as well as of assessing the annual performance of the Institute.

SCIENTIFIC COUNCIL

Prof. Dr. Martin Kaltschmitt
Director of Institute of Environmental Technology and Energy
University of Technology, Germany

Dr. Nazim Muradov
Principal Research Scientist
Florida Solar Energy Center
University of Central Florida, USA

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

Dr. Michael Epstein
Head of Solar Research Facilities Unit
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Dr. Carmen M. Rangel
Research Coordinator
National Laboratory of Energy and Geology, Portugal

Prof. Dr. Javier Soria Ruiz
Research Professor
Institute of Catalysis and Petrochemistry, CSIC, Spain

Prof. Dr. Aldo Steinfeld
Professor of Renewable Energy Carriers
ETH Zurich, Switzerland

Prof. Dr. Iacovos Vasalos
Emeritus Research Professor
Chemical Process Engineering Research Institute, Greece

Prof. Dr. Adriano García-Loygorri
President of the Social Council
Polytechnic University of Madrid, Spain

Prof. Dr. Nikos Hatziargyriou
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Power Division of the Electrical Engineering Department
National Technical University of Athens, Greece

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

Prof. Dr. Francesc Castells
Emeritus Professor
University of Barcelona, Spain

2.3. Executive Board

The Executive Board is responsible for managing and dealing with the main business administration and scientific activities of the whole Institute, except those decisions taken by or shared with the Board of Trustees.

General Director: Prof. David Serrano Granados

The General Director is the chief executive of the IMDEA Energy Institute and chairman of the Executive Board. It is elected by the Board of Trustees, being responsible for the management, supervision and promotion of the organization activities, including business and research administration. Moreover, he is in charge of representing the interests of the Institute both internally and externally according to the directions approved by the Board of Trustees.

Deputy Director: Dr. Manuel Romero Álvarez

The Deputy Director supports the work and may take over some of the responsibilities of the General Director. Likewise, the Deputy Director may represent the IMDEA Energy Institute on behalf of the General Director.

General Manager: Ms. Marta Jiménez Menéndez

The General Manager is responsible for the management and coordination of the different administration issues, such as financial & accounting, legal aspects, human resources and general services. The latter includes all those services that support the day-to-day running activities of the different Research Units and administration staff of the Institute. The General Manager is also in charge of elaborating the general budget draft, which is submitted annually for approval by the Board of Trustees.

2.4. Research Units

Researchers and scientists in the IMDEA Energy Institute are organized in Research Units defined according to their expertise and specialization. The following six R&D Units have been operational during 2014:

- Thermochemical Processes Unit
- Electrochemical Processes Unit
- Biotechnological Processes Unit
- High Temperature Processes Unit
- Electrical Systems Unit
- System Analysis Unit

2.5. Management, Administration & Technical Support Unit

By the end of 2014 the Management, Administration and Technical Support Unit of IMDEA Energy is formed by 10 persons, whose main function is to perform a variety of management activities, such as accounting, expenses, contracts, inventory, project management, and technical services, which are essential for supporting the work of the different scientists and R&D units.

The Management, Administration and Technical Support Unit includes the following areas of work:

Economic Management and Human Resources Area

- Ms. Nuria Merino Benito, Responsible
- Ms. Carlota Álvarez Pellicer
- Ms. Andrea García García
- Ms. Isabel Gámez Soria

Main responsibilities of this area are as follows:

- Accounting and financial management.
- Purchases management and monitoring.
- Supplier's management.
- Human resources management.
- Elaboration and update of the inventory.
- Travel and allowance.
- Labor risks prevention.
- General services management.
- Bibliographic resources management.
- Institute webpage update.

Project Management Area

- Dr. Carmen Perez Rodriguez
- Ms. Eloisa Mateos Sevilla

Their main responsibilities are as follows:

- R&D project management and support.
- Identification and dissemination of R&D funding opportunities (regional, national and international calls).
- Preparation of proposals to be submitted to public R&D calls.
- Contracts with companies and agreements assessment.
- Intellectual property rights management.
- Technology watch reports.
- Elaboration of the Institute annual activities report.

External Relationships and Technology Transfer Area

- Dr. Felix Marín Andrés
- Ms. Carolina García Cortés

Its main objective is to increase the national and international visibility of the R&D&i capabilities and scientific infrastructure of IMDEA Energy that make the Institute a valuable partner for companies, research centers and universities all over the world.

Infrastructure and Facilities Area

- Ms. Silvia Mateo Rincón, Responsible

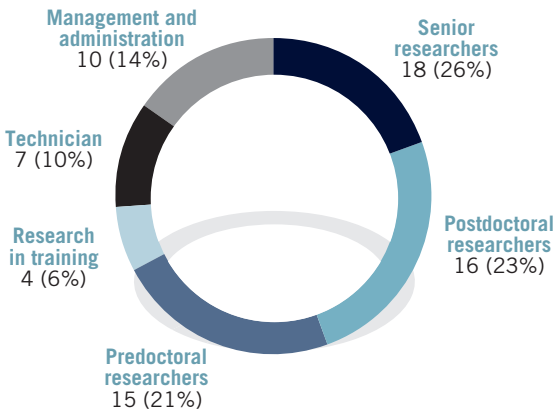
The main competences of this area are focused on the building facilities: management, adaptation works, maintenance and scientific equipment support.

Technical Support Area

- Ms. Mª Eugenia di Falco Salmerón, Laboratory Technician
- Ms. Laura García Firgaira, Laboratory Technician
- Dr. Fernando Picó Morón, Microscopy Technician
- Mr. Pablo Matatagui, Electrical Laboratory Technician
- Dr. Javier Celaya, Pilot Plant Technician
- Mr. Javier Marcos, Pilot Plant Technician
- Mr. Daniel Fernández, Pilot Plant Technician
- Mr. Ignacio Almonacid, Pilot Plant Technician

The technical support area is formed by technicians working in the IMDEA Energy laboratories, as responsible of managing and using scientific equipment and infrastructures.

At the end of 2014, the personnel working in the IMDEA Energy Institute reached 70 persons distributed as follows: 53 researchers, 7 technicians and 10 management staff. In addition, about 43 undergraduate students have been doing different types of work and activities (internships and B.Sc and M.Sc final projects) in connection with the IMDEA Energy Institute.



research lines

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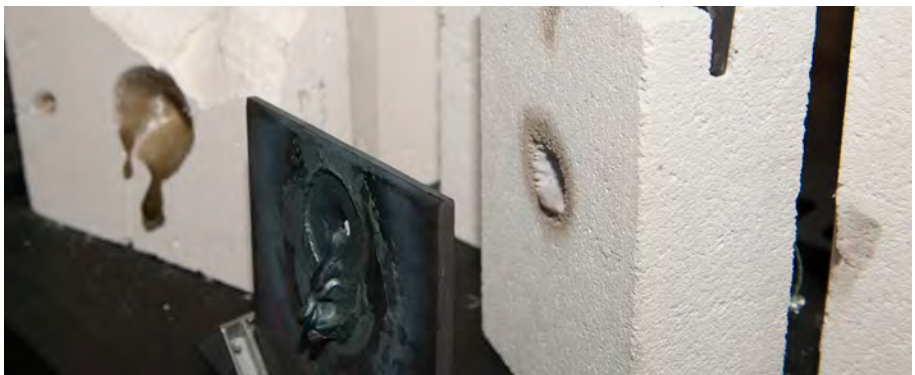
3.1. Concentrating solar power

The Concentrating Solar Thermal Power (CSP) systems are important candidates for providing distpatchable solar electricity needed within the next few decades in highly irradiated regions and emerging solar markets. The approval in the past few years of specific financial incentives in Spain, USA, Italy, Algeria, India and China and some relevant projects funded by the World Bank in developing countries like Egypt, Mexico and Morocco, are serving as technology and market drivers. In most cases Spanish companies are leading the developments and subsequently revitalizing the demand of R&D. This first generation of commercial projects is mainly based on technological developments and concepts matured after more than two decades of research. Nevertheless, the current generation of solar thermal power plants is still based on conservative schemes and technological devices which do not exploit the enormous potential of concentrated solar energy. Commercial projects use technologies of parabolic troughs with low concentration in two dimensions and linear focus, or systems of central tower and heliostat fields, operating with thermal fluids at relatively modest temperatures, below 400 ºC. The most immediate consequence of these conservative designs is the use of systems with efficiencies below 20% in the conversion of direct solar radiation to electricity, the tight limitation in the use of efficient energy storage systems, the high water consumption and land extension due to the inefficiency of the integration with the power block, the lack of rational schemes for their integration in distributed generation architectures and the limitation to reach the temperatures needed for the production of solar fuels, like hydrogen.

The main technological challenges to be faced by the concentrating solar energy technologies in the following years are:

- Significant improvement of global profitability of solar thermal power plants, through a cost reduction of the main system components like absorbers, receivers and solar concentrators, the reduction of associated O&M and elaboration of testing procedures and measurement techniques.

- Better integration of CSP systems into thermal power plants by developing advanced designs able to create more efficient and modular schemes of hybridization or solar stand-alone systems with heat storage, as well as other applications like the generation of solar fuels or chemical products.



3.2. Production of sustainable fuels

The transport sector plays a relevant role in the energy panorama of both Spain and "Comunidad de Madrid". Most of the liquid fuels so far employed have a fossil origin, and therefore the transport sector is responsible in a large extent for the greenhouse gases emissions. Accordingly, the development of alternative and environmentally friendly fuels is of high interest. Within this research topic two different areas are considered:

Advanced biofuels

Biofuels are renewable energy sources because they are derived from biomass, principally from plants. The CO_2 emitted during their transformation into useful energy is balanced, at least in part, by the CO_2 absorbed during the growth of the plants. While some biofuels have already reached the production at a commercial scale, many limitations still exist that hinder the substitution of conventional liquid fuels at significant rates. Accordingly, the use of biofuels must be currently supported by the public administrations through tax reduction policies or by making mandatory the inclusion of a minimum amount of biofuels in the formulation of commercial fuels. Likewise, in many cases the raw materials employed for biofuels production are also applied in the food manufacture. This fact may have undesired effects by coupling the energy and food markets. This is the case of bioethanol production from sugar-rich plants and the biodiesel production from oil-rich crops (first generation of biofuels). Therefore, a very important challenge is the development of new processes for the production of biofuels using raw materials that are not applied in the food industry, such as lignocellulosic materials, microalgae and agriculture wastes.

Areas for technology development in this field are:

- Development of innovative processes for the production of advanced biofuels from biomass resources: production of bioethanol non-edible by hydrolysis and fermentation of lignocellulosic biomass, catalytic pyrolysis of agriculture and forestry residues for the production of bio-oils, and development of feasible processes for turning microalgae carbohydrates into biofuels.

- Optimization and improvement of biofuel production via flash pyrolysis or catalytic pyrolysis of lignocellulose biomass. This route also implies the subsequent catalytic hydrodeoxygenation processes for bio-oil upgrading. Research should concentrate on the development of very active and selective multifunctional catalysts and the possible integration of biomass transformation processes into oil refineries in order to develop and demonstrate the feasibility of the bio-refinery concept.

CO_2-free hydrogen production

Hydrogen is considered as a clean fuel since the only product formed during its combustion is water. However, hydrogen is not a primary energy source as it cannot be found free in our planet. Currently, almost all the hydrogen is produced by steam reforming of natural gas, but this process generates significant CO_2 emissions. Therefore, new CO_2-free routes must be developed for obtaining hydrogen in order to achieve a fully sustainable energy vector. In this way, methane decomposition, using both thermal and catalytic treatments, has been recently proposed as an interesting alternative for hydrogen generation because the carbon contained in methane is fixed as a carbonaceous solid and therefore no CO_2 is released. Other production routes that may need long term developments are those related to the hydrogen generation from water using renewable energies to perform H_2O dissociation. The following R&D lines summarize the priorities in the hydrogen production field:

- Hydrogen production by decarbonisation of hydrocarbons, with special emphasis in biogas (methane) decomposition. As this process involves the formation of large amounts of solid carbon, CO_2 emissions can be avoided, but at the same time it makes necessary the development of new commercial applications for this by-product. In this respect, controlling the selectivity to the different carbon allotropes is crucial to facilitate the applicability of this product in electronic or as an additive of building materials.

- Development of hydrogen production processes via thermochemical routes using solar power and hybrid cycles. This line requires the development of new thermochemical cycles having high overall efficiencies and stability during the cyclic operation, as well as moderate working temperatures.

- Hydrogen generation by photocatalytic and photoelectrochemical dissociation of water. Although these transformations present the advantage of taking place at room temperature, the main challenge is the development of systems having high efficiency and stability under visible and near-UV light irradiation as to achieve an efficient solar energy conversion.

3.3. Energy storage coupled to renewable energies

The main objective of the R&D in this field is to develop technologies and systems for the storage of energy enabling the increased penetration of renewable energies and the distributed generation of electricity. The energy storage systems that are considered of interest for being investigated at the IMDEA Energy Institute are the following:

Electrochemical energy storage

In this topic, research aims to the development of newer, safer and more environmentally friendly electrochemical storage systems, namely batteries and capacitors. Sustainable electric grids involve a considerable proportion of renewable generation and the manageability of such type of grids requires an increasing capacity of electrical energy storage for a variety of uses such as voltage sags and reactive power compensation, peak shaving, frequency regulation, load shifting, renewables firming, black start and many others. Likewise, sustainable transport is based on electrification and electric accumulators in which much higher energy densities are required if the range of electric vehicles has to be extended to values that make them more acceptable for a majority of drivers. At the same time accumulators for transport applications must provide sufficient power to facilitate good dynamic behavior, long cycle life to avoid early battery replacements, guaranteed safety in case of crash or abuse, and everything at contained cost. Such combination of requirements makes this an extremely demanding application for electrochemical storage systems. The research programme focuses on how newer materials and designs may improve the performance of these systems and on the application of electrochemical storage systems to renewable power generation, sustainable buildings and electrical vehicles. R&D priorities in this field are the following:

- High energy-density electrochemical capacitors for stationary and transport applications, with focus on using both electrochemical double layer capacitor and pseudocapacitor approaches. Emphasis is placed on non-conventional electrolytes such as hydrogels, ionic liquids, polymeric ionic liquids, and electrode materials alternative to activated carbons, such as carbon fibers, carbon nanotubes, metal oxide nanoparticles.

- Low-cost flow batteries for stationary applications in solar and wind power plants with research on (a) new highly reversible redox couples as advanced electrolytes with higher energy efficiency and lower cost, and (b) nanoporous separators as an alternative to traditional ion exchange membranes increasing proton selectivity via pore size exclusion.

- High-performance flow batteries based on the use of organic redox couples, to avoid transition metals, making the electrolytes more environmentally friendly and providing unusually high energy densities that would make flow batteries useful in transport applications.

- Electrically rechargeable metal-air batteries characterized for their very high energy densities and with abundant and low cost raw materials (in the case of sodium, magnesium and aluminum), which make them ideal candidates for transport applications, where Li-ion systems do not reach the cost and performance objectives.

Thermal and thermochemical energy storage

To the urgent need to provide a higher degree of dispatchability to renewable energy power plants and grid-stability, it should be added the interest on enhancing the performance of (high-energy consuming) thermal processes and optimising the heat management in netzero buildings. All these issues converge in an active R&D program in the field of thermal energy storage. The IMDEA Energy Institute addresses within its strategic programme research activities on materials and storage systems making use of sensible, latent and/ or thermochemical heat. They comprise water adsorption on porous materials for low temperature (80-120 ºC) seasonal storage, phase change materials (PCM) and gas/solid systems customized for medium (250-400 ºC) and high temperature redox systems for high temperatures (400-900 ºC). PCMs and thermochemical storage are mainly focused on solar thermal applications.

3.4. Smart management of electricity demand

Further deployment of renewable energy technologies and decarbonisation of energy supply mix in electricity networks are both pending on a consensual solution for a series of complex legal, economic and technical issues. This fact underlines the importance of introduction of new flexible power network architectures and development of new network management algorithms. Increased levels of energy system integration and modularity are expected with the clear objective of improving the security of supply of critical loads, improving the load factor of distribution feeders and providing for all network users more flexibility in grid connection and accessing the future real-time electricity market. Smart management algorithms rely largely on the capacity of information technologies to acquire and distribute real-time data between all the parties in future power networks and also on the deployment of various types of energy storage devices across the network. The core R&D lines and topics of the IMDEA Energy Institute in regard to the smart management techniques for future electricity networks are as follows:

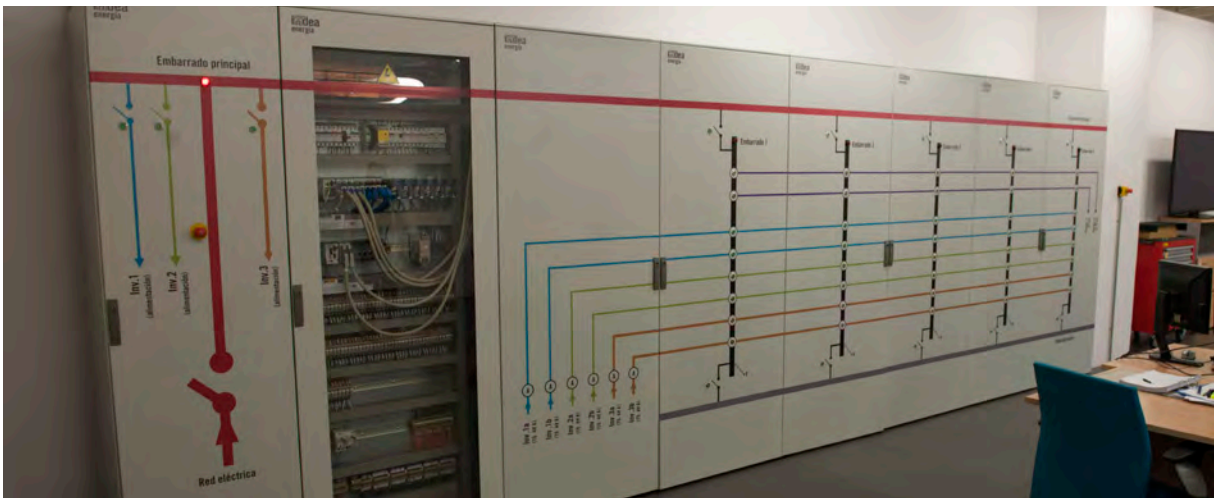
- New management algorithms for introducing more flexibility in achieving energy balance in all principal subsystems forming electricity networks - generation, distribution and consumption. Centralised and decentralised control architectures, real-time measurement and control, more intensive use of energy storage systems are only some of the proposed solutions. It is also relevant the creation of new energy-aware services and demand response schemes for final energy users, network operators and energy providers. Development of new power network models that include both dynamic and stochastic properties for the connected network devices is one of the principal tasks.

- "Smart Neighbourhoods", "Smart Buildings" and "Smart Homes". Starting from the definition of local energy demand, energy supply available and relevant cost information, an optimal hybrid generation system can be proposed. This coordinated scheme is possible to apply on different power levels and can produce significant cost and energy savings as well as an additional level of flexibility in meeting the energy demand. Effects of integration of on-site renewable generation for improving autonomy, self-consumption and net balance are all under investigation.

- Energy efficiency in industrial applications. Development of the next generation of industrial control systems is necessary to achieve high efficiency of energy consumption and high flexibility of energy demand. This also assumes research and development of real-time algorithms for estimation and optimisation of energy consumption and control of available energy storage devices and power electronics interfaces.

- Integration of energy storage to electricity networks. Various scenarios on how distributed energy storage devices (including electric vehicle battery storage) can be used to contribute to network control, increase capture from intermittent energy sources and provide vehicle charging are investigated.

- Electrical energy conversion and power interfaces. Power electronics converters emulating operation and dynamics of real distribution feeders, generators and load profiles provide the testing environment for development and implementation of algorithms for future power networks. The system optimisation targets can be then flexibly changed to match any power network scenario and verify the control criteria set.



3.5. Energy systems with enhanced efficiency

In the IMDEA Energy Institute the use of energy systems with enhanced efficiency are contemplated from the point of view of better integration of solar thermal power plants in advanced thermodynamic cycles and/or cogeneration systems and the connection to the smart electricity management of demand. Research activities focus onto the hybridization of several renewable energy sources for applications in dwellings, hotels, commercial centres, power plants and communities. The optimization of this integration implies the design of efficient integration schemes, flowsheeting and performance analysis with appropriate tools. Controllability and management of demand are also key aspects in this research field. Polygeneration and efficient end-use of energy are topics of enormous impact on energy saving and efficiency enhancement. The combination and integration of several products or energy vectors like electricity, heat, cooling or water desalination should lead to a more efficient energy cascade and facilitate the penetration of modular integrated utility systems. Since most polygeneration systems make use of rejected heat, for example from gas turbines, solar receivers, chemical reactors or heat-exchangers operating at moderate temperatures, they are strongly connected to new developments on thermal power generation systems.

An additional issue of interest is the development of water treatment technologies with a very efficient use of the energy supplied to remove dissolved ions from hard, brackish or sea water and the production of the smallest possible amount of effluents. This will be based on novel deionization technologies but also in the appropriate design of the electrochemical reactor and of the treatment process, as well as the selection of adequate operating conditions.

3.6. Confinement and valorization of CO_2 emissions

This topic tries to cope with the increasing CO_2 concentration in the atmosphere by fixing these emissions by different methodologies. So far most of the initiatives carried out in this line have been focused in the CO_2 concentration and capture, but enormous uncertainties still exist about the stability of the stored CO_2. Likewise, a number of alternatives have been recently proposed with the objective of considering the feasibility of the re-use and valorization of CO_2 produced by the combustion.

Based on this context, the following R&D themes are considered at the IMDEA Energy Institute within this topic:

- Evaluation of the viability of the different alternatives under consideration for CO_2 confinement: storage in exhausted mine sites, accumulation in the deep waters of the ocean and confinement in form of carbonates and solid carbon, by means of life cycle analysis.

- Development of CO_2 valorization routes by its transformation into high-demand valuable products. Since this kind of processes will be in most cases endothermic, solarisation of the CO_2 transformation will be necessary in order to get a positive overall energy balance. This can be accomplished by photocatalytic or thermocatalytic routes. In this respect the main challenge is to achieve larger production yields, since those obtained up to now are far from being competitive with other technologies. Likewise, the demand of the transformed products is a key reference in order to determine the feasibility of the different alternatives considered.

scientists and research units

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The different strategic research lines are covered through R&D Units characterized by their specialisation fields. This results on an efficient transversal organization, which is providing high versatility for dealing with the different research topics and high flexibility for being adapted to the changes in the R&D needs along the time.

The different Research Units included in the IMDEA Energy Institute are the following:

- **Unit of Thermochemical Processes (TCPU).** Involved in production of clean and sustainable fuels, using different raw material sources, like hydrogen (methane decomposition, thermochemical cycles) and biofuels (biomass pyrolysis and hydrotreating processes). It is also active in CO_2 valorization (photocatalytic process) and waste conversion into energy products.

- **Unit of High-temperature Processes (HTPU).** This unit is largely focused in the development of projects related to concentrating solar power, although its expertise is also of high interest in other topics such as thermal energy storage, solar-driven hydrogen production and CO_2 valorization.

- **Unit of Electrochemical Processes (ECPU).** This unit plays a leading role on the development of new electrochemical energy storage systems coupled to renewable energies, sustainable buildings and green vehicles (ultracapacitors and batteries) and energy efficient water treatment systems (capacitive deionization).

- **Unit of Biotechnological Processes (BTPU).** This unit is engaged in the development of novel processes for biofuels production with primary focus on technologies to convert biomass (lignocellulosic biomass, algae, and other biological material) into biofuels. The BTPU researchers are working to improve the efficiency and economics of the biochemical conversion process by focusing on the most challenging steps such as both enzyme and fermenting microorganism's development and biofuels production from microalgae.

- **Unit of Electrical Systems (ELSU).** This unit deals mainly with the R&D activities related to the smart management of electricity demand, and related topics like integration of renewables in distributed generation systems, design and control of microgrids, industrial energy saving and power network simulation.

- **Unit of System Analysis (SAU).** This unit provides global analysis of the different energy alternatives and problems, including technological-scientific aspects, like life cycle assessment, but also economic, social, legal and environmental issues.

4.1. Thermochemical Processes Unit

Research activities

One of the main objectives of the thermochemical processes unit (TCPU) is to provide technological alternatives to current dependence on fossil fuels, and more particularly for the transportation sector. Obviously, this is a very ambitious goal, which is indeed pursued by research groups around the world, and it requires a multidisciplinary approach to identify the most reliable and sustainable resources and processes in terms of cost and efficiency, according the niches of end use. Within this context, the activity of the UPTQ focuses on the study of catalysts for application in some chemical transformations that definitely play an important role in the establishment of a more rational energy model.

In the year 2014, special attention has been paid to the development of routes for the generation of hydrogen without associated CO_2 emissions. In this regard, some of the most promising approaches are the dissociation of water using thermochemical cycles coupled with technologies of solar concentration or the use of photocatalytic processes in more benign conditions of operation. With respect to this latter process, it is important to highlight that the UPTQ researchers have recently developed a very efficient photocatalysts from modification of $NaTaO_3$ by introducing Nb into the structure and increasing the surface area through a hydrothermal treatment. In addition, the unit has been working of chemical modification of the thermochemical cycle of Mn_2O_3-NaOH for hydrogen production at less harsh conditions of temperature and reducing the corrosion processes. In parallel, the development of new perovskites with redox capacity has also approached as possible materials active for the thermal water splitting.

The possible use of biomass residues from agriculture or forestry as resources for the production of a second generation bio-fuels, are among the strategic research lines of

TCPU. Within this context, optimization of heterogeneous catalysts for pyrolysis is currently underway as an effective alternative to reduce the oxygen content of bio-oils. In this respect interesting results have been obtained using basic oxide supported on modified zeolites. In parallel, the research group has been actively working in the hydrotreating of both, bio-oils produced by flash-pyrolysis and triglycerides from specific energy crops such as camelina, in order to explore the upgrading of these feedstocks, as to improve their compatibility with conventional fuels. This research line relies crucially in the design of multi-functional heterogeneous catalysts with enhanced selectivity and stability. In this field, very positive results have been obtained using hydrogenating active phases based on transition metal or metal phosphides dispersed on micro -mesoporous supports with moderate acidity.

Another relevant field of research for the TCPU is the fixation of atmospheric CO_2 throughout the conversion into useful chemicals, in a process which mimics the photosynthesis of plants. This is a very challenging approach for tackling greenhouse emissions, which require a long-term investigation which implies the design of new photoactive components based on semiconductor and hybrid organic-inorganic materials. Although the efficiency of this technology is still very low and accordingly it is far from what it would require its commercial development, it offers great potential for the storage of solar energy in chemicals form such as light hydrocarbons (mainly methane) or methanol. In addition, this process could help to significantly reduce CO_2 emissions. In this context, the investigations of the TCPU have also approached the fundamental understanding of the mechanisms governing the photoactivation process using spectroscopic techniques such as TAS (Transient Absorption Spectroscopy).

Finally, another area of activity of this unit is the development of improved materials with thermal storage capacity, as a way to enhance the production of electricity solar thermal plants. In the case high temperature applications it has been proposed to work in redox reactions with transition metals such as the pair Mn_2O_3/Mn_3O_4. In this system modification of the chemical composition and morphology are crucial aspects that determine the stability and kinetics of redox processes.

As a summary, it can be concluded that considering that most of the above mentioned processes involve the use of heterogeneous catalysts or reactive solids, it is worth noting the expertise of the TCPU is developing macro, meso and microporous materials with different physicochemical characteristic, can be conveniently adapted to a wide variety of energetic processes.

scientists

Prof. David P. Serrano

Research Professor
Head of the Unit

He is Full Professor of Chemical Engineering at Rey Juan Carlos University and Director of IMDEA Energy. He is also the Head of the Thermochemical Processes Unit. He received his Ph.D. from Complutense University of Madrid in 1990 awarded with the Extraordinary Mention and he has been Visiting Scholar in the California Institute of Technology (CALTECH, 1991) and in the California University of Santa Barbara in 2006. He was appointed as Professor at Complutense University of Madrid in 1990-1999, and subsequently at Rey Juan Carlos University. In the latter, he has been in charge of different management and academic positions: Coordinator of the Environmental Sciences Area in 1999-2001, Vice-rector for Research and Technological Innovation in 2001-2002 and Head of the Chemical and Environmental Technology Department in 2002-2007. His main research interests are development of novel zeolitic and mesostructured materials, plastic wastes valorisation, production of advanced biofuels from different biomass sources and hydrogen production free of CO_2 emissions. He has been involved in more than 50 research projects funded by both public and industrial partners. He is author of about 150 publications in scientific journals, 5 patents and of 4 books. Besides he has presented more than 200 communications in scientific conferences. He has supervised 19 Ph.D. theses. He is member of the editorial board of several journals and of the scientific council of CIESOL and the German Biomass Research Centre.

Dr. Juan M. Coronado

Senior Researcher

Ph.D. in Chemistry by the Complutense University of Madrid in 1995. In 1997 he was awarded a grant of the "Marie Curie" EU program and spent two years as a postdoctoral fellow at the University of Dundee (UK). He was a "Ramon y Cajal" researcher at the ICP-CSIC. Since 2005 he was a tenured scientist at CIEMAT. In 2009 he was appointed as senior researcher at IMDEA Energy. His scientific activity is mainly focused on the development of processes for the production of sustainable biofuels using advanced hydrodeoxygenation catalysts, the photocatalytic valorization of CO_2 and the development of new materials for thermochemical storage. He has published more than 80 research papers, he has presented more than 80 communications to international and national conferences and he has participated in 12 research projects funded by different public institutions and companies.

Dr. Victor A. de la Peña

Senior Assistant Researcher

Ph.D. in 2003 by the Catalysis and Petrochemistry Institute of CSIC. In 2004, he was awarded with a "Juan de la Cierva" fellowship at the UB and since 2008 he is a "Ramon y Cajal" researcher of the TCPU. Among other topics, his research interests are focused on heterogeneous catalysis, theoretical chemistry and in-situ characterization fields and their application on selective reactions of energetic interest. He is author of 58 publications in peer-reviewed journals and 1 world patent. He has participated in 40 scientific conferences, and he has been involved in 10 research projects.

Dr. Patricia Pizarro
Associated Researcher

Ph.D. in Chemical Engineer in 2006 with extraordinary Award by the Rey Juan Carlos University, where she is now Associated Professor. She is an expert in the preparation of mesostructured and zeolitic materials. She has published 25 scientific articles, presented over 40 communications to conferences and she has participated in 22 research projects. In addition, she has supervised 21 Student Research Projects at Rey Juan Carlos University.

Dr. Prabhas Jana
Senior Assistant Researcher

Ph.D. by the National Chemical Laboratory (NCL), India in 2007. He has a considerable expertise on the preparation of catalysts including those based on supported gold nanoparticles. He is author of 30 articles in several international journals and he holds 4 U.S. patents.

Dr. Javier Fermoso
Postdoctoral Researcher

PhD by the National Institute of Coal, CSIC, Spain in 2009 focused on the high-pressure co-gasification of coal and biomass. From 2010 to 2012 he was working at the Catalysis Group at the Norwegian University of Science and Technology, NTNU in Trondheim (Norway). He is co-author of 20 research articles and he has presented more than 25 communications to conferences.

Dr. Sankaranarayanan T. Murugan
Postdoctoral Researcher

Ph.D. degree from Anna University, Chennai, India in 2013 with the research performed at the National Centre for Catalysis Research under the supervision of Prof. S. Sivasanker. He has 6 publications in international journals. He has participated in 10 research projects.

Dr. Inés Moreno
Associate Postdoctoral Researcher

Ph. D. at Rey Juan Carlos University in 2009. Currently, she works as assistant lecturer in the Department of Chemical and Energy Technology at Rey Juan Carlos University. Her current research is focused on the synthesis and catalytic application of zeolitic materials with hierarchical porosity for the production of 2nd Generation biofuels.

Laura Collado
Predoctoral Researcher

Graduated in Environmental Sciences by Alcala de Henares University in 2007. Master in Energy Technology and Resources by Rey Juan Carlos University in 2010. She is working on CO_2 valorization.

Alfonso J. Carrillo
Predoctoral Researcher

Graduated in Chemical Engineering by University of Salamanca in 2009. Master in Renewable Energies by the University of Leon in 2011. She is working on materials for thermochemical storage.

Antonio M. Berenguer
Predoctoral Researcher

Graduated in Chemical Engineering by University of Granada in 2011. He holds a Master in Renewable Energies from the University of Jaen in 2012. He is currently working on the development of hydrotreating catalyst.

Héctor Hernando
Researcher in training

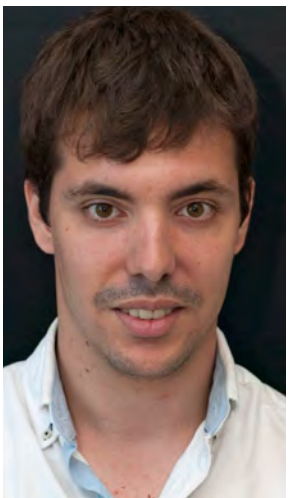
Graduated in Chemical Engineering by Complutense University of Madrid in 2012. He holds a Master in Environmental Management, Quality and Audit in 2014. He is currently working on catalytic pyrolysis to produce advanced biofuels.

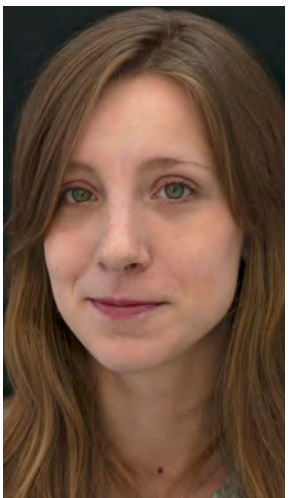
Lydia Zazo
Researcher in training

Graduated in Chemical Engineering by Rey Juan Carlos University of Madrid in 2013. She is working on thermochemical processes for hydrogen production.

Patricia Reñones
Researcher in training

Graduated in Chemical Engineering by Rey Juan Carlos University of Madrid in 2013. She is currently working on production of fuels and industrial products of interest through photocatalytic reduction of CO_2.





4.2. High Temperature Processes Unit

Research activities

The High Temperature Processes Unit (HTPU) has as main objective the development of efficient and cost-effective high temperature technologies and applications with special emphasis on Concentrating Solar Power (CSP). The commercial deployment of CSP systems in Spain and elsewhere is based on first generation technologies with critical limitations. Therefore, the R&D effort focuses on the development of new solar concentrators, absorbers, high-temperature materials, heat transfer fluids, heat storage and thermodynamic and thermoelectrochemical cycles of high efficiency.

The development of modular solar central receiver schemes for high and ultra-high temperature applications is one of the key topics of research of the HTPU. The challenge is to optimize the optical engineering of mini-tower systems with small heliostats able to provide irradiances above 2000 kW/m^2 for incident power in the hundred-kW range. The research involves advanced ray tracing simulation and optical engineering to integrate solar heliostat fields in building façades, urban communities and site constrained areas.

High temperature solar receivers making use of volumetric porous absorbers or directly illuminated particle receivers are two of the key topics of research of HTPU. Volumetric configurations making use of stacks of thin multi-channel monoliths with hierarchical porosity, wall-flow absorbers or organized structures manufactured by selective laser melting techniques are subject of research. The thermal and fluid-dynamics CFD studies include the influence of the optical properties (absorptivity and reflectivity), the geometrical characteristics of the structure (length, wall thickness and spacing between elements) and the incident radiation profile (related to different heliostats field configurations). For experimental characterization of absorber materials a fully equipped test bench has been developed, including mass flow control, temperature measurement and imaging in the visible and infrared spectrum using CCD, CMOS and IR cameras. Particle receivers based

upon the use of rotary kilns or circulating fluidized beds are also subject of research and development for thermal and chemical applications.

Thermal energy storage (TES) systems based on phase change materials (PCM) and reversible chemical reactions can be smaller, more efficient and a lower cost alternative to sensible thermal storage systems for application to CSP. However, most PCMs have low thermal conductivity which leads to slow charging and discharging rates. IMDEA Energy carries out textural and thermal characterization of PCMs and develops modelling tools both for shaped PCM elements and for storage systems with enhanced heat transfer. TES based on thermochemical cycles is an interesting option as reversible chemical reactions can provide high energy storage density at low cost. HTPU is conducting research on oxides and hydroxides based systems as potential TES candidates for solar thermal power plants. The research involves both heat and mass transfer simulation and lab-scale characterization at high temperatures.

Solar fuels and chemicals are a medium to long-term application of CSP systems with an enormous potential. The motivation behind the R&D on solar-driven thermochemical cycles stems from the capability of solar towers to reach temperatures up to 2000 ºC and energy fluxes up to 5000 kW/m^2. The redox pairs analyzed strongly demand to solving the optimization of the integration of the chemical process into the solar system. Research in this field at HTPU focuses on the development of efficient solar reactors and solar engineering associated to materials and components and analysis of system integration.

Techniques for the characterization and measurement of temperatures inside receiver cavities subject to high-flux are still needing substantial improvement. HTPU is developing a world-class characterization laboratory with thermal imaging systems, CCD cameras, pyrometers, calorimeters, radiometers and spectroradiometers. Two high-flux solar simulators with motorized test beds, are available to test materials and receivers/reactors in the thermal power range of 1-15 kW.

scientists

Dr. Manuel Romero

Research Professor
Head of the Unit

Ph.D. in Chemical Engineering in 1990 by the University of Valladolid, Spain. He is Deputy Director and Principal Researcher of the HTPU at IMDEA Energy. M. Romero has received the" Farrington Daniels Award-2009", by the International Solar Energy Society, conferred for his R&D contributions to the development of high temperature solar concentrating systems. At present he is Vice-President of ISES and member of its Board, and President of the Spanish Association of Solar Energy, AEDES.In June 1985 he joined CIEMAT (Spain's National Laboratory for Energy Research), working as Project Manager till 2002 with responsibilities on R&D for solar thermal power plants and solar hydrogen. In 2002 he became Director of the Plataforma Solar de Almeria and Director of the Renewable Energy Division of CIEMAT since June 2004 till August 2008. During his career he has participated in 58 collaborative R&D projects in energy research, 18 of them financed by the European Commission. He was Associate Editor (AE) of the ASME Journal of Solar Energy Engineering since January 2007-2013 and Associate Editor of Solar Energy Journal since January 2002 till January 2007. He is AE of the International Journal of Energy Research (IJER) published by Wiley & Sons since December 2009. Editor of 6 books related to solar concentrating technologies. Author of 4 chapters in handbooks of solar energy, 63 papers in scientific journals and more than 100 publications in books of proceedings with ISBN and peer review. He is co-inventor of eight patents on solar technologies and applications.

Dr. José González

Senior Researcher

Ph.D. in Physics by University of Cantabria, Spain in 1999. Habilitation à Diriger des Recherches by University Paul Sabatier, Toulouse, France, in 2007. Ramón y Cajal research Fellow 2009. Maître assistant associé at the Ecole nationale supérieure des Mines de Paris in 2006 - 2009. Research engineer at Center of Energy and Processes, ARMINES/MINES ParisTech, France in 2000 – 2006. EU-TMR NANOCOMP postdoctoral researcher in 2000-2004, Center of Energy and Processes, ARMINES/MINES ParisTech, France. Currently, his research interests concern concentrating solar energy systems and technologies. He has co-directed 4 doctoral theses and numerous master theses and collaborates in various master and postgraduate courses on thermal heat transfer and renewable energy. He has participated in 28 research projects. Co-author of 54 papers in peer review journals, 2 chapters in books on solar energy, more than 100 communications in conferences and two international and three national patents (French and Spanish). Secretary of the Spanish Association of Solar Energy, AEDES from 2012. Theme Chair in the ISES Solar World Congresses 2013 and 2015. Associate Editor (Concentrated Solar Power) of the Solar Energy Journal.

Dr. Selvan Bellan

Postdoctoral Researcher

Ph.D. in Physics from VIT University, India in 2010. He was awarded the Junior Research Fellowship for his doctoral research from BRNS and spent a research stay at Laser and Plasma Technology division, Bhabha Atomic Research Center (BARC), India in 2007-2009. After finishing his Ph.D work, he joined as Scientific Officer in Center for Research in Thermal Management, Karunya University, India (2009-2010), and later he worked as Research Scientist in Development Department, Plasma Giken Co., Ltd, Tokyo, Japan in 2010-2011. In this period, he focused on 3D numerical modeling on Cold Spray Processes and spent a research stay in the Joining and Welding Research Institute, Osaka University, Japan. Currently, his research area is numerical modeling on concentrating solar energy systems. He has published 15 papers in peer reviewed international journals and 19 papers in international conferences.

Dr. Jian Li

Postdoctoral Researcher

Ph.D. in Electrical Engineering by the Institute of Electrical Engineering, Chinese Academy of Sciences, China in 2013. He has published 6 research papers in SCI journals, and 7 papers in international conferences. Currently, his research is mainly focused on optical and energy characterization of solar concentrating systems under high flux/high temperature conditions.

Dr. James Spelling

Postdoctoral Researcher

PhD from the Royal Institute of Technology in Stockholm, Sweden, in the field of technical and economic performance analysis of hybrid solar thermal power systems. His work at IMDEA concerns the integration of innovative technologies into solar thermal power plants, and evaluating the technical, economic and environmental performance of these new systems.

Sandra Alvarez
Predoctoral Researcher

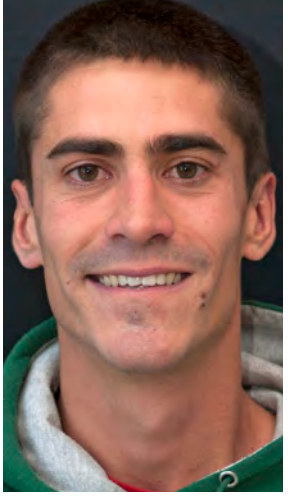
Graduated in Chemical Engineering by University Rey Juan Carlos in 2007. Predoctoral researcher working on thermochemical energy storage systems for solar thermal power plants.

Alessandro Gallo
Predoctoral Researcher

Graduated from University of Bologna in Energy Engineering in 2006. MSc Degree in Energy Engineering by University La Sapienza of Rome in 2011. Predoctoral researcher working on integration of solar energy technologies in energy systems and buildings.

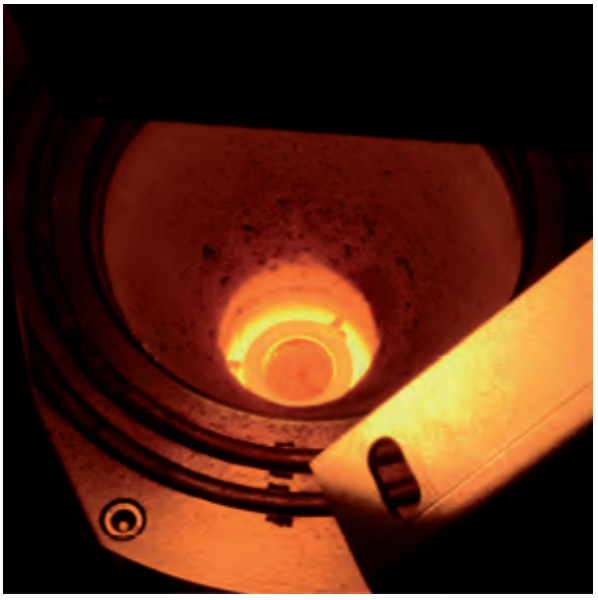
Lucía Arribas
Predoctoral Researcher

Graduated in Chemical Engineer and Business Administration by Rey Juan Carlos University in 2013. She is working on the development of advanced thermal storage systems in solar thermal power plants and solar fuels production.



Sergio Santiago
Researcher in training

Graduated in Mechanical Engineering by Polytechnic University of Madrid in 2014. He is currently working on the development of advanced solar receivers for solar thermal power tower plants.



Solar reactor inner trough quartz window during a high-temperature solar experiments for solar fuels production

4.3. Electrochemical Processes Unit

Research activities

One of the main objectives of the Electrochemical Processes Unit (ECPU) is to develop new concepts and technologies for electrochemical energy storage. The storage systems developed by the ECPU can be applied to stationary renewable power sources and to the electrification of transport. Another objective of the Unit is the development of water treatment technologies through electrochemical capacitors. In this case the main goal is energy efficiency, but reducing the production of effluents and minimizing operating costs are added values.

Regarding stationary applications of the electrochemical storage, the ECPU has been working with high capacity technologies such as flow batteries; while for high power and fast response electrochemical capacitors have been studied. In the area of electric vehicles, the main weakness is the short driving range caused by the low storage capacity per weight or volume. The ECPU is studying new technologies than could cope with such disadvantage using metal-air batteries and electrochemical capacitors.

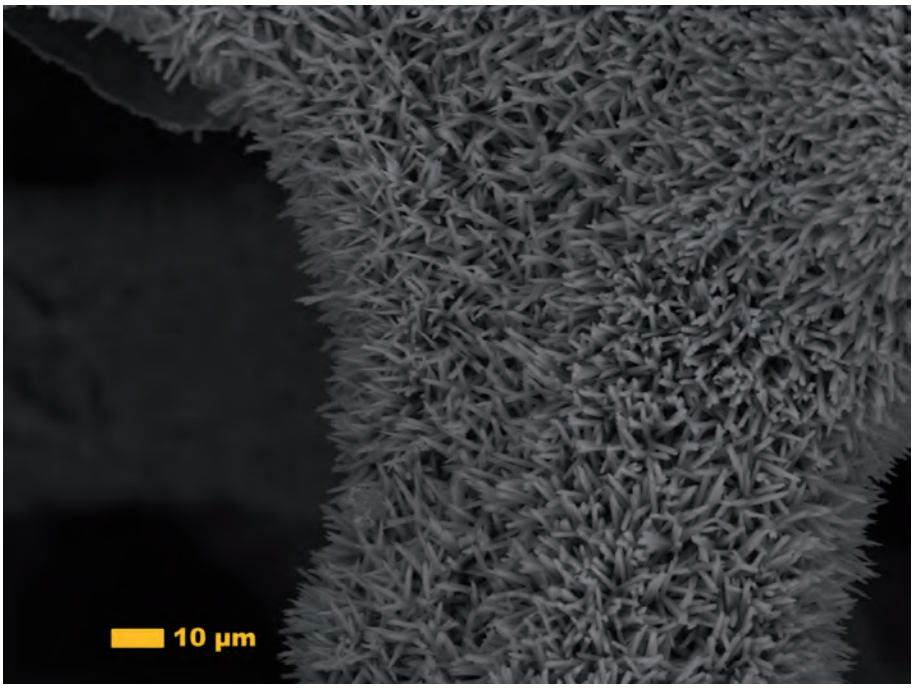
The ECPU works in two types of flow batteries (1) low cost flow batteries in which the main sources of cost, namely the electrolytes and the ion exchange membranes, are substituted by lower cost materials; and (2) improved batteries with better performance and particularly higher specific energy than the state-of-the-art chemistries.

The theoretical energy density of metal-air batteries is much higher than that of Li-ion batteries, their great drawback being they are not rechargeable. Thus, the ECPU works on the development of the main components of electrically rechargeable metal-air batteries using metal oxide nanoparticles as catalysts for the air electrode and advanced electrolytes based on ionic liquids.

In the field of electrochemical capacitors, laboratory devices using polymeric solid electrolytes are being investigated. The advantage of solid electrolytes is that no further cell or module packing is required. Additionally, the use of ionic liquids as electrolyte allows increasing the maximum operating voltage with a subsequent increase of the storage capacity. On the other hand, the combination of polymer electrolytes and electrodes with improved mechanical properties may lead to flexible supercapacitors with a good balance of electrical and mechanical properties.

In the field of water treatment, the ECPU works in capacitive deionization, an energy efficient water treatment technology that allows removal of dissolved ions in a way similar to electrodialysis but that does not use membranes and has the possibility of recovering part of the energy applied in the ion removal process.

The ECPU is also dedicated to battery and capacitor testing. The aim is to monitor performance and ageing with cycling under duty cycles that simulate the electrical requirements of new emerging stationary and transport applications. This information is used to create models that predict the cycle life of electrochemical energy storage devices.



"Hydrothermally grown $FeCo_2O_4$ Nanowires on Nickel Foam, a promising positive electrode material for electrochemical energy storage devices such as supercapacitors or metal-air batteries." Photo originally published in Journal of Materials Chemistry A, 2015, 3, 16849-16859, © the Royal Society of Chemistry.

scientists

Prof. Marc A. Anderson

Research Professor,
Head of the Unit

He is Head of the Electrochemical Processes Unit (ECPU). At the same time he is Chair of the Environmental Chemistry & Technology Program at the University of Wisconsin-Madison, where he is also Full Professor at the Department of Civil & Environmental Engineering. He received his Ph.D. in Environmental Engineering from Johns Hopkins University in 1976. He has been Visiting Researcher in the Catholic University of Louvain, Belgium in 1981, the Institute of Ceramics and Glass of CSIC (Spain, 1989), and CIEMAT, Spain in 2002. His main research interests are chemistry and materials science aspects of micro and nanoporous thin-films applied to a variety of uses, but mostly in areas related to their photoelectrochemical and electrochemical properties. He has been involved in many research projects supported with public and private funds coming from US organizations and private companies. He is author of about 200 publications in scientific journals, more than 25 patents and of 1 book. His historical Hirsch Scientific Index is 53. Besides, he has presented numerous communications in scientific conferences, many of them as keynote speaker.

Dr. Jesús Palma

Senior Researcher

He is Senior Researcher of the ECPU and Lecturer at Rey Juan Carlos University. Formerly he was Director of the R&D Centre of Tecnicas Reunidas. He received his Ph.D. in Chemistry from Autonoma University of Madrid in 1994. He has been Visiting Researcher at the Imperial College, United Kingdom, the Energy Research Centre of the Netherlands (ECN) and the University of Wisconsin-Madison, USA; and in research centers of companies such as Iberdrola, Spain, Ansaldo Ricerche, Italy and Philips Components, Netherlands. His work has been mainly related to electrochemistry and electrochemical engineering applied to energy storage, energy conversion, metal recovery, and decontamination of residues and effluents. He has participated in more than 40 research projects funded by public institutions, national and international companies; being the principal researcher of about 20. He has been involved in 6 European research projects. He is co-author of 25 scientific papers in international journals and 1 patent.

Dr. Rebeca Marcilla

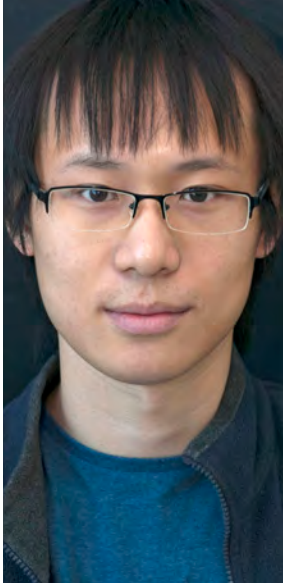
Senior Assistant Researcher

Ph.D. in Chemistry by the University of the Basque Country in 2006. After her PhD, she joined the Technological Center CIDETEC - Centre for Electrochemical Technologies and performed two research stays at the Eindhoven University of Technology, Chemical Engineering and Chemistry-Polymer Chemistry, and at the University College London, London Center for Nanotechnology. Her main research interest is the development of electrochemical energy storage devices by using new Ionic Liquid-based electrolytes. She is co-author of more than 40 scientific papers in international journals and 2 patents. Her Hirsch Scientific Index is 23.

Dr. Enrique Garcia-Quismondo

Postdoctoral Researcher

Ph.D. in Chemistry by the Autonoma University of Madrid in 2010. He has worked at the R&D Centres of Exide-Technologies and Tecnicas Reunidas, building up an experience of 10 years in the fields of advanced lead-acid batteries, flow batteries and metal-air batteries, participating in research projects funded by the European Union, the Spanish Government and by private companies. He is specialized in development of electrochemical prototypes, through modelling, design and assembling of cells and packs, and scaling them up. Currently he is working in the development of electrochemical energy storage, prototypes by using new concepts generated in the laboratory. In 2013 he received a grant from Iberdrola Foundation under the Call "Research in Energy and Environment 2013-2014".



Dr. Puiki Leung

Postdoctoral Researcher

PhD in Electrochemical Engineering by Southampton University in 2011. He has worked in three research institutes, including Southampton University (Engineering Sciences Dept), Hong Kong University of Science & Technology (School of Engineering) and Warwick University (WMG & School of Engineering). He has worked in several electrochemical energy storage systems for grid-scale applications, particularly redox flow batteries (Zn-Ce, V-Ce and V-V), aqueous batteries (lead acid and Zn-PbO2), molten salt batteries (Mg-) and lithium-ion batteries (Mechanical aspects). He is author of more than 10 peer reviewed journal papers and has participated in several national/international conferences.

Dr. Afshin Pendasteh

Postdoctoral Researcher

PhD in Analytical Chemistry by Tarbiat Modares University (TMU) in 2009, Iran. He has been working on electrode materials for electrochemical energy storage systems, particularly pseudocapacitors. He has investigated the effect of highly-oriented porous characteristics on performance of metal oxides in energy applications. He is author of 8 peer reviewed journal papers and has participated in several national/international conferences.

Dr. Lida Heidari - Khoshkalat

Postdoctoral Researcher

PhD in Analytical Chemistry by the University of Guilan, Iran in 2011. Her main research focus is the characterization and application of carbon nanotubes (CNT) in electrochemical sensors and electrodes. She has published several research papers in peer reviewed international journals and has presented her findings in national and international electrochemistry seminars.

Girum Tiruye

Predoctoral Researcher

Graduated in Applied Chemistry by Arba Minch University, Ethiopia in 2009. Master in Environmental Sciences by Wageningen University and Research Center (WUR), The Netherlands in 2012. Predoctoral researcher working on "Application of Innovative Polyelectrolytes and Graphitic Materials in Supercapacitors".

Cleis Santos

Predoctoral Researcher

Graduated in Chemical Engineering by Rey Juan Carlos University in 2012. Master in Energies and Fuels for the Future by Autonoma University of Madrid in 2013. Predoctoral researcher working on materials and designs for capactive deionization for water treatment.

Paula Navalpotro

Predoctoral Researcher

Graduated in Chemical Engineering by Rey Juan Carlos University in 2012. She holds a master degree entitled "Energy and fuels for the future" at the Autonoma University of Madrid in 2013. She is working on the development of ionic liquid-based electrolytes and their application in high performance supercapacitors.

Evgeny Senokos

Predoctoral Researcher

Graduated in Physical Chemistry from Lomonosov Moscow State University, Russia in 2014. In September 2014 he joined Electrochemical Processes Unit at IMDEA Energy Institute and Multifunctional Nanocomposites group at IMDEA Materials Institute as a Pre-Doctoral Researcher to perform his PhD project partly in both Institutes. He is working on creation of carbon nanocomposites for application in supercapacitors.

4.4. Biotechnological Processes Unit (Joint Unit CIEMAT / IMDEA Energy)

Research activities

The goal of UPBT is to gain knowledge and develop processes and technologies to produce biofuels via biological processes using lignocelullosic and microalgal biomass. The Joint Unit is composed by researchers of IMDEA Energy and CIEMAT "Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas del Ministerio de Economía y Competitividad", who are specialists in the different areas related to energy production via biological processes.

The researchers of UPBT focus on two main topics:

1. Obtaining sugars from lignocellulosic biomass for their conversion into biofuels and added value bioproducts. The investigation is focused on the steps that are more challenging such as the study of enzymatic systems for cellulose and hemicellulose hydrolysis and fermentative microorganisms for the production of bioethanol.

2. Development of economically competitive systems for the production of microalgae and their subsequent conversion into biofuels and added value bioproducts. Research is devoted to overcome two of the main bottlenecks for the obtaining of bioproducts using microalgae, namely cheap cultivation media and cell wall disruption methods.

With regard to the microalgae research line, the developed activity continues focused on the use of wastewater as cultivation media of microalgae and on the study of pretreatments of microalgae biomass for the optimization of methanogenic potential achievable using these substrates. In this context, research has deepen in the thermal (120ºC) and enzymatic (screening of different enzymatic cocktails) pretreatments. This in-depth study of pretreatments entailed their effect on different microalgae strains and different digestion modes. More specifically, the pretreatments that resulted promising in batch

mode digestion were evaluated in semi-continuous digestion mode. This investigation helped identifying the inhibitors of the process when operated in semi-continuous digestion mode and the development of potential strategies to overcome them. In addition, keeping in mind that microalgae pretreatments increase considerable production costs, the Unit started to work with cyanobacteria. This type of photosynthetic microorganisms differs from microalgae on their cell wall, being much weaker towards bacterial attack.

The research line about biofuel production from lignocellulosic materials by biochemical routes has been mainly focused on studying the effect of laccase addition on enzymatic hydrolysis. In this context, it was concluded that phenoxil radicals and oligomeric phenols resulting from laccase action affect negatively the enzymatic hydrolysis. Furthermore, it has been demonstrated that the presence of lignin plays a decisive role in these processes. Besides, within this research line, preliminary studies have been performed in order to understand how the mechanical stress affects yeast cells in ethanol production processes at high substrate loading. The effect of this stress on cell tolerance to inhibitors needs to be also elucidated.

scientists

Dr. Mercedes Ballesteros

Research Professor,
Head of the Unit

Ph.D. in Biology by Autonoma University of Madrid and Master in Biotechnology by Complutense University of Madrid. Head of the joint Unit on Biotechnological Processes for Energy Production at IMDEA Energy from April 2011 and Head of Biofuels Unit at CIEMAT from January 2010. She was Head of Biomass Unit at CIEMAT (2004-2010) and Leader of the Liquid Biofuels Project (2000-2004). Project manager at CIEMAT since 1990 till 2000 with responsibilities on R&D for biomass characterization and energy production from biotechnological processes. She is member of the Spanish Society for Biotechnology (SEBIOT), of the European Biofuels Technology Platform (EBTP) and Vice-president of the Spanish Biomass Association (ADABE). Spanish representative in the European Bioenergy Industrial Initiative of the Strategy Energy Technology Plan, member of the Steering Group in the European Energy Research Alliance in Bioenergy and member of the Coordinator Core in the Spanish Technology Platform (Bioplat). She has been guest speaker at numerous meetings and conferences on energy, especially in the area of bioenergy. She is a teacher in many courses organized by various universities and organizations. She has participated in more than 50 R&D projects on biomass research, 10 of them financed by the European Commission. She has authored about 80 papers in SCI journals and 12 chapters in technical handbooks. She is co-author of 4 patents and external consultant for ECLAC of United Nations and the Spanish Agency for International Cooperation (AECID).

Dr. Cristina González

Senior Assistant Researcher

Her research career started in University of Cincinnati (USA) where she has worked in developing analytical methods to quantify endocrine disruptor compounds in wastewater in 2005. After that, she got her Ph.D. in Chemical Engineering and Environmental Technology at the University of Valladolid in 2008. Subsequently she joined the technological Center ITACyL where she worked on lab and real-scale plants dealing with livestock effluent treatments. After that, she got a postdoc position at the French National Institute for Agricultural Research (LBE-INRA, France) to work on the optimization of biogas production using microalgae. She is co-author of 32 scientific publications. She has been involved in European and national funded research projects, as well as in projects with private companies.

Dr. Marie Demuez

Postdoctoral Researcher

Ph.D. in Biochemistry at INSA of Toulouse in 2007. She had a position in UC Davis / UC Berkeley and then a postdoctoral contract at IMDEA Energy to work on biological production of hydrogen by nitrogenase. She is co-author of 8 scientific publications, and has been involved in European and national funded research projects. She has participated in 8 national and international research projects.

Dr. Elia Tomás
Postdoctoral Researcher

PhD with European Mention in Microbiology at Complutense University of Madrid in 2007. During her PhD studies she was visiting student at the Technical University of Denmark (Lyngby, Dinamarca) and at Chalmers University of Technology (Gothenburg, Sweden). After her PhD, she worked as a postdoctoral project assistant for almost two years at CIEMAT in the Biofuels Unit. From March 2011 to February 2013 she worked as Postdoctoral Researcher in the Industrial Biotechnology Group at Chalmers University of Technology in Sweden. She has been working in the bioethanol field since 2005. She has studied different configuration processes, optimized process conditions and done studies on yeast physiology, adaptation and propagation. She is co-author of more than 18 peer-reviewed papers and book chapters and co-inventor of 2 patents. She is member of the Editorial Advisory Board of the open access journal "Bioethanol".

Dr. Mª. José Negro
Associated Senior Researcher

Her research career has been developed in the Biofuels Unit at Renewable Energies Division of the Department of Energy of CIEMAT. She has more than 20 years of experience in the development of biomass as renewable energy source. The main research areas include production and characterization of starchy and lignocellulosic biomass, including biological processes for energy production from biomass, ethanol production by enzymatic hydrolysis, microorganisms research for biofuel production, fermentative processes and biomass pre-treatment. She is co-author of more than 37 peer-reviewed papers and book chapters and co-inventor of 2 patents. She has supervised 1 PhD thesis and 2 Master theses.

Dr. Ignacio Ballesteros
Associated Senior Researcher

He is a Senior Researcher at CIEMAT. He obtained his Ph.D. degree in Biology at the University of Alcalá de Henares in 2000. His entire research career has been developed within the Department of Renewable Energy at CIEMAT. His research has focused on the production of biofuels and their use in the transport sector, mainly in bioethanol production processes from lignocellulosic biomass: characterization of raw materials; lignocellulosic biomass pre-treatment; hydrolysis of polysaccharides (acid and enzymatic) and fermentation. He is the co-author of more than 40 peer-reviewed papers and book chapters, and co-inventor of 3 patents. He has participated in more than 30 national and international research projects, focusing on the production of bioethanol from biomass. He has supervised 2 PhD Thesis.

Dr. Felicia Sáez
Associated Senior Researcher

She has developed her research career in the Renewable Energy Division, Department of Energy of CIEMAT. Her research has focused on the development of analytical techniques necessary for the determination of chemical compounds generated at various stages during the chemical and biological processes for the bioethanol production from biomass and of techniques for emissions testing produced in the process of transformation of biomass into heat and electricity, including the environmental aspects of this renewable energy. She has participated in more than 30 national and international projects. She is co-author of around 40 papers presented in research journals and congress proceedings and of over 25 technical reports in the area of biomass in relation to development projects.

Alfredo Oliva
Predoctoral Researcher

Graduated in Biology by University of Alcala, Spain in 2010. Master in Genetic and Cellular Biology in 2011. Predoctoral student working on the integration of laccases in the bioethanol production process by studying the effect on enzymatic hydrolysis and fermentation.

Ahmed Mahdy
Predoctoral Researcher

Graduated in Genetic Engineering by University of Zagazig, Egypt in 2005. Master in Microbiology in 2011. Predoctoral researcher working on biological pretreatments for cell wall disruption of microalgae biomass and subsequent conversion to biogas.

Lara Méndez
Predoctoral Researcher

Graduated in Biology by Complutense University, Spain in 2008. Master in Clinical Analysis in 2010. Predoctoral researcher working on thermochemical pretreatments for cell wall disruption of microalgae and cyanobacteria and subsequent conversion to biogas.

4.5. Electrical Systems Unit

Research activities

The main objective of the Electrical Systems Unit is to participate actively in the undergoing process of the paradigm change regarding how electrical energy is generated, distributed, stored and consumed. Substantial improvements are necessary in energy management and power conversion systems applied in generation, transmission and distribution systems so they can provide the required level reliability and robustness. The principal challenge is, therefore, creation of new, highly coordinated, decentralised management algorithms that would take advantage of the increased information flows provided by real-time monitoring and control resources.

Active management of distribution power networks is the principal research line. The emphasis of the work is now on development of new services and related tools for distribution system operators (DSOs) and incorporation of residential and industrial users to the management schemes. New, intelligent schemes for solving distribution network issues like state estimation, demand forecasting, voltage control, congestion management etc. have been sought. Exploring demand management and coordinated demand response schemes and their application in industrial and buildings sector are some of the main research challenges. Also, reliability of distribution power networks with high penetration of renewable technology has been studied.

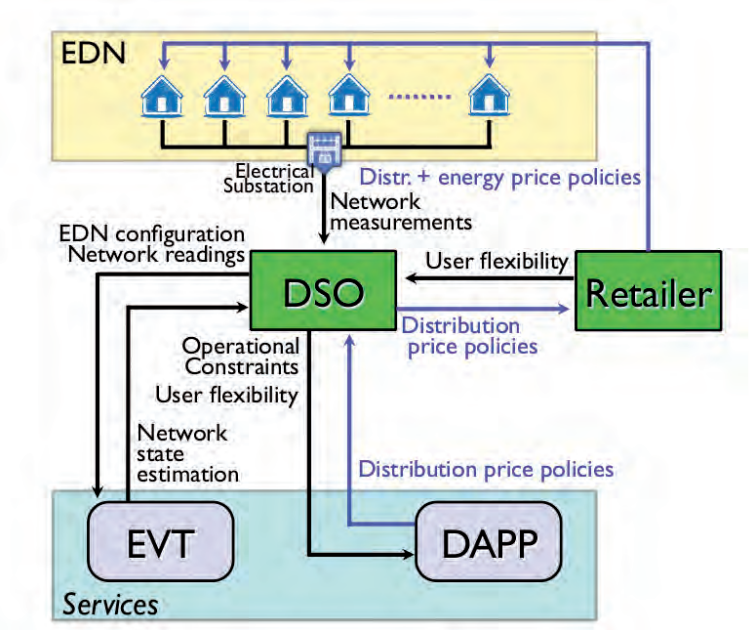
“Smart buildings” and “Smart Homes”, their energy management, coordination and integration to power networks, are all of increased importance to this research unit. Holistic, probabilistic and user oriented approaches have are all been used for modelling energy demand of a building. Meanwhile, options for renewable integration and storage device utilisation are sought in order to improve the building autonomy and increase its

self-consumption. Finally, real-time optimal energy resource management techniques aimed at the minimisation of operational costs are under development.

Another closely related topic is energy management of microgrids where both islanded and grid-connected networks are considered. Control and operational aspects of power converters, renewable and storage management, proactive and optimal dispatch algorithms and stability analysis for small power networks are all studied. Any energy scenario or particular event of interest for renewable and storage integration can now be recreated in "Smart Energy Integration Lab" and the proposed control algorithms validated.

One of the well-established lines of research is energy efficiency in industrial applications. By using detail modelling of the consumption profiles and pattern, the options for possible energy saving are sought.

Principal technologies behind the implementation of the proposed energy efficiency schemes are information systems, power electronics converters and energy storage systems.Energy storage systems, their charge/discharge process, their integration to power networks and their application to electric vehicles have been of particular interest. The research activities include both development of future battery test equipment based on advanced power electronics interfaces and also development of management and control algorithms for storage applications in power networks.



Software design architecture for Grid Intelligent Automation Services in SmartHg project

scientists

Dr. Milan Prodanovic

Senior Researcher,
Head of the Unit

B.Sc. degree in Electrical Engineering from the University of Belgrade, Serbia in 1996 and obtained his Ph.D. degree from Imperial College, London, UK in 2004. From 1997 to 1999 he was engaged with GVS engineering company, Serbia, developing power electronic circuits and control algorithms for inverter and UPS systems. He has been Work Package leader in a number of national and international projects and was closely collaborating with his partners in UK, Belgium, Switzerland, Kenya and Japan. He authored several journal and conference papers and is holder of 3 international patent applications in the area of energy efficiency and converter control. His research interests lie in design and control of power electronic systems, real-time simulation of power networks, decentralized control of distribution power networks and microgrids and energy efficiency in industrial applications.

Dr. Jörn Klaas Gruber

Postdoctoral Researcher

Graduated at University of Stuttgart in 2002, his MSc degree from Polytechnic University of Valencia in 2004 and his Ph.D. from University of Seville in Automation and Control Engineering in 2010. Thereafter, he joined Gamesa, working in the area of wind turbine control before joining IMDEA Energy. His research interests are in the fields of smart grid optimization, model predictive control, nonlinear and robust control, distributed generation and decentralized control. He is author of a number of international journal and conference papers and holds 2 international patents.

Dr. Francisco Huerta

Postdoctoral Researcher

Graduated in Telecommunications Engineering in 2004 and in Electronics Engineering in 2006 from the University of Alcala, Spain. He obtained his doctoral degree in 2011 from the same university as a holder of a prestigious funding scheme PIA introduced by the Regional Government of Madrid. Francisco has authored various journal and conference articles and he has participated in several research projects related to control and applications of power electronics converters in renewable energy systems and control of grid connected power electronics converters. His research interests include converter control, power quality, distributed generation systems and microgrids.

Dr. Barry Hayes
Postdoctoral Researcher

B. Eng. Degree in Electrical and Electronic Engineering from University College Cork in 2005 and a Master degree from the National University of Ireland Maynooth in 2008. He then moved to the University of Edinburgh, Scotland, where he completed his Ph. D. in 2013. As part of his Ph.D. research, he had a placement at National Grid at the UK Energy Network Centre in Berkshire, England in 2011. In addition, He has worked as a Research Fellow at the University of Edinburgh in projects related to power system reliability and wind resource assessment and has published a number of journal and conference papers.

Tokhir Gafurov
Predoctoral Researcher

MSc Degree in Electric Power Systems from Tashkent State Technical University in Uzbekistan in 2005 and MSc Degree in Mechanical Engineering from Royal Institute of Technology (KTH) in Sweden in 2008. He worked for three years as an electrical engineer in Design Surveying & Scientific-Research JSC “Sredazenergosetprojekt” in Uzbekistan and two years as a junior gas turbine aerodynamicist at Siemens Industrial Turbomachinery AB in Sweden. He is predoctoral researcher in energy efficiency in industrial applications, renewable integration and future energy markets.

Alejandro Bayón
Researcher in Training

Graduated in Industrial Electronics and Automation by Carlos III University of Madrid in 2014. He is working on the development and testing of power electronics converters.

4.6. System Analysis Unit

Research activities

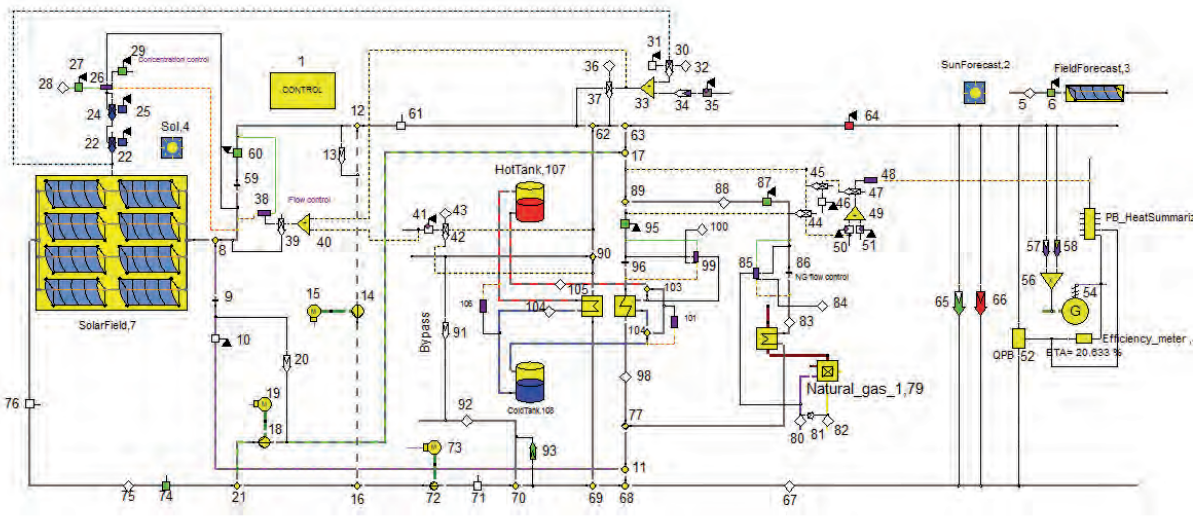
The System Analysis Unit has continued the development of new tools to study the sustainability of energy systems. The integration of social and economic aspects and indicators into life cycle assessment methodology has been investigated. Also in this field, the most adequate social indicators to be implemented in the LCA+DEA (Life Cycle Assessment plus Data Envelopment Analysis) were studied. As a new tool, it has been explored the hybridization of emergy with DEA for policymaking. Linked to LCA, the ecodesign of industrial products has been started as research line.

The first energy model of the Community of Madrid has been completed by using LEAP (Long-range Energy Alternatives Planning) methodology with 2010 as reference year. Technology aspects were especially addressed and, therefore, this model allows defining different scenarios no just from the demand side as usual, but from the supply side by tuning the modules designed for the different energy production technologies. Using this LEAP-Madrid model, roadmaps can be developed, for instance, for the introduction of different power-train vehicles, energy efficiency techniques or renewables in buildings. Currently, the LEAP-Spain model is under development.

Between the previous research lines, the hybridization of energy modelling with LCSA (Life Cycle Sustainability Assessment) has been started in collaboration with the Institute of Energy Technology of Norway (IFE) with a project to determine the social effects of energy policies, using photovoltaics as case study.

Regarding clean fuels, the activity has been focused on the economic estimation of biofuels manufacturing from lignocellulosic biomass through pyrolysis and in the study of different process layouts of biomass gasification, including the production of hydrogen, electricity or the coproduction of fuels (through Fischer-Tropsch) and hydrogen. In all these cases, the pretreatment step was identified as key for the economic feasibility.

In the hydrogen field, new processes for its clean manufacturing were explored, identifying the most viable processes in the short-term. As well, the economic implementation of hydrogen was investigated, including transportation, distribution, refueling stations and FCE vehicles.



Simulation diagram of a CSP plant

scientists

Dr. Javier Dufour

Senior Researcher

Head of the Unit

BSc in 1990 and PhD in 1995 in Chemical Sciences, with emphasis on Industrial Chemistry, by the Complutense University of Madrid, where he developed his teaching career from 1991 until 2003. Previously, he got a grant for researching at the National Centre for Metallurgical research (CSIC). He enjoyed a postdoctoral stay at the TNO Institute for Industrial Technology (Holland) during 1996 and 1997. In this time, his main research lines were focused on the design of processes for the recovery of metallurgical and steelmaking wastes and the conservation of cultural heritage goods supported on paper. He joined Rey Juan Carlos University in October of 2003, where he is currently Associate Professor. His research lines are focused in the analysis of energy systems, design, simulation and optimization of processes, life cycle assessment and hydrogen production in membrane reactors. He is author of 65 papers published in international journals, more than 100 contributions to conferences and 3 patents. He has collaborated in 44 research projects (6 international ones), being the responsible researcher in 24 of them. He was awarded with the AETEPA award for the best research work in the paintings field presented at the EUROCOAT 94 conference. He is Coordinator of the PhD Program on Chemical and Environmental Engineering at the Rey Juan Carlos University, Chairman of the Spanish Network of Life Cycle Assessment and Operating Agent of Task 36 “Life Cycle Sustainability Assessment of Hydrogen Energy Systems” of the Hydrogen Implementing Agreement of the International Energy Agency.

Dr. Diego Iribarren

Senior Assistant Researcher

Ph.D. in Chemical and Environmental Engineering in 2010 at University of Santiago de Compostela. His research includes environmental management (Life Cycle Assessment, Carbon Footprinting, LCA+ Data Envelopment Analysis), as well as simulation and optimization of production systems. He has been involved in 9 research projects and published more than 20 research articles.

Dr. Abel Sanz
Postdoctoral Researcher

Ph.D. in Chemical Engineering in 2012 by Complutense University of Madrid. His investigation is focused in the simulation, design and optimization of processes in the energy field.

Dr. Tadhg O´Mahony
Postdoctoral Researcher

Following completion of his BSc and Dip in Environmental Management, he worked in industry for two years. He was awarded an Irish government scholarship and successfully completed his Ph.D. in 2010 in Dublin Institute of Technology on scenario analysis of the Irish energy system.

Jens Peters
Predoctoral Researcher

Dipl. Ing. in Electronic Engineering (Information Technologies) from TU Munich, Germany in 2003 and MSc in Renewable Energies, Fuel Cells and Hydrogen from Universidad Internacional Menendez Pelayo and CSIC in 2010. Predoctoral researcher working on assessment of biomass pyrolysis.

Ana Susmozas
Predoctoral Researcher

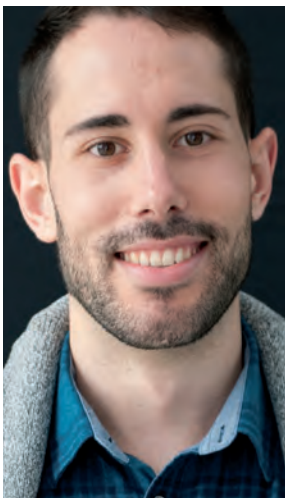
Chemical Engineer by Rey Juan Carlos University of Madrid in 2010. Predoctoral researcher working on biomass gasification.

Pedro Luis Cruz
Predoctoral Researcher

Chemical Engineer by Rey Juan Carlos University of Madrid in 2013. Predoctoral researcher working on biomass integration in crude refineries.

Mario Martín
Predoctoral Researcher

BSC on Enviromental Science by Rey Juan Carlos University of Madrid in 2013. Predoctoral researcher devoted to the development of tools to assess the environmental performance of energy systems.



facilities and scientific infrastructures

annual report 2014

5.1. Building and general infrastructures

The building and laboratories of IMDEA Energy Institute are located at the Technological Park of Mostoles on a land with 10,000 m^2. The ownership of the land was ceded in 2008 by the Municipality of Mostoles. The building counts on 6 labs, 2 pilot plants, offices and an auditorium for 130 people

During 2014 it has been intensified the use of the building by holding numerous events, conferences, workshops, scientific meetings, among others. These activities has increased even more, national and international visibility of the R&D capabilities of the Institute and have released the excellent research facilities, which make IMDEA Energía a partner of great potential for companies, research centers and universities.

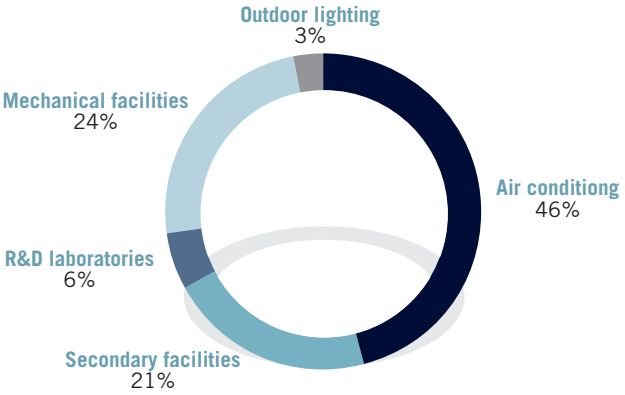
The IMDEA Energy headquarters have been built thanks to the funding coming from different sources: the Regional Government of "Comunidad de Madrid", the Spanish Ministry of Economy and Competitiveness and European Union Structural Funds.

An energy-efficient building

The building design incorporates high efficiency systems in terms of energy saving and comfort, as well as geothermal pumps, cogeneration with natural gas and solar thermal and photovoltaic systems, determining an Energy Efficiency Label of Category A and the Gold LEED certificate, indicative of a minimum environmental impact of both the building and the construction process, having a high international recognition.

It is important to highlight that the IMDEA Energy headquarters also has a computerized management and control system that provides data about the consumption of the most of the building facilities, providing valuable information to modify the operating parameters and optimize continuously energy efficiency.

Next figure shows the main consumption of the building by type of facility in the year 2014. The highest consumption is regarding the conditioning of the spaces of the building with a 46% of the total consumption, followed by the consumption of the mechanical installations with a 24%, and the secondary building facilities (lifts, interior lighting, etc.) with a 21%. In a smaller percentage it is the consumption related to the R&D laboratories with a 6% and the outdoor lighting with a 3%.



5.2 Scientific equipment and laboratories

Considering the multidisciplinary character of energy research, the need of scientific instrumentation, devoted to support and complement the experimental research performed by the different research units, was considered crucial for establishing the IMDEA Energy Institute as a world-class research centre. These laboratories have been provided with some of the state-of-the-art instruments for the characterization of solids and surfaces. In addition, this facility is also provided with advanced equipment for chemical and thermal analyses. In order to facilitate their utilization and management the apparatus were grouped in the following laboratories:

Laboratory of Thermal and Chemical Analysis

- ICP-OES (Chemical Measurements) Perkin Elmer OPTIMA 7300DV with autosampler.
- Microwave for sample Digestion Anton Parr Multiwave 3000.
- Thermal Diffusivity Measurements Equipments Netzsch LFA 457 Microflash.
- Thermo Gravimetric Analyser (TGA/DSC) TA Instrument.
- New Thermo-Gravimetric Analyser (TGA/DSC) for measurements at high temperature and under reactive atmosphere (water vapour) Netzsch Jupiter F3 449.

Laboratory of Spectroscopy

- UV/Vis/NIR Spectrometer (Optical Properties Measurements) Perkin Elmer Lambda 1050.
- Fluorescence Spectrometer (Optical Properties Measurements) Perkin Elmer Ls 55.
- Two FTIR Spectrometer NICOLET 6700 with MCT detector and provided with the following accessories: TG-FTIR, DRIFT Chamber, ATR Cell, Veemax, and Fiber Optic.

- Laser Raman Spectrometer Jasco NRS-5100 with two laser sources (λ= 532nm and 785 nm) with a LINKAM atmospheric chamber.

Laboratory of Structural and Textural Properties

- Multypicnometer (Materials Density Measurements) Quantachrome Instruments MVP.6DC.
- Quadrasorb (Analysis of Textural Properties) Quantachrome Instruments SI MP-9.
- Autosorb (Analysis of Textural Properties) Quantachrome Instruments Asiq Mv022.
- Chemisorption Analyzer (reduction/desorption/oxidation) provided with Thermal Conductivity Detector (TCD) or Mass Spectrometry, Micromeritics Autochem II.
- XRD diffractometer X'Pert Pro MPD.
- XRD diffractometer BrukerD8 Advanced, provided with a high temperature cell and an Ag source for performing Pair Distribution Function analysis (PDF).

Laboratory of Microscopy

- Bench-top Scanning Electron Microscope Model Hitachi TM-1000. It includes an Energy Dispersive X-Ray analyzer from Oxford Instruments.
- Atomic Force Microscope Model Park XE-100 with 12 μm Z, 100 μm X-Y scan ranges. Close loop. Available modes: contact, non-contact, lateral force, magnetic force, scanning tunnelling, electrochemistry, scanning kelvin probe, photoconductivity.
- Stereo microscope with transmitted and reflected light with continuous zoom 0.67-4.5x.
- Biological optical microscope with 5 plan achromatic objectives (4 x, 10 x, 20 x, 40 x and 100 x immersion). Both optical microscopes are equipped with 3-Megapixel CCD digital camera.

In addition, the following equipments are available for specific use within the different research units:

- **High Temperature Processes Unit:** scientific installation for generating high radiation fluxes/temperatures and characterizing them. It has a closed box equipped with a laboratory-scale 7 kW_e solar simulator capable of delivering 2000 kW/m^2, including gas feeding and gas extraction and water cooling systems for materials and receivers testing under well-controlled conditions, thermal imaging and CCD cameras, Gardon-type calorimeters and bicromatic pyrometers, gas analysis test bed (H_2, O_2, CO, CO_2, CH_4) for continuous gas monitoring and micro-gas chromatograph, and data acquisition instruments. Heliostat of 150 m^2 for outdoor testing. Sintering furnace up to 1600 ºC and two high precision thermostats of 300 and 600 W. A Chatillon dynamometer to measure hardness.

- **Thermochemical Processes Unit:** one high pressure continuous flow microactivity reactor for catalytic assays, three batch high pressure reactors, two lab scale pyrolysis reactors, two photocatalytic reactors provided with a UV-transparent window and with gas and liquid manifold, five GC (two of the them with double channel), a GC-MS with autosampler, a mass spectrometer for gas analysis (up to 200 amu), two tubular furnaces, centrifuge, balls mill, high power ultrasonic probe, microwave oven, an spectrometer for lamp calibration, three ovens (one with vacuum), one water content analyzer by Karl Fischer method and a rotary evaporator.

- **Electrochemical Processes Unit:** one precision potentiostat, one routine potentiostat, two multipotentiostats totalizing 15 standard channels, 4 impedance channels, and three power booster channels, a Z potential meter, cryostat, a glove box, four ovens (one with vacuum), climatic chamber, an automatic film applicator, a dip coater, a hydraulic press, several multipurpose filter-press electrochemical reactors, one doctor-blade coater for electrodes up to 30 x 60 cm, one roll press, one discs puncher, one vacuum sealing machine, one vacuum ink mixer, one high-power ultrasonic probe, one unit for testing Rotating Disk Electrodes (RDE) and Rotating Ring-Disk Electrodes (RRDE).

- **Biotechnological Processes for Energy Production Unit:** french press, microwave, homogenizator, FPLC, HPLC with refraction index and UV-Vis detector, GC with flame ionization detector, centrifuge, ultracentrifuge, incubation and laminar flow cabinet, autoclave, classic polymerase chain reaction, Quantitative Real-Time polymerase chain reaction, Gel Doc system, electroporator, shakers, photobioreactors and anaerobic digesters. During 2014, the laboratory was equipped with a cell disruptor and a system of denaturing gradient gel electrophoresis.

- **Electrical Processes Unit:** Two bench power supplies, four-channel oscilloscope, digital multimetre, three differential, high bandwidth voltage probes, three 100A, high bandwidth current probes.

Likewise, the following software for scientific and technical applications is available:

- Software HSC Chemistry 6.1
- VAPS 5.2
- COMSOL Multiphysics
- Simapro 7.2 Professional
- MATLAB-ALL and Simulink
- Trace Pro
- TRNSYS 16 and 17
- Aspen Plus
- Solidworks premium
- LABVIEW

- Ebsilon Professional
- IPSA
- PowerWorld
- Gabi
- LEAP

5.3 Pilot plants

Smart Energy Integration Lab

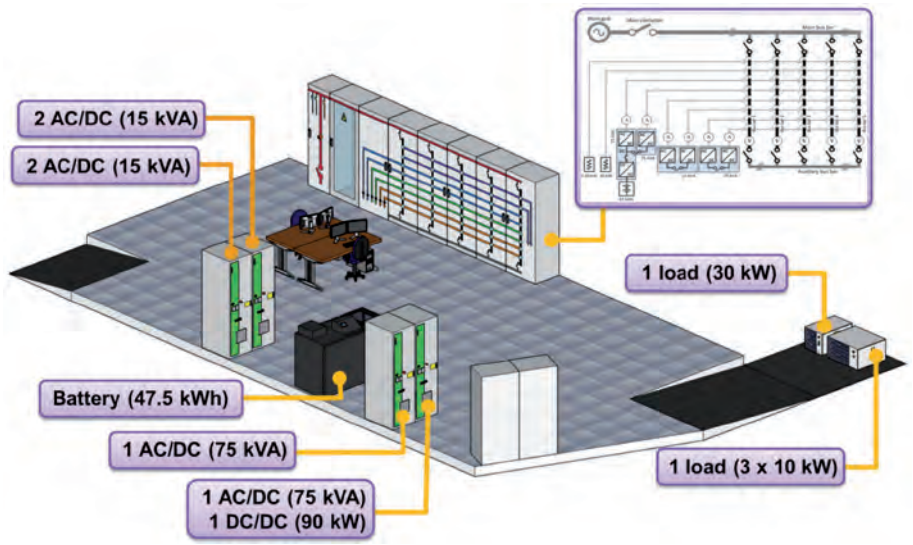
Electrical Systems Unit has created a test environment specifically designed for research, development and testing of control algorithms in energy systems. This environment is named "Smart Energy Integration Lab" because of its inherent flexibility allowing rapid development of control systems required for management and connection of energy resources to electricity networks. The approximate lab capacity for power processing is 210 kVA and the lab consists of a set of power electronics converters, resistive loadbanks, 47.5 kWh battery system, distribution panels and monitoring and control systems. This platform allows analysis, development and testing of energy resources integration to AC and DC networks and simulation and operation of distribution power networks, islanded networks and microgrids under most realistic test conditions. The results obtained from this test environment are more reliable and accurate than any results obtained through model based computer simulation.

What distinguishes this laboratory is its flexibility in implementation of control algorithms and simple access to all test and management data from any part of the network. The lab microgrid is capable of recreating a large number of different events that occur in real power networks and, therefore, represents a useful tool when it comes to research, development and implementation of energy management algorithms. For example, the lab network is capable of emulating at the same time a generation and load mix consisting of various wind, photovoltaic and conventional generators and passive and active loads all together connected to a wide area network whose dynamic is emulated in real-time. The role for the power converters acting as energy resources in such network is simply defined by assigning a different control block to each one of them. In addition to this, the battery system installation offers all the flexibility needed for the development of management algorithms for future power network.

The Smart Energy Integration Lab consists of:

- 4 x 15kVA three-phase power inverters
- 2 x 75kVA three-phase power inverters
- 4 industrial PCs with RT operating systems

- 2 x 30kW balanced and unbalanced, programmable resistive loadbanks
- 47.5kWh Li-Ion battery system with BMS
- 90KW Bidirectional, wide bandwidth, programmable battery charger
- Distribution panels with 5 independent busbars and contactor control
- Independent monitoring and control system



Floor plan of Smart Energy Integration Lab (SEIL)

Control algorithms for power inverters are programmed via Matlab Simulink and code generation tools and are then executed in real-time on industrial PCs. Real-time data exchange provides access to all control variables and parameters during the test. In this way the desired flexibility in reproducing real dynamic characteristics of any energy source, generator or load it is achieved.

The monitoring and control system allows an independent, remote, real-time access to laboratory resources including the network reconfiguration, control of contactors and connection to the external power grid. Moreover, by harnessing the potential of the communication network installations any centralised or decentralised management control algorithm can be achieved.

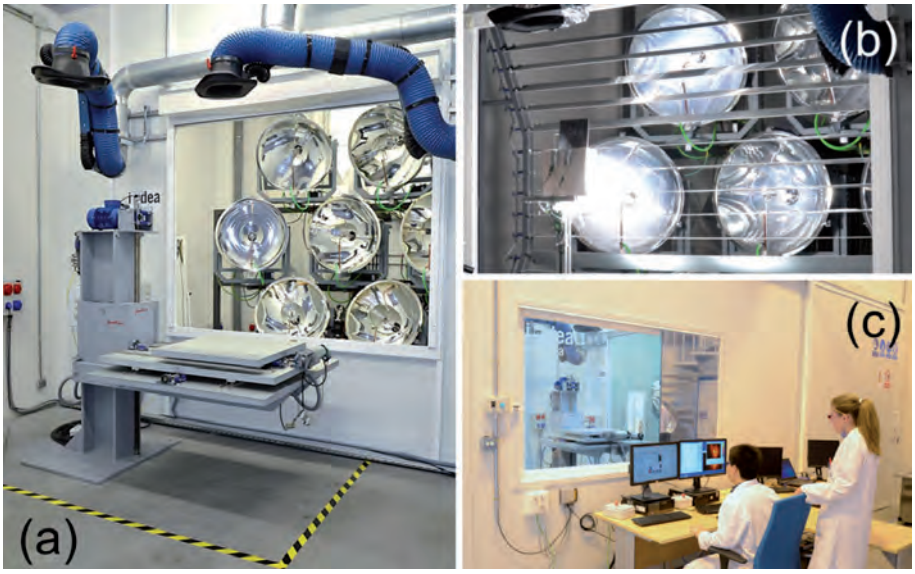
High Flux Solar Simulator

The 42 kWe high-flux solar simulator (HFSS) (called KIRAN42) is a facility that recreates in the laboratory the high flux densities met in solar concentrating systems in well-

defined conditions without the external perturbations due to the intermittency of the solar resource. This HFSS allows achieving up to 14 kW of radiant energy with a peak flux of 3,500 kW/m^2.

The associated pilot plant consists in a 7 m x 5 m x 4 m enclosure divided in two compartments. One room contains the highflux solar simulator (including reflectors, lamps and power supplies...) and the shutter (which is required to attenuate the radiation generated by the lamps). The second room is devoted to house the experimental test beds. It has been supplied with electricity, gases, water cooling circuit, gas extraction and a positioning table with a maximum load capacity of 300 kg.

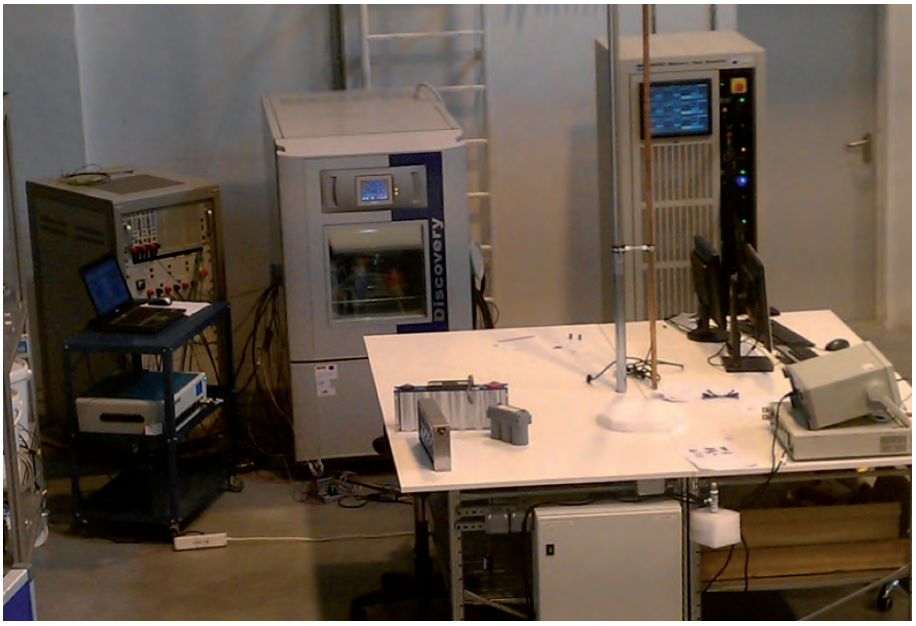
KIRAN42 is composed of seven independent units distributed at the vertices and center of a regular hexagon. Each unit consists of an elliptical aluminum reflector and a 6 kWe short-arc Xenon lamp mounted on a common support, which provides two degrees of freedom in azimuth and elevation. The facility design allows different aiming point strategies (and therefore various flux density distributions) on the working plane. Finally, the overall pilot plants is monitored and controlled by means of network composed by cRIO and cDAQ instruments under LabView.



Front view of solar simulator array and test table
(a), exploded view of lamps (b) and control system (c)

Electrochemical Devices Test Laboratory (EDTL)

This experimental facility has been designed for testing cells, modules and small packs of batteries and electrochemical capacitors under controlled temperature and humidity conditions. Electrical tests are made with two types of cyclers, one with 3 low power channels (300 W each) and the other with 3 high power channels (8 kW each). The parallel interconnections of channels allow operating voltages and currents of 30 V and 180 A in the low power cycler, and up to 120 V and 600 A in the high power unit. The control system allows programming charge and discharge cycles under controlled power, voltages, currents and resistances. Additionally, frequency domain response analyses can be performed. The laboratory includes a bench test unit designed for flow batteries and capacitive deionization reactors. It includes two electrolyte circuits with holding tanks, recirculation pumps, temperature control loops, valves, pipes and instruments for temperature, flow rate, pressure, pH, rH, and conductivity measurements. Tests programming, process control and data acquisition are made with LabVIEW programming platform.



Electrochemical devices test facilities

Photobioreactors pilot plant

The experimental investigation conducted at lab-scale can be scaled-up and optimized at pilot plant scale. The pilot plants consists of two types of photobioreactors, namely open (raceways) and closed to the atmosphere (bubbled-columns). The working volume of the

raceways is 0.35 m^3 each. In the case of the closed photobioreactor, it consists of three modules of 4 columns each module. Each column has a working volume of 0.076 m^3. The pilot plant is highly versatile since the reactors may be operated independently or in sequential mode. The photobioreactors are fully equipped to monitor the microalgae cultivation online. The following figure shows a picture of the pilot plant located in the headquarters of IMDEA Energy. This singular infrastructure has been designed in order to compare and optimise two of the most common algae cultivation systems. Performance, productivity and associated costs of different algae cultivation systems are being compared at pilot scale.

Plant for the cultivation of microalgae

Pilot Plant for the Production of Advanced Biofuels

The pilot plant for the production of advanced biofuel via thermochemical transformations was constructed and commissioned in 2014. This reaction system was designed to carry out the following processes:

- Catalytic Pyrolysis of Biomass. The system consists of a fluidized bed reactor which is fed by an Archimedes screw with the lignocellulosic biomass located in two hoppers. The unit operates with (catalytic pyrolysis) or without catalyst (thermal pyrolysis) under a high flow of N_2 to achieve very short residence times. The reactor operates at atmospheric pressure and temperatures between 400 and 600 °C. After a series of successive filters for collecting solid particles and heat exchanger the bio-oils are condensed and collected in a reservoir for further treatment.

- Hydrodeoxygenation. Fast pyrolysis oil can be introduced via a high pressure high accuracy liquid pump in a continuous fixed bed reactor where it is subjected to a treatment of catalytic hydrodeoxygenation at temperatures up to 400 °C and using hydrogen pressures up to 50 bar. The outlet stream of the reactor goes throughout a gas-liquid separator to split the two products and collect the upgraded biofuel.

These two separate reactors can operate independently or coupled in series depending of the characteristics of the assay. An online microGC is connected to the system for the continuous analysis of the gas stream.

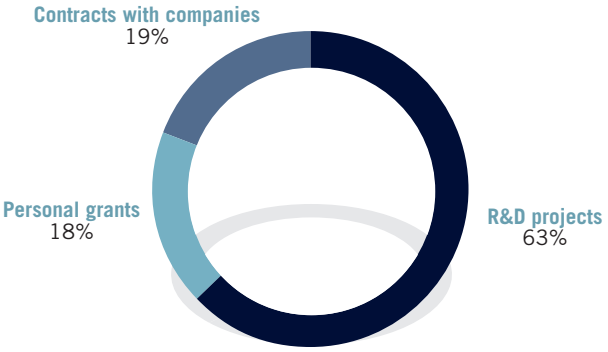
Pilot plant for the production of advanced biofuels

The laboratories and the pilot plants have been mostly equipped with funds received from R&D projects and from the National Programme of Technical-Scientific Infrastructures, National Sub-programme of Actions for Scientific and Technological Parks, Ministry of Science and Innovation and from European Union Structural Funds.

R&D projects, contracts and grants

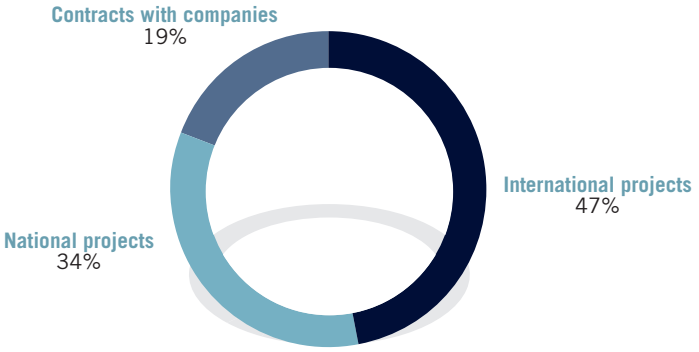
annual report 2014

The total external funding obtained and spent by IMDEA Energy coming from R&D projects, contracts with companies and personnel grants during 2014 reached the amount of 1.88 M€. The main source of funding came from R&D projects (63%), following by personnel grants (18%) and contracts with companies (19%).



6.1. R&D projects and contracts

The external funding obtained and spent by IMDEA Energy Institute from R&D projects and contracts with companies during 2014 has reached the amount of 1.535.065 €. The main source of the external funding in 2014 came from came from international R&D programs (47%), following by projects corresponding to calls of national R&D programs (34%) and finally from contracts with companies (19%).



The following list shows the R&D projects and contracts active in 2014:

Regional projects

Title/Acronym: Storage and conversion of concentrated solar power/ALCCONES
Partners: IMDEA Energy Institute (Coordinator); URJC; CIEMAT; CSIC; Abengoa Research; SENER Ingeniería y Sistemas; Empresarios Agrupados
Period: 2014-2018
Funding Institution/Program: Comunidad de Madrid/ Program of R&D activities between research groups in Technology
IMDEA Energy Institute external funding: 232.921 €

Title/Acronym: Use of agro-forest and oily residues to produce clean transportation fuels/ RESTOENE2
Partners: ICP-CSIC (Coordinator); CIEMAT; GIQA-URJC; IMDEA Energy Institute; UAM; Laboratorio-URJC; Abengoa Bioenergía; Repsol; Exide Technologies; Soluciones Catalíticas Ibercat
Period: 2014-2018
Funding Institution/Program: Comunidad de Madrid/ Program of R&D activities between research groups in Technology
IMDEA Energy Institute external funding: 143.451 €

Title/Acronym: Fundamental properties and application of graphene and other 2D materials/MAD2D
Partners: ICMM-CSIC (Coordinator); IMDEA Energy Institute; IMDEA Nanoscience Institute; IMDEA Materials Institute; Autonoma University of Madrid; Laboratory-IMDEA Materials; Laboratory-IMDEA Nanoscience; Laboratory-IMDEA Energy; Airbus Operations; Repsol; Bruker; Albufera Energy Storage; Nanoinnova Technologies
Period: 2014-2018
Funding Institution/Program: Comunidad de Madrid/ Program of R&D activities between research groups in Technology
IMDEA Energy Institute external funding: 140.371 €

Title/Acronym: Smart grids for the Community of Madrid/PRICAM
Partners: Alcalá University (Coordinator); Rey Juan Carlos University; Carlos III University; Pontificia Comillas University of Madrid; Laboratory-IMDEA Energy; Iberdrola; Indra; Real Academia de Ingeniería; Hospital Universitario de Fuenlabrada
Period: 2014-2018
Funding Institution/Program: Comunidad de Madrid/ Program of R&D activities between research groups in Technology
IMDEA Energy Institute external funding: 148.500 €

Title/Acronym: Industrial applications of spirulina/INSPIRA1
Partners: CIB-CSIC (Coordinator); ICP-CSIC; ICV-CSIC; UAM; UCM; URJC; Laboratory-IMDEA Energy; Biodesma; Micro algae Solutions; Laboratorios Actafarma; Isolux Corsán; Canal de Isabel II; UPM (Dr. Diego García de Jalón)
Period: 2014-2018
Funding Institution/Program: Comunidad de Madrid/ Program of R&D activities between research groups in Technology
IMDEA Energy Institute external funding: 80.000 €

National projects

Title/Acronym: Production of hydrogen via solar driven high temperature process/SolH2
Partners: Abengoa Hidrógeno (Coordinator); IMDEA Energy Institute; University of Seville; CIEMAT
Period: 2011-2014
Funding Institution/Program: Ministry of Economy and Competitiveness/ Sub-program INNPACTO 2011
IMDEA Energy Institute external funding: 107.100 €

Title/Acronym: Application of capacitive deionization to wastewater treatment/ADECAR
Partners: Isolux Ingeniería (Coordinator); IMDEA Energy Institute; Nanoquimia; Proingesa; University of Cordoba
Period: 2011-2014
Funding Institution/Program: Ministry of Economy and Competitiveness/ Sub-program INNPACTO 2011
IMDEA Energy Institute external funding: 221.149 €

Title/Acronym: Tailored semiconductor nanocrystals for supercapacitors/CAPSETA2
Partners: IMDEA Energy Institute (Coordinator); SAFT Batteries; EINSA
Period: 2012-2014
Funding Institution/Program: Ministry of Economy and Competitiveness/ Subprogram of Fundamental non-oriented research
IMDEA Energy Institute external funding: 145.200 €

Title/Acronym: Oxygen generation and transport by based-on manganese oxides solar thermochemical processes/SOLARO2
Partners: IMDEA Energy Institute (Coordinator); IBERDROLA; Fundación Ciudad de la Energía
Period: 2012-2015
Funding Institution/Program: Ministry of Economy and Competitiveness/ Subprogram of Fundamental non-oriented research
IMDEA Energy Institute external funding: 205.700 €

Title/Acronym: Development of novel catalytic systems for the production of 2nd-Generation Biofuels by deoxygenation of lignocellulosic biomass processes/LIGCATUP
Partners: IMDEA Energy Institute (Coordinator); URJC; Repsol; Abengoa Bioenergía; Algaenergy
Period: 2012-2014
Funding Institution/Program: Ministry of Economy and Competitiveness/ Subprogram of Fundamental non-oriented research
IMDEA Energy Institute external funding: 169.400 €

Title/Acronym: Assessment of the manufacturing routes of high energy density biofuels from lignocellulosic via platform molecules/ASBIOPLAT
Partners: URJC (Coordinator); IMDEA Energy Institute; Novotec Consultores
Period: 2012-2014
Funding Institution/Program: Ministry of Economy and Competitiveness/ Subprogram of Fundamental non-oriented research
IMDEA Energy Institute external funding: 71.390 €

Title/Acronym: Development of a process at pilot plant scale for the production of advanced biofuels by hydrodeoxygenation of second generation vegetable oils and pyrolysis bio-oils
Partners: Abengoa Research (Coordinator); IMDEA Energy Institute; Camelina Company España
Period: 2012-2015
Funding Institution/Program: Ministry of Economy and Competitiveness/ Sub-program INNPACTO 2012
IMDEA Energy Institute external funding: 308.997 €

Title/Acronym: Development of high performance supercapacitors by using novel ionic liquid-based electrolytes/SUPERLION
Partners: IMDEA Energy Institute (Coordinator); Repsol; Solvionic
Period: 2013-2015
Funding Institution/Program: Ministry of Economy and Competitiveness/ Subprogram of Fundamental non-oriented research
IMDEA Energy Institute external funding: 174.330 €

Title/Acronym: Design of multifunctional redox systems based on mesoporous transition metal oxides for thermochemical energy storage/MULTISTOR
Partners: IMDEA Energy Institute (Coordinator); Repsol; Abengoa Hidrógeno
Period: 2013-2015
Funding Institution/Program: Ministry of Economy and Competitiveness/ Subprogram of Fundamental non-oriented research
IMDEA Energy Institute external funding: 140.400 €

Title/Acronym: Integration of renewable energy in the smart grid/RESmart
Partners: Carlos III University (Coordinator); IMDEA Energy Institute; Unión Fenosa Distribución
Period: 2014-2016
Funding Institution/Program: Ministry of Economy and Competitiveness/ State Program of Research, Development and Innovation Oriented Challenges of the Society. Research Challenges 2013
IMDEA Energy Institute external funding: 65.340 €

Title/Acronym: Algal biogas from wastewater bioremediation: seeking for insights on population dynamics and cell wall characteristics/WWWAL-GAS
Partners: IMDEA Energy Institute (Coordinator); Explotación Agropecuaria Jose Mario Anton Andrés; Bodega Valdehermoso; Aqualia
Period: 2014-2017
Funding Institution/Program: Ministry of Economy and Competitiveness/ State Program of Research, Development and Innovation Oriented Challenges of the Society. Research Challenges 2013
IMDEA Energy Institute external funding: 127.050 €

Title/Acronym: European projects office Madrimasd-IMDEA/OPE MADRIMASD-IMDEA
Partners: Fundación madrimasd para el conocimiento (Coordinator); IMDEA Energy Institute; IMDEA Water Institute; IMDEA Food Institute; IMDEA Materials Institute; IMDEA Nanoscience Institute; IMDEA Networks Institute; IMDEA Software Institute
Period: 2014-2017
Funding Institution/Program: Ministry of Economy and Competitiveness/ State Program of Research, Development and Innovation Oriented Challenges of the Society. Acciones de dinamización “Europa Redes y Gestores”

Title/Acronym: Dissemination and support to companies regarding Carbon Footprint Register/RHueCa
Partners: Asociación sostenibilidad y energías renovables (Coordinator); IMDEA Energy Institute; Inabensa; Eagle digital technologies
Period: 2014-2015
Funding Institution/Program: Ministry of Industry, Energy and Tourism/ Apoyo a agrupaciones empresariales innovadoras
IMDEA Energy Institute external funding: 17.508 €

Title/Acronym: Multifunctional Hybrid photocatalysts for artificial photosyntesis/Hydrid-Leaf
Partners: IMDEA Energy Institute
Period: 2014-2015
Funding Institution/Program: Ministry of Economy and Competitiveness/ State Program for Promotion of Scientific and Technical Reseach Excellence. *Acciones de dinamización "Proyectos Europa Excelencia"*
IMDEA Energy Institute external funding: 85.000 €

Title/Acronym: Enzymatic, chemical and engineering challenges to the use of agroforestry resources nonfood (lignocellulose) in a more sustainable bio-economy and cleaner
Partners: CIB-CSIC (Coordinator); INIA; CIEMAT; EYOWN Technologies; Alcalá University; ICP-CSIC; Valladolid University; IRNASE-CSIC; Barcelona University; IMDEA Energy Institute; Jaén University; Celulosas de Levante; Instituto de Biotecnología de León; CRAG; Polytechnic University of Catalonia; Foresa-Industrias químicas del noroeste; Biopolis; Santiago de Compostela University; CID-CSIC; CIFOR-INIA; Vigo University; Zaragoza University; IATA-CSIC
Period: 2014-2015
Funding Institution/Program: Ministry of Economy and Competitiveness/ State Program of Research, Development and Innovation Oriented Challenges of the Society. *Proyectos de investigación fundamental orientada y acciones complementarias del INIA*

Title/Acronym: New challenges in the production of solar fuels/FOTOFUEL
Partners: IMDEA Energy Institute (Coordinator); ICP-CSIC; ICIQ; UPV-CSIC; IMDEA Materials Institute; ALBA-CELLS; University of Barcelona; Universitat Jaume I de Castello; Plataforma Solar de Almería; MATGAS
Period: 2014-2016
Funding Institution/Program: Ministry of Economy and Competitiveness/ State Program for Promotion of Scientific and Technical Reseach Excellence. *Acciones de dinamización "Redes de excelencia"*
IMDEA Energy Institute external funding: 18.000 €

International projects

Title/Acronym: New materials for sorption-based thermal energy storage/STOREHEAT
Partners: National Institute of Chemistry (Coordinator); IMDEA Energy Institute; Silkem
Period: 2011-2014
Funding Institution/Program: European Union and Fundación Madri+d para el conocimiento/ MATERA-ERANET-Call 2010

Title/Acronym: Thermochemical energy storage for concentrated solar power plants/ TCSPower
Partners: Deutsches Zentrum für Luft- und Raumfahrt (DLR) (Coordinator); Siemens CSP (SCSP); Bühler; Eramet et Comilog Chemicals; IMDEA Energy Institute; Paul Scherrer Institute; Universität Siegen
Period: 2011-2015
Funding Institution/Program: European Union/ FP7-Cooperation. Call identifier: FP7-ENERGY-2011-1
IMDEA Energy Institute external funding: 436.418 €

Title/Acronym: Concentrated Solar Power in Particles/CSP2
Partners: Centre National de la Recherche Scientifique (CNRS) (Coordinator); The University of Warwick; Eidgenössische Technische Hochschule Zürich; IMDEA Energy Institute; COMESSA; TORRESOL Energy Investments; European Powder & Process Technology
Period: 2011-2015
Funding Institution/Program: European Union/ FP7-Cooperation. Call identifier: FP7-ENERGY-2011-1
IMDEA Energy Institute external funding: 203.478 €

Title/Acronym: Energy demand aware open services for smart grid intelligent automation/SmartHG
Participantes: Partners: Sapienza University of Rome (Coordinator); Aarhus University; IMDEA Energy Institute; Joint Institute for Power and Nuclear Research; ATANVO; GridManager; Panoramic Power; Solintel; SEAS- NVE; Kalundborg Municipality; Minskenergo
Period: 2012-2015
Funding Institution/Program: European Union/ FP7-Cooperation. Call identifier: FP7-ICT-2011-8
IMDEA Energy Institute external funding: 440.832 €

Title/Acronym: Training network in innovative polyelectrolytes for energy and environment/RENAISSANCE
Partners: University of the basque country (Coordinator); CNRS-University of Bordeaux I; Max Planck Institute of Colloids and Interfaces; Linköping University; University of Liege; IMDEA Energy Institute; Kitozyme; Procter & Gamble Italia; Procter & Gamble Services Company
Period: 2012-2016
Funding Institution/Program: European Union/ FP7-People Program. Call identifier FP7-PEOPLE-2011-ITN
IMDEA Energy Institute external funding: 223.481 €

Title/Acronym: CAScade deoxygenation process using tailored nanoCATalysts for the production of BiofuELs from lignocellullosic biomass/CASCATBEL
Partners: IMDEA Energy Institute (Coordinador); ENCE; Universita' degli studi di milanobicocca; Charles University in Prague; Institute of Physical Chemistry; Universiteit Utrecht; Aston University; Abengoa Research; ETH Zürich; Max Planck Institut fuer Kohlenforschung; MAST Carbon International; Silkem; Nanologica; Center for Research and Technology Hellas/Chemical Process and Energy Research Institute; ENI; Hamburg University of Technology; OUTOTEC
Period: 2013-2017
Funding Institution/Program: European Union/ FP7-Cooperation. Call identifier: FP7-NMP-2013-LARGE-7
IMDEA Energy Institute external funding: 900.217 €

Title/Acronym: Scientific and Technological Alliance for Guaranteeing the European Excellence in Concentrating Solar/STAGE-STE
Partners: CIEMAT (Coordinator); more than 40 partners, companies, universities, research centres, associations, from all over the world
Period: 2014-2018
Funding Institution/Program: European Union/ FP7-Cooperation. Call identifier: FP7-ENERGY-2013-IRP
IMDEA Energy Institute external funding: 472.222 €

Title/Acronym: Checking the actual sustainability of renewables. Developing of new tools/SuReTool
Partners: IMDEA Energy Institute (Coordinator); IFE
Period: 2014-2015
Funding Institution/Program: European Economic Area (EEA)/ NILS Ciencia y Sostenibilidad/EEA Grants-Call: Coordinated Mobility of Researchers
IMDEA Energy Institute external funding: 15.730 €

Contracts with companies and other organizations

Title/Acronym: Energy efficiency in systems for vibration testing
Company: IMV Corporation (Japan)
Period: 2010-2015
IMDEA Energy Institute external funding: 111.156 €

Title/Acronym: Development of a modular central receiver concentrated solar power plant for decentralized power generation/CRISPTower
Company: Sunborne Energy Technologies (India)
Period: 2011-2014
IMDEA Energy Institute external funding: 81.320 €

Title/Acronym: Ecodesign of products
Company: Repsol (Spain)
Period: 2013-2014
IMDEA Energy Institute external funding: 34.235 €

Title/Acronym: Study about the effect of ripple of recharge current in lithium ion batteries
Company: Repsol (Spain)
Period: 2013-2014
IMDEA Energy Institute external funding: 22.198 €

Title/Acronym: Development of a rechargeable metal-air battery
Company: Albufera Energy Storage (Spain)
Period: 2013-2015
IMDEA Energy Institute external funding: 40.000 €

Title/Acronym: Valorization of sub-products generated from the process of obtaining second-generation ethanol/VOLETOL
Institution: Rey Juan Carlos University (Spain)
Period: 2014
IMDEA Energy Institute external funding: 2.000 €

Title/Acronym: Consulting on the state of the art in nanotechnology for energy applications
Institution: IMDEA Nanoscience Institute (Spain)
Period: 2014-2015
IMDEA Energy Institute external funding: 3.500 €

Title/Acronym: Hydrogen prospective/H2R2
Company: Repsol (Spain)
Period: 2014
IMDEA Energy Institute external funding: 48.843 €

Title/Acronym: Next generation battery testing equipment/NGBTE
Company: IMV Corporation (Japan)
Period: 2014-2016
IMDEA Energy Institute external funding: 259.416 €

Title/Acronym: Energy demand estimation tool for buildings-feasibility and cost savings study/HERCON
Company: IMESAPI (Spain)
Period: 2014
IMDEA Energy Institute external funding: 14.776 €

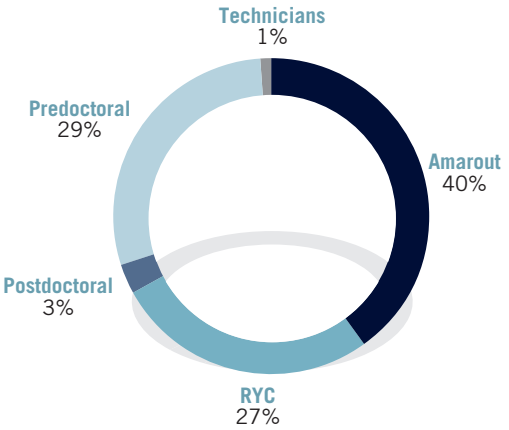
Title/Acronym: Development of new structural materials for energy harvesting and storage/DESMAN
Institution: IMDEA Materials Institute (Spain)
Period: 2014-2017
IMDEA Energy Institute external funding: 151.600 €

Title/Acronym: Ecodesign of products2
Company: Repsol (Spain)
Period: 2014-2015
IMDEA Energy Institute external funding: 13.092 €

6.2. Researcher grants and mobility actions

6.2.1. Researcher grants

The extermal funding obtained by IMDEA Energy from fellowships and grants during 2014 according to the funding source, has been the amount 346.878 €. The main source of external funding has been the European Programme Amarout (40%), the second, the Ramón y Cajal (RYC) program (27%) and finally other grants for hiring predoctoral researchers (29%).



Program: Ramón y Cajal 2009
Project: Development and validation of kinetic mechanisms and multi-fluids numerical model adapted to the synthesis of nanomaterials in the gas phase and plasma-assisted combustion
Period: 2010-2014
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 177.480 €
Dr. José González

Program: Predoctoral Research Grant (FPI)
Project/Acronym: CO_2 Valorization by photocatalytic processes/ FOTOVALCO2
Period: 2010-2014
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 97.000 €
Ms. Laura Collado

Program: Technical Support Staff 2011
Period: 2011-2014
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 57.600 €
Dr. Fernando Picó

Program: Ramón y Cajal 2011
Project: Intelligent power interfaces for real-time management of future power networks
Period: 2012-2016
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 168.600 €
Dr. Milan Prodanovic

Program: Ramón y Cajal 2011
Project: Application of ionic liquid-based materials in high performance supercapacitor
Period: 2012-2016
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 168.600 €
Dr. Rebeca Marcilla

Program: Fellowship of Ministry of Higher Education
Project: Characterization and development of indigenous microalgae for biofuels production
Period: 2012-2016
Funding Institution: Ministry of Higher Education
IMDEA Energy Institute external funding: 108.000 €
Mr. Ahmed Abdel-Mohsen Mahdy

Program: Call for research funding in Energy and Environment 2013-2014
Project: Redox flow batteries for consumption management of electric power
Period: 2013-2014
Funding Institution: IBERDROLA Foundation
IMDEA Energy Institute external funding: 20.000 €
Dr. Enrique García-Quismondo

Program: "Marie Curie" AMAROUT Europe II. FP7-People Program. Call identifier FP7-PEOPLE-2011-COFUND
Period: 2013-2015
Funding Institution: European Union
IMDEA Energy Institute external funding: 35.702 €
Dr. Tadhg O'Mahony

Program: "Marie Curie" AMAROUT Europe II. FP7-People Program. Call identifier FP7-PEOPLE-2011-COFUND
Period: 2013-2015
Funding Institution: European Union
IMDEA Energy Institute external funding: 36.991 €
Dr. Jian Li

Program: "Marie Curie" AMAROUT Europe II. FP7-People Program. Call identifier FP7-PEOPLE-2011-COFUND
Period: 2013-2016
Funding Institution: European Union
IMDEA Energy Institute external funding: 55.876 €
Dr. Barry Hayes

Program: "Marie Curie" AMAROUT Europe II. FP7-People Program. Call identifier FP7-PEOPLE-2011-COFUND
Period: 2013-2016
Funding Institution: European Union
IMDEA Energy Institute external funding: 55.038 €
Dr. Sankaranayanan Thangaraju

Program: Predoctoral Research Grant (FPI)
Project/Acronym: Development of novel catalytic systems for the production of 2nd-Generation Biofuels by deoxygenation of lignocellulosic biomass processes/LIGCATUP
Period: 2013-2017
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 97.000 €
Mr. Antonio M. Berenguer

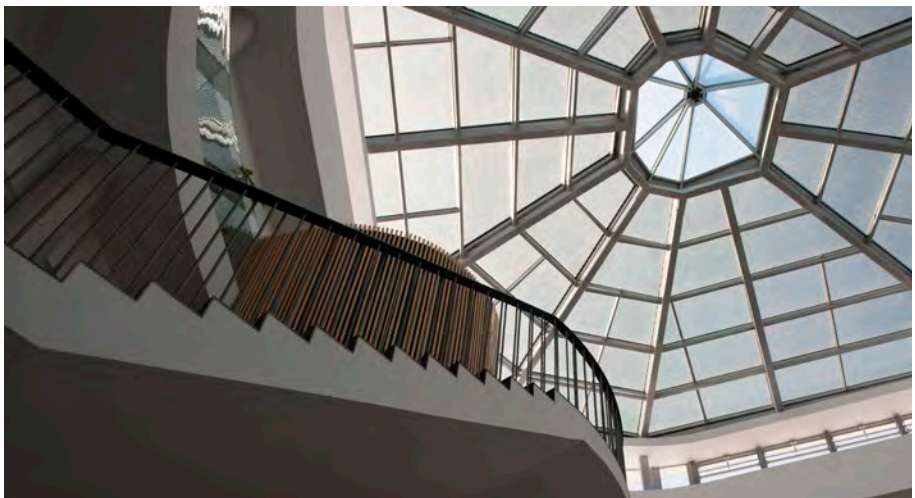
Program: Contract FPI
Project/Acronym: Development of high performance supercapacitors by using novel ionic liquid-based electrolytes/SUPERLION
Period: 2014-2017
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 82.400 €
Ms. Paula Navalpotro

Program: Call for research funding in Energy and Environment 2014-2015
Project: New flexible systems for thermochemical energy storage by redox cycles
Period: 2014-2015
Funding Institution: IBERDROLA Foundation
IMDEA Energy Institute external funding: 20.000 €
Mr. Alfonso Carrillo

Program: "Marie Curie" AMAROUT Europe II. FP7-People Program. Call identifier FP7-PEOPLE-2011-COFUND Period: 2014
Funding Institution: European Union
IMDEA Energy Institute external funding: 13.756 €
Dr. James Spelling

Program: "Marie Curie" AMAROUT Europe II. FP7-People Program. Call identifier FP7-PEOPLE-2011-COFUND Period: 2014-2016
Funding Institution: European Union
IMDEA Energy Institute external funding: 48.783 €
Dr. Elia Tomás

Program: "Marie Curie" AMAROUT Europe II. FP7-People Program. Call identifier FP7-PEOPLE-2011-COFUND Period: 2014-2016
Funding Institution: European Union
IMDEA Energy Institute external funding: 37.768 €
Dr. Puiki Leung



Program: "Marie Curie" AMAROUT Europe II. FP7-People Program. Call identifier FP7-PEOPLE-2011-COFUND Period: 2014-2016
Funding Institution: European Union
IMDEA Energy Institute external funding: 37.768 €
Dr. Afshin Pendashteh

Program: "Marie Curie" AMAROUT Europe II. FP7-People Program. Call identifier FP7-PEOPLE-2011-COFUND Period: 2014-2016
Funding Institution: European Union
IMDEA Energy Institute external funding: 34.969 €
Dr. Lida Heidari

Program: Acciones de programación conjunta tipo COFUND
Project/Acronym: AMAROUT-Sp
Period: 2014-2015
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 21.009 €

6.2.2. Mobility actions

Stay at Synchrotron ALBA Cells, Barcelona, Spain
Period: 1 week, 2014
Funding Institution: IMDEA Energy Institute
Dr. Víctor de la Peña, Dr. Juan Coronado, Dr. Prabhas Jana and Ms. Laura Collado

Stay at University of Salamanca, Spain
Period: 2 weeks, 2014
Funding Institution: IMDEA Energy Institute
Mr. Alfredo Oliva

Stay at ETH Zurich, Switzerland
Period: 1 month, 2014
Funding Institution: IMDEA Energy Institute
Dr. Manuel Romero

Stay at Institute for Energy Technology (IFE), Oslo, Norway
Program: NILS Ciencia y Sostenibilidad/EEA Grants
Period: 1 month, 2014
Funding Institution: European Economic Area (EEA)
Dr. Javier Dufour

Stay at Deakin University, Melbourne, Australia
Period: 1 week, 2014
Funding Institution: IMDEA Energy Institute
Dr. Rebeca Marcilla

Stay at ETH Zurich, Switzerland
Period: 3 weeks, 2014
Funding Institution: IMDEA Energy Institute
Mr. Alfonso Carrillo

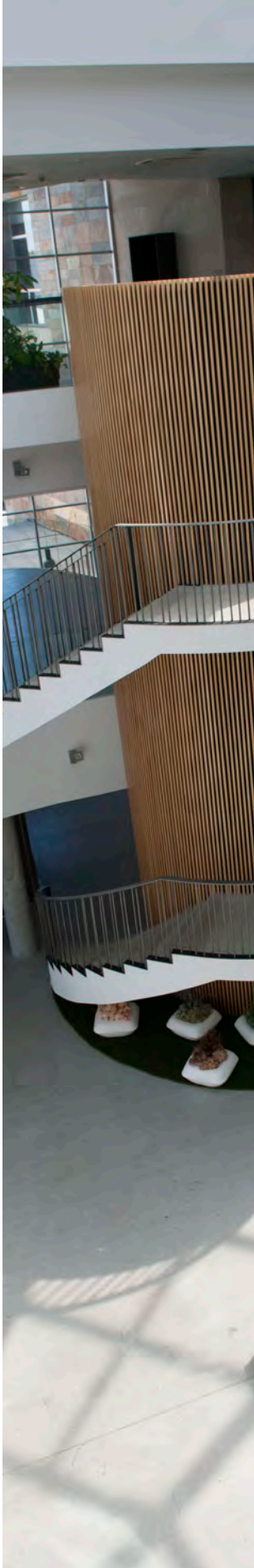
Stay at Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing, China
Period: 3 weeks, 2014
Funding Institution: IMDEA Energy Institute
Dr. José González

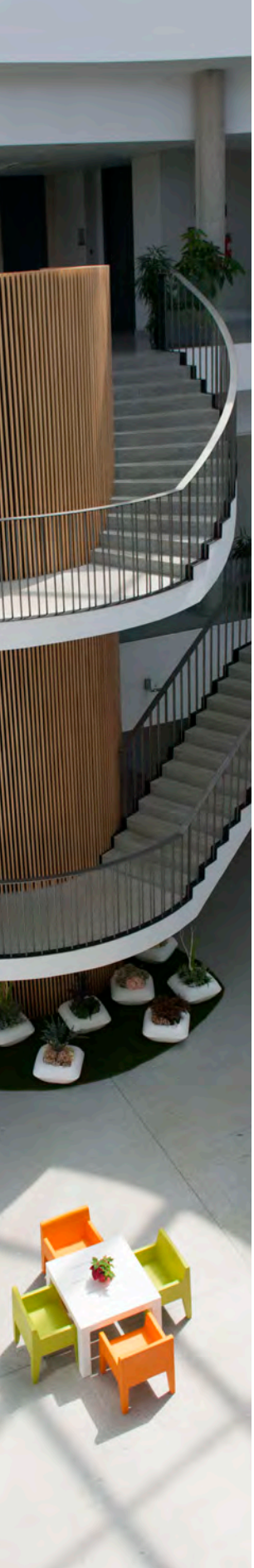
Stay at LBR-INRA, Narbonne, France
Period: 3 months, 2014-2015
Funding Institution: IMDEA Energy Institute
Ms. Lara Méndez

Visiting researchers

Prof. Dr. Aldo Steinfeld, Professor of Renewable Energy Carriers at ETH and Head of the Solar Technology Laboratory at the Paul Scherrer Institute
Origin Institution: ETH, Switzerland
Unit: High Temperature Processes Unit
Period: 1 month, 2014
Activity: Collaboration in the field of Concentrating Solar Power and exploration of possible project proposals to H2020

Mr. Mehmet Isik, Investigador predoctoral
Origin Institution: POLYMAT, University of the Basque Country, Spain
Unit: Electrochemical Processes Unit
Period: 3 weeks, 2014
Activity: Electrochemical characterization of different gels based on ionic liquids within of RENAISSANCE project





Ms. Isabel Plana, PhD Student
Origin Institution: Massachusetts Institute of Technology, USA
Unit: Thermochemical Processes Unit
Period: 2 months, 2014
Activity: Testing of various specific catalysts for the process of hydrodeoxygenation (HDO) of pyrolysis bio-oils of lignocellulosic biomass for the production of advanced biofuels

Mr. Ludovic Hervé, PhD Student
Origin Institution: ITII Pays de la Loire, France
Unit: High Temperature Processes Unit
Period: 2 months, 2014
Activity: Integration analysis of latent heat thermal storage systems in concentrating solar power plants

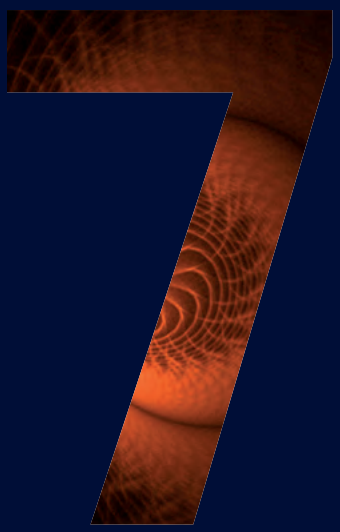
Dr. Diego García, Postdoctoral Researcher
Origin Institution: Institute for Energy Technology (IFE), Norway
Unit: System Analysis Unit
Periodo: 2 weeks, 2014
Activity: Collaboration in the SURETOOL project.

Mr. Alejandro Bautista, PhD Student
Origin Institution: National Autonoma University of Mexico (UNAM), Mexico
Unit: High Temperature Processes Unit
Period: 2 months, 2014
Activity: Collaboration in the STAGE-STE project. Solar-driven gasification of low-grade petcoke

Mr. Mohammed Kebir, PhD Student
Origin Institution: Center of Research in Physical and Chemical Analysis (CRAPC), Argelia
Unit: Thermochemical Processes Unit
Period: 1 month, 2014
Activity: Production of solar fuels via photocatalytic processes using perovskites

Mr. Yacine Azoudj, PhD Student
Origin Institution: Center of Research in Physical and Chemical Analysis (CRAPC), Argelia
Unit: Thermochemical Processes Unit
Period: 1 month, 2014
Activity: Production of solar fuels via photocatalytic processes using perovskites

cooperation framework



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7.1. Cooperation with research institutions and universities

The following table lists cooperation activities established with different Research Institutions and Universities that have been active during 2014.

Institution	Cooperation
Indian Institute of Tehnology Delhi/Center for Energy Studies (India)	Participation in the project funded by the company Sunborne Energy Technologies Pvt Ltd. Period: 2011-2014
University of South Florida (USA)	Coordinator of the project funded by the company Sunborne Energy Technologies Pvt Ltd. Period: 2011-2014
University of Seville (Spain)	Cooperation within the framework of SolH2 project for hydrogen production. Period: 2011-2014
University of Córdoba (Spain)	Cooperation within the framework of ADECAR project for the application of capacitive deionization to wastewater treatment. Period: 2011-2014
National Institute of Chemistry (Slovenia)	Cooperation in the project STOREHEAT for development of materials for thermal energy storage. Period: 2011-2014
Istituto per la Microeletronica e Microsistemi-CNR (Italy)	Cooperation within the framework of CAPSETA2 project for the design of supercapacitors. Period: 2011-2014
University of Warwick (United Kingdom)	Cooperation within the framework of CSP2 project for solar concentrating systems. Period: 2011-2015
Centre National de la Recherche Scientifique (CNRS) (France)	Cooperation in projects related to solar concentrating systems (Project CSP2). Period: 2011-2015
Paul Scherrer Institute (PSI) (Switzerland)	Cooperation within the framework of TCSPower project related to solar concentrating systems Period: 2011-2015
Institute of Energy Technology (ETH-Zurich) (Switzerland)	Cooperation in the CSP2 project for solar concentrating systems and CASCATBEL project for the production of second-generation biofuels. Period: 2011-2017
National Autonoma University of Mexico (UNAM) (Mexico)	Cooperation in research projects on concentrating solar power. Period: 2011-present
Sapienza University of Rome (Italy)	Coordinator of the project SmartHG for smart grid intelligent automation. Period: 2012-2015

Institution	Cooperation
University of the Basque Country (Spain)	Coordinator of the project RENAISSANCE for training network in innovative polyelectrolytes for energy and environment. Period: 2012-2016
Rey Juan Carlos University (URJC) (Spain)	Cooperation in projects to the production of sustainable fuels, energy storage, smart grids and aplications of the spirulina (Projects: LIGCATUP, ASBIOPLAT, RESTOENE2 , ALCCONES, PRICAM e INSPIRA1). Period: 2012-2018
Max Planck Institut fuer Kohlenforschung (Germany)	Cooperation within the framework of CASCATBEL project for the production of second-generation biofuels. Period: 2013-2017
CERTH/CPERI (Greece)	Cooperation within the framework of CASCATBEL project for the production of second-generation biofuels. Period: 2013-2017
Hamburg University of Technology (Germany)	Cooperation within the framework of CASCATBEL project for the production of second-generation biofuels. Period: 2013-2017
Carlos III University (Spain)	Cooperation within the framework of RESmart project for the integration of renewable energies into smart grids. Period: 2014-2016
Fundación madrimasd para el conocimiento (Spain)	Cooperation within the framework of OPE MADRIMASD-IMDEA project for the creation of an office of European projects. Period: 2014-2017
Centre of Energy, Environmental and Technological Research (CIEMAT) (Spain)	Cooperation in projects to the production of sustainable fuels and solar concentrating systems (Proyectos: RESTOENE2 y ALCCONES). Period: 2014-2018
Autonoma University of Madrid (UAM) (Spain)	Cooperation in projects to the production of sustainable fuels and applications of the spirulina (Projects: RESTOENE2 and INSPIRA1). Period: 2014-2018
Higher Council for Scientific Research (CSIC) (Spain)	Cooperation in projects to the production of sustainable fuels, applications of graphene and spirulina (Projects: RESTOENE2, MAD2D e INSPIRA1). Period: 2014-2018
University of Alcalá (Spain)	Coordinator of the PRICAM project to smart grids. Period: 2014-2018

7.2. Cooperation with other IMDEA Institutes

The following table lists cooperation agreements established with other IMDEA Institutes, which have been active during 2014.

Institution	Cooperation
IMDEA Software, IMDEA Materials; IMDEA Networks; IMDEA Water; IMDEA Food; IMDEA Nanoscience	Cooperation within the framework of AMAROUT II Program Period: 2013-2016
IMDEA Software; IMDEA Networks; IMDEA Nanoscience; IMDEA Food; IMDEA Materials	Cooperation within the framework of AMAROUT-Sp project in the framwork of the COFUND2014 program Period: 2014-2015
IMDEA Water; IMDEA Food; IMDEA Materials; IMDEA Nanoscience; IMDEA Networks; IMDEA Software	Cooperation within the framework of OPE MADRIMASD-IMDEA project Period: 2014-2017
IMDEA Nanoscience	Cooperation within the framework of MAD2D project Period: 2014-2018 Contract for a report on the state of the art in the field of nanotechnology Period: 2014-2015
IMDEA Materials	Cooperation within the framework of MAD2D project Period: 2014-2018 Contract for the development of materials for energy storage Period: 2014-2017

7.3. Cooperation with industry

Cooperation in R&D&i with companies is one of the main objectives of IMDEA Energy Institute. In this sense, the Institute maintains an intense activity aimed to attract companies and collaborations with industrial partners, and a strong presence in international networks and platforms with industrial participation. In 2014, IMDEA Energy promoted a high number of meetings with companies and was actively involved in the organization and participation in business events. In 2014 more than 200 companies were contacted and more than 10 new R&D proposals have been launched. In the following table, it is shown the efforts made by the Institute in 2014 in order to promote business relationships:

Number of events organized by IMDEA Energy	10
Number of corporate events hosted by IMDEA Energy	3
Number of external corporate events with the presence and participation of IMDEA Energy	70
Number of meetings with companies	92

The following table lists the companies that have projects and contracts in collaboration with the IMDEA Energy Institute.

Company	Cooperation
IMV Corporation (Japan)	Cooperation on energy efficient processes. Period: 2010-2015
Sunborne Energy Technologies (India)	Coordinator of the project titled "Development of a Modular Central Receiver Concentrated Solar Power Plant for Decentralized Power Generation". Period: 2011-2014
Silkem (Slovenia)	Cooperation in the project STOREHEAT for development of materials for thermal energy storage. Period: 2011-2014
PROINGESA (Spain)	Cooperation within the framework of ADECAR project for the application of capacitive deionization to wastewater treatment. Period: 2011-2014
Nanoquimia (Spain)	Cooperation within the framework of ADECAR project for the application of capacitive deionization to wastewater treatment. Period: 2011-2014
Bühler (Switzerland)	Cooperation within the framework of TCSPower project related to solar concentrating systems. Period: 2011-2015
COMESSA (France)	Cooperation in projects related to solar concentrating systems (Project CSP2). Period: 2011-2015
Eramet et Comilog Chemicals (Belgium)	Cooperation within the framework of TCSPower project related to solar concentrating systems. Period: 2011-2015
European Powder & Process Technology (Belgium)	Cooperation in projects related to solar concentrating systems (Project CSP2). Period: 2011-2015
Siemens Concentrated Solar Power (Israel)	Cooperation within the framework of TCSPower project related to solar concentrating systems. Period: 2011-2015

Company	Cooperation
Torresol Energy Investments (Spain)	Cooperation in projects related to solar concentrating systems (Project CSP2). Period: 2011-2015
Abengoa Hidrógeno (Spain)	Cooperation in projects and activities related to hydrogen production and thermochemical energy storage (Projects: SolH2 and MULTISTOR). Period: 2011-2016
Isolux Ingeniería (Spain)	Cooperation in projects for the application of capacitive deionization to wastewater treatment and applications of the spirulina (Projects: ADECAR and INSPIRA1) Period: 2011-2018
Algaenergy (Spain)	Cooperation within the framework of LIGCATUP project for the production of second generation biofuels. Period: 2012-2014
SAFT Baterías (Spain)	Cooperation within the framework of CAPSETA2 project for the design of supercapacitors. Period: 2012-2014
Equipos Industriales de Manutención (Spain)	Cooperation within the framework of CAPSETA2 project for the design of supercapacitors. Period: 2012-2014
Novotec Consultores (Spain)	Cooperation within the framework of ASBIOPLAT project for the production of biofuels. Period: 2012-2014
Camelina Company España (Spain)	Cooperation in projects for the production of second generation biofuels. Period: 2012-2015
Abengoa Bioenergía (Spain)	Cooperation in projects for the production of second generation biofuels (Proyectos: LIGCATUP, RESTOENE2). Period: 2012-2018
Repsol (Spain)	Cooperation in projects for the production of second generation biofuels (Proyectos:, LIGCATUP, SUPELION, MULTISTOR , RESTOENE2 y MAD2D). Period: 2012-2018
Abengoa Research (Spain)	Cooperation in projects for the production of second generation biofuels and energy storage (Projects: INNPACTO'12, CASCATBEL and ALCCONES) Period: 2012-2018
Iberdrola (Spain)	Cooperation in projects for solar thermochemical processes based on manganese oxides and smart grids (Projects: SOLARO2 and PRICAM) Period: 2012-2018

Company	Cooperation
Solvionic (France)	Cooperation within the framework of SUPERLION project for development of supercapacitors. Period: 2013-2015
MAST Carbon International Ltd. (United Kingdom)	Cooperation within the framework of CASCATBEL project for the production of biofuels. Period: 2013-2017
Silkem (Slovenia)	Cooperation within the framework of CASCATBEL project for the production of biofuels. Period: 2013-2017
Nanologica (Sweden)	Cooperation within the framework of CASCATBEL project for the production of biofuels. Period: 2013-2017
Outotec (Germany)	Cooperation within the framework of CASCATBEL project for the production of biofuels. Period: 2013-2017
Albufera Energy Storage (Spain)	Cooperation in projects for the development of a rechargeable metal-air battery and cooperation within the framework MAD2D project for applications of graphene Period: 2013-2018
Inabensa (Spain)	Cooperation within the framework of RHueCa project for carbon footprint register. Period: 2014-2015
Unión Fenosa Distribución (Spain)	Cooperation within the framework of RESmart project for the integration of renewable energies into smart grids. Period: 2014-2016
Aqualia (Spain)	Cooperation within the framework of WWWAL-GAS project for biogas production from microalgae. Period: 2014-2017
MATGAS (Spain)	Cooperation within the framework of FOTOFUEL project for the production of solar fuels. Period: 2014-2015
Empresarios Agrupados (Spain)	Cooperation within the framework of ALCCONES project for solar energy storage. Period: 2014-2018
SENER Ingeniería y Sistemas (Spain)	Cooperation within the framework of ALCCONES project for solar energy storage. Period: 2014-2018
Exide Technologies (Spain)	Cooperation within the framework of RESTOENE2 for the production of second generation biofuels. Period: 2014-2018

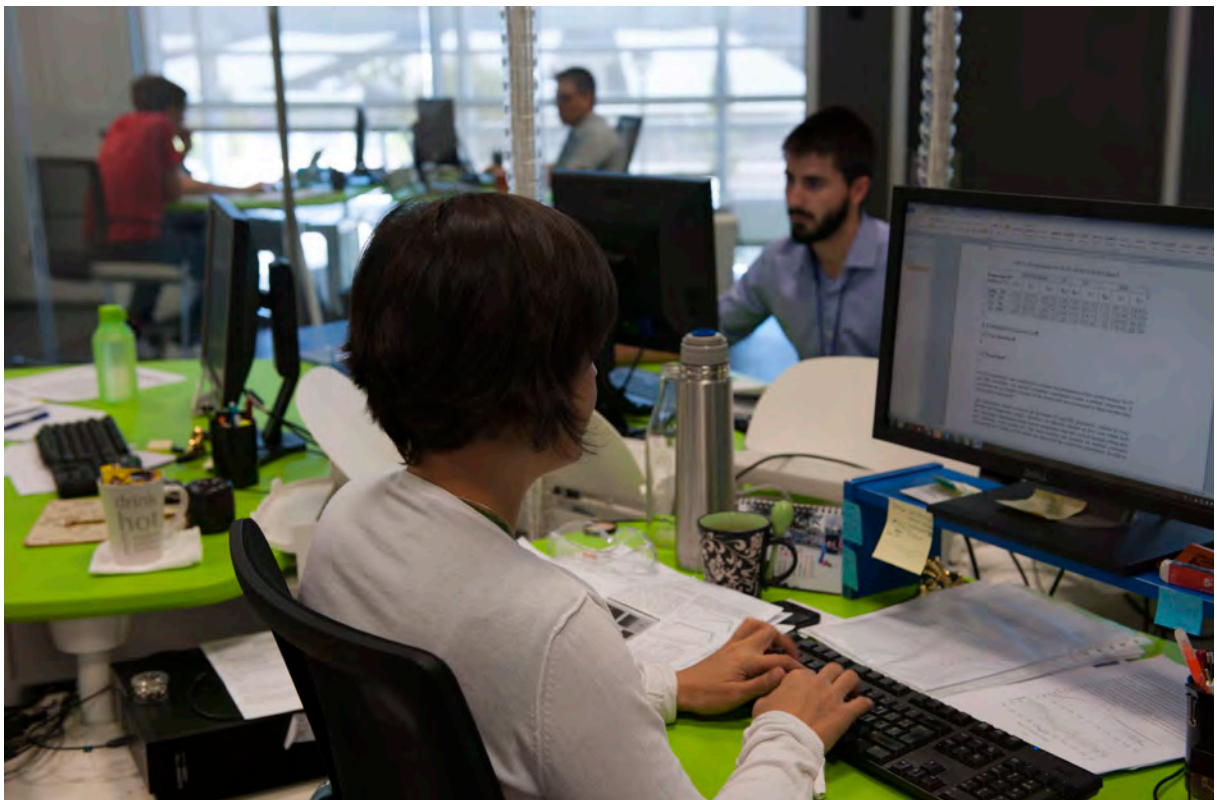
Company	Cooperation
Soluciones catalíticas Ibercat (Spain)	Cooperation within the framework of RESTOENE2 for the production of second generation biofuels. Period: 2014-2018
Airbus Operations (Spain)	Cooperation within the framework of MAD2D project for applications of graphene. Period: 2014-2018
Nanoinnova Technologies (Spain)	Cooperation within the framework of MAD2D project for applications of graphene. Period: 2014-2018
Bruker (Spain)	Cooperation within the framework of MAD2D project for applications of graphene. Period: 2014-2018
Indra (Spain)	Cooperation within the framework of PRICAM projet for smart grids. Period: 2014-2018

7.4. Cooperation with networks and associations

IMDEA Energy Institute, since its creation, has considered as a relevant activity its participation in associations, technology platforms, expert groups and alliances of the energy sector. This is also a means of increasing the external visibility of IMDEA Energy Institute, establishing new links with companies and research institutions and to gain updated information on the initiatives being planned and launched related to the different energy topics. The following lists gives the main associations in which IMDEA Energy Institute is participating as a member in 2014:

- Joint Programme on Energy Storage in the EERA (European Energy Research Alliance).
- Joint Programme on Bioenergy in the EERA (European Energy Research Alliance).
- Joint Programme on Concentrating Solar Power in the EERA (European Energy Research Alliance).
- Joint Programme on Economic, Environmental and Social Impacts of Energy Policies and Technologies in the EERA (European Energy Research Alliance).
- Research Grouping of the Joint Undertaking on Fuel Cells and Hydrogen of the VII Framework Programme of the EC (N.ERGHY).
- European Industrial Initiative in Bioenergy (BBI).
- Alliance of Energy Research and Innovation (ALINNE).
- President of the Cluster on Sustainability and Renewable Energies of Madrid Network.
- Aerospace Cluster of Madrid Network.
- Spanish Technological Platform on Hydrogen and Fuel Cells (PTE – HPC).

- Spanish Technological Platform on CSP technologies Solar Concentration (PTE – SOLAR CONCENTRA).
- Spanish Technological Platform for Biomass (BIOPLAT).
- Spanish Technological Platform for Energy Efficiency (PTE-EE).
- Spanish Electrical Grid Platform (FutuRed).
- Spanish Technological Platform on CO_2 (PTECO2).
- Spanish Technological Platform for Automotive and Mobility (Move2future).
- Spanish Network of Life Cycle Assessment (esLCA).
- Thematic Network LIGNOCEL on Biotechnology of lignocellulosic materials.
- International Solar Energy Society (ISES).
- Club Español de la Energía.
- Spanish Association for Quality (AEC).
- HIA30 of the International Energy Agency.
- European Solar Thermal Electricity Association (ESTELA).



scientific results

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The works published by researchers of the IMDEA Energy Institute during 2014 is listed below, as well as the communications to congresses.

8.1. Scientific publications

Scientific Journals

1. Alonso, E.; Pérez-Rábago, C.; Gonzalez-Aguilar, J.; Romero, M.
"A novel lab-scale solar reactor for kinetic analysis of non-volatile metal oxides thermal reductions".
Energy Procedia, **2014**, *57*, 561-569.

2. Álvarez de Miguel, S.; Gonzalez-Aguilar, J.; Romero, M.
"100-Wh multi-purpose particle reactor for thermochemical heat storage in concentrating solar power plants".
Energy Procedia, **2014**, *49*, 676-683.

3. Archibold, A.R.; Gonzalez-Aguilar, J.; Rahman, M.M.; Goswami, D.Y.; Romero, M.; Stefanakos, E.K.
"The melting process of storage materials with relatively high phase change temperatures in partially filled spherical shells".
Applied Energy, **2014**, *116*, 243-252.

4. Archibold, A.R; Rahman, M.; Gonzalez-Aguilar, J.; Goswami, D.Y.; Stefanakos, E.Y.; Romero, M.
"Phase change and heat transfer numerical analysis during solidification on an encapsulated phase change material".
Energy Procedia, **2014**, *57*, 653-661.

5. Bellan, S.; Alonso; E.; Pérez-Rábago, C.; Gonzalez-Aguilar, J.; Romero, M.
"Numerical modeling of solar thermochemical reactor for kinetic analysis".
Energy Procedia, **2014**, *49*, 735-742.

6. Bellan, S.; Gonzalez-Aguilar, J.; Archibold, A.; Romero, M.; Rahman, M.; Goswami, D.Y.; Stefanakos, E.K.
"Transient numerical analysis of storage tanks based on encapsulated PCMs for heat storage in concentrating solar power plants".
Energy Procedia, **2014**, *57*, 672-681.

7. Bellan, S.; Gonzalez-Aguilar, J.; Romero, M.; Rahman, M.M.; D. Goswami, Y.; Stefanakos, E.K.; Couling, D.
"Numerical analysis of charging and discharging performance of a thermal energy storage system with encapsulated phase change material".
Applied Thermal Engineering, **2014**, *71*, 481-500.

8. Botas, J.A.; Serrano, D.P.; García, A.; Ramos, R.
"Catalytic conversion of rapeseed oil for the production of raw chemicals, fuels and carbon nanotubes over Ni-modified nanocrystalline and hierarchical ZSM-5".
Applied Catalysis B: Environmental, **2014**, *145*, 205-215.

9. Carrillo, A.J.; Moya, J.; Bayón, A.; Jana, P.; de la Peña O'Shea, V.A.; Romero, M.; Gonzalez-Aguilar, J.; Serrano, D.P.; Pizarro, P.; Coronado, J.M.
"Thermochemical energy storage at high temperature via redox cycles of Mn and Co oxides: Pure oxides versus mixed ones".
Solar Energy Materials and Solar Cells, **2014**, *123*, 47-57.

10. Carrillo, A.J.; Serrano, D.P.; Pizarro, P.; Coronado, J.M.
"Thermochemical heat storage based on the Mn_2O_3/Mn_3O_4 redox couple: influence of the initial particle size on the morphological evolution and cyclability".
Journal of Materials Chemistry A, **2014**, *2 (45)*, 19435-19443.

11. Díaz, R.
"Electrochemical energy storage technologies and applications".
Journal of Energy and Power Engineering, **2014**, *8*, 794-804.

scientific journals

12. Dufour, J.; Martos, C.; Ruiz, A.; Maroño, M.; Sánchez, J.M.
"Synthesis of copper promoted high temperature water-gas shift catalysts by oxidation-precipitation".
International Journal of Hydrogen Energy, **2014**, *39 (31)*, 17600-17607.

13. D'Vries, R.F.; de la Peña-O'Shea, V.A.; Benito Hernández, A.; Snejko, N.; Gutiérrez-Puebla, E., Monge, M.A.
"Enhancing Metal–Organic Framework net robustness by successive linker coordination increase: from a hydrogen-bonded two-dimensional supramolecular net to a covalent one keeping the topology".
Crystal Growth and Design, **2014**, *14 (10)*, 5227-5233.

14. Epifani, M.; Comini, E.; Díaz, R.; Andreu, T.; Genc, A.; Arbiol, J.; Siciliano, J.; Faglia, G., Morante, J.R.
"Solvothermal, Chloroalkoxide-based synthesis of monoclinic WO_3 quantum dots and gas-sensing enhancement by surface oxygen vacancies".
ACS Applied Materials and Interfaces, **2014**, *6 (19)*, 16808-16816.

15. Escola, J.M.; Aguado, J.; Serrano, D.P.; Briones, L.
"Transportation fuel production by combination of LDPE thermal cracking and catalytic hydroreforming".
Waste Management, **2014**, *34 (11)*, 2176-2184.

16. Escola, J.M.; Serrano, D.P.; Arroyo, M.; Alba, A.
"Conversion of LDPE into transportation fuels by a two-stage process using Ni/Al-SBA-15 as catalyst".
Journal of Material Cycles and Waste Management, **2014**, *16 (3),* 435-441. Impact factor: 0.831

17. Fechler, N.; Tiruye, G.A.; Marcilla, R.; Antonietti, M.
"Vanadium nitride@N-doped carbon nanocomposites: Tuning of pore structure and particle size through salt templating and its influence on supercapacitance in ionic liquid media".
RSC Advances, **2014**, *4 (51),* 26981-26989.

18. Fermoso J.; Gil M.V.; Rubiera F.; Chen D.
"Multifunctional Pd/Ni–Co catalyst for hydrogen production by chemical looping coupled with steam reforming of acetic acid".
ChemSusChem, **2014**, *7 (11)*, 3063-3077.

19. Fresno, F.; Portela, R.; Suárez, S.; Coronado, J.M.
"Photocatalytic materials: Recent achievements and near future trends".
Journal of Materials Chemistry A, **2014**, *2 (9)*, 2863-2884.

20. Gafurov, T.; Prodanovic, M.
"Indirect coordination of electricity demand for balancing wind power".
IET Renewable Power Generation, **2014**, *8 (8),* 858-866.

21. Gallo, A.; Téllez, M.B.; Prodanovic, M.; González-Aguilar, J.; Romero, M.
"Analysis of net zero-energy building in Spain".
Integration of PV, solar domestic hot water and air-conditioning systems".
Energy Procedia, **2014**, *48*, 828-836.

22. García-Muñoz, R.A.; Morales, V.; Linares, M.; González, P.E.; Sanz, R.; Serrano, D.P.
"Influence of the structural and textural properties of ordered mesoporous materials and hierarchical zeolitic supports on the controlled release of methylprednisolone hemisuccinate".
Journal of Materials Chemistry B, **2014**, *2*, 7996-8004.

23. García-Quismondo, E.; Santos, C.; Palma, J.; Anderson, M.A.
"On the challenge of developing wastewater treatment processes: capacitive deionization".
Desalination and Water Treatment, **2014**, 1-10.

24. Goel, N.; Gonzalez-Aguilar, J.; Romero, M.; Steinfeld, A.; Stefanakos, E.; Goswami, D.Y.
"CRISPTower-a solar power tower R&D initiative in India".
Energy Procedia, **2014**, *57*, 301-310.

25. Gómez-García, F.; Tamayo-Pacheco, S.; Olalde, G.; Romero, M.
"Numerical analysis of radiation attenuation in volumetric solar receivers composed of a stack of thin monolith layers".
Energy Procedia, **2014**, *57*, 457-466.

26. González, A.; Gonzalez-Aguilar, J.; Romero, M.
"Determination of glint and glare of heliostat fields integrated on building façades".
Energy Procedia, **2014**, *57*, 331-340.

27. González, M.D.; Salagre, P.; Linares, M.; García, R.; Serrano, D.P.; Cesteros, Y.
"Effect of hierarchical porosity and fluorination on the catalytic properties of zeolite beta for glycerol etherification".
Applied Catalysis A: General, **2014**, *473*, 75-82.

28. González-Pardo, A.; Rodríguez, A.; Gonzalez-Aguilar, J.; Romero, M.
"Analysis of solar shading caused by building-integrated vertical heliostat fields".
Energy and Buildings, **2014**, *76*,199-210.

29. Gruber, J.K.; Jahromizadeh, S.; Prodanovic, M.; Rakocevic V.
"Application-oriented modelling of domestic energy demand".
International Journal of Electrical Power and Energy Systems, **2014**, *61*, 656-664.

30. Gruber, J.K.; Prodanovic, M.
"Two-stage optimization for building energy management".
Energy Procedia, **2014**, *62*, 346-354.

31. Han, L.; Karthikeyan, K.G.; Anderson, M.A.; Gregory, K.B.
"Exploring the impact of pore size distribution on the performance of carbon electrodes for capacitive deionization".
Journal of Colloid and Interface Science, **2014**, *430*, 93-99.

32. Hayes, B.; Hernando-Gil, I.; Collin, A.; Harrison, G.; Djokic, S.
"Optimal power flow for maximizing network benefits from demand-side management".
IEEE Transactions on Power Systems, **2014**, *24 (4)*, 1739-1747.

33. Iribarren, D.; Susmozas, A.; Petrakopoulou, F.; Dufour, J.
"Environmental and exergetic evaluation of hydrogen production via lignocellulosic biomass gasification".
Journal of Cleaner Production, **2014**, *69*, 165-175.

34. Iribarren, D.; Vázquez-Rowe, I.; Rugani, B.; Benetto, E.
"On the feasibility of using emergy analysis as a source of benchmarking criteria through data envelopment analysis: A case study for wind energy".
Energy, **2014**, *67*, 527-537.

35. Isikli, S.; Lecea, M.; Ribagorda, M.; Carreño, M.C.; Díaz, R.
"Influence of quinone grafting via Friedel-Crafts reaction on carbon porous structure and supercapacitive performance".
Carbon, **2014**, *66*, 654-661.

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International Journal of Hydrogen Energy, **2014**, *39*, 5283-5290.

37. Lado, J.J.; Pérez-Roa, R.E.; Wouters, J.J.; Tejedor-Tejedor, M.I.; Anderson, M.A.
"Evaluation of operational parameters for a capacitive deionization reactor employing asymmetric electrodes".
Separation and Purification Technology, **2014**, *133*, 236-245.

38. Larrégola, S.A.; Alonso, J.A.; De la Peña-O'Shea, V.A.; Sheptyakov, D.; Pomjakushin, V.; Fernández-Díaz, M.T.; Pedregosa, J.C.
"Localization and impact of Pb-non-bonded electronic pair on the crystal and electronic structure of Pb_2YSbO_6".
Inorganic Chemistry, **2014**, *11*, 5609-5618.
Impact factor: 4.794

39. León-Reyes, A.; Epifani, M.; Chávez-Capilla, T.; Palma, J.; Díaz, R.
"Analysis of the different mechanisms of electrochemical energy storage in magnetite nanoparticles".
International Journal of Electrochemical Science, **2014,** *9*, 3837-3845**.**

40. Leung, P.K.; Ponce-De-León, C.; Recio, F.J.; Herrasti, P.; Walsh, F.C.
"Corrosion of the zinc negative electrode of zinc-cerium hybrid redox flow batteries in methanesulfonic acid batteries".
Journal of Applied Electrochemistry, **2014**, *44 (9)*, 1025-1035.

41. Li, J.; González-Aguilar, J.; Pérez-Rábago, C.; Zeaiter, H.; Romero, M.
"Optical analysis of a hexagonal 42kWe High-Flux solar simulator".
Energy Procedia, **2014**, *57*, 590-596.

42. Mahdy, A; Méndez, L.; Ballesteros, M.; González-Fernández, C.
"Enhanced methane production of *Chlorella vulgaris* and *Chlamydomonas reinhardtii* by hydrolytic enzymes addition".
Energy Conversion and Management, **2014**, *85*, 551-557.

43. Mahdy, A.; Méndez, L.; Ballesteros, M.; González-Fernández, C.
"Autohydrolysis and alkaline pretreatment effect on *Chlorella vulgaris* and *Scenedesmus sp.* methane production".
Energy, **2014**, *78*, 48-52.

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"Protease cell wall degradation of *Chlorella vulgaris*: Effect on methane production".
Bioresource Technology, **2014**, *171C*, 421-427.

45. Martins, J.P.; Martín-Ramos, P.; Coya, C.; Álvarez, A.L.; Pereira, L.C.; Díaz, R.; Martín-Gil, J.; Ramos Silva, M.
"Lanthanide tetrakis-b-diketonate dimers for solution-processed OLEDs".
Materials Chemistry and Physics, **2014**, *147 (3)*, 1157-1164.

46. Méndez, L.; Mahdy, A.; Demuez, M.; Ballesteros, M.; González-Fernández, C.
"Effect of high pressure thermal pretreatment on Chlorella vulgaris biomass: Organic matter solubilisation and biochemical methane potential".
Fuel, **2014**, *117A*, 674-679.

47. Méndez, L.; Mahdy, A.; Ballesteros, M.; González-Fernández, C.
"Methane production of thermally pretreated *Chlorella vulgaris* and *Scenedesmus sp.* biomass at increasing biomass loads".
Applied Energy, **2014**, *129*, 238-242.

48. O'Mahony, T.
"Integrated scenarios for energy: A methodology for the short term".
Futures, **2014**, *55*, 41-57.

49. Pablos, C.; Marugán, J.; van Grieken, R.; Adán, C.; Riquelme, A.; Palma, J.
"Correlation between photoelectrochemical behaviour and photoelectrocatalytic activity and scaling-up of P25-TiO_2 electrodes".
Electrochimica Acta, **2014**, *130*, 261-270.

50. Peters, J.; Petrakopoulou, F.; Dufour, J.
"Exergetic analysis of a fast pyrolysis process for bio-oil production".
Fuel Processing Technology, **2014**, *119*, 245-255.

51. Ramasamy, C; Palma, J.; Anderson, M.A.
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56. Sanz, A.; Dufour, J.
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Journal of Solar Energy Engineering, **2014**, *136*, 010908-1.

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Applied Energy, **2014**, *131*, 238-247.

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Journal of Power Sources, **2014**, *268*, 121-128.

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Catalysis Today, **2014**, *227*, 15-25. Impact factor: 3.309

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Applied Catalysis B: Environmental, **2014**, *146*, 35-42.

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"Narrowing the mesopore size distribution in hierarchical TS-1 zeolite by surfactant-assisted reorganization". Microporous and Mesoporous Materials, **2014**, *189*, 71-82.

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"Review of life-cycle approaches coupled with data envelopment Analysis: Launching the CFP+DEA method for energy policy making".
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Applied Catalysis B: Environmental, **2014**, *145*, 91-100.

Patents

Granted patents

1. Patent: ES2411813, Title: "Method and device for the generation and transport of oxygen through solar thermochemical processes based on metal oxides". Date of application: 03/01/2012. Date of grant: 31/01/2014. Holder: Fundación IMDEA Energía. Inventors: González-Aguilar, J.; Romero, M.

2. Patent ES2398330, Title: "Campo Vertical de Heliostatos". Date of application: 12/08/2011 (O.E.P.M). Date of grant: 17/01/2014. Holder: Fundación IMDEA Energía. Inventors: González, A.; Romero, M.; González-Aguilar, J.

3. Patent: ES2351494, Title: "Material organo-inorgánico microporoso cristalino basado en cationes alcalinotérreos, procedimientos de preparación y usos". Date of application: 30/06/2009 (O.E.P.M). Date of grant: 16/11/2011. Holders: ICMM-CSIC, Fundación IMDEA Energía. Inventors: Platero-Prats, A.E.; Gutiérrez-Puebla, E.; Monge Bravo, A.; Snejko, N.; Iglesias Hernández, M.; Gómez-Lor Pérez, B.; de la Peña-O'Shea, V.A.

Submitted patents

1. Application number: P201330186, Title: "Batería de flujo acuosa con pares rédox orgánicos". Date of application: 13/02/2013 (O.E.P.M.). Holders: Fundación IMDEA Energía; Universidad Autónoma de Madrid. Inventors: Díaz, R.; Isikli, S.; Palma, J.; Carreño, M.C.; Ribagorda, M.; Guillamón, M.A.; Barradas, S.; Lecea, M.

2. Application number 2312/DEL/2011, Title: "Absorber for concentrated solar power system". Date of application: 08/08/2011 (IPO). Holders: Sunborne Energy Technologies Pvt. Ltd.; Fundación IMDEA Energía; Aldo Steinfeld. Inventors: Goel, N.; Romero, M.; Pokkunuri, P.; Steinfeld, A.; Stefanakos, E.K.; Goswami, D.Y.

Books/Chapters of books

1. Iribarren D.; Dufour J. **2014**. Chapter: "Carbon footprint as a single indicator in energy systems: The case of biofuels and CO_2 capture technologies". Book: Assessment of Carbon Footprint in Different Industrial Sectors, Volume 2. Ed: Springer, Singapore. ISBN: 978-981-4585-74-3 [hardcover]; 978-981-4585-75-0 [ebook].

2. Gonzalez-Fernandez, C.; Timmers, R.A.; Ruiz, B.; Molinuevo-Salces, B. **2014**. Chapter 8: "Ultrasound-enhanced biogas production from different substrates". Book: Production of Biofuels and Chemicals with Ultrasound. Ed: Springer, pp. 209-242. ISBN: 978-94-017-9624-8 [ebook].

patents
chapters of books

Articles in general journals

1. Ballesteros, M.; Dufour, J.; Marín, F. "Biotecnología para la producción de energía". Article of opinión in website madrimasd. Date: 03/04/2014.

2. Gonzalez-Aguilar, J.; González-Fernández, C.; Gruber, J.; Bayón, A. "Instituto IMDEA Energia: investigadores en Móstoles". Revista de información municipal de Móstoles, nº. 32, March 2014, pp 14-15.

3. Gonzalez-Aguilar, J.; Romero, M. "Plantas solares de receptor central: Rendimiento óptico-energético de campos solares. Ánalisis de la influencia de la dimensión de los helióstatos". Journal Era solar: Energías renovables, nº 180, May-June 2014, pp. 36-41.

4. Gonzalez-Aguilar, J.; Zeaiter, Z.; Romero, M. "Estudio de procesos de altos flujos de radiación y altas temperaturas". Journal Era solar: Energías renovables, nº 181, July-August 2014, pp. 40-43.

5. De la Peña-O'Shea, V.A.; Marcilla, R.; Coronado, J.M.; Palma, J.; Serrano, D.P. "Graphene based materials for energy applications". Energetica International, nº 6, July-August 2014, pp 58-59.

6. "IMDEA Energía. Madrid como referente sostenible". Report section "Dónde se innova" INNOVASPAIN. Date: 20/10/2014.

Ph.D. Thesis

1. Title: Desarrollo de un reactor solar para el estudio de la etapa de reducción de ciclos termoquímicos basados en óxidos metálicos no volátiles
Author: Elisa Alonso Romero
Director: Dr. Manuel Romero and Dr. José González-Aguilar
Tutor: Dr. Javier Dufour
Venue: Rey Juan Carlos University, Móstoles, Madrid
Date: 13 March 2014

2. Title: Producción de hidrógeno mediante ciclos termoquímicos basados en compuestos de Na y Mn acoplados a energía solar de concentración
Author: Alicia Bayón Sandoval
Director: Dr. Juan Manuel Coronado and Dr. David P. Serrano
Venue: Rey Juan Carlos University, Móstoles, Madrid
Date: 13 June 2014

3. Title: Development and application of new copper-chloride electrolandtes in redox flow batterand sandstems
Author: Laura Sanz Rubio
Director: Dr. Jesús Palma and Dr. Enrique García-Quismondo
Tutor: Dr. Pilar Ocón (UAM)
Venue: Autonoma University of Madrid, Madrid
Date: 24 October 2014

articles
PhD thesis

8.2. Congress communications

Oral communications

1. Title: Production of advanced biofuels by catalytic upgrading of oleaginous and lignocellulosic bio-oils
Speaker: Serrano, D.P.
Congress: School of Molecular Sieves. Catalysis
Venue: Praga, Czech Republic
Date: 17-18 March 2014
Organizer: J. Heyrovský Institute of Physical Chemistry of the ASCR, v.v.i

2. Title: CO_2-free hydrogen production by methane catalytic decomposition over pure silica materials
Authors: Botas, J.A.; Serrano, D.P.; Pizarro, P.; Gómez, G.
Congress: European Hydrogen Energy Conference (EHEC 2014)
Venue: Seville, Spain
Date: 12-14 March 2014
Organizer: AeH_2

3. Title: Life-cicle performance of hydrogen production via biofuel reforming
Authors: Susmozas, A.; Iribarren, D.; Dufour, J.
Congress: European Hydrogen Energy Conference (EHEC 2014)
Venue: Seville, Spain
Date: 12-14 March 2014
Organizer: AeH_2

4. Title: Techno-environmental evaluation of steam-iron as an alternative process for hydrogen storage or purification
Authors: Sanz, A.; Iribarren, D.; Dufour, J.
Congress: European Hydrogen Energy Conference (EHEC 2014)
Venue: Seville, Spain
Date: 12-14 March 2014
Organizer: AeH_2

5. Title: HDO catalysts based on supported transition metal phosphides
Authors: Berenguer, A.; Yang, Y.; Moreno, I.; Coronado, J.M.; Pizarro, P.; Serrano, D.P.
Congress: School of Molecular Sieves. Catalysis
Venue: Praga, Czech Republic
Date: 17-18 March 2014
Organizer: J. Heyrovský Institute of Physical Chemistry of the ASCR, v.v.i

6. Title: Palladium supported over hierarchical ZSM-5: an efficient catalyst for the hydroreforming of the oil from LDPE thermal cracking
Authors: Serrano, D.P.; Escola, J.M.; Arroyo, M.
Congress: School of Molecular Sieves. Catalysis
Venue: Prague, Czech Republic
Date: 17-18 March 2014
Organizer: J. Heyrovský Institute of Physical Chemistry of the ASCR, v.v.i

7. Title: Demand management for home energy networks using cost-optimal appliance scheduling
Authors: Rakocevic, V.; Jahromizadeh, S.; Gruber, J.K.; Prodanovic, M.
Congress: SMARGREENS 2014
Venue: Barcelona, Spain
Date: 3-4 April 2014
Organizer: INSTICC

8. Title: Chlorella vulgaris anaerobic biodegradability: effect of thermal pretreatment at increasing biomass loads
Authors: Méndez, L.; Mahdy, A.; Ballesteros, M.; González, C.
Congress: Young Algaeneers Symposium 2014 (YAS2014)
Venue: Narbonne, France
Date: 3-5 April 2014
Organizer: Biocore; LOV; LBE; INRIA; UPMC; CNRS; INRA

9. Title: On the challenge of developing waste water treatment processes: capacitive deionization
Authors: García-Quismondo, E.; Santos, C.; Palma, J.; Anderson, M.A.
Congress: International Conference ADAPTtoCLIMATE
Venue: Nicosia, Cyprus
Date: 27-28 March 2014
Organizer: Department of Environment of the Ministry of Agriculture; Natural Resources & Environment of Cyprus; National Technical University of Athens; National Observatory of Athens

10. Title: Desarrollo de materiales para desionización capacitiva (CDI) aplicada al tratamiento de aguas y al almacenamiento de energía
Authors: Santos, C.; Palma, J.; García-Quismondo, E.; Anderson, M.A.
Congress: XXI Congress de la Iberoamerican Society of Electrochemistry.
Lubar: La Serena, Chile
Date: 6-11 April 2014
Organizer: Iberoamerican Society of Electrochemistry

11. Title: Is Carbon Footprinting an appropriate method to combine with Data Envelopment Analysis for environmental benchmarking? The CFP+DEA method
Authors: Iribarren, D.; Vázquez-Rowe, I.
Congress: SETAC Europe 24th Annual Meeting
Venue: Basilea, Switzerland
Date: 11-15 May 2014
Organizer: SETAC

12. Title: Dynamic modelling of PMSM - wind turbines for power network integration
Authors: Huerta, F.; Prodanovic, M.; Matatagui P.
Congress: ElectrIMACS 2014
Venue: Valencia, Spain
Date: 19-22 May 2014
Organizer: Technical University of Valencia and University of Tunisia El Manar

13. Title: Capacitive deionization for waste water re-use: energy efficiency considerations
Authors: Santos, C.; García-Quismondo, E.; Palma, J.; Anderson, M.A.
Congress: Interfaces in Water and Environmental Science (IAP2014)
Venue: Leeuwarden, Holland
Date: 25-28 May 2014
Organizer: Wetsus

14. Title: Improving the performance of thermochemical heat storage at high temperatures based on redox metal oxides
Authors: Carrillo, A.J.; Serrano, D.P; Pizarro, P.; Coronado, J.M.
Congress: Eurotherm Seminar 99: Advances in Thermal Energy Storage
Venue: Lleida, Spain
Date: 28-30 May 2014
Organizer: GREA Innovació Concurrent; Universitat de Lleida

15. Title: Is carbohydrates solubilisation a key parameter on methane production enhancement using microalgae biomass?
Authors: González-Fernández, C.; Mendez, L.; Mahdy, A.; Ballesteros, M.
Congress: 10th edition of the International Conference on Renewable Resources & Biorefineries
Venue: Valladolid, Spain
Date: 4-6 June 2014
Organizer: University of Valladolid; University of Ghent

16. Title: The social and cultural dimensions of sustainable development, mitigation and scenarios: Grasping the opportunities for human development
Authors: O´Mahony, T., Dufour, J.
Congress: Futures infinite academic conference-sustainable futures in a changing climate
Venue: Helsinki, Finland
Date: 11-12 June 2014
Organizer: Messukeskus; Finland Futures Research Centre; Finland Futures Academy

17. Title: Thermoeconomic evaluation of solar thermal and photovoltaic hybridization options for combined-cycle power plants
Authors: Spelling, J.; Laumert Björn
Congress: ASME Turbo Expo 2014
Venue: Düsseldorf, Germany
Date: 16-20 June 2014
Organizer: ASME

18. Title: Fast liquefaction of cellulose and black poplar sawdust using microwave heating in acidic medium
Authors: Moreno, I.; Zazo, L.; Pizarro, P.; Coronado, J.M.; Serrano, D.P.
Congress: 22nd European Biomass Conference and Exhibition (BC&E 2014)
Venue: Hamburg, Germany
Date: 23-26 June 2014
Organizer: JRC

19. Title: Effect of the noble metal co-catalyst on the photocatalytic H_2 production over modified $NaTaO_3$ semiconductors
Authors: Jana, P.; Mata-Montero; C.; Pizarro, P.; Coronado, J.M.; Serrano, D.P.; de la Peña-O'Shea, V.A.
Congress: 8th International Symposium on Group Five Elements
Venue: Málaga, Spain
Date: 24-27 June 2014
Organizer: University of Málaga

20. Title: Two-stage optimization for building energy management
Authors: Gruber, J.K.; Prodanovic, M.
Congress: 6th International Conference on Sustainability in Energy and Buildings 2014 (SEB-14)
Venue: Cardiff, Reino Unido
Date: 25-27 June 2014
Organizer: KES International

21. Title: Plasmonic photocatalysts with improved charge transfer dynamics for artificial photosynthesis
Authors: Collado, L.; Reynal, A.; Durrant, J.R.; Coronado, J.M.; Serrano; D.P.; de la Peña-O'Shea, V.A.
Congress: 8th European meeting on solar chemistry and photocatalysis: environmental applications (SPEA8)
Venue: Thessaloniki, Greece
Date: 25-28 June 2014
Organizer: University of Thessaloniki; University of Patras

22. Title: Numerical modeling of thermal energy storage system
Authors: Bellan, S.; Gonzalez-Aguilar, M, Romero, M.; Rahman, M.M.; Goswami, Y.; Stefanakos, E.K.
Congress: 8th International Conference on Energy Sustainability (ASME 2014)
Venue: Boston, USA
Date: 30 June-2 July 2014
Organizer: ASME

23. Title: Numerical study of a beam-down solar thermochemical reactor for chemical kinetics analysis
Authors: Bellan, S.; Cerpa, C.; Gonzalez-Aguilar, M, Romero, M.
Congress: 8th International Conference on Energy Sustainability (ASME 2014)
Venue: Boston, USA
Date: 30 June-2 July 2014
Organizer: ASME

24. Title: Induced production of hydrolytic enzymes by aspergillus aculeatus in submerged fermentation on exploded wheat-straw
Authors: Demuez, M.; González-Fernández, C.; Negro, M.J.; Ballesteros, M.
Congress: BIOTEC2014
Venue: Madrid, Spain
Date: 1-4 de July 2014
Organizer: Spanish Society of Biotechnology; SEBIOT

25. Title: Effect of laccase on enzymatic hydrolysis of steam-exploded wheat straw
Authors: Oliva, A.; Moreno, A.D.; Demuez, M.; Tomás-Pejó, E.; González-Fernández, C.; Ballesteros, M.
Congress: BIOTEC2014
Venue: Madrid, Spain
Date: 1-4 de July 2014
Organizer: Spanish Society of Biotechnology; SEBIOT

26. Title: Towards a holistic view of energy systems: Sustainability assessment of wind farms
Authors: Iribarren, D.; Martín-Gamboa, M.; Dufour, J.
Congress: II International Congress of Chemical Engineering of ANQUE
Venue: Madrid, Spain
Date: 1-4 July 2014
Organizadores: ANQUE; SEBIOT

27. Title: Simulation of alternative systems for the co-production of biofuels and electricity from lignocellulosic biomass
Authors: Cruz, P.L.; Susmozas, A.; Iribarren, D.; Dufour, J.
Congress: II International Congress of Chemical Engineering of ANQUE
Venue: Madrid, Spain
Date: 1-4 July 2014
Organizadores: ANQUE; SEBIOT

28. Title: Enzymatic pre-treatment: a promising procedure to enhance Chlorella vulgaris biomethane production
Authors: Mahdy, A.; Méndez, L.; Ballesteros, M.; González-Fernández C.
Congress: International Conference of Green Chemistry and Sustainable Engineering
Venue: Barcelona, Spain
Date: 29-31 July 2014
Organizer: Instituto Politécnico de Portalegre; University of Extremadura

29. Title: Joint production of biodiesel and biogas using spent biomass from microalgae
Authors: Vicente, G.; Bautista, L.F.; Morales, V.; Mendoza A.; Ballesteros M.; González, C.; Méndez, L.
Congress: International Conference of Green Chemistry and Sustainable Engineering
Venue: Barcelona, Spain
Date: 29-31 July 2014
Organizer: Instituto Politécnico de Portalegre; University of Extremadura

30. Title: Biomass-photovoltaic hybrid plant for hydrogen production via steam electrolysis
Authors: Sanz, A.; Dufour, J.
Congress: The 17th Conference on Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction (PRES2014)
Venue: Praga, Czech Republic
Date: 23-27 August 2014
Organizer: Research Institute of Chemical and Process Engineering; University of Pannonia

31. Title: Synthesis of polymer electrolytes based on polymeric ionic liquids & ILs and their application in all-solid supercapacitors
Authors: Tiruye, G.A.; Palma, J.; Marcilla, R.
Congress: XIV International Symposium on Polymer Electrolytes (ISPE-14)
Venue: Geelong, Australia
Date: 24-29 August 2014
Organizer: Deakin University

32. Title: SmartHG: Energy demand aware open services for smart grid intelligent automation
Authors: Tronci, E.; Mancini, T.; Mari, F.; Melatti, I.; Jacobsen, R.H.; Ebeid, E.; Mikkelsen, S.A.; Prodanovic, M.; Gruber, J.K.; Hayes, B.
Congress: 17th Euromicro Conference on Digital System Design (DSD '14)
Venue: Verona, Italy
Date: 27-29 August 2014
Organizer: University of Verona, EDALab

33. Title: Capacitive deionization: an electrochemical technique to store energy and treat water
Authors: Anderson, M.A.; García-Quismondo, E.; Santos, C.; Palma, J.
Congress: 65th Annual Meeting of the International Society of Electrochemistry
Venue: Laussanne, Switzerland
Date: 31 August-5 September 2014
Organizer: International Society of Electrochemistry

34. Title: All-solid state supercapacitors based on a binary mixture of Ionic liquids & Polymeric Ionic liquid
Authors: Tiruye, G.A.; Palma, J.; Anderson, M.A.; Marcilla, R.
Congress: 65th Annual Meeting of the International Society of Electrochemistry
Venue: Laussanne, Switzerland
Date: 31 August-5 September 2014
Organizer: International Society of Electrochemistry

35. Title: Hydrodeoxygenation of anisole as bio-oil model compound over nickel and cobalt supported on hierarchical zsm-5 and sba-15
Authors: Sankaranarayanan, T.M.; Berenguer, A.; Ochoa-Hernández, C.; Moreno, I.; Coronado, J.M.; Pizarro, P.; Serrano, D.P.
Congress: Zeolite Workshop 2014 (Post-FEZA 2014)
Venue: Třešť, Czech Republic
Date: 11-15 September 2014
Organizer: Jiří Čejka and Kyung Byung Yoon

36. Title: Narrowing the mesopore size distribution in hierarchical ZSM-5 zeolite
Authors: Serrano, D.P.; García, R.A.; Escola, J.M.; Peral, A.; Linares, M.; Cuesta, S.
Congress: Zeolite Workshop 2014 (Post-FEZA 2014)
Venue: Třešť, Czech Republic
Date: 11-15 September 2014
Organizer: Jiří Čejka and Kyung Byung Yoon

37. Title: A power-HIL microgrid tested: Smart Energy Integration Lab (SEIL)
Authors: Huerta, F.; Gruber, J.K.; Prodanovic, M.; Matatagui, P.
Congress: IEEE Energy Conversion Congress & Expo 2014 (ECCE '14)
Venue: Pittsburgh, USA
Date: 14-18 September 2014
Organizer: IEEE

38. Title: Analysis of demand and energy saving at different types of hotels with integration of solar systems and geothermal heat pumps
Authors: Gallo, A.; Gonzalez-Aguilar, J.; Prodanovic, M.; Romero, M.
Congress: EuroSun 2014
Venue: Aix les Bains, France
Date: 16-19 September 2014
Organizer: ISE Europe

39. Title: A high-efficiency solar thermal power plant using a dense particle suspension as the heat transfer fluid
Authors: Spelling, J.; Gallo, A.; Romero, M.; Gonzalez-Aguilar, J.
Congress: SOLARPACES 2014
Venue: Beijing, China
Date: 16-19 September 2014
Organizer: SOLARPACES

40. Title: Preliminary design and performance analysis of a Multi-Megawatt scale dense particle suspension receiver
Authors: Gallo, A.; Spelling, J.; Romero, M.; Gonzalez-Aguilar, J.
Congress: SOLARPACES 2014
Venue: Beijing, China
Date: 16-19 September 2014
Organizer: SOLARPACES

41. Title: Numerical investigation of PCM-based thermal energy storage system
Authors: Bellan, S.; Gonzalez-Aguilar, J.; Romero, M.; Rahman, M.M.; Goswami, D.Y.; Stefanakos, E.K.
Congress: SOLARPACES 2014
Venue: Beijing, China
Date: 16-19 September 2014
Organizer: SOLARPACES

42. Title: Smart Energy Integration Lab (SEIL): Tecnología PHIL aplicada al estudio de las Microrredes
Authors: Huerta, F.; Prodanovic, M.; Gruber, J.K.; Matatagui, P.
Congress: II Congreso Iberoamericano sobre Microrredes con Generación Distribuida
Venue: Soria, Spain
Date: 6-8 October 2014
Organizer: Centro de Desarrollo de Energías Renovables CEDER-CIEMAT y el Ayuntamiento de Soria

43. Title: Diseño óptico y análisis de producción de una planta eléctrica temosolar para Bom Jesús Da Lapa en Brasil
Authors: Migliorini, G.; Gonzalez-Aguilar, J.; Romero, M.
Congress: XXXVIII Semana Nacional de Energía Solar y XI Congreso Iberoamericano de Energía Solar
Venue: Querétaro Qro., México
Date: 8-10 October 2014
Organizer: ANES y AEDES

44. Title: Diseño y construcción de un banco de ensayos de tipo "beam-down" para estudios de termoquímica solar: reducción de ceria
Authors: Cerpa, C.A.; Gonzalez-Aguilar, J.; Romero, M.
Congress: XXXVIII Semana Nacional de Energía Solar y XI Congreso Iberoamericano de Energía Solar
Venue: Querétaro Qro., México
Date: 8-10 October 2014
Organizer: ANES and AEDES

45. Title: Comportamiento térmico e hidrodinámico de absorbedores volumétricos para centrales solares de torre
Authors: Gómez, F.; Gonzalez-Aguilar, J.; Romero, M.
Congress: XXXVIII Semana Nacional de Energía Solar y XI Congreso Iberoamericano de Energía Solar
Venue: Querétaro Qro., México
Date: 8-10 October 2014
Organizer: ANES and AEDES

46. Title: Influence of the propagation strategy in an ethanol production process from glucose and xylose: proteomics and gene expression analysis
Authors: Tomás-Pejó, E.; Jeusset, L.; Olsson, L.
Congress: 31st International specialised symposium on yeast (ISSY31)
Venue: Nova Gorica/Vipava, Slovenia
Date: 9-12 October 2014
Organizer: International Commission on Yeast

47. Title: New insights in the CO_2 photo-activation mechanism using TiO_2-based catalysts
Authors: Collado, L.; Fermoso, J.; Garrido, L.; Coronado, J.M.; Serrano, D.P.; de la Peña O'Shea, V.A.
Congress: Photocatalysis for energy (Photo4E)
Venue: Lyon, France
Date: 15-17 October 2014
Organizer: IFP Energies nouvelles

48. Title: A laboratory environment for real-time testing of energy management scenarios
Authors: Huerta, F.; Gruber, J.K.; Prodanovic, M.; Matatagui, P.; Gafurov, T.
Congress: 3rd International Conference on Renewable Energy Research and Applications (ICRERA '14)
Venue: Milwaukee, USA
Date: 19-22 October 2014
Organizer: International Journal of Renewable Energy Research

49. Title: State estimation techniques for electric power distribution systems
Authors: Hayes, B.; Prodanovic, M.
Congress: European Modelling Symposium 2014 (EMS '14)
Venue: Pisa, Italy
Date: 21-23 October 2014
Organizer: IEEE

50. Title: Real-time power-hardware-in-the-loop discrete modeling of PMSM wind turbines
Authors: Huerta, F.; Prodanovic, M.; Matatagui, P.
Congeso: 40th Annual Conference of the IEEE Industrial Electronics Society (IECON '14)
Venue: Dallas, TX, USA
Date: 29 October-1 November 2014
Organizer: IEEE

51. Title: Enhancing the economic dimension of LCA + DEA studies for sustainability assessment
Authors: Iribarren, D.; Martín-Gamboa, M.
Congress: The 4th World Sustainability Forum
Venue: [Virtual congress]
Date: 1-30 November 2014
Organizer: MDPI

52. Title: Demand-Aware price policy synthesis and verification services for smart grids
Authors: Mancini, T.; Mari, F.; Melatti, I.; Salvo, I.; Tronci, E.; Gruber, J.K.; Hayes, B.; Prodanovic, M.; Elmegaard, L.
Congress: 5th Annual IEEE International Conference on Smart Grid Communications (SmartGridComm)
Venue: Venizia, Italy
Date: 3-6 November 2014
Organizer: IEEE

poster communications

Poster communications

1. Title: The performance of Vanadium nitride@N-doped carbon as electrode material in Supercapacitors with Ionic Liquid electrolyte
Authors: Tiruye, G.A.; Fechler, N.; Antonietti, M.; Marcilla, R.
Congress: The 2nd International Forum on Progress and Trends in Battery and Capacitor Technologies. Power our future 2014
Venue: Vitoria, Spain
Date: 1-4 April 2014
Organizer: EnergiGune

2. Title: Electrochemical performance of Ionic Liquid based electrolytes in EDLCs. PYR14TFSI, PYR14FSI and their mixtures; a comparative study
Authors: Navalpotro, P.; Palma, J.; Anderson, M.A.; Marcilla, R.
Congress: The 2nd International Forum on Progress and Trends in Battery and Capacitor Technologies. Power our future 2014
Venue: Vitoria, Spain
Date: 1-4 April 2014
Organizer: EnergiGune

3. Title: Water desalination and energy storage by capacitive deionization: scale up validation
Authors: Santos, C.; García-Quismondo, E.; Palma, J.; Anderson, M.A.
Congress: The 2nd International Forum on Progress and Trends in Battery and Capacitor Technologies. Power our future 2014
Venue: Vitoria, Spain
Date: 1-4 April 2014
Organizer: EnergiGune

4. Title: Fermentation of diluted acid hydrolysates of Scenedesmus spp.: Saccharomyces cerevisiae vs Kluyveromyces marxianus
Authors: Mahdy, A.; Méndez, L.; Demuez, M.; Ballesteros, M.; González, C.
Congress: Young Algaeneers Symposium 2014 (YAS2014)
Venue: Narbonne, France
Date: 3-5 April 2014
Organizer: Biocore; LOV; LBE; INRIA; UPMC; CNRS; INRA

5. Title: Bio-oils production from black poplar sawdust by microwave-assisted liquefaction
Authors: Moreno, I.; Pizarro, P.; Coronado, J.M.; Serrano, D.P.
Congress: 4th International Congress on Green Process Engineering (GPE 2014)
Venue: Seville, Spain
Date: 7-10 April 2014
Organizer: GPE; EFCE

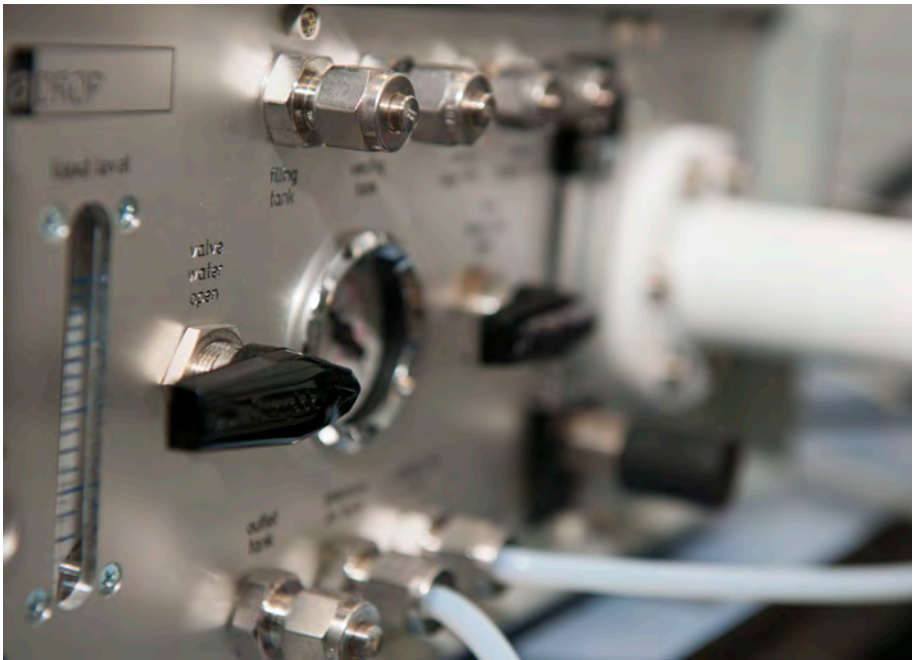
6. Title: Influence of the loadingon the performance of Ni_2P/SBA-15 catalystsfor the hydrodeoxygenation of methyl esters
Authors: Yang, Y.; Pizarro, P.; de la Peña-O'Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: 4th International Congress on Green Process Engineering (GPE 2014)
Venue: Seville, Spain
Date: 7-10 April 2014
Organizer: GPE; EFCE

7. Title: Hydrodeoxygenation of anisole as bio-oil model compound over supported nickel and cobalt catalysts
Authors: Sankaranarayanan, T.M.; Berenguer, A.; Ochoa-Hernández, C.; Moreno, I.; Jana, P.; Coronado, J.M.; Pizarro, P.; Serrano, D.P.
Congress: Summer School. Catalysis of Biomass
Venue: Líblice, Czech Republic
Date: 8-11 June 2014
Organizer: Jiri Cejka and David Serrano

8. Title: Synthesis of catalysts based on supported transition metal phosphides for phenol hydrodeoxygenation
Authors: Berenguer, A.; Ochoa-Hernández, C.; Yang, Y.; Moreno, I.; Coronado, J.M.; Pizarro, P.; Serrano; D.P.
Congress: Summer School. Catalysis of Biomass
Venue: Líblice, Czech Republic
Date: 8-11 June 2014
Organizer: Jiri Cejka and David Serrano

9. Title: More than just a phrase: the benchmarking of sustainability performance for industry and policy-makers
Authors: Iribarren, D.; Martín-Gamboa, M.; O'Mahony, T.; Dufour, J.
Congress: SETAC Europe 24th Annual Meeting
Venue: Basel, Switzerland
Date: 11-15 May 2014
Organizer: SETAC

10. Title: Short-term operational planning and state estimation in power distribution networks
Authors: Hayes, B.; Prodanovic, M.
Congress: CIRED Electricity Distribution Workshop
Venue: Roma, Italy
Date: 11-12 June 2014
Organizer: Aim-Association



11. Title: Experimental validation of the predictive pyrolysis model in Aspen Plus
Authors: Peters, J.; Banks, S.W.; Susmozas, A.; Dufour, J.
Congress: 22nd European Biomass Conference and Exhibition (BC&E 2014)
Venue: Hamburg, Germany
Date: 23-26 June 2014
Organizer: JRC

12. Title: Comparative life cycle assessment of synthetic fuels from lignocellulosic biomass
Authors: Peters, J.; Susmozas, A.; Iribarren, D.; Dufour, J.
Congress: 22nd European Biomass Conference and Exhibition (BC&E 2014)
Venue: Hamburg, Germany
Date: 23-26 June 2014
Organizer: JRC

13. Title: Thermodynamic evaluation of energy systems for the coproduction of synthetic biofuels and electricity
Authors: Susmozas, A.; Cruz, P.; Iribarren, D.; Peters, J.; Dufour, J.
Congress: 22nd European Biomass Conference and Exhibition (BC&E 2014)
Venue: Hamburg, Germany
Date: 23-26 June 2014
Organizer: JRC

14. Title: Hydrolytic enzymes production from aspergillus aculeatus using steam-exploded pretreated wheat straw as carbon source
Authors: Demuez, M.; González-Fernández, C.; Negro, M.J.; Ballesteros, M.
Congress: 13th European Workshop on Lignocellulosics and Pulp (EWLP-2014)
Venue: Seville, Spain
Date: 24-27 June 2014
Organizer: Grupo de Materiales Lignocelulósicos del IRNAS

15. Title: Improvement of the photocatalytic activity for hydrogen production form water/methanol solutions by the synergetic effect of Ta and Nb
Authors: Jana, P.; Mata-Montero, C.; Pizarro, P.; Coronado, J.M.; Serrano, D.P.; de la Peña-O'Shea, V.A.
Congress: 8th European meeting on solar chemistry and photocatalysis: environmental applications (SPEA8)
Venue: Thessaloniki, Greece
Date: 25-28 June 2014
Organizer: University of Thessaloniki; University of Patras

16. Title: Activation of CO_2 over titania-based catalysts for artificial photosynthesis
Authors: Collado, L.; Fermoso, J.; Pérez-Dieste, V.; Escudero, C.; Coronado, J.M.; Serrano, D.P.; de la Peña-O'Shea, V.A.
Congress: 20th International conference on conversion and storage of solar energy (IPS-20)
Venue: Berlín, Germany
Date: 27 July-1 August 2014
Organizer: IPS-20 local organizing committee at HZB

17. Title: Electrochemical performance of parabenzoquinone-PYR14TFSI-based electrolyte in supercapacitors
Authors: Navalpotro, P.; Palma, J.; Anderson, M.A.; Marcilla, R.
Congress: 65th Annual Meeting of the International Society of Electrochemistry
Venue: Laussanne, Switzerland
Date: 31 August-5 September 2014
Organizer: International Society of Electrochemistry

18. Title: Optimización en dos etapas para la gestión energética en edificios
Authors: Gruber, J.K.; Prodanovic, M.
Congress: XXXV Jornadas de Automática
Venue: Valencia, Spain
Date: 3-5 September 2014
Organizer: Polytechnic University of Valencia

19. Title: Beta zeolitic-like materials with enhanced accessibility as catalysts in epoxide rearrengement reactions
Authors: Serrano, D.P.; Linares, M.; García-Muñoz, R.A.; Vicente, G.; Procházková, D.; Čejka, J.
Congress: Zeolite Workshop 2014 (Post-FEZA 2014)
Venue: Třešt', Czech Republic
Date: 11-15 September 2014
Organizer: Jiří Čejka and Kyung Byung Yoon

20. Title: Experimental and numerical investigation of a packed-bed latent heat thermal storage system with encapsulated phase change material
Authors: Alam, T.E.; Bellan, S.; Dhau, J.; Goswami, D.Y.; Rahman, M.M.; Stefanakos, E.; Gonzalez-Aguilar, J.; Romero, M.
Congress: EuroSun 2014
Venue: Aix les Bains, France
Date: 16-19 September 2014
Organizer: ISE Europe

21. Title: Line-concentrating flux analysis of 42kWe high-flux solar simulator
Authors: Li, J.; Gonzalez-Aguilar, J.; Romero, M.
Congress: SOLARPACES 2014
Venue: Beijing, China
Date: 16-19 September 2014
Organizer: SOLARPACES

22. Title: Improvement of the photocatalytic activity for hydrogen production from water/methanol solutions by the Pt/M-$NaTaO_3$ (M = Y, La, Yb, Nb) photocatalysts
Authors: Jana, P.; Mata, C.; Coronado, J.M.; Serrano, D.P.; de la Peña O'Shea, V.A.
Congress: Photocatalysis for energy (Photo4E)
Venue: Lyon, France
Date: 15-17 October 2014
Organizer: IFP Energies nouvelles

23. Title: Geothermal energy potential for renewable power generation
Authors: Martín-Gamboa, M.; Iribarren, D.; Dufour, J.
Congress: II Symposium of the Spanish Network of LCA
Venue: Zamudio, Spain
Date: 6 November 2014
Organizer: AZTI-Tecnalia, IMDEA Energy

training and dissemination activities

annual report 2014

9.1. Organization of conferences and courses

The IMDEA Energy Institute has been involved in the organization of the following conferences, courses, masters, workshops and congresses:

1. Congress: El futuro del modelo energético en España
Panel discussion: de la Peña-O`Shea, V.; Romero, M.; Dufour, J.
Venue: URJC, Móstoles, Madrid, Spain
Date: 15 January 2014
Organizer: URJC; IMDEA Energy Institute; Asociación de Ambientólogos de Madrid

2. Workshop Repsol-IMDEA Energy
Venue: IMDEA Energy Institute, Móstoles, Madrid, Spain
Date: 13 February 2014
Organizer: IMDEA Energy Institute

3. Workshop: Organización y gestión de la transferencia de tecnología: generando valor a partir de resultados de investigación
Venue: IMDEA Energy Institute, Móstoles, Madrid, Spain
Date: 20 February 2014
Organizer: IMDEA Energy Institute; Madri+d Foundation

4. III Foro Móstoles Innova
Venue: IMDEA Energy Institute, Móstoles, Madrid, Spain
Date: 6 March 2014
Organizer: IMDEA Energy Institute; Móstoles City Hall

5. Madrid Network Aerospace cluster
Venue: IMDEA Energy Institute, Móstoles, Madrid, Spain
Date: 5 May 2014
Organizer: Madrid Network Aerospace cluster; IMDEA Energy Institute

6. International Workshop: Biotechnology in energy production
Venue: IMDEA Energy Institute, Móstoles, Madrid, Spain
Date: 6 May 2014
Organizer: IMDEA Energy Institute

7. Workshop: Smartligthing: El alumbrado inteligente
Venue: IMDEA Energy Institute, Móstoles, Madrid, Spain
Date: 8 May 2014
Organizer: Móstoles City Hall; Anfalum; IMDEA Energy Institute

8. IMDEA Energy-CIEMAT meeting about R&D in energy technologies
Venue: IMDEA Energy Institute, Móstoles, Madrid, Spain
Date: 29 May 2014
Organizer: IMDEA Energy Institute; CIEMAT

9. Summer School. Catalysis of Biomass
Member of the Organizer Committee: David Serrano
Venue: Liblice, Czech Republic
Date: 8-11 June 2014
Organizer: Jiri Cejka and David Serrano

10. Eurosun 2014
Member of the Organizer Committee: Manuel Romero
Venue: Aix les Bains, France
Date: 16-19 September 2014
Organizer: ISES Europe

11. XXXVIII Semana Nacional de Energía Solar-XI Congreso Iberoamericano de Energía Solar
Member of the Organizer Committee: Manuel Romero
Venue: Querétaro Qro., Mexico
Date: 8-10 October 2014
Organizer: ANES/AEDES

12. Workshop: Batteries for electromobility
Venue: IMDEA Energy Institute, Móstoles, Madrid, Spain
Date: 30 October 2014
Organizer: M2F; Sernauto; IMDEA Energy Institute

13. Workshop: Biotechnological applications for the energy sector
Venue: IMDEA Energy Institute, Móstoles, Madrid, Spain
Date: 26 November 2014
Organizer: IMDEA Energy Institute

14. III Annual Workshop of Young Researchers of IMDEA Energía
Venue: IMDEA Energy Institute, Móstoles, Madrid, Spain
Date: 12 December 2014
Organizer: IMDEA Energy Institute

lectures and seminars

9.2. Organization of lectures and seminars

The IMDEA Energy Institute has been involved in the organization of the following lectures and technical seminars:

1. Oral presentation: "Modeling of concentrating solar power plant for power system reliability studies"
Speaker: Tokhir Gafurov (IMDEA Energy Institute)
Date: 16 January 2014

2. Lecture: "Key challenges and future trends in the energy sector"
Speaker: Javier Dufour (Head of System Analysis Unit, IMDEA Energy Institute)
Date: 31 January 2014

3. Oral presentation: "Design of Mn based materials for thermochemical heat storage at high temperatures"
Speaker: Alfonso Carrillo (IMDEA Energy Institute)
Date: 14 February 2014

4. Oral presentation: "Integrating laccase treatment for lignocellulosic bioethanol production from steam-exploded wheat straw: effects on enzymatic hydrolysis"
Speaker: Alfredo Oliva (IMDEA Energy Institute)
Date: 14 March 2014

5. Oral presentation: "Synthesis of catalysts based on supported transition metal phosphides for phenol hydrodeoxygenation"
Speaker: Antonio Berenguer (IMDEA Energy Institute)
Date: 11 April 2014

6. Oral presentation: "Chlorella vulgaris anaerobic biodegradability: effect of thermal pretreatment at increasing biomass loads"
Speaker: Lara Méndez (IMDEA Energy Institute)
Date: 16 May 2014

7. Oral presentation: "All-Solid state supercapacitors based on solid electrolytes: Yes or Ooops?
Speaker: Girum Tiruye (IMDEA Energy Institute)"
Date: 12 June 2014

8. Oral presentation: "How can we improve biogas production using microalgae as substrate?"
Speaker: Ahmed Mahdy (IMDEA Energy Institute)
Date: 11 July 2014

9. Oral presentation: "Towards sustainability assessment of energy systems"
Speaker: Mario Martín (IMDEA Energy Institute)
Date: 19 September 2014

10. Oral presentation: "Capacitive deionization: from the idea to the pilot plant"
Speaker: Cleis Santos (IMDEA Energy Institute)
Date: 17 October 2014

11. Lecture: "Energy and sustainability: CO_2 as a resource"
Speaker: Dr. Lourdes Vega (Matgas Director)
Date: 5 November 2014

12. Oral presentation: "100-Wh multi-purpose particle reactor for thermochemical heat storage: experimental work"
Speaker: Sandra Álvarez (IMDEA Energy Institute)
Date: 14 November 2014

9.3. Participation in conferences, courses and seminars

The following list includes invited lectures and conferences in courses, masters, technical seminars and workshops given by researchers of the IMDEA Energy Institute:

1. Invited conference at Politecnica University of Madrid
Conference: New services for management of power networks
Speaker: Prodanovic, M.
Venue: Madrid, Spain
Date: 27 March 2014
Organizer: Politecnica University of Madrid

2. Diploma award ceremony of UPM
Speaker: Romero, M.
Venue: Madrid, Spain
Date: 8 April 2014
Organizer: ETSIDI

3. Course: "Battery University"
Conference: Supercapacitors and hydrogen fuel cells
Speaker: Palma, J.
Venue: Madrid, Spain
Date: 22-23 May 2014
Organizer: Albufera Energy Storage

4. Invited conference at Aalborg University
Conference: Renewable integration and active demand management for Smart Buildings
Speaker: Prodanovic, M.
Venue: Aalborg, Denmark
Date: 9 June 2014
Organizer: Aalborg University

5. Seminar: "Opportunities for graduates in Energy Engineering"
Speaker: Palma, J.
Venue: Móstoles, Madrid, Spain
Date: 13 June 2014
Organizer: Rey Juan Carlos University

6. Invited conference at The College of Economics and Management, Nanjing University of Aeronautics and Astronautics (NUAA)
Conference: Technological development and sustainable development: driving forces and energy scenarios
Speaker: O'Mahony, T.
Venue: Nanjing, China
Date: 23-27 June 2014
Organizer: Nanjing University of Aeronautics and Astronautics

7. 1st Summer School in "Polymers for a Sustainable World" (SUSPOL)
Conference: Polymers/Ionic Liquids in Energy Devices
Speaker: Marcilla, R.
Venue: San Sebastián, Spain
Date: 24-27 June 2014
Organizer: Marie Curie Initial Training Networks-Renaissance; Refine

8. Workshop: "EMerging TECHnologies for chemicals and fuels production (EMTECH)"
Conference: CASCATBEL project: from lignocellulose to advanced biofuels through cascade coupling of catalytic deoxygenation steps
Speaker: Serrano, D.P.
Venue: Ghent, Belgium
Date: 1 July 2014
Organizer: OCMOL Consortium

9. Invited conference at Centro Cultural de Puertollano
Conference: Nuevas fórmulas para conectar estrategia empresarial con la protección del medio ambiente
Speaker: Dufour, J.
Venue: Puertollano, Spain
Fecha: 8 Julio 2014
Organizer: Factoría de Innovación de Castilla-La Mancha

10. Summer School 2014: "Air pollution, climate effect and role of renewable energies
Conference: Las energías renovables en el contexto energético actual y su potencial en la reducción de emisiones atmosféricas"
Speaker: Gonzalez-Aguilar, J.
Venue: Ciudad Real, Spain
Date: 9-10 July 2014
Organizer: Castilla La Mancha University

11. Summer School: "Energy efficiency and sustainable transport: Energy storage and electric vehicle"
Conference: Challenges and perspectives of electric energy storage: batteries and supercapacitors
Speaker: Palma, J.
Venue: Madrid, Spain
Date: 07-11 July 2014
Organizer: Rey Juan Carlos University

12. Summer School: "The energy sector: towards a sustainable model"
Conference: Energy storage
Speaker: Palma, J.
Venue: La Granja, Segovia, Spain
Date: 14-15 July 2014
Organizer: Politecnica University of Madrid

13. Workshop: "Reaction kinetics of solar thermochemical redox cycles for splitting H2O and CO_2"
Conference: Experiences and challenges in the solarization of thermochemical redox reactors: from materials to scaling-up
Speaker: Gonzalez-Aguilar, J.; Romero, M.
Venue: Zürich, Switzerland
Date: 11 September 2014
Organizer: German Aerospace Center DLR; ETH Zurich; Technical University Clausthal; Karlsruhe Institute of Technology

14. Workshop: "The road to hydrogen as an energy vector"
Conference: Roadmapping: Paving the way for hydrogen
Speaker: Dufour, J.
Venue: Oporto, Portugal
Date: 11 September 2014
Organizer: CHEMPOR

15. SolarPACES Meetings – Task II. Description of activities in Spain
Participant: Gonzalez-Aguilar, J.
Venue: Beijing, China
Date: 15 September 2014
Organizer: SOLARPACES

16. SOLARPACES 2014 Congress
Members of Scientific Committee: Romero, M.; González-Aguilar, J.
Sesion chairman "Thermal/Thermochemical Energy Storage": Gonzalez-Aguilar, J.
Venue: Beijing, China
Date: 16-19 September 2014
Organizer: Institute of Electrical Engineering-Chinese Academy of Science; SOLARPACES

17. Invited conference at Institute of Electrical Engineering
Conference: China-United States-Australia Seminar on CSP Technology
Speaker: González-Aguilar, J.
Venue: Beijing, China
Date: 22 September 2014
Organizer: Institute of Electrical Engineering-Chinese Academy of Science

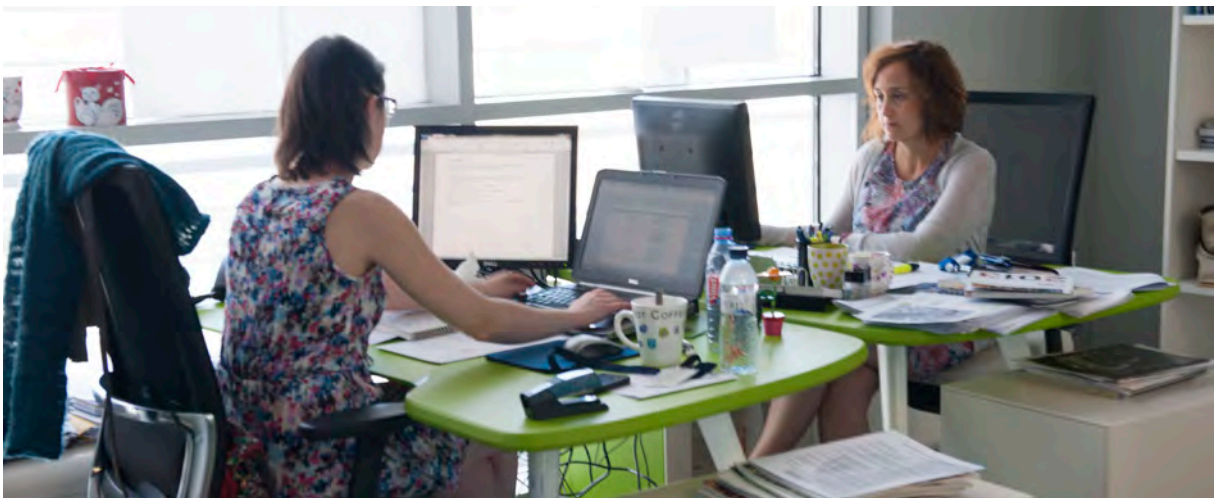
18. Invited conference at Institute of Coal Chemistry
Conference: Concentrating solar energy: from electricity to solar fuels production
Speaker: González-Aguilar, J.
Venue: Beijing, China
Date: 27 Sepember 2014
Organizer: Institute of Coal Chemistry-Chinese Academy of Science

19. II Congress Smart Grids
Panel discussion: R&D spanish strategies for the development of Smart Grids
Speaker: Prodanovic, M.
Venue: Madrid, Spain
Date: 27 October 2014
Organizer: II Congress Smart Grids

20. IEA Hydrogen Implementing Agreement
Conference: IEA Energy Technology Perspectives 2016 urban energy systems planning workshop
Speaker: O´Mahony, T. (task 36 representative)
Venue: Paris, France
Date: 28-29 October 2014
Organizer: IEA Hydrogen Implementing Agreement

21. Workshop: "Alternative energy in road transport"
Conference: Biofuels
Speaker: Pizarro, P.
Venue: Bilbao, Spain
Date: 25 November 2014
Organizer: EVE-Ente Vasco de la Energía

22. Invited conference at Carlos III University of Madrid
Conference: "New tools and techniques for congestion management and demand forecasting in smart grids"
Speaker: Hayes, B.P.
Venue: Madrid, Spain
Date: 16 December 2014
Organizer: Carlos III University of Madrid



9.4. Participation in science dissemination activities

The main science dissemination events in which IMDEA Energy has been involved in 2014 are listed below:

1. GENERA 2014
a) Participation in "Brokerage event"
Date: 6 and 7 May 2014
b) Jornada sobre participación de Instituciones Madrileñas en Proyectos Europeos en Energía
Conference: Nuevos procesos para la producción de biofuel líquido de segunda generación-Proyecto CASCATBEL
Speaker: Serrano, D.P.
Date: 8 May 2014
Venue: IFEMA, Madrid, Spain
Organizer: Madri+d Foundation

2. European Researchers' Night 2014
Activity: House of Energy
Date: 26 September 2014
Venue: Móstoles, Madrid, Spain
Organizer: IMDEA Energy Institute

3. European Researchers' Night 2014
Activity: Your car and an F1 viewed by researchers of the IMDEA institutes
Speaker: García-Quismondo, E.
Date: 26 September 2014
Venue: Espacio Fundación Telefónica, Madrid, Spain
Organizer: IMDEA Institutes

4. Participation in "Brokerage Event Etrera 2020"
Date: 17 October 2014
Venue: Casablanca, Morocco
Organizer: Madrid Network; University Cadi Ayyad of Marrakech

5. MATELEC-International Exhibition of Solutions for the Electrical and Electronics Industry
Presentation of poster: "Diseño de baterías Aluminio-aire para el almacenamiento energético"
Participant: IMDEA Energy Institute, Autonoma University of Madrid, Albufera Energy Storage
Date: 28-31 October 2014
Venue: Madrid, Spain
Organizer: MATELEC

6. Science Week 2014
Activity 1: The energy of the XXI Century
Date: 4 November 2014
Activity 2: Guided tour of the Energy IMDEA Institute
Date: 11 November 2014
Venue: Móstoles, Madrid, Spain
Organizer: IMDEA Energy Institute

7. Participation in "Brokerage Event of Conama Congress 2014"
Date: 24 November 2014
Venue: Madrid, Spain
Organizer: Conama Foundation; Madri+d Foundation

science dissemination activities

9.5. Training activities

IMDEA Energy has been involved during 2014 in a variety of training activities devoted to undergraduated students. Those activities are very interesting for the Institute that has signed an important number of educational agreements with national and international universities.

1. Álvarez, Sara
B. Sc. in Energy Engineering, Rey Juan Carlos University
Project title: Life cycle assessment of syngas production via carbon dioxide and steam co-electrolysis in a solid oxide fuel cell
Supervisor: Dr. Javier Dufour and Dr. Diego Iribarren, SAU
Date of defense: April 2014

2. Arribas, Sergio
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Internship work: Follow up of closed and open photobioreactor for microalgae cultivation
Supervisor: Dr. Cristina González (BTPU)
Period: March-August 2014

3. Belinchón, Adrián
M. Sc. in Chemical Engineering, Rey Juan Carlos University/Autonoma University of Madrid
Project title: Numerical analysis of the melting process of an encapsulated phase change material for thermal storage in concentrating solar power plants.
Supervisor: Dr. José González (HTPU) and Dr. Gema Vicente (URJC)
Date of defense: December 2014

4. Blanco, Daniel
M. Sc. in Renewable Energy in Electrical Systems, Carlos III University of Madrid
Project title: State estimation of smart grids
Supervisor: Dr. Barry Hayes, ELSU
Date of defense: September 2014

5. Cano, Laura
M. Sc. in Technology and Energy Resources, Rey Juan Carlos University
Project title: Integration of renewable energy sources to energy markets
Supervisor: Dr. Milan Prodanovic, ELSU
Date of defense: January 2014

6. Calvo, Daniel
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Assays to increase the biofuel production achievable from the microalgae *Scenedesmus sp.*
Supervisor: Dr. Cristina González (BTPU) and Dr. Natalia González (URJC)
Date of defense: October 2014

7. Cerpa, Cristina
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Design and construction of a test bed based on beam-down concept for solar thermochemistry
Supervisor: Dr. José González (HTPU) and Dr. Raúl Molina (URJC)
Date of defense: June 2014

8. Castel, Álvaro
B. Sc. in Energy Engineering, Rey Juan Carlos University
Internship work: Prototyping of hybrid supercapacitors
Supervisor: Dr. Rebeca Marcilla and Dr. Afshin Pendashteh, ECPU
Period: October-December 2014

9. Cruz, Pedro
M. Sc. in Renewable Energy, Fuel Cells and Hydrogen, UIMP-CSIC
Project title: Evaluation and improvement of the thermodynamic operation of a biomass energy system for co-production of biofuels and electricity
Supervisor: Dr. Javier Dufour, SAU
Date of defense: June 2014

10. Daza, Óscar
B. Sc. in Energy Engineering, Rey Juan Carlos University
Internship work: Vanadium - Copper Redox Flow Battery Operation
Supervisor: Dr. Enrique García-Quismondo, ECPU
Period: June-August 2014

11. De Diego, Carmen
B. Sc. in Energy Engineering, Rey Juan Carlos University
Internship work: Techno-environmental assessment of concentrated solar power plants
Supervisor: Dr. Javier Dufour, SAU
Period: October-December 2014

12. Dorado, Javier
B. Sc. in Energy Engineering, Rey Juan Carlos University
Internship work: Development of control system for a CO_2 photoreactor
Supervisor: Dr. Víctor de la Peña, TCPU
Period: February-August 2014

13. Escardó, Paula
B. Sc. in Sociology, University of Barcelona
Internship work: Selection of indicators to determine the social impact of energy systems
Supervisor: Dr. Tadhg O´Mahony, SAU
Period: February-July 2014

14. Esteban, Marcos
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Copper (II) sulfide electrochemistry in various electrolytes
Supervisor: Dr. Raúl Díaz and Dr. Jesús Palma, ECPU
Date of defense: January 2014

15. Fernández, Carlos
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Internship work: Photosynthetic microorganisms cultivation: growth rate follow up, chemical characterization and usage for energy purposes
Supervisor: Dr. Cristina González, BTPU
Period: April-June 2014

16. Foncubierta, Laura
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Catalytic hydrodesoxygenation of model compounds from pyrolysis bio-oils
Supervisor: Dr. Patricia Pizarro and Dr. Juan Coronado, TCPU
Date of defense: July 2014

17. García, Rubén
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Internship work: Research in advanced biofuels
Supervisor: Dr. Inés Moreno and Dr. Patricia Pizarro, TCPU
Period: January-March 2014

18. González, Elena
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Internship work: H_2 production by photocatalytic processes
Supervisor: Dr. Víctor de la Peña, TCPU
Period: February-May 2014

19. Humanes, Álvaro
B. Sc. in Environmental Science, Rey Juan Carlos University
Internship work: Study of the LCC methodology for application to energy systems
Supervisor: Dr. Diego Iribarren, SAU
Period: March-August 2014

20. Jiménez, Carlos Javier
B. Sc. in Energy Engineering, Rey Juan Carlos University
Internship work: Development of a simulator of energy demand in Smart Buildings
Supervisor: Dr. Milan Prodanovic, ELSU
Period: October-December 2014

21. Jiménez, Sergio
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Internship work: Activities in the pilot plant for biofuel production
Supervisor: Dr. Patricia Pizarro, TCPU
Period: September-November 2014

22. Jiménez, Sergio
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Production of liquid biofuels from lignocellulosic biomass by pyrolysis and hydrodeoxigenation processes
Supervisor: Dr. David Serrano, TCPU
Date of defense: June 2014

23. Linacero, Rubén
B. Sc. in Energy Engineering, Rey Juan Carlos University
Internship work: Life cycle assessment of fuel cells and shale gas; assessment of externalities
Supervisor: Dr. Javier Dufour, SAU
Period: December 2014-March 2015

24. Löhrl, Christian
B. Sc. in Chemical Engineering, Hamburg University of Technology
Project title: Solar-driven gasification of low-grade carbonaceous materials
Supervisor: Dr. Manuel Romero, HTPU
Date of defense: October 2014

25. López, Ángel
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Design of a test bed based on tubular receiver for hydrogen production
Supervisor: Dr. José González (HTPU) and Dr. Raúl Molina (URJC)
Date of defense: July 2014

26. López, Lucía
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Microalgae cell wall disruption for an efficient biogas production
Supervisor: Dr. Cristina González (BTPU) and Dr. Javier Dufour (SAU)
Date of defense: January 2014

27. Manzanares, Ana M.
B. Sc. in Energy Engineering, Rey Juan Carlos University
Internship work: Development of control system for a CO_2 photoreactor
Supervisor: Dr. Víctor de la Peña, TCPU
Period: January-March 2014

28. Martín, Mario
M. Sc. in Renewable Energy, Fuel Cells and Hydrogen, UIMP-CSIC
Project title: Novel methodological approach for sustainability assessment: Development and application to wind farms
Supervisor: Dr. Javier Dufour and Dr. Diego Iribarren, SAU
Date of defense: June 2014

29. Martínez, Eduardo
B. Sc. in Engineering of roads, canals and ports, Polytechnic University of Madrid
Internship work: Design of ultra-modular central receiver concentrating solar systems
Supervisor: Dr. Manuel Romero (HTPU) and Dr. Juan Mario García (UPM)
Period: April-July 2014

30. Martínez, Eduardo
M. Sc. in Renewable energy and environment, Polytechnic University of Madrid
Project title: Design of ultra-modular and small-size solar fields using heliostats technology, for high-temperature processes
Supervisor: Dr. Manuel Romero (HTPU) and Dr. Juan Mario García (UPM)
Date of defense: July 2014

31. Migliorini, Gleicy Kelly
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Design, optimisation and production analysis of a concentrating solar power plant in Brazil
Supervisor: Dr. Manuel Romero (HTPU) and Dr. Jacinto Monje (URJC)
Date of defense: June 2014

32. Migliorini, Gleicy Kelly
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Internship work: Materials characterization for thermochemical storage in concentrating solar power plants
Supervisor: Dr. José González (HTPU) and Dr. Patricia Pizarro (TCPU)
Period: January-April 2014

33. Miroslavov, Veselin
B. Sc. in Energy Engineering, Rey Juan Carlos University
Project title: Design of a rotary kiln for solar thermochemistry
Supervisor: Dr. José González (HTPU) and Dr. Raúl Molina (URJC)
Date of defense: July 2014

34. Molina, Antonio
B. Sc. in Chemistry, Autonoma University of Madrid
Internship work: Assembly and characterization of supercapacitor making use of electrodes based on carbon nanotube (CNT) fibers
Supervisor: Dr. Rebeca Marcilla, ECPU
Period: June-July 2014

35. Montero, Esperanza
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Internship work: Collaboration in the development of software for exergy analysis
Supervisor: Dr. Abel Sanz (SAU) and Dr. Patricia Pizarro (TCPU)
Period: June-July 2014

36. Muñoz, Ana
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Internship work: Electrodeposition of Aluminium from ionic liquids
Supervisor: Dr. Rebeca Marcilla (ECPU) and Dr. Patricia Pizarro (TCPU)
Period: January-May 2014

37. Muñoz-Torrero, David
M. Sc. in Renewable Energy and Fuels for the Future, Autonoma University of Madrid
Project title: Development and characterization of polymer electrolytes for supercapacitors
Supervisor: Dr. Rebeca Marcilla, ECPU
Date of defense: June 2014

38. Picatoste, Álvaro
B. Sc. in Energy Engineering, Rey Juan Carlos University
Project title: Development, programming and implementation of an automation system to improve energy efficiency
Supervisor: Dr. Jorn K: Gruber, ELSU
Date of defense: November 2014

39. Reñones, Patricia
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Internship work: H_2 production by methane decomposition
Supervisor: Dr. Víctor de la Peña, TCPU
Period: September-November 2014

40. Soria, Jorge
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Energy analysis of capacitive deionization as a water treatment method
Supervisor: Dr. Enrique García Quismondo (ECPU) and Dr. Jose A. Calles (URJC)
Date of defense: July 2014

41. Soto, María
B. Sc. in Energy Engineering, Rey Juan Carlos University
Internship work: CO_2 photoreduction processes
Supervisor: Dr. Víctor de la Peña, TCPU
Period: January 2014-February 2015

42. Tello, Ronald
M. Sc. in Renewable Energy in Electrical Systems, Carlos III University of Madrid
Project title: Discrete modeling of wind turbines for real-time systems
Supervisor: Dr. Francisco Huerta, ELSU
Date of defense: September 2014

43. Valente, Antonio
Student Erasmus Placement 2013/2014, Lifelong Learning Programme
Origin Institution: University of Cassino and Southern Lazio, Italy
Unit: System Analysis Unit
Period: 5 months, 2014
Activity: Life cycle assessment of hydrogen production and use in hydropower plants

44. Villajos, Axier
B. Sc. in Energy Engineering, Rey Juan Carlos University
Project title: Catalytic production of H_2 and graphene
Supervisor: Dr. Víctor de la Peña, TCPU
Date of defense: April 2014

scientific highlights

10

annual report

2014

development of new

Development of New Tools and Services for Smart Power Distribution Networks

for smart power distribution networks

Power distribution networks have traditionally been designed and operated as passive systems, where power flows are unidirectional and relatively easy to predict and manage. However, distribution networks are seeing increasing penetrations of distributed energy resources, such as small-scale generation from renewable sources, as well as new technologies such as demand-responsive loads, electric vehicles and devices with energy storage capability. Increasingly, power distribution networks are being viewed as distribution systems, where the network operator, or Distribution System Operator (DSO), is required to actively monitor and control the networks in real-time. All relevant studies suggest that such trends towards more actively-managed distribution systems are set to continue, and that the integration of new energy technologies will lead to more frequent occurrences of problems in the distribution network, such as congestions and excessive voltage variations [1]-[3].

At the same time, advances in information and communications technology are creating new opportunities for operating power distribution systems in a more pro-active and intelligent way. In particular, the widespread introduction of smart meters means that an unprecedented amount of detailed historical data on user demands is becoming available. Measurements from smart meters and other sensors can be used, along with data from traditional network monitoring systems to better understand and model the behaviour of end user demands, and to improve network operation [4], [5]. This has led to significant research interest in adapting techniques which were previously only used at the transmission level, such as state estimation and short-term operational planning, to distribution systems [6].

The state of any power network can be represented by a matrix of the voltages and power flows describing the condition of entire system. State estimation refers to a set of computational techniques that are used to estimate, or predict, the network state accurately, allowing operational and control decisions be taken with confidence. State estimation is used to improve the visibility of the network to the operator, to detect and remove errors in the network data, and to reduce the impacts of measurement and communica-

tion system noise on network operation. For several decades, state estimation has been a critical part of the operation of large-scale bulk transmission systems, where control decisions are critical, and operator errors can have serious consequences.

Recently, there has been much interest in implementing state estimation tools and services in distribution networks. This provides benefits to the DSO by improving the local-level system monitoring and visibility, and allowing better integration of renewable energy resources. However, there are many challenges in implementing state estimation in distribution networks, which require more research and development. For instance, the quantity and quality of measurements available from distribution networks is usually limited, creating challenges for state estimation robustness and accuracy. New energy forecasting tools are also required for the efficient operation of actively-managed, "smart" distribution systems. These tools are important in order to provide DSOs with early warning of potential network problems. Forecasting is also used for planning of network operation and maintenance activities, and optimisation of resources such as local renewable generation and energy storage.

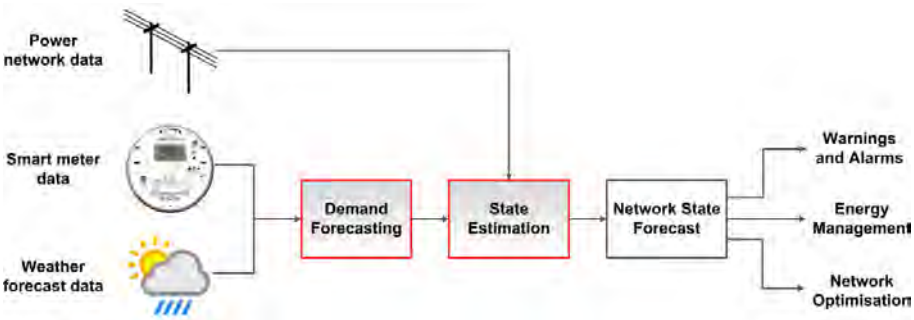


Figure 1. Information flowchart for distribution network state estimation and forecasting services.

In order to address these challenges, an integrated demand forecasting and state estimation tool has been developed at the IMDEA Electrical Systems Unit. This is designed to improve monitoring and operation in active distribution systems (Figure 1 shows an overview of the information flow, with the main services highlighted). The inputs to the demand forecasting are recorded smart meter data, and also local weather forecasts, since the weather has a strong influence on both electrical load demand and on genera-

tion from renewable sources such as solar PV. This information, along with traditional power network measurements (e.g. substation monitoring and switch/breaker statuses) is used to estimate the network state.

The state estimation is comprised of several steps. The first step checks and validates that the distribution network model is correct and up to date. Next, an observability analysis is carried out, and if the network, or parts of it are not observable, estimated values of network inputs called pseudo-measurements need to be provided. The final step involves the filtering and replacement of bad data such as noise, errors, and missing data points from the input measurement data set. The demand forecasting service can provide the necessary pseudo-measurements to fill in gaps in the input measurement data. It also allows us to carry out state forecasting, or estimation of the network state ahead of time, e.g. several hours or days in the future. Figure 2 shows the structure of Non-linear Auto-Regressive eXogenous (NARX) model proposed for forecasting the demand and local generation at each node in the distribution network. It was demonstrated that a flexible, non-linear model such as NARX provided the best results for this application, since it can adapt successfully to changes in load behaviour over time [7].

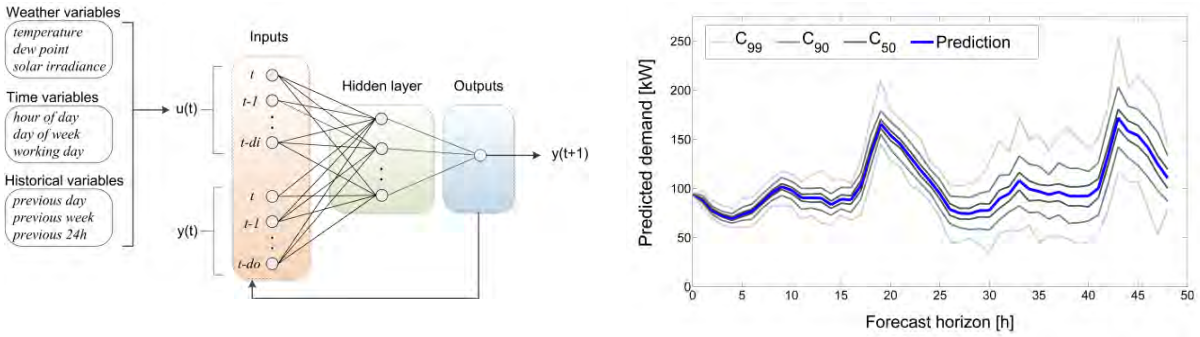


Figure 2. (Left) Non-linear Auto-Regressive eXogenous (NARX) model for substation demand forecasting. (Right) Sample of demand forecasting results at a single substation, where the forecasting horizon is varied from 1 hour ahead to 48 hours ahead, with confidence intervals shown at 50%, 90% and 99%.

This research work provides useful new services to the DSO, including warnings of potential network congestions or voltage problems, and can also give advice and recommendations to optimise the configuration of the network and management of distributed energy resources. The services developed in the Electrical Systems Unit of IMDEA Energy have been demonstrated using real data from the test network for the EU project "SmartHG" [8], a medium voltage distribution network located in Denmark. Figure 3 shows an example of the application of demand forecasting and state estimation in this network. It shows a scenario where heavy network loading has caused low voltage issues in the extreme parts of the network (per unit voltages of 0,95 pu in Figure 3, Left). This

situation is forecasted ahead of time and appropriate warnings are issued to the DSO. Recommendations for corrective actions are also provided. In this case, adjustment of network transformer tap ratios can bring voltages to an acceptable level throughout the network (Figure 3, Right).

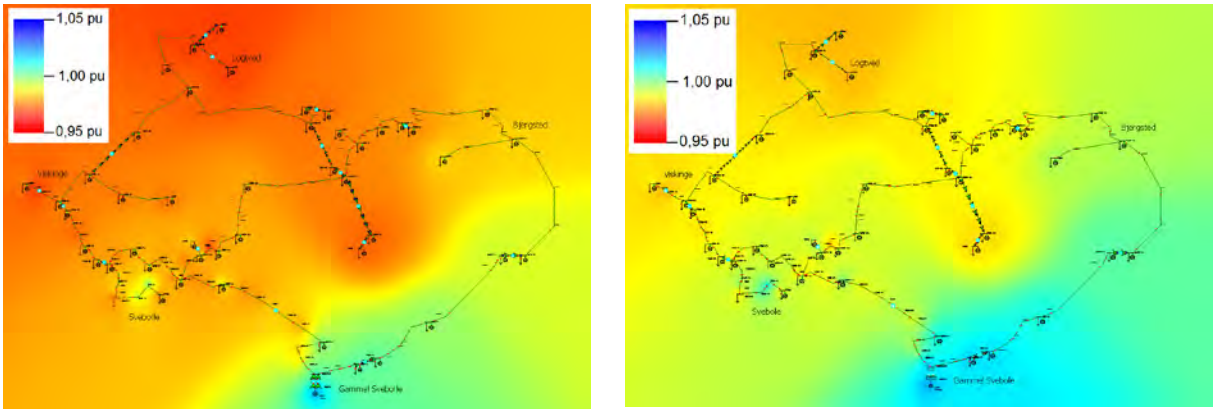


Figure 3. (Left) Results of state estimation showing Danish medium voltage distribution network with low voltage issues. (Right) Results after the proposed corrective actions have been taken by DSO.

Further work at the Electrical Systems Unit of IMDEA Energy will extend these services to include additional advanced features, such as optimisation of local energy resources and network voltages, and will test their performance in various types of distribution systems.

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energy model for "Co

Energy Model for "Comunidad de Madrid"

In last decades, climate change has evolved as one of the major threats to the earth's sustainability. Even though the Kyoto Protocol came into effect in February 2005, from a global perspective its environmental effectiveness is reduced due to the lack of participation of several key countries and cities. Therefore, new policy architectures based on a bottom-up approach are necessary in order to deal more successfully with ever-increasing emissions [1]. In this sense, the consideration of energy models that encompass alternative pathways and long-term energy planning is increasingly important to adequately balance the energy needs of a region with other economic, social and environmental aspects [2]. The model LEAP Madrid is the result of the work carried out by the Systems Analysis Unit of the IMDEA Energy Institute in 2013-2014. This model represents the entire energy system of the Comunidad de Madrid and constitutes a scenario analysis tool for exploring current opportunities and future challenges. The base year used is 2010, as the most recent year with all relevant data available. The Long range Energy Alternatives Planning System (LEAP), a widely-used software for energy policy analysis and climate change mitigation assessment, was used to develop this energy model for the region of Madrid. One of the main features of LEAP is that it is a scenario-based platform covering: energy demand, energy supply, resources, environmental loadings, cost-benefit analysis and non-energy sector emissions. As mitigation and energy policy continue to increase in importance, it is becoming more common for policy to be implemented at the regional level, to move towards a sustainable energy system. Private sector interest is also increasing as the scope for contribution from new energy technologies, management systems, new energy supply forms and renewable energy increases. The potential applications for an energy model for the region of Madrid are thus not only at the level of local government but expand to utility companies, transport, etc.

LEAP Madrid has been developed to encompass the entire Comunidad de Madrid, including both the urban centre and its wider region (6.5 million inhabitants), which constitutes a suitable scale for policymaking. In this respect, LEAP Madrid has been developed as an accounting framework with details on both the supply and demand side. As there is little indigenous energy supply or electricity in the region of Madrid (electricity generation in 2010 in the Comunidad de Madrid was 6,9% of final demand), its importation from other regions is included. On the other hand, there is greater concentration on the demand side including the following sectors: industry, services, agriculture, transport, residential and others. A detailed representation of transport and residential sectors is included in this

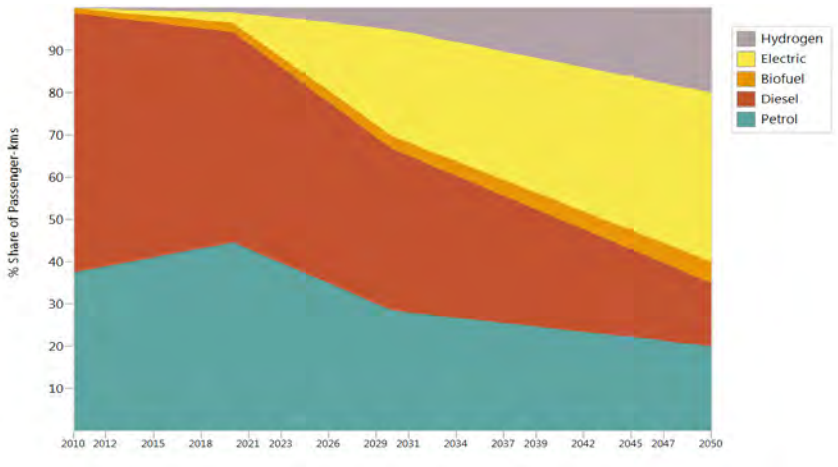

Figure 1: Illustrative application of the LEAP Madrid model showing the projected distribution of passenger vehicles

model due to their high energy demand. In this sense, the residential sector is the second largest consumer of energy in the Comunidad de Madrid, more than double that of industry or services. Additionally, the transport sector plays a key role in the region and its structure in LEAP Madrid is formed on the basis of technologies for passenger and freight. Many different local, national and international data sources have been used in the development of data for base year of 2010. Furthermore, data included in the key assumptions of “LEAP Madrid” include a number of categories such as income, GDP and population, which can be modified depending on the features of the scenario (e.g., “business as usual” scenario). In this respect, “LEAP Madrid” is the basis for building scenarios of how the energy system of the region of Madrid might evolve over time in a particular socio-economic setting and under a particular set of policy conditions. In this way, scenarios of the region Madrid could be used to characterise an envelope of expected future conditions or quantify savings potential measures from policy (e.g., policies oriented to increase the proportion of renewable energies in the energy system of the region of Madrid), technology (e.g., improvements in efficiency and fuel economy of electric and fuel cell vehicles), or behavioural changes (e.g., increasing the level of public awareness on energy efficiency practices). LEAP Madrid enables the evaluation of these systematic changes and impacts in order to explore the most appropriate energy pathways within this context.

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new heat tra

New heat transfer fluids: increasing performance in solar thermal power plants

increasing performance in solar thermal power plants

Current commercial concentrating solar power (CSP) plants are still largely based on mineral oil parabolic trough technology, developed nearly 30 years ago, and molten-salt and direct steam generation towers [1]. At the same time, Fresnel technology has not fully developed its complete potential achieving a limited deployment and Stirling dish technology has not reached the required degree of development and cost-reduction in order to be competitive with respect to the other STE technologies. Parabolic trough power plants employ Rankine-cycle power blocks with low temperature (< 400ºC) steam turbines which operate with relatively low efficiencies (~35% when dry-cooled [2]), whilst central receiver CSP plants achieve higher temperatures, which have cycle efficiencies about 40%, leading to reduced costs. Despite this, both technologies have their associated drawbacks.

Molten-salt systems are limited to operating temperatures below 565 °C by the thermal stability of the salt itself, preventing the use of even more efficient, higher temperature power conversion cycles. Molten-salt systems also suffer from freezing problems if the salt temperature drops too low, resulting in high parasitic power consumption for heat-tracing. Direct steam systems are not limited in the temperatures they can achieve, as no intermediary heat transfer fluid is used. However, they typically operate with steam temperatures in the region of 535 °C and no cost-effective large-scale storage system has been developed for live steam. Use of this technology therefore negates the key advantages of solar thermal power: the ability to store energy [1]. As such, if the true potential of CSP technology is to be unlocked, new advances on heat transfer media (HTM) are needed that can both reach higher temperatures and easily be stored. Reaching higher temperatures is seen as key to future cost reductions, as higher temperatures lead to both higher power conversion efficiencies and increased storage densities, directly reducing the total cost of the solar collector field and the specific cost of the storage units. Recent

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reports points out that improvement in heat transfer fluids (HTFs) and storage solutions result in an expected LCOE reduction varying from 2.3% for Central Receiver to 5.6% for Parabolic Troughs CSP plants [3].

A wide range of alternative high-temperature HTM are being studied for use in CSP plants, including improved molten salts, liquid metals, gases, and solid particles [4]. In principle, the simplest solution would appear to be to develop new molten salt materials that are capable of resisting higher temperatures and/or have lower melting temperatures; in this way existing receiver technology could be used, reducing the required investment. However, in order to overcome the temperature limitations imposed by the nitrate salts currently used in CSP plants [5], it is necessary to switch to ternary, quaternary or even quinary mixtures based on nitrate, carbonates and chloride salts, which suffer from corrosion issues at high temperatures, significantly increasing maintenance costs [6]. Liquid metals, mainly based on sodium and lead and their alloys (NaK, lead-bismuth eutectic) are also being explored as HTF due to their high thermal conductivity and low viscosity. However, these fluids have important safety hazards. Alkali metals react with both air and water, thus leading to the risk for accidental fires. Lead-containing liquid metals require specific measures in order to avoid their toxicity by ingestion (proper ventilation, isolation and hygiene facilities). In addition, liquid metals have higher costs that molten salts currently used in CSP plants and they have lower heat capacities, which conduct to lower performance than molten salts as storage media [7].

Inert gases (e.g. air, helium, sCO_2, etc.) are other alternative as HTF, eliminating the thermal decomposition and corrosion problems and even use them directly as working fluid in appropriate turbines or thermal engines. Thus intermediate heat exchangers are avoided increasing the energy available for electricity production. The use of air as the working fluid in solar tower power plants has been demonstrated since the early 1980s. Main advantages of using air are its availability from the ambient, environmentally-friendly characteristics, no troublesome phase change, higher working temperatures, easy operation and maintenance and high dispatchability. It is a suitable heat transfer fluid in desert areas, where water availability is scare. However its low heat transfer poses challenges for receiver design, while their low densities complicate the integration of energy storage [8]. Supercritical CO_2 has recently attracted the solar community attention as HTF since it can operate at very high temperatures, provides suitable thermophysical

properties related to the supercritical state and can be directly used as working fluid in sCO_2 turbines [9].

The use of solid particles as the HTM is another option, capable of reaching temperatures of 1000 °C when ceramic particles are used [10]. Solid particle HTM are also ideally suited for storage applications, which can be easily implemented through simple bulk storage of hot particles. The solid particles are typically directly irradiated by the concentrated sunlight, allowing for very high heat fluxes as there is no interposing material to limit heat transfer. However, this approach leads to high heat losses (thermal efficiencies < 50% under real conditions [11]) and significant difficulties in controlling the flow of loose particles within the receiver. Within this approach, the dense particle suspension (DPS) is an alternative to the classical solid particle HTM, combining the good heat transfer properties of liquids and the ease of handling of gases with the high temperature properties of solid particles. The DPS consists of very small (μm-scale) particles which can be fluidized at low gas and then be easily transported in a similar manner to a gas [12].

Inert gases (Air and sCO_2) and solid particles (including DPS), which have the highest potential to operate at very high-temperatures between the aforementioned HTFs, are currently investigated in the High Temperature Processes Unit in the framework of national and international research projects (CM Alccones, FP7 CSP2, FP7 IRP and STAGE-STE). The research focuses on the development of innovative solar receivers and reactors capable to handle these heat transfer fluids including testing at 15 kW_{th} scale using high-flux solar simulators as well as the design of plant layouts in order to analyze the integration of these HTF (including specific components) and its impact on the CSP plant performances.

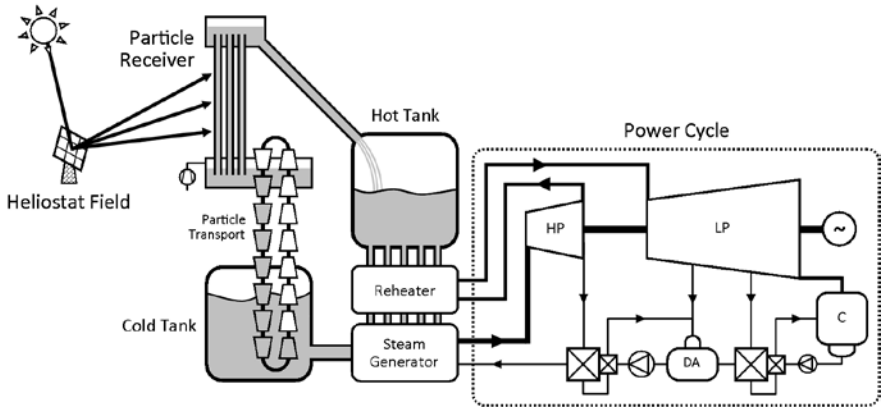

Figure 1. Scheme of a CSP plant using dense particles suspension as Heat Transfer Fluid [12]

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development of tail

Development of tailored nanocatalysts for the transformation of lignocellulosic biomass into advanced biofuels via a cascade process

for the trasformation of
lignocellulosic biomass into advanced
biofuels via a cascade process

Mainly due to the concerns about competition with food supply, but also as a consequence of the inefficiencies on the production processes, first generation biofuels (bioethanol and biodiesel) have not reached the initial expectations regarding the progressive replacement of petroleum-derived fuels. Nevertheless, the urgent need of taking active measures for climate change mitigation, have increased the interest in developing biofuels produced from non-edible lignocellulosic biomass. This structural component of plants is the most abundant source of terrestrial biomass and it is usually a low-cost raw material obtained in large amounts from either forestry or agriculture residues. The total energy potential of wood by-products considering only the EU Western countries is estimated at 17.5 Mtoe/year, while agricultural wastes in the EU could reach 39.9 Mtoe/year by 2020 [1]. Accordingly, lignocellulose resources could provide a significant proportion of the energy consumed in the transportation sector, playing an important role in reducing the external European fossil fuel dependency and decreasing the overall CO_2 emissions, in line with Europe 2020 Strategy and related SET Plan [2].

However, lignocellulose-based materials are very complex feedstock that requires an intensive processing for their transformation into useful chemicals. Although conversion of lignocellulose into transportation fuels has been attempted by a number of different routes, this is not a trivial task due to its chemical heterogeneity, elevated stability and high oxygen content. Currently, three main pathways are considered for the conversion of lignocellulose into fuels and chemicals, which are based on hydrolytic, biochemical and thermochemical transformations, respectively. Among the various thermochemical transformations, biomass pyrolysis has shown to be a very promising option for the conversion of large volumes of solid biomass into liquids [3]. In this route, biomass is treated under inert atmosphere to yield gases, liquids (bio-oil) and a solid residue (char). In

order to maximize the yield to bio-oil it is well-established that fast pyrolysis conditions should be adopted: very short residences times (<1 s), moderate temperatures (around 500 ^{0}C) and extremely high heating rates (up to 1000 ºC/s).

Bio-oil presents interesting properties as a potential fuel since it retains up to 70% of the energy stored in the raw biomass and contains less N and S than petroleum fractions. The composition of this liquid fraction is very complex, as it can be constituted by more than 400 different components, and it contains 15-25 wt% of water and more than 40 wt% of oxygen. As a consequence of these characteristics, bio-oils present strong corrosiveness (pH = 2–4), high viscosity, immiscibility with conventional fuels and poor chemical stability due to polymerization. Consequently, an upgrading treatment is crucial to transform bio-oils in a useful liquid fuel to improve its properties. Hydrodeoxygenation (HDO) has been often proposed as an option for refinining pyrolysis bio-oil obtained from biomass. This process involves the removal of most of the oxygen contained in the bio-oil via hydrogenation under high pressure (up to 200 bar) and temperatures in the range 300-400 ºC. HDO yields a naphtha-like product that could be blended in refineries with conventional transportation fuels [4]. However, full deoxygenation in a single step involves high hydrogen consumption, making this process hardly competitive in economic terms with conventional fossil fuels. Therefore, minimizing the hydrogen consumption in HDO is especially important to reduce the operation costs.

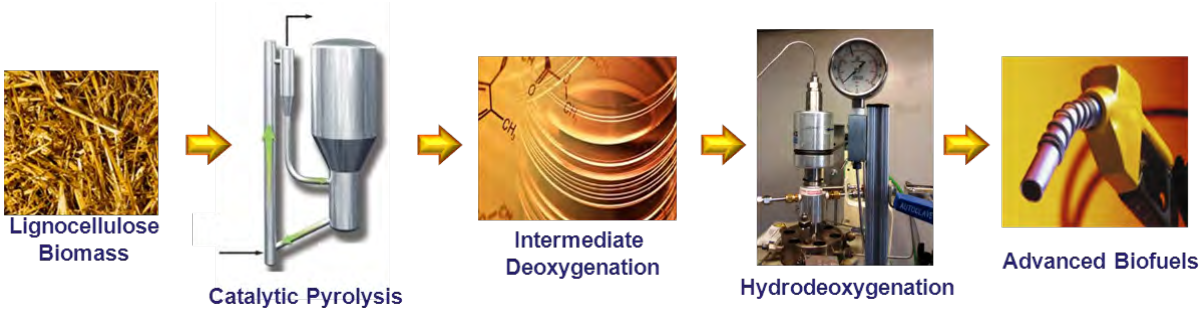

Figure 1. Reaction scheme of the lignocellulose cascade deoxygenation catalytic processes for advanced biofuels production

In order to overcome the present technological limitations, recently an innovative processing scheme (see Fig. 1) has been proposed. This route is based on the development of finely tuned nanocatalysts to promote a cascade of transformations leading to the production of premium fuels from lignocellulose biomass in a competitive way. The key aspect of this approach is to achieve a progressive deoxygenation in the successive steps: first through catalytic pyrolysis to produced boil-oils with lower oxygen content, then by a series of condensation and deoxygenation reactions, and finally via an optimized hydrodeoxygenation. For all these processes the design of specific multifunctional nanocatalysts, based mainly on abundant and inexpensive elements is crucial for developing a successful technology. This strategy is expected to result in the production of liquid biofuels, with enhanced yield and energy density, and having chemical compositions and properties very similar to those of petroleum-derived fuels. Such alternative reaction pathway is currently under investigation by an European consortium of academic and industrials partners, which has received financial support of the FP7 (CASCATBEL) [5].

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kluyveromyces

Kluyveromyces marxianus as an emerging new platform for the production of biofuels, enzymes, flavor and fragrance molecules

as an emerging new platform for
the production of biofuels, enzymes,
flavor and fragrance molecules

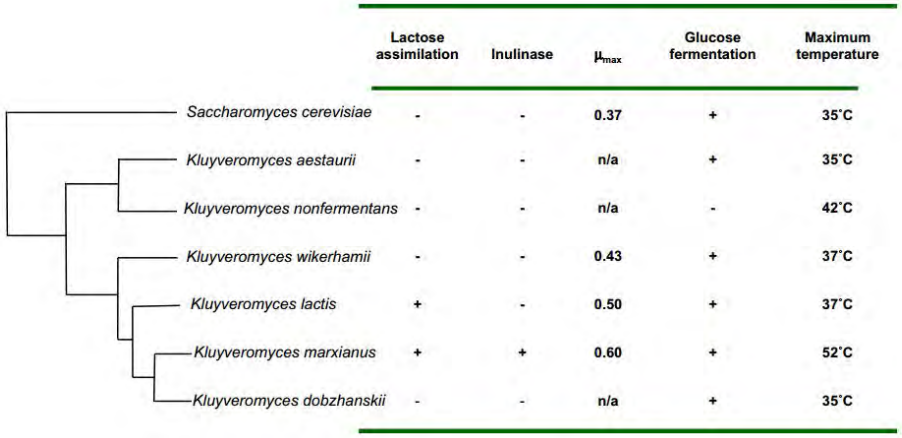
Yeasts are widely used in both traditional and modern biotechnology for the production of foods, beverages, enzymes, fine chemicals and pharmaceutical reagents. Yeasts have also been to the forefront of research in modern genetics, molecular biology and cell biology, although it is true that the majority of research has focused on *Saccharomyces cerevisiae* strains. *S. cerevisiae*, and related species, are particularly well-known because of their importance in making fermented beverages (beer, wine, cider). However, there is a wide diversity of yeasts, for example within the *Kluyveromyces, Pichia, Debarromyces and Yarrowia* genera, with high potential roles in biotechnology that have only been studied superficially [1]. As applications in the biotechnology sector continue to develop, there is increasing interest in applying modern molecular tools to understand and improve some of the so-called "non-conventional" yeasts.

Among non-conventional yeast *Kluyveromyces marxianus* has been shown to have a wide range of metabolic capabilities that could be used in industrial applications. *K. marxianus* is attractive for cell factory applications due to its thermotolerance, high secretory capacity and its capability to grow on cheap media (lactose, inulin, cellulosic sugars) [2]. Moreover, *K. marxianus* holds the GRAS status (Generally Regarded As Safe) and QPS (Qualified Presumption of Safety) in the United States and European Union, respectively. This designation means that there are few restrictions in the biotechnology sector, allowing straightforward food and pharmaceutical applications of this microorganism and its derivatives.

The underlying interest in *K. marxianus* is undoubtedly driven by applications in the biotechnology industry. This is reflected in the scientific literature, where there are more papers dealing with biotechnological applications than metabolism, molecular biology, or

other fundamental aspects of this yeast. In fact, whey permeate, formerly a problematic waste product, has become a key inexpensive substrate for the growth of *K. marxianus* to produce several by-products to be used in the food processing industry. Commercially, the ß-galactosidase activity of *K. marxianus* has been exploited for some time, where the yeast was used to treat lactose-containing waste from the cheese industry [3].

Other interesting application of *K. marxianus* is ethanol production. The interest in ethanol is driven by the development of biofuels. There are a number of process advantages which could be exploited through the use of thermophilic microorganisms such as energy savings through reduced cooling costs, higher saccharification and fermentation rates, continuous ethanol removal and reduced contamination. Moreover, the capability of *K. marxianus* to simultaneously consume glucose and xylose is an important trait in the fermentation of lignocellulosic biomass residues that can be exploited in order to maximize ethanol productivity [4].



	Lactose assimilation	Inulinase	μ_{max}	Glucose fermentation	Maximum temperature
Saccharomyces cerevisiae	-	-	0.37	+	35°C
Kluyveromyces aestaurii	-	-	n/a	+	35°C
Kluyveromyces nonfermentans	-	-	n/a	-	42°C
Kluyveromyces wikerhamii	-	-	0.43	+	37°C
Kluyveromyces lactis	+	-	0.50	+	37°C
Kluyveromyces marxianus	+	+	0.60	+	52°C
Kluyveromyces dobzhanskii	-	-	n/a	+	35°C

Figure 1: Relationship of K. marxianus to other yeasts. The tree shows the phylogenetic relationships between the species in the genus Kluyveromyces with Saccharomyces cerevisiae included for comparison. Some key traits are also presented, highlighting notable features of K. marxianus that differentiate this yeast from other Kluyveromyces species

The production of native enzymes, such as inulinase, ß-galactosidases and pectinases by the exploitation of *K. marxianus* as cell factory is particularly interesting at commercial level. Inulinase is of particular interest as this enzyme is not commonly found in other yeasts or fungi [5]. Apart from the production of some novel enzymes, its rapid growth and ease of handling make *K. marxianus* a preferable system to filamentous fungi, which are often an alternative source of fungal enzymes.

Waste management is another interesting field for *K. marxianus* application. Their biosorption and bioaccumulative properties have been utilized in bioremediation of textile dyes and copper from wastewaters, and it has been also used to treat waste and paper sludge.

Lately, *K. marxianus* has emerged as a new platform organism for the production of flavor and fragrance compounds [6]. Consumers demand for biologically-synthetized molecules for use in foods other products create an interesting opportunity to exploit the unique traits of *K. marxianus* for cell factory application.

However, the major impediment to its development has been the limited fundamental knowledge of its genetics and physiology. Since *Kluyveromyces* genus has only been studied superficially, further investigation is needed to exploit its immense potential as a tool for tailored biotechnological production. The Biotechnology Process Unit at IMDEA Energy works to overcome this limitation and exploit the unique potential of *K. marxianus* as a new platform organism for the production of fuel, chemicals and pharmaceutical compounds. As more tools become available, it is likely that the intrinsic advantages of *K. marxianus* over other yeasts will see increasing applications in the biotechnology and biopharmaceutical sectors. Future developments will certainly include the construction of recombinant strains producing additional enzymes.

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a new concept

liquid electrolytes in supercapacitors

A New Concept of Redox Ionic Liquid Electrolytes in Supercapacitors

Renewable energy technologies and electric transport (hybrid and electric vehicles) are being developed as a solution to decrease the strong dependence of traditional sources in our energy system. In this sense, efficient energy storage is a crucial factor. Energy accumulators allow matching between power generation and demand and facilitate the penetration of renewable generation technologies. Nowadays, there are different ways to store energy such as mechanical, thermal, electromagnetic, electrochemical, etc. The choice of the ideal storage technology to be used depends on a number of factors, these are among others, the amount of energy or power to be stored, the time for which this stored energy is required to be retained or to be released, spacing, cost and location of the network.

The Electrochemical Processes Unit in IMDEA Energy is actively working at present on the development of high performance electrochemical energy storage devices, among which supercapacitors (SCs) are included. SCs are characterized by having a high power density. For this reason they have been usually proposed for power applications such as stop-start systems in vehicles, power quality enhancement, and bridge power systems in weak or isolated grids [1]. The main disadvantage of SCs is their low energy density compared to batteries which is calculated as shown in equation (1). In order to boost energy density, different strategies are pursued to increase both capacitance (C) and voltage (V).

$$E_{max} = \tfrac{1}{2} CV^2 \quad (1)$$

On one hand, the limited operating voltage of aqueous, up to 1.2 V, and organic electrolytes, up to 2.5-2.7 V, has been extended up to 3.5 V by using ionic liquids (ILs) that exhibit a wide electrochemical stability window. ILs also have very low vapor pressure, high thermal stability and good conductivity; for these reasons ILs are used as electrolytes [2].

# of redox ionic

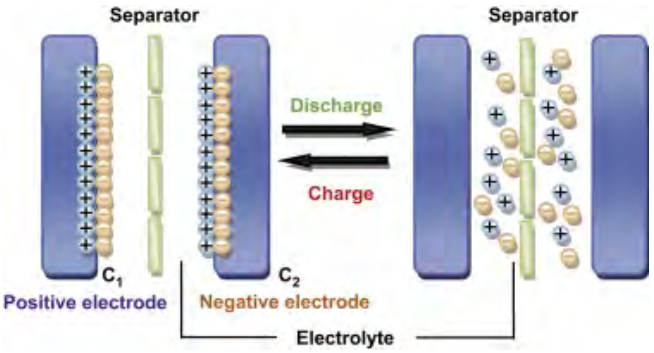

Figure 1. Diagram showing the charge distribution in an electric double-layer capacitor when it is charged (left) and discharged (right)[3].

On the other hand, in order to enhance the capacitance (C), activated carbons have been most widely employed as active material for SC electrodes due to their high specific surface area (1000-2000 m^2g^{-1}), high electric conductivity and low cost. Although small improvements have been gained using sophisticated carbonaceous structures such as carbide derived carbons (CDCs), carbon nanotubes (CNTs) and graphenes [4], a significant enhancement in capacitance seems to be only achievable by using pseudocapacitive materials such as transition metal oxides, conducting polymers or their composites with carbonaceous materials. The modification of the carbon surface by grafting active redox active molecules is attracting a growing interest in the last years since and their use as an active material in aqueous supercapacitors [5]. In those systems, the energy storage mechanism is a combination of electrical double layer formation and faradaic reaction at the electrode-electrolyte interface resulting in supercapacitors having higher capacitance and energy.

Presently, there is a new trend in exploiting the pseudocapacitive phenomena where the electrolyte itself becomes the origin of additional capacitance. Some examples of redox active molecules being used in redox electrolytes are: bromine/bromide [6], iodine/iodide [7] (Figure 2), vanadium/vanadyl [8] and several organic redox couples [9]. This type of electrolytes, can be denominated as redox electrolytes, are promising candidates to be used in supercapacitors with improved properties. IMDEA Energy is doing research on different redox pairs dissolved into the electrolyte using a wide electrochemical stability window. The aim is to develop electrolytes that provide an enhanced capacitance with

a high operating voltage at the same time and consequently, having advanced supercapacitors allow for achieving to meet the requirements of new applications.

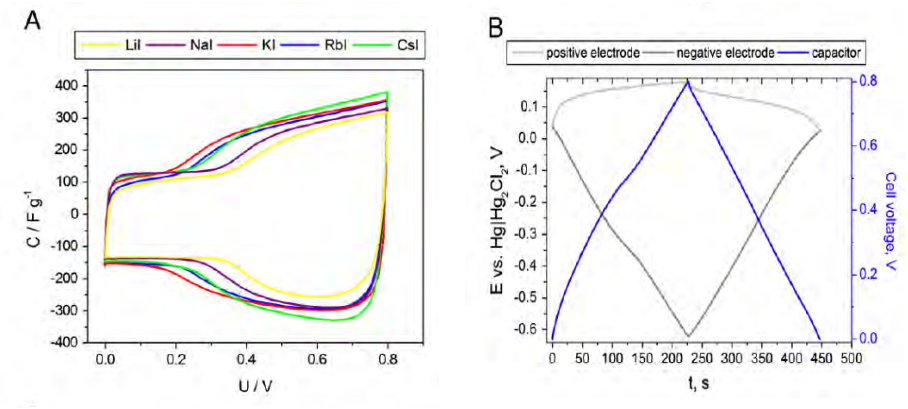

Figure 2. Capacitance values of the carbon electrode estimated from voltammetry characteristics at 10mVs^{-1} in different alkali metal iodide solutions (A); galvanostatic charge/discharge at 0.5 Ag^{-1} for RbI aqueous solution in two and three electrode cell (B)[7].

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