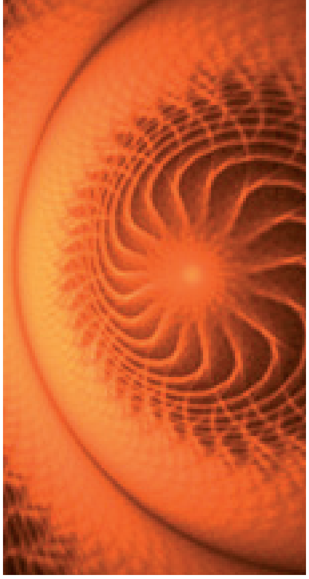


madrid institute
for advanced studies

annual report 2012

institute imdea energy

annual report 2012

f o r e w o r d

foreword

David Serrano
Director of the IMDEA Energy Foundation

Móstoles, March 2013

I am glad of introducing the Annual Report of the IMDEA Energy Institute, summarizing the main activities and achievements corresponding to 2012. IMDEA Energy is an R&D institution focused on clean energy and renewable energy technologies. It was created in 2006 by the Regional Government of "Comunidad de Madrid" as a Foundation, which provides IMDEA Energy with a very efficient and flexible management system. Scientific excellence, international impact and cooperation with industry are the key drivers of the IMDEA Energy activities.

The IMDEA Energy Institute is aimed to generate and foster scientific and technological developments for progressing towards a low-carbon energy system. The research topics addressed by IMDEA Energy include a variety of subjects with high current interest and relevance: concentrated solar power systems, production of sustainable fuels, energy storage materials and devices, smart energy grids, reduction and control of CO_2 emissions by means of valorization and confinement alternatives, and development of high-efficiency end-use systems.

The researchers at IMDEA Energy are integrated in six different research units, all of them now in full operation. By the end of 2012 a total of 50 researchers were working at the Institute, more than half of them holding a Ph.D degree. Up to 14 different nationalities have been represented in the IMDEA Energy staff, as a consequence of the international profile of the Institute.

The research activities of IMDEA Energy are mainly organized within the framework of projects approved in competitive calls and research contracts with private companies. A total of 19 research projects funded by public administrations and 9 contracts with companies have been under development along 2012, whereas up to 18 personnel grants have been active in IMDEA Energy. These figures evidence the success achieved in getting external funding, allowing about 50% of the total operational costs of the Institute to be covered with these external resources.

The research activities have led to a significant number of scientific contributions: 37 scientific works published in prestigious journals, 3 book chapters, 1 patent and 56 communications presented in scientific congresses. Likewise, IMDEA Energy researchers have participated in a wide variety of scientific dissemination actions, such as invited lectures in courses, masters and technical seminars. Moreover, the Institute has promoted and has been involved in the organization of 7 conferences/courses and 16 scientific seminars.

In regard to infrastructure and facilities, 2012 has been a landmark for IMDEA Energy since the first phase of the definitive headquarters, located in the Technological Park of Móstoles, was occupied, whereas important progress was carried out for conditioning and setting up phase 2 so it can be operative along the next year. This has led to a very important enhancement in the quality of the working environment for scientists, technicians and administrative personnel.

In summary, we can state that at present IMDEA Energy is well positioned for facing successfully the current challenges thanks to the excellent work and strong effort of its researchers and staff, as well as to the relevant support received continuously from the Regional Government of "Comunidad de Madrid".

t a b l e o f
c o n t e n t s

table of contents

a n n u a l r e p o r t
2012

general presentation

1

annual report

2012

The IMDEA Energy Institute is a Research Centre established by the Regional Government of Comunidad de Madrid and operates as a non-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 ultimate goal of the IMDEA Energy Institute is to achieve outstanding scientific and technological contributions for reaching a sustainable energy system. 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 six areas:

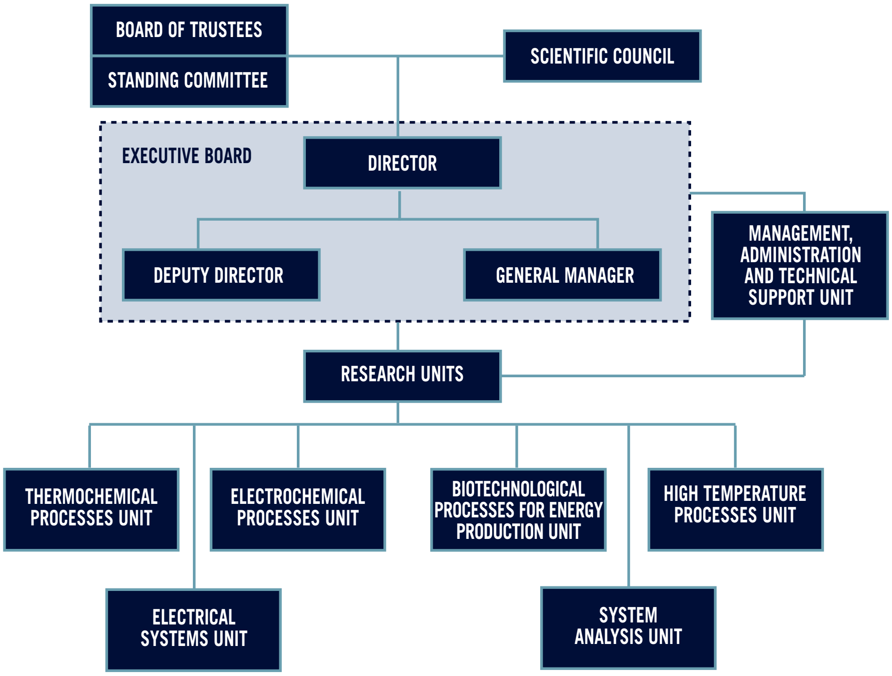
- Solar energy systems and technologies, with special emphasis in concentrating solar power.
- Production of sustainable fuels for the transport sector: hydrogen, biofuels and waste-derived fuels.
- Energy storage coupled to renewable energies.
- Smart management of electricity demand.
- Energy systems 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 with selected targets for 2020 and 2050; the Plan for Renewable Energy of Spain PER 2011-2020; technology roadmaps of recognized international institutions and associations and implementation agreements of the International Energy Agency.

governing bodies and functional structure

2

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.

BOARD OF TRUSTEES

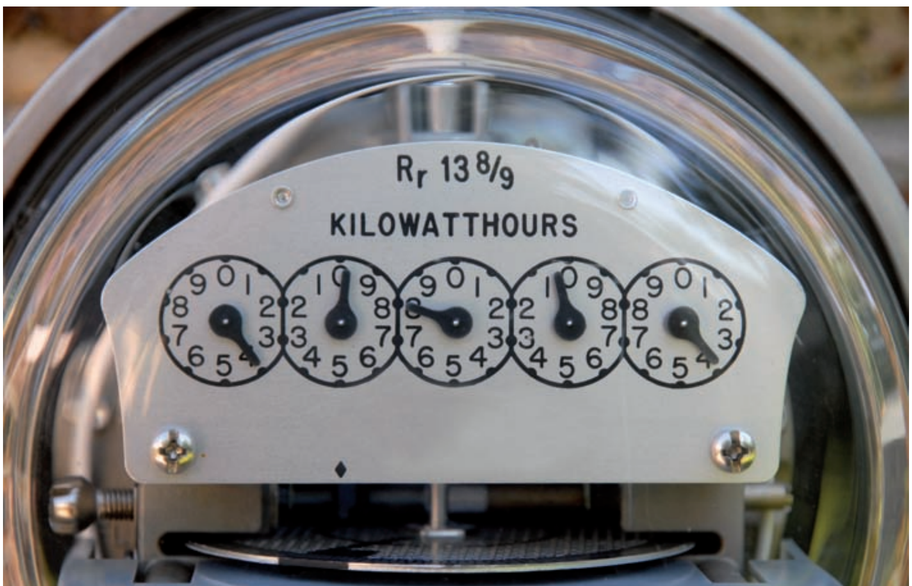
Standing Committee

The Standing Committee holds a large fraction of delegated Powers of the Trust, with the aim to support the day-to-day operation of the Foundation. The composition of the Standing Committee as of December 31st, 2012 is listed below:

- Mr. Jon Juaristi Linacero, President
- Mr. Juan Ángel Botas Echevarría
- Mr. José de la Sota Ríus
- Mr. Rafael van Grieken Salvador
- Mr. Julián García Pareja, Secretary

2.2. Scientific Council

The IMDEA Energy Scientific Council is composed by the scientific members of the Board of Trustees and an additional number of scientists. 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. In 2012, the IMDEA Energy activities along a 4-year period (2008 – 2011) were evaluated and assessed by the Scientific Council. The evaluation report highlighted in a very positive way its numerous achievements and provided a list of recommendations to be taken into account regarding the orientation and organization of IMDEA Energy at short-mid term.



SCIENTIFIC COUNCIL

Prof. Dr. Martin Kaltschmitt
Director of Institute of Environmental Technology and Energy, Hamburg 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
Weizmann Institute of Science, Israel

Dr. Carmen M. Rangel
Research Coordinator
LNEG, Portugal

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

Prof. Dr. Aldo Steinfeld
Professor of Renewable Energy Carriers at the ETH Zurich and Head of the Solar Technology Laboratory at the Paul Scherrer Institute, Switzerland

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

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

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

Dr. Castells
Emeritus Professor
University Barcelona, Spain

Dr. Cirio
Coordinator of Bioenergy Unit at National Laboratory of Energy and Geology, LNEG, Portugal

2.3. Executive Board

The Executive Board is composed by the General Director, the Deputy Director and the General Manager. 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-today 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

The 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 2012:

- Thermochemical Processes Unit
- Electrochemical Processes Unit
- Biotechnological Processes for Energy Production Unit
- High Temperature Processes Unit
- Electrical Systems Unit
- Systems Analysis Unit

2.5 Management, Administration & Technical Support Unit

By the end of 2012 the Management, Administration and Technical Support Unit of IMDEA Energy is formed by 9 persons, whose main function is to perform and manage a variety of management activities, such as accounting, expenses, contracts, inventory, project management, and technical support, 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. 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 Pérez Rodríguez
- Ms. Eloísa 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 Institute annual activities report.

Infrastructure and Facilities Area

- Ms. Silvia Mateo, Responsible

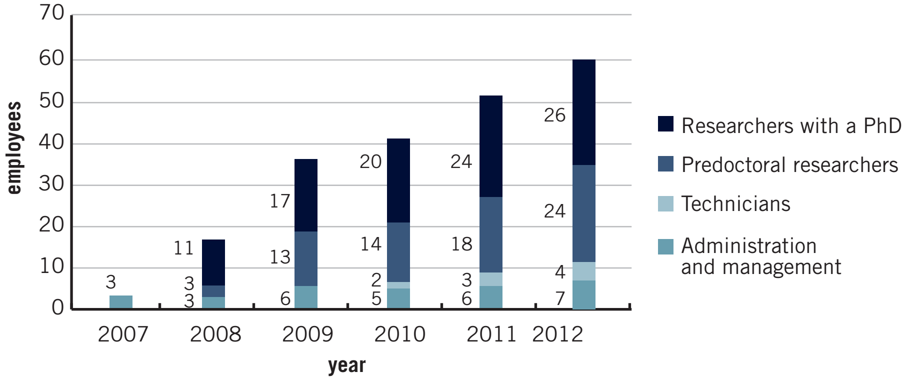
The main competences of this area are focused on building facilities management, building adaptation works to the requirements of the scientific activities, building maintenance management, scientific equipment support, building supplier's management.

Technical Support Area

- Ms. Mª Eugenia di Falco Salmerón
- Ms. Laura García Firgaira
- Dr. Fernando Picó Morón

This area is formed by the technical staff working in the IMDEA Energy laboratories, as responsible of managing and using the scientific equipment and infrastructures of general use of the Institute. Among their competences and techniques applied in 2012 there are the following: analyses of the textural properties of solids using N_2 adsorption isotherms, FTIR measurements, elemental analyses by means of ICP-OES, optical characterization by UV-Vis-NIR spectroscopy and microscopy analysis

The next figure illustrates the growth undergone along the past five years in the numbers of persons working at the IMDEA Energy Institute, showing that there has been a continuous increasing trend up to reach 61 persons at the end of 2012. In addition, about 32 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.



Evolution in the staff working at the IMDEA Energy Institute.

research lines

3

The research lines addressed at the IMDEA Energy Institute cover the research topics outlined in the Scientific Programme, being distributed within the following areas:

3.1. Concentrating solar power

The Concentrating Solar Thermal Power (CSP) systems are important candidates for providing the bulk 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% nominal 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 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 line two different areas are considered:

Second Generation Biofuels

Biofuels are renewable energy sources because they are products 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 which are not applied in the food industry, such as lignocellulosic materials, algae and agriculture wastes (second generation of biofuels). Areas for technology development in this field are:

- Development of innovative processes for the production of second generation biofuels from biomass resources different than those of common use by the food industry: production of bioethanol by hydrolysis and fermentation of lignocellulosic biomass, 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 catalytic hydrodeoxygenation and hydrodecarboxylation processes for upgrading bio-oils generated by pyrolysis. Research should concentrate on the development of very active and selective catalysts and the 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 alternatives 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 subproduct. In this respect, controlling the selectivity to the different carbon allotropes is crucial to warrant the feasibility of this process.

- Development of hydrogen production via thermochemical processes 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 photobiological, 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 in electricity networks. 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 battery and ultracapacitor systems. Sustainable electric grids involve a considerable proportion of renewable generation and the manageability of such type of grids requires an important capacity of electrical energy storage. Likewise, sustainable transport is based on electrification and larger electric accumulators are required if the range of electric vehicles has to be extended to values that make them more acceptable for a majority of drivers. 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 systems, 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 symmetric capacitors of different carbon materials as electrodes, such as carbon fibers and various activated carbon powders, and on asymmetric capacitors making use of metal oxide nanoparticles and through the modification of carbons with materials of pseudocapacitive behavior.

- Energy storage and efficient water treatment by means of electrochemical capacitors with research on electrodes with higher deionization capacity, low resistance and chemical stability; the design of compact and easy maintenance reactor prototypes for capacitive deionization; and on the definition of testing protocols for deionization and regeneration cycles.

- Low-cost flow batteries for stationary applications in solar and wind power plants with research of new highly reversible redox couples as advanced electrolytes with higher energy efficiency and lower cost.

Thermal and thermochemical energy storage

The urgent need to provide a higher degree of dispatchability to renewable energy power plants is supporting the R&D field on energy storage by means of thermochemical reversible reactions. The IMDEA Energy Institute includes within its strategic programme research activities on high-temperature chemical reactions able to provide long-term storage of solar energy. Thermochemical pipes and thermochemical storage systems are targeted through appropriate demonstrators integrated within renewable energy schemes.

Thermal energy storage systems are also a subject of research at the IMDEA Energy Institute. They comprise water adsorption materials for low temperature (80-120 ºC) seasonal storage, phase change materials and gas/solid systems customized for medium (250-400 ºC) and high temperature (400-900 ºC) solar thermal applications.

3.4. Smart management of the electricity demand

Further deployment of renewable energy sources and distributed generation in electricity networks is pending on a consensual solution for a series of complex legal, economic and technical issues. This fact only emphasises an extraordinary importance of the development of new flexible architectures and management algorithms for future power networks. High levels of integration and modularity are expected with the clear objective of improving the security of supply of critical loads, increasing 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:

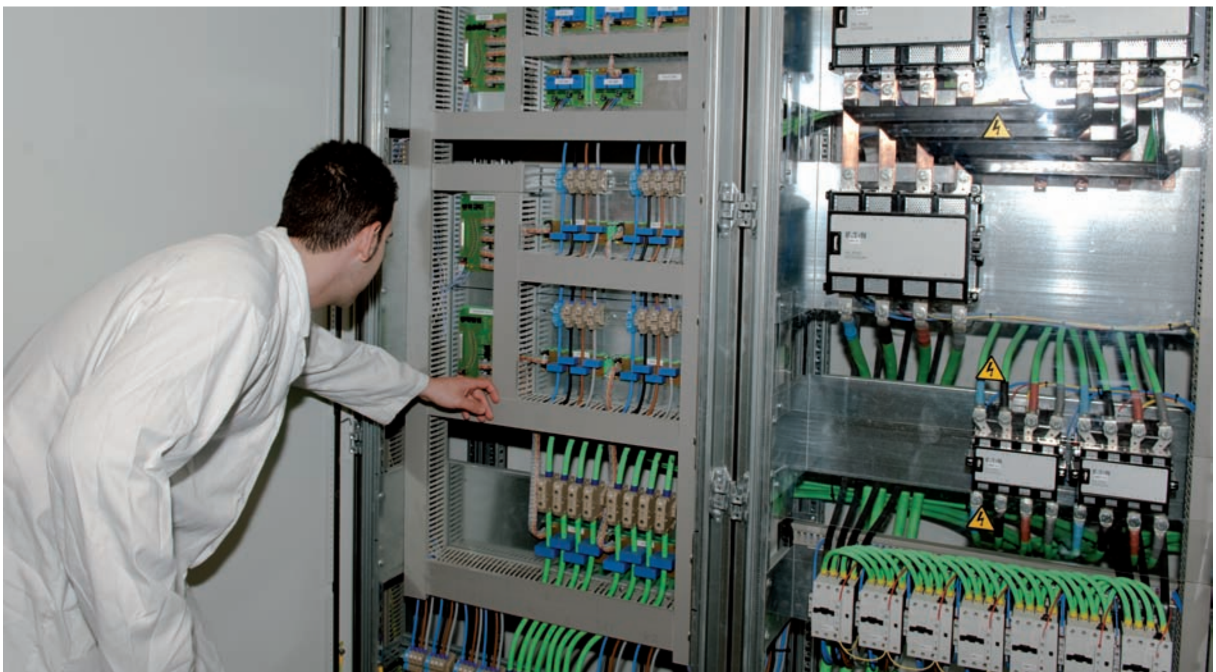
- Integration of new technologies to achieve a better management of electricity generation, transmission and consumption. Centralised and decentralised control architectures, real-time measurement and control, applications and more intensive use of energy storage systems are only some of the proposed technologies. Creation of new energy-aware services for final energy users, network operators and energy providers. Development of new power network models that include the 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 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 total energy demand. Effects of integration of on-site renewable generation for self-sufficiency, 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. 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 electric vehicles to electricity networks. As millions of new electric cars are about to be connected and charged from the grid in the next decade, more electrical energy will need to be generated and an enormous distributed storage of energy will also be at the disposal. Various scenarios on how this energy storage can be used to contribute to network control, increase capture from intermittent energy sources and provide vehicle charging will be investigated.

- Model based approach in real-time simulation of small power networks and microgrids. 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 flexibly changed to match any power network scenario and verify the control criteria set.



3.5. Energy systems with enhanced efficiency

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.

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.

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 being considered 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. Likewise, the volume of commercial applications of the transformed products is a key reference in order to determine the feasibility of the different alternatives considered.

scientists and research units

4

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 for Energy Production (BTPU).** This unit is engaged in the development of novel processes for biofuels production with primary focus on the development of 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 microorganisms 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

thermochemical

Research activities

One of the main aims of the Thermochemical Processes Unit (TCPU) is to provide technological alternatives to the current dependence of fossil fuels, particularly for the transportation sector. Obviously, this is a very ambitious task, pursued by many research groups worldwide, and it requires a multidisciplinary approach in order to identify the most reliable and sustainable resources, and the most efficient and cost effective processes considering the final application niches. Within this general framework, the activity of the TCPU is focused on the study of some of the chemical transformations which are likely to play a relevant role in the establishment of a more rational energy model.

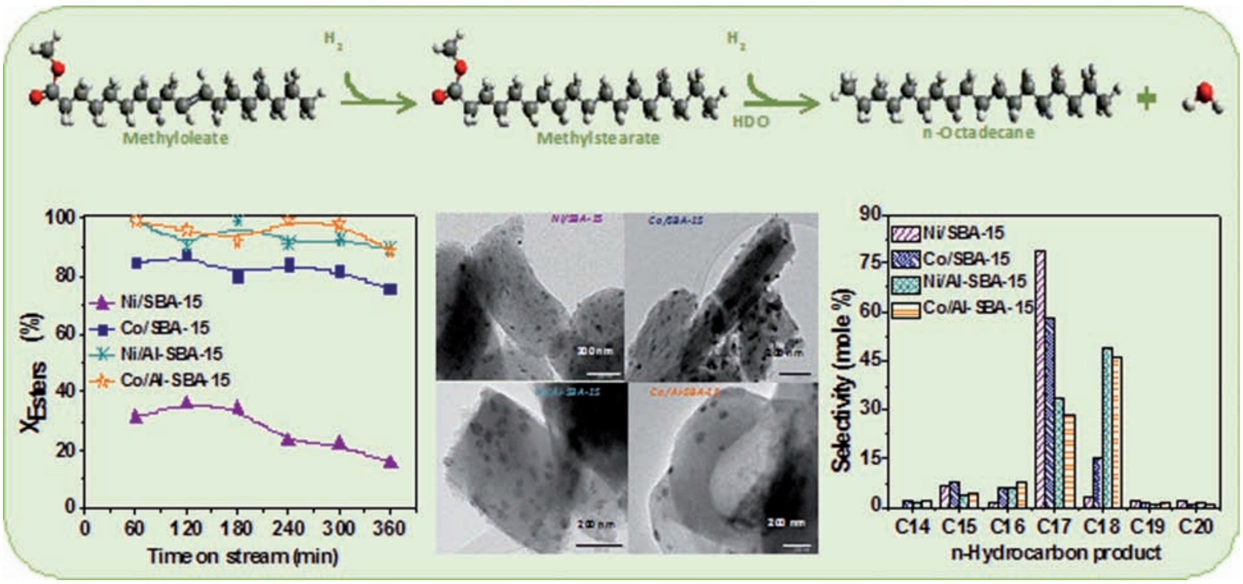
Special attention is being paid to the development of feasible routes for the generation of CO_2-free hydrogen. In this context, some of the most promising approaches are water splitting either by means of thermochemical cycles coupled to solar concentrating power or by photocatalytic processes under softer conditions. Methane decomposition is also an interesting alternative for hydrogen production, which simultaneously can yield different carbon materials with attractive electronic properties. Furthermore, if biogas is used as raw material, the sustainability of the decarbonisation process in terms of the reduction of CO_2 emissions is highly favourable.

The possible utilization of residues as feedstock for fuel production, as well as the development of second-generation biofuels, are also strategic research lines of the TCPU. In this way, the hydrotreating of bio-oils obtained either from flash pyrolysis of agro-forestry wastes or triglycerides extracted from specific energetic crops such as microalgae, is one of the approaches currently explored for upgrading biofuels in order to improve its compatibility with conventional ones. This research line relies on the design of multi-functional heterogeneous catalysts with enhanced selectivity and stability.

Finally, mimicking plant photosynthesis to fix atmospheric CO_2 and transform it into useful chemicals is a long term challenge which is been approached by photocatalytic processes using semiconductors. Although the efficiency of this technology is still far from that required for commercial development, it holds a remarkable potential for storing solar energy as useful chemicals like light hydrocarbons (mainly methane) or methanol. Besides, this process could contribute to reduce significantly CO_2 emissions.

Another area of activity of this Unit is focused on the development of materials with enhanced heat storage capacity in connection with thermosolar power production. For domestic low temperature applications water adsorbents are being monitoring, whereas for high temperature applications redox reactions of transition metal oxides such as Mn_2O_3/Mn_3O_4 are being investigated.

As most of the above mentioned processes imply the use of catalysts, it is not surprising that TCPU posseses a notable expertise in heterogeneous catalysis. In this way, it is worth emphasising the capacity of this research unit to synthesise mesostructured and microporous solids among other materials with tunable activity in a wide variety of energy-related processes.



Hydrocarbons production through hydrotreating of methyl esters over catalysts based on Ni and Co supported on SBA-15 and Al-SBA-15. Activity, product distribution and TEM images

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 (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 (2006). He was appointed as Professor at Complutense University of Madrid (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 (1999-2001), Vice-rector for Research and Technological Innovation (2001-2002) and Head of the Chemical and Environmental Technology Department (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 40 research projects funded by both public and industrial partners. He is author of about 130 publications in scientific journals, 5 patents and of 4 books. Besides he has presented more than 150 communications in scientific conferences. At present, his h index is 30. He has supervised 14 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

He received his Ph.D. in Chemistry from 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 "Ramón 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 on the development of new materials for the thermochemical storage. He has published more than 75 research papers, he has presented more than 70 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

He obtained his PhD in 2003 at 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 "Ramón 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 42 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

She received her Ph.D in Chemical Engineering in 2006 with extraordinary Award from 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 20 scientific articles and presented over 40 communications to conferences and she has participated in 22 research projects. In addition, she has supervised 21 Research Final Projects at Rey Juan Carlos University.

Dr. Prabhas Jana
Postdoctoral Researcher

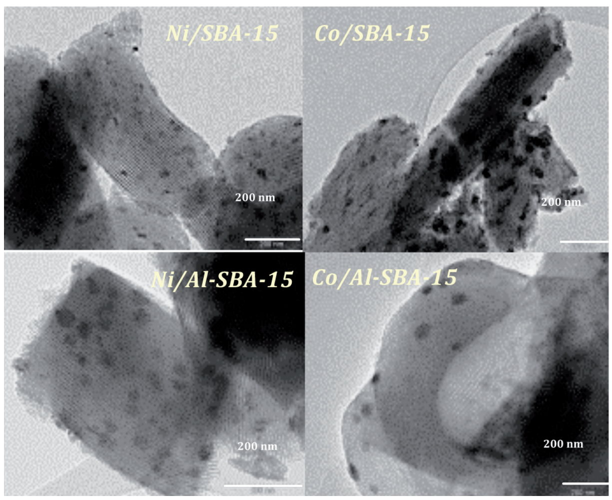
He moved to IMDEA Energy after finishing his Ph.D in the National Chemical Laboratory (NCL), Pune (India). He has a considerable expertise on the preparation of catalysts including those based on supported gold nanoparticles. He is author of 28 articles in several international journals and he holds 4 U.S. patents.

Dr. Yongxing Yang
Postdoctoral Researcher

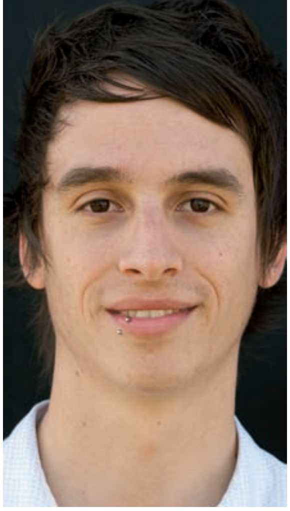
He received his Ph.D. at Dalian Institute (China) and he has been a postdoctoral fellow at Laval University (Canada). His research activity has been focussed on the development of hydrotreating catalysts. He is author of 15 articles in international journals and 1 patent.

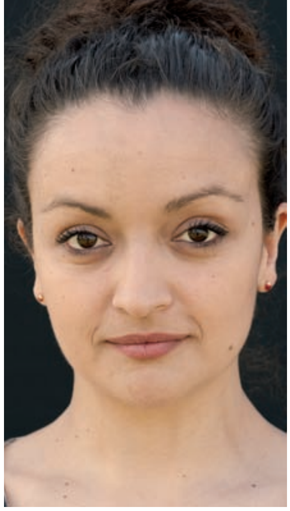
Dr. Javier Fermoso
Postdoctoral Researcher

He received his Ph.D. in chemical engineering by the University of Oviedo in 2009. Currently, he works on the CO_2 valorisation by photocatalytic processes. He has been involved in several national and European research projects and he is co-author of 20 research articles included in SCI journals, as well as he has presented more than 25 communications in national and international conferences.



Transmission electron micrographs of catalysts based on Ni and Co supported on SBA-15 and Al-SBA-15.





Julio Núñez
Predoctoral Researcher

Graduated in Environmental Sciences by Rey Juan Carlos University and Master in Energy Technology and Resources. He is predoctoral researcher working on CO_2 valorization.

Cristina Ochoa
Predoctoral Researcher

Graduated in Technical Industrial Engineering and in Chemical Engineering by Rey Juan Carlos University. Master in Engineering of Chemical and Environmental Processes. Predoctoral researcher working on biofuel upgrading.

Alicia Bayón
Predoctoral Researcher

Graduated in Technical Industrial Engineering by Rey Juan Carlos University. Master in Energy Technology and Resources. Master in Engineering of Chemical and Environmental Processes. Predoctoral researcher working on hydrogen production by thermochemical cycles.

Laura Collado
Predoctoral Researcher

Graduated in Environmental Sciences by Alcalá de Henares University. Master in Energy Technology and Resources by Rey Juan Carlos University. Predoctoral researcher working on CO_2 valorization.

Alfonso J. Carrillo
Predoctoral Researcher

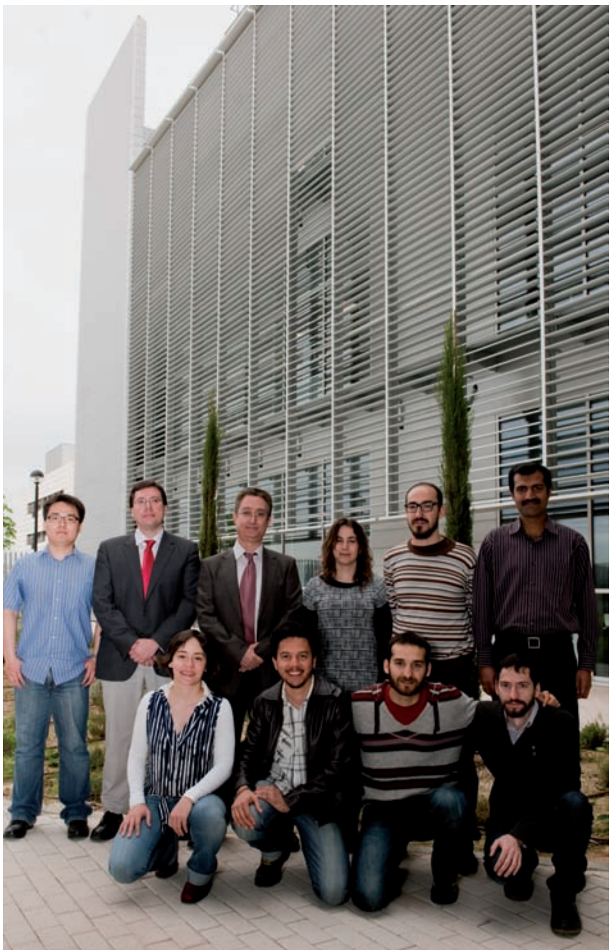
Graduated in Chemical Engineering by the University of Salamanca in 2009. Master in Renewable Energies by the University of Leon. Predoctoral researcher working on materials for thermochemical storage.


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 Systems (CSP) and production of Solar Fuels and Chemicals (SFC). The impressive commercial deployment of CSP systems in Spain and elsewhere, still based on first generation technologies, is accelerating the development of new solar concentrators, absorbers, high-temperature materials, heat storage and demanding the technical support from new laboratories and research institutions like the IMDEA Energy Institute.

The development of modular solar central receiver schemes for high and ultra-high temperature applications is one of the key topics of research of HTPU. Sizing and optical analysis of that systems imply the improvement of ray tracing techniques. In particular optical-energetical analysis of 100-1500 kW mini-tower solar fields with heliostats are being carried out. The analysis includes urban integration of such modular systems and the objective of reaching high solar fluxes above 1 MW/m^2, in spite of the small size of the solar field, as well as parametric and topological studies for the elaboration of multi-tower solar fields. High flux/high temperature demand of such systems built up with off-axis optics and multi-tower configurations are being simulated in detail. Development of dynamic simulation tools for solar thermal power plants and application to the analysis of new receiver designs, heat storage systems and thermodynamic cycles are within the activities of HTPU.

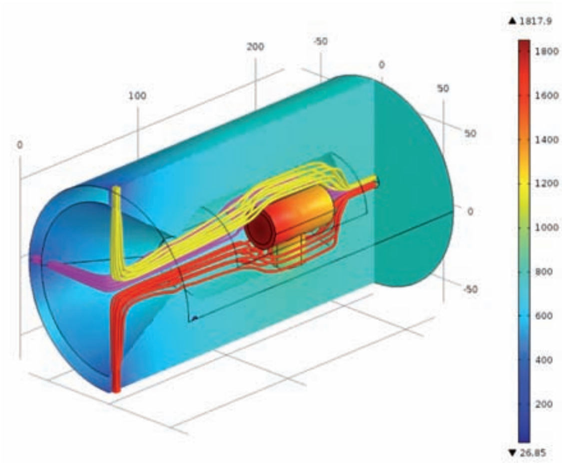


High temperature solar receivers making use of volumetric porous absorbers or directly illuminated particle receivers are two of the key topics of research of HTPU. Volumetric receivers are specifically conceived to optimize the heat exchange with air as thermal fluid, being the illuminated absorber a matrix or porous medium (metallic wire mesh or ceramic monolith), through which the refrigerating gas flows. In the case of volumetric receivers the efforts in R+D are currently focused on the durability of the absorber materials, the improvement of the penetration and effect of the photon capture in the porous matrix and the improvement of efficiencies by reducing the thermal losses at high temperatures, together with the system of air return. 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.

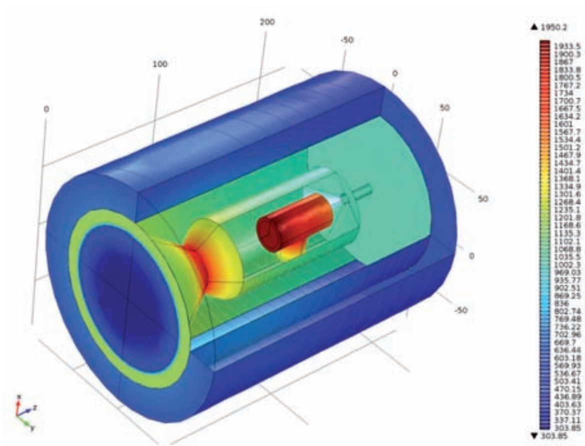
Thermal energy storage (TES) systems based on phase change materials (PCM) can be smaller, more efficient and a lower cost alternative to sensible thermal storage systems for application to CSP. However, most PCMs have low thermal conductivity which leads to slow charging and discharging rates. Several methods employed by researchers to enhance the heat transfer in PCMs include, using extended surfaces, thermal conductivity enhancement using metallic structures, PCM impregnated foams, dispersion of highly conductive particles and encapsulation of PCM. IMDEA Energy carries out textural and thermal characterization of PCMs and develops modelling tools both for individual pellets and storage systems. Storage by means of chemical reactions has also been considered by many researchers for a wide range of temperatures using reversible endothermic/exothermic reactions. TES based on thermochemical cycles is an interesting option as reversible chemical reactions can provide high energy storage density at low cost. Drawbacks may include complexity, cyclability, uncertainties in the thermodynamic properties of the reaction components and of the reaction kinetics under a wide range of operating conditions, high cost, toxicity, and flammability. IMDEA Energy is conducting research on oxide based systems as potential TES candidates for solar thermal power plants.

Characterization techniques, measurement of temperatures inside receiver cavities and high-flux measurement are relevant topics of research, still needing substantial improvement. HTPU is developing a world-class characterization laboratory with thermal imaging systems, CCD cameras, pyrometers, calorimeters, pyranometers, radiometers and spectroradiometers. A 7-kW solar simulator, with motorized test bed, for testing components and receivers/reactors at high temperature/high flux solar systems has been implemented and a new 42-kW solar simulator is planned for inauguration in 2013.

Solar Fuels and Chemicals are a medium to long-term application of CSP systems with an enormous potential. The developments being carried out by HTPU on high temperature receivers and systems can be adapted for application on solar-driven production of hydrogen via thermochemical cycles and are performed in cooperation with the Thermochemical Processes Unit (TCPU). The motivation behind the R&D on solar-driven thermochemical cycles stems from the capability of solar towers to reach temperatures up to 2000ºC and energy fluxes up to 5000 kW/m^2. The MO_{ox}/MO_{red} systems currently studied are based on CeO_2/Ce_2O_3, Mn_2O_3/MnO and $M_xFe_{3-x}O_4$ ferrites, being M a generic metal. One of the key aspects to solve is the optimization of the integration of the chemical process into the solar system. Optical losses at the heliostat field and thermal losses at the solar reactor may lead to an unacceptable decrease of global efficiency. In particular HTPU is dealing with the design, construction and testing of a solar reactor at laboratory scale for the endothermal reduction step of the Mn_2O_3/MnO cycle for the production of hydrogen, as well as with the scaling up to a solar demonstrator.



Temperature distribution of the flow stream lines inside a solar thermochemical cavity reactor for 1.3kW radiation power and 9 liter/minute of argon gas flow rate



Temperature distribution along aperture, cavity wall and testing sample in a solar thermochemical reactor for 1.3kW radiation power and 9 liter/minute of argon gas flow rate

scientists

Dr. Manuel Romero

Research Professor,
Head of the Unit

He received his PhD in Chemical Engineering in 1990 by the University of Valladolid. At present 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 Science & Technology affairs of ISES and member of its Board. 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 Almería and Director of the Renewable Energy Division of CIEMAT since June 2004 till August 2008. He is Associate Editor of the ASME Journal of Solar Energy Engineering since January 2007 and at the International Journal of Energy Research (IJER) published by Wiley & Sons since December 2009. He was Associate Editor of the International Journal of Solar Energy since January 2002 till January 2007. Editor of 6 books related to solar concentrating technologies. He is author of 3 chapters in handbooks of solar energy, 32 papers in scientific journals with SCI and 80 publications in books of proceedings with ISBN. He is co-author of four international patents.

Dr. José González

Senior Researcher

He received his Ph.D. in Physics by the University of Cantabria (Spain) in 1999 and his Habilitation à Diriger des Recherches from the University Paul Sabatier, Toulouse (France) in 2007. Between 2000 and May 2009 he worked as R&D engineer – Project manager at the Center for Energy and Processes – MINES ParisTech. In September 2006 he became Associate Professor at MINES ParisTech (or Ecole Nationale Supérieure des Mines de Paris). Currently, his research interests concern concentrating solar energy systems and technologies. José González has participated in 23 national and international research projects and published 32 papers in peer review journals. He has two international patents and a French patent and he is author of more than 65 communications in national and international conferences.

Dr. Carlos Pérez

Visiting Researcher

He received his Ph.D. in Engineering by National Autonoma University of Mexico (Universidad Nacional Autónoma de México, UNAM). He graduated with distinction in 2007. The same year, he joined the group of Solar Concentration, at the Centre for Energy Research, UNAM, Mexico. There, he developed solar concentration optical systems, studied transportation phenomena in solar systems and implementation of control systems. He has collaborated in five Mexican research projects, published 6 papers, two Mexican patents and he is author of more than 20 communications in national and international conferences.




Dr. Selvan Bellan
Postdoctoral Researcher

He received his Ph.D in Physics from VIT University (India) in 2010. He was awarded with 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 (2007-2009). After finishing his Ph.D work, he joined as Scientific Officer in the Center for Research in Thermal Management, Karunya University, India (2009-2010), and later he worked as Research Scientist in the Development Department, Plasma Giken Co., Ltd, Tokyo, Japan (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 8 papers in peer reviewed international journals and 12 papers in international and national conferences.

Aurelio J. González
Predoctoral Researcher

Graduated in Mechanical Engineering by the Polytechnic University of Valencia. Master on Renewable Energy, Hydrogen and Fuel Cells by CSIC-UIMP. Predoctoral researcher working on concentrating optics design and ray tracing techniques.

Elisa Alonso
Predoctoral Researcher

Graduated in Chemical Engineering by the University of Salamanca. Master in Energy Technology and Resources by Rey Juan Carlos University. Predoctoral researcher working on solar receivers and reactors.

Javier Sanz
Predoctoral Researcher

Graduated in Mechanical Engineering by the University Carlos III of Madrid. Master in Engineering of Chemical and Environmental Processes. Predoctoral researcher working on integration of advanced solar thermal power systems.

Fabrisio L. Gómez
Predoctoral Researcher

Graduated in Mechanical and Electrical Engineering by Universidad Iberoamericana (UIA). Master in Energy Engineering by UNAM, Mexico. Predoctoral researcher working on measurement and characterization of high flux/high temperature solar systems.

Sandra Álvarez
Predoctoral Researcher

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

Alessandro Gallo
Predoctoral Researcher

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

4.3. Electrochemical Processes Unit

electrochemical

Research activities

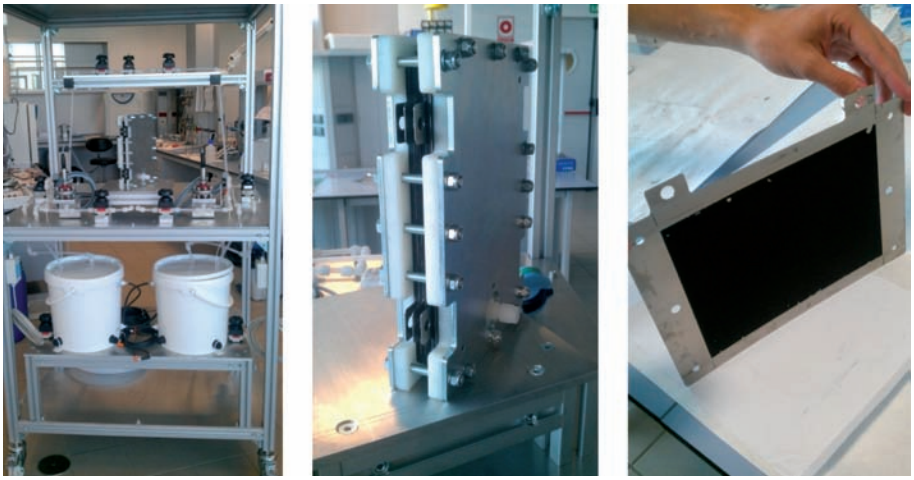
One of the main targets of the Electrochemical Processes Unit (ECPU) is to provide new concepts and technological alternatives for electrochemical energy storage. The energy storage systems developed by the ECPU are aimed to be applied both to renewable energies and to the electrification of transport.

Energy storage is becoming a critical issue in electric grids in which a large contribution of renewable sources is creating a mismatch between generation and demand. In this way, bulk storage technologies enable utilities and system operators to harvest the full potential of intermittent renewable power by storing wind and solar energy produced during off-peak periods. Large-scale storage technologies connected at the transmission level offer ancillary services such as following load, providing ramping duty, or stabilizing voltage and frequency. Finally, smaller-scale distributed energy storage technologies can enhance service to end-users by providing ride-through protection against outages; such systems can also improve power quality by protecting against harmonic distortions, voltage sags, and surges. Depending on the specific application different technologies can be applied. Specifically, the ECPU works on large storage capacity systems by using flow batteries, and in high power and rapid response systems based on electrochemical capacitors.

In the ECPU we believe that electrification of both the mobility and transport system is one possible answer to the challenge created by a combination of factors as for instance, the limitation of fossil energy resources, the impact on the climate change of CO_2 emissions from internal combustion engines, a growing demand for mobility and energy in emerging regions, and the continuous increase of population concentrated in urban areas that lead to higher requirements of transportation of goods and persons. Consequently, new concepts and new technologies need to be developed to realize efficient electric vehicles suited for mobility in urban areas.

Regarding cruising range, affordability and space provided in the vehicle, today's electric vehicles fulfil customer requirements only to a limited extent. From a customer point of view, the main difference between an internal combustion engine and an electric vehicle (EV) is the significantly lower autonomy of EV and the longer recharging time. Nowadays, the major technological limitation to bridge these gaps relays in the battery. Advanced batteries with higher energy densities are necessary for extending the range of EV as well as to shorten the recharge time. Technologies such as Li-ion batteries are currently under development, but in the ECPU we want to go further working on newer technologies of much higher energy densities such as metal-air batteries.

Other requirement of full electric and hybrid electric vehicles is an efficient regenerative braking system in which the energy must be rapidly recovered and stored. Furthermore, power peaks for acceleration and for steep slopes require additional power supply to the motor drive that can be reached by over dimensioning of the battery or by implementing technologies complementary to batteries such as capacitors. This last is the approach selected at the ECPU, which is now working on hybrid capacitors with higher energy densities.



Electrochemical reactor prototyping and testing. Left: bench test unit, Centre: reactor prototype; Right: 300 cm² electrode.

Electrochemical Processes Laboratory

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 PhD in Environmental Engineering from Johns Hopkins University. He has been Visiting Researcher in the Catholic University of Louvain (Belgium, 1981), the Institute of Ceramics and Glass of CSIC (Spain, 1989), and CIEMAT (Spain, 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 organisations and private companies. He is author of more than 155 publications in scientific journals, more than 25 patents and of 1 book. His historical Hirsch Scientific Index is 48. Besides, he has presented numerous communications in scientific conferences, many of them as keynote speaker.

Dr. Jesús Palma

Senior Researcher

Formerly he was Director of the R&D Centre of Tecnicas Reunidas. He received his PhD in Chemistry from Autonoma University of Madrid. He has been Visiting Researcher at the Imperial College (UK), 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 Richerce (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 as researcher or as work package leader.

Dr. Raul Díaz

Senior Assistant Researcher

He is a “Ramon y Cajal” researcher of the ECPU. He received his PhD in Chemistry from the University of Barcelona in 2002. He has experience in the fields of electrochemistry and materials science, including postdoctoral stages in the Department of Chemistry of the University of California Berkeley and in the Materials Science Division of the Lawrence Berkeley National Laboratory. He is author of around 30 publications in journals and holds 1 international patent. He has participated in more than 30 scientific conferences, and 15 research projects. He recently received one of the “2010 R&D 100 Awards” for technological innovation.

Dr. Rebeca Marcilla
Senior Assistant Researcher

Ph.D. in Chemistry by the University of the Basque Country in 2006. After her Ph.D., 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 IL-based electrolytes. She is co-author of more than 30 scientific papers in international journals and 2 patents.

Dr. Chandrasekaran Ramasamy
Senior Assistant Resercher

Ph.D. degree at Physics center from Anna University. Postdoctoral researcher at Alagappa University (Karaikudi, India), Aichi Institute of Technology (Nagoya, Japan), Tsukuba, (AIST west, Japan), Kansai University (Osaka, Japan) and Central electrochemical research institute, CSIR-CECRI (Karaikudi, India). His main research activities are electrochemical and physical characterizations of electrode and electrolyte materials. He has about 20 research articles in his credits. He has received 7 patents and contributed to 6 scientific meetings at national and international level.

Dr. Enrique García-Quismondo
Postdoctoral Researcher

PhD degree in Chemsitry by 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.

Susana Vaquero
Predoctoral Researcher

Graduated in Chemistry by Complutense University of Madrid. Master in Energies and Fuels for the Future by Autonoma University of Madrid. Predoctoral researcher working on the designing and testing of electrochemical capacitors based on carbons.

Suheda Isikli
Predoctoral Researcher

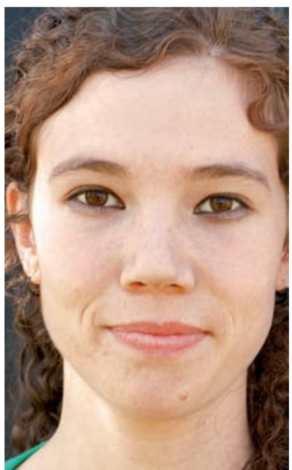
Graduated in Chemistry by the Middle East Technical University of Ankara (Turkey). Master in Energies and Fuels for the Future by Autonoma University of Madrid. Predoctoral researcher working on the electrochemistry and energy applications of organic compounds.

Laura Sanz
Predoctoral Researcher

Graduated in Chemical Engineering by Rey Juan Carlos University. Master in Electrochemistry: science and technology by Autonoma University of Madrid. Predoctoral researcher working on redox flow batteries.

Teresa González de Chávez
Predoctoral Researcher

Graduated in Chemistry by Autonoma University of Madrid. Master in Chemical Science and Technology by UNED. Predoctoral researcher working on synthesis and characterization of pseudocapacitve materials.



4.4. Unit of Biotechnological Processes for the Production of Energy (Joint Unit CIEMAT / IMDEA Energy)

biotechnological

Research activities

This unit is engaged in the development of novel processes for biofuels productions. Since 2011, the Unit has been focused on the development of 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 processes by focusing on the most challenging steps such as both enzyme and fermenting microorganisms development and biofuels production from microalgae.

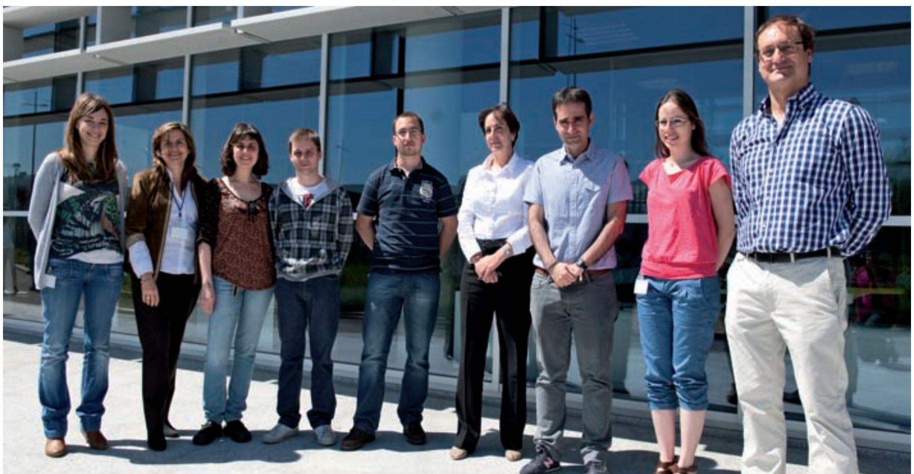
The Joint Research Unit was created on March 2011 with researchers from IMDEA Energy Institute and from CIEMAT (Public Research Agency for excellence in energy and environment belonging to the Spanish Ministry of Economy and Competitiveness). The joint research group is an integrated team of scientists who are specialist in different areas of producing energy by means of biotechnological processes.

In 2012, the acquisition of lab equipment was finished and three new predoctoral students joined the Unit. The laboratory become operative in July and, right after, the experimental research started.

BTPU research activity has been focused on:

- Increasing ethanol production by using oxidoreductases enzymes for the elimination of phenolic compounds from pretreated biomass slurries.
- Determination of both storage and structural carbohydrates in microalgae.
- Microalgae cell wall disruption pretreatments to enhance biofuel production (bioethanol and biogas).

In addition, the main activities in 2012 have been the recruitment of scientific personnel to reinforce IMDEA Energy research team and the acquisition of the basic technical equipment to equip the new laboratory.



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. 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 50 papers in SCI journals and 5 chapters in technical handbooks. She is co-author of 3 patents and external consultant for ECLAC of United Nations and the Spanish Agency for International Cooperation (AECID).

Dr. Cristina González

Senior Assistant Researcher

Ph.D. in Chemical Engineering and Environmental Technology by the University of Valladolid (2008). After her Ph.D., 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 around 22 scientific publications. Additionally, she has been involved in European and national funded research projects, as well as in projects with private companies.

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 35 peer-reviewed papers and book chapters and co-inventor of 2 patents. She has supervised 1 Ph.D. Thesis and 2 Master theses. She has participated as external evaluator of research projects (FONDECYT-Chile, NWO-Netherlands).

Dr. Ignacio Ballesteros

Associated Senior Researcher

He is a Senior Researcher at CIEMAT. He obtained his PhD degree in Biology at the University of Alcalá de Henares (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 35 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. Marie Demuez

Postdoctoral Researcher

Ph.D. in Biochemistry at the INSA of Toulouse (2007). She had a position in UC Davis / UC Berkeley and then a postdoctoral contract at IMDEA Energy Institute to work on biological production of hydrogen by nitrogenase. She is co-author of 5 scientific publications, and has been involved in European and national funded research projects.. She has participated in 8 national and international research projects.

Antonio D. Moreno

Predoctoral Researcher

Graduated in Biochemistry by the University of Extremadura. Diploma of Advanced Studies in Biochemistry and Molecular Biology. Predoctoral researcher working on the development of biological systems for detecting interactions of oxygen sensitive proteins.

Alfredo Oliva
Predoctoral Researcher

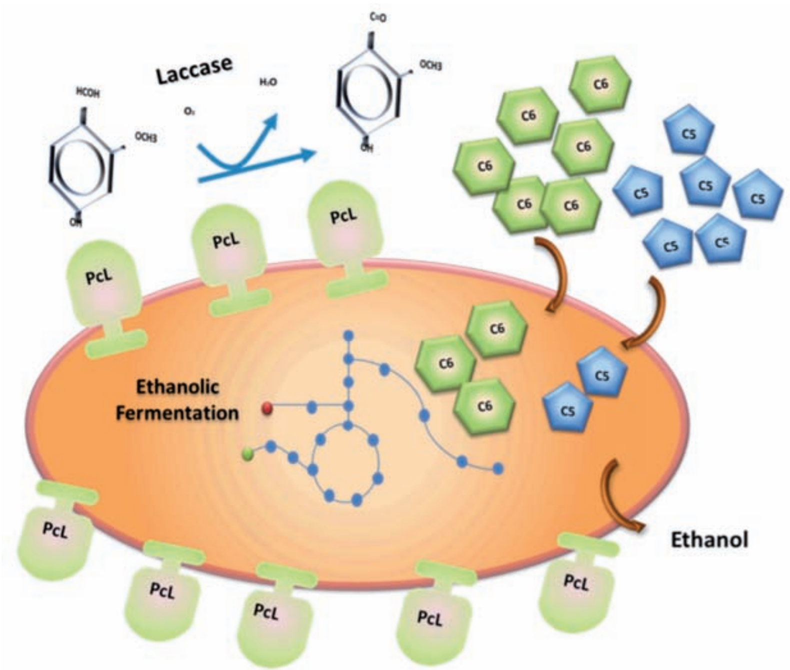
Graduated in Biology by the University of Alcala (Spain). Master in Genetic and Cellular Biology. Predoctoral researcher working in the improvement of lignocellulosic ethanol production by displaying laccases on fermentative yeast.

Ahmed Mahdy
Predoctoral Researcher

Graduated in Genetic Engineering by the University of Zagazig (Egypt). Master in Microbiology. Predoctoral researcher working on microalgae accumulation of carbohydrates and subsequent conversion to bioethanol.

Lara Mendez
Predoctoral Researcher

Graduated in Biology by Complutense University (Spain). Master in Clinical Analysis. Predoctoral researcher working on pretreatments for cell wall disruption of microalgae and cyanobacteria.



Laccases surface display on fermentative yeast Kluyveromyces marxianus *employing genetic engineering*

4.5. Electrical Systems Unit

electrical

Research activities

The main objective of the Electrical Systems Unit (ELSU) is to participate in the process of transformation of future power networks by proposing and developing new, more efficient management algorithms and by fully taking advantage of system real-time monitoring and control resources. There is now a widely adopted consensus that the conventional methods of control used for energy generation, transmission and distribution cannot provide the required level of system reliability and robustness.

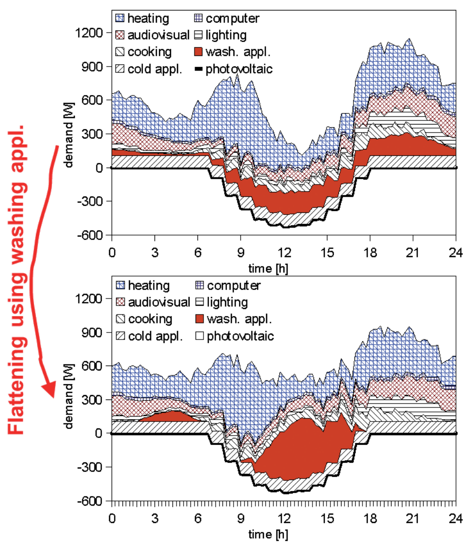
Most of the unit research activities are related with development of more flexible network management schemes that has already seen many competing ideas for decentralised, islanded and microgrid. By harnessing the potential of communication networks to provide reliable, real-time monitoring of the network generation and demand, new and unprecedented management techniques need be deployed to increase the network efficiency and enable further integration of renewables. “Smartgrids” is a common term used to describe such a complex set of changes required at all levels of power networks and this research unit is engaged in development of intelligent algorithms for control of future power networks and participation in future real-time energy markets.

“Smart buildings” and “Smart Homes”, as well as their management and integration to power networks, is one of the important and challenging tasks of this unit. Starting from an integrated approach in looking into energy demand of a building, the optimal demand management techniques can be proposed and developed. Meanwhile, renewable integration and storage device utilisation should be explored to offset total energy consumption or provide total energy self-sufficiency.

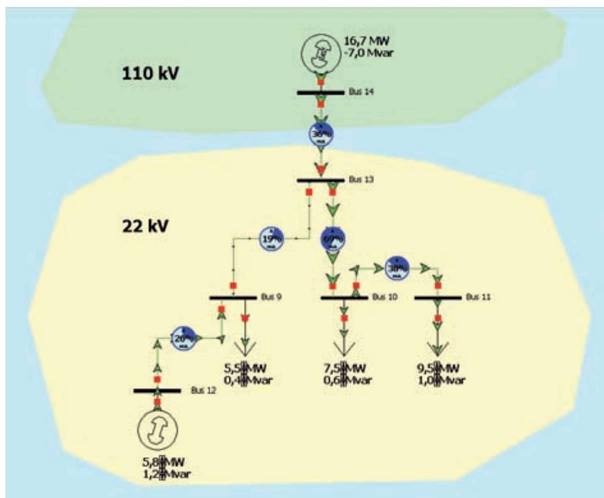
Improving energy efficiency in industrial applications is one of the principal activities of the research unit. By detail modelling of the consumption profiles and patterns along the nominal modes of operation, the potential for energy saving is investigated. The main technologies providing the energy efficiency improvement and energy management are information systems, power electronics converters and energy storage devices.

Energy storage devices will be more extensively used in future power networks to improve the network inertia and robustness and to provide more efficient capture of energy from intermittent renewable sources. Many advances in this field have also become feasible by the development of more efficient power conversion devices. The Electrical Processes Unit is developing novel methods for management of energy storage devices not only in support of active demand side and thermal constraint management, but also to actively control the network voltage and its reactive power flows.

It was for the advances in the electrochemical storage and power electronics devices that contributed to the creation of commercial electric vehicles. Now, it is expected that the following decades will see the number of electric cars dramatically increased that, as an effect, will have a significant impact on power networks and their capacity. The research activities in this respect include electric vehicle integration to power networks and optimisation the energy consumption patterns.



Management of residential energy demand in presence of PV generation



Estimation of a distribution network with renewable generation

scientists

Dr. Milan Prodanovic

Senior Researcher,
Head of the Unit

He received his 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. Milan was 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. Milan 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 efficient industrial applications.

Dr. Jörn Klaas Gruber

Postdoctoral Researcher

He obtained his first degree at University of Stuttgart in 2002, his MSc degree from Polytechnic University of Valencia in 2004 and his PhD 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 several international journal and conference papers and holds 2 international patents.

Tokhir Gafurov

Predoctoral Researcher

MSc Degree in Electric Power Systems from Tashkent State Technical University in Uzbekistan and MSc Degree in Mechanical Engineering from Royal Institute of Technology (KTH) in Sweden. Predoctoral researcher working in energy efficiency in industrial applications, renewable integration and future energy markets.

Belén Téllez Molina

Predoctoral Researcher

Engineering Degree in Electronics and Telematics from University of Málaga, Spain. Predoctoral researcher working in the development of intelligent algorithms for management of future power networks.

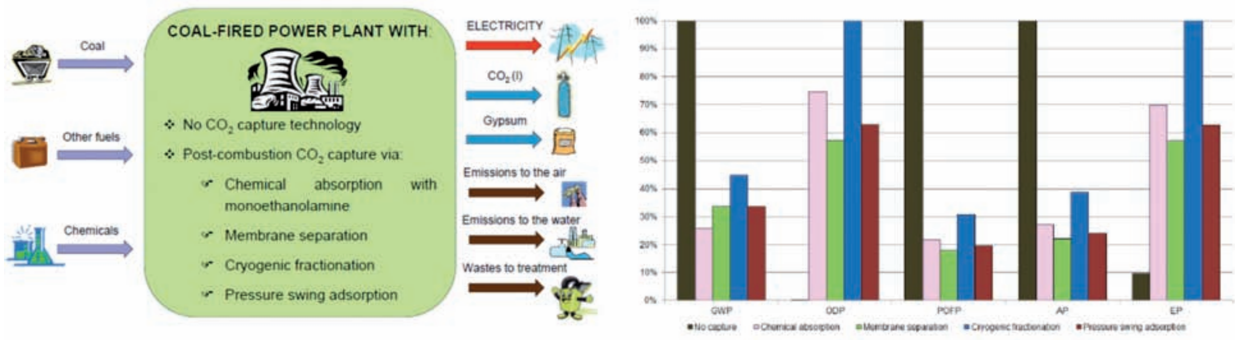
4.6. System Analysis Unit

Research activities

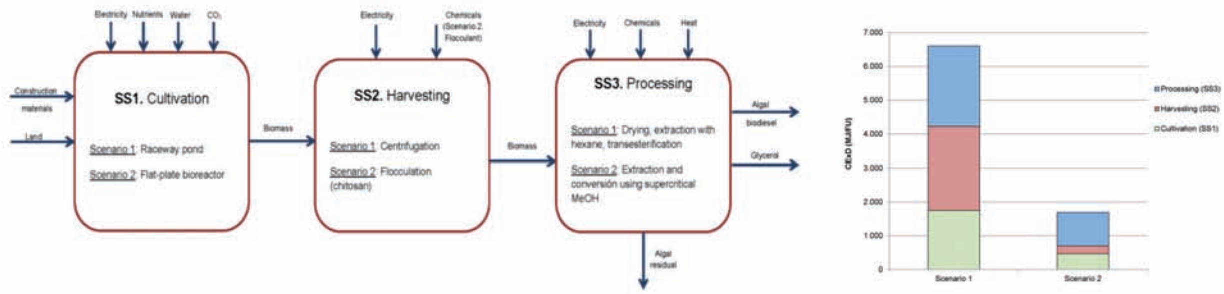
The study of second generation biofuels and clean fuels has been the main research activity of the SAU along 2012. A simulation model for the pyrolysis of different types of biomass has been developed. It allows predicting the yields and compositions obtained for different operation conditions (fast and slow pyrolysis). It has been checked with several references showing errors lower than 5%. The model incorporates more than 150 reactions and the products are simulated with more than 30 compounds. Also in this research line, a prospective study has been developed about the processes for obtaining lignocellulosic ethanol and the synthesis of high-density biofuels through platform molecules obtained from depolymerized lignocellulosic sugars. Their main economic parameters were estimated. Also to obtain bioethanol, a process for its manufacture from microalgae has been laid-out and the determination of its bottlenecks and main environmental aspects were initiated. This alternative process to obtain alcohols from biomass shows interesting advantages such as its independence from large land demands. Finally, the gasification of biomass to obtain hydrogen has been also continued. A simulation model has been developed, including Fischer-Tropsch processing of syngas to produce clean biofuels. Different typical Spanish waste raw materials were studied through life cycle assessment, demonstrating that those coming from forestry show better environmental performances. As well, an exploratory study for obtaining hydrogen by decomposition of vegetable or microalgae oils was carried out, determining those leading to positive energy and negative CO_2 balances.

The second research line started out on last year about capture and valorization of CO_2 has been also continued. The capture study was completed, including absorption, PSA, membrane and cryogenic separations as postcombustion treatments, oxycombustion, and steam reforming of natural gas and coal gasification (as precombustion processes). Currently, the CO_2 storage is under study through life cycle assessment. As well, the analysis of valorization processes was initiated on the last months in collaboration with the Thermochemical Processes Unit.

The hybridization of photovoltaics with biomass to generate hydrogen by high-temperature electrolysis was also investigated in collaboration with the High-Temperature Processes Unit.



LCA comparison of postcombustion CO_2 capture techniques



Cumulative exergy demand for conventional and advanced processing of microalgae

scientists

Dr. Javier Dufour
Senior Researcher,
Head of the Unit

B.Sc. (1990) and Ph.D. (1995) in Chemical Sciences, with emphasis on Industrial Chemistry, by 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 2003, where he is currently Associate Professor. Currently, he is Coordinator of the Ph.D. Programme on Chemical and Environmental Engineering at the Rey Juan Carlos University and Chairman of the Resources Commission of ESCET. His main research lines are energy systems analysis, life cycle assessment and management of processes and products, simulation and optimization of processes, and economical estimations. He is author of 50 papers published in international journals, more than 90 contributions to conferences and 3 patents. He has collaborated in 32 research projects, being the responsible researcher in 14 of them. Currently, he is the Coordinator of the Spanish Network of LCA.

Dr. Diego Iribarren
Postdoctoral Researcher

PhD in Chemical and Environmental Engineering (2010) at the 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 19 research articles.

Dr. Fontina Petrakopoulou
Postdoctoral Researcher

PhD in Energy Engineering from the Technical University of Berlin (Germany) in 2010. Her work focuses on the simulation, evaluation and improvement of energy conversion systems using cost- and environmentally-related exergy-based methods. She is an author of 2 book chapters and 15 papers. She has participated in 27 international conferences and workshops.

Dr. Abel Sanz
Postdoctoral Researcher

PhD in Chemical Engineering (2012) by Complutense University of Madrid. His investigation in Institute IMDEA Energy is focused in the simulation, design and optimization of processes in the energy field.

Jens Peters
Predoctoral Researcher

Dipl. Ing. in Electronic Engineering (Information Technologies) from TU Munich, Germany (2003) and MSc in Renewable Energies, Fuel Cells and Hydrogen from Universidad Internacional Menéndez Pelayo and CSIC (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 in research on biomass gasification.

facilities and scientific infrastructures

5

annual report 2012

5.1. Building and general infrastructures

The building and laboratories of IMDEA Energy Institute are located at the Technological Park of Móstoles on a land with 10,000 m^2. The ownership of the land was ceded in 2008 by the Municipality of Móstoles. Design and construction of the building was conceived in two consecutive phases.

The first phase of the construction was commissioned by July 2011, with 3,139 m^2 of surface built above ground level and 583 m^2 underground. Phase 1 includes spaces for up to a maximum of 60 persons and 6 research groups as well as an auditorium, a parking lot, and provisional areas for the administration and management. During January 2012 the transfer of personnel and equipment of IMDEA Energy Institute to the Phase 1 of the building took place. The end of construction works and commissioning of Phase 2 was completed at the beginning of 2012, with 3,180 m^2 of surface built above ground level and 1,000 m^2 underground. It includes the central hub, with general services, working areas for two research groups and definitive premises for administration and management. Likewise, Phase 2 is provided at the rear part of the building with an area for pilot plants.

The 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 for the building. Likewise, it is foreseen to obtain the Gold LEED certificate, indicative of a minimum environmental impact of the building and the construction process and with a high international recognition.

Lateral view of the IMDEA Energy Institute building.

The IMDEA Energy Institute 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 the European Regional Development Funds (ERDF).

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

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 (Ï= 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 Por MPD

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 have been acquired 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.

- Thermochemical Processes Unit: one high pressure continuous flow microactivity reactor for catalytic assays, two batch high pressure reactor, one photocatalytic reactor provided with a UV-transparent window and with gas and liquid manifold, three GC (two of the them with double channel), 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), 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, and several multipurpose filter-press electrochemical reactors.

- 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.

- Electrical Systems 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:

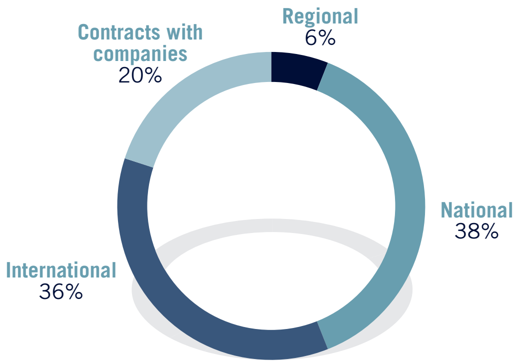
- Software HSC Chemistry 6.1
- VAPS 5.2
- CFD code COMSOL
- Simapro 7.2 Professional
- MATLAB-ALL and Simulink
- Trace Pro
- TRNSYS 16 and 17
- Aspen Plus
- Solidworks premium
- LABVIEW
- Ebsilon Professional
- IPSA
- PowerWorld

The laboratories 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

6

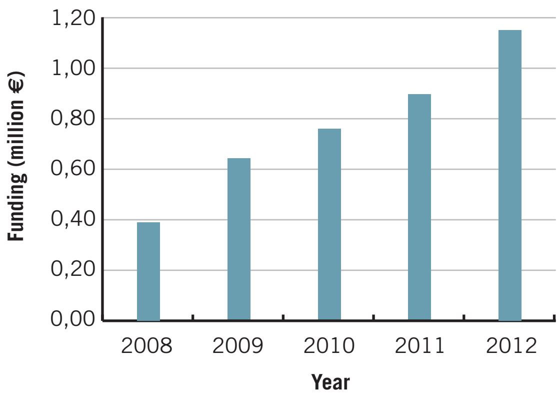
The external funding obtained by IMDEA Energy Institute from R&D projects and contracts since the beginning of its activity, according to the funding source, has been the over 7 M€. According to the data in the figure below, the main source of external funding has been obtained from national programs (38%), following by projects corresponding to calls of international programs (36%). Significant funding has been also obtained from research contracts with companies (20%) and, in a lesser extension, from regional calls (6%).



External funding obtained by IMDEA Energy Institute from R&D projects and contracts

The external funding obtained by the IMDEA Energy Institute from R&D projects and contracts during 2012, has been the amount of 1.152.696€. The main source of external funding in 2012 has been obtained from research national programs (42%), following by projects corresponding to calls of the international programs (24%), contracts with companies (24%), and finally from regional calls (10%).

Next figure shows the evolution of the external funding achieved and spent in R&D activities in the period 2008-2012. This data indicates a continuous increase in the external funding, which has allowed the research expenses to be covered in a high proportion by external sources.



Annual external funding from R&D projects and contracts achieved and spent during 2008-2012

6.1. R&D projects and contracts

The following list shows the R&D projects and contracts active in 2012:

Regional projects

Title/Acronym: Modular, efficient and dispatchable high flux solar thermal power systems/SOLGEMAC
Partners: IMDEA Energy Institute (Coordinator); INTA; Rey Juan Carlos University; Autonoma University of Madrid; CIEMAT; Abengoa Hidrógeno, S.A.; Torresol Energy
Period: 2010-2013
Funding Institution/Program: Comunidad de Madrid/ Program of R&D activities between research groups in Technology
IMDEA Energy Institute external funding: 267.205 €

Title/Acronym: Use of agro-forest and oily residues to produce clean transportation fuels/RESTOENE
Partners: CSIC (Coordinator); Rey Juan Carlos University; Autonoma University of Madrid; CIEMAT; Petrolab; IMDEA Energy Institute; Abengoa Bioenergy; Repsol YPF; Green Fuels
Period: 2010-2013
Funding Institution/Program: Comunidad de Madrid/ Program of R&D activities between research groups in Technology
IMDEA Energy Institute external funding: 134.790 €

National projects

Title/Acronym: CO_2 valorization by photocatalytic processes/FOTOVALCO2
Partners: IMDEA Energy Institute (Coordinator); Acciona Infraestructuras, S.A.
Period: 2010-2012
Funding Institution/Program: Ministry of Economy and Competitiveness/ Subprogram of Fundamental not-oriented research
IMDEA Energy Institute external funding: 149.556 €

Title/Acronym: Multipurpose electrochemical reactor for energy and environmental applications/REM
Partners: PROINGESA (Coordinator); IMDEA Energy Institute
Period: 2010-2013
Funding Institution/Program: Ministry of Economy and Competitiveness/ Sub-program INNPACTO 2010
IMDEA Energy Institute external funding: 131.359 €

Title/Acronym: Production of hydrogen via solar driven high temperature process/SolH2
Partners: Abengoa Hidrógeno, S.A. (Coordinator); IMDEA Energy Institute; University of Seville; CIEMAT
Period: 2011-2013
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, S.A. (Coordinator); IMDEA Energy Institute; Nanoquimia, S.L.; Proingesa; University of Cordoba
Period: 2011-2014
Funding Institution/Program: Ministry of Economy and Competitiveness/ Sub-program INNPACTO 2011
IMDEA Energy Institute external funding: 222.649 €

Title/Acronym: Tailored semiconductor nanocrystals for supercapacitors/CAPSETA2
Partners: IMDEA Energy Institute (Coordinator); SAFT Batteries, S.L.; 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: 2012-2014
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); Rey Juan Carlos University; Repsol YPF, S.A.; Abengoa Bioenergía; Algaenergy, S.A
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, S.A.
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: 309.942 €

Title/Acronym: Equipment for the headquarters of the Madrid Institute for Advanced Studies in Energy
Partners: IMDEA Energy Institute
Period: 2012-2014
Funding Institution/Program: Ministry of Economy and Competitiveness/ Sub-program INNPLANTA
IMDEA Energy Institute external funding: 448.325 €

The following national projects have been approved during 2012 and will start in 2013:

Title/Acronym: Development of high performance supercapacitors by using novel ionic liquid-based electrolytes/SUPERLION
Partners: IMDEA Energy Institute (Coordinator); Repsol-YPF; Solvionic
Period: 2013-2016
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-YPF; Abengoa Hidrógeno, S.A.
Period: 2013-2016
Funding Institution/Program: Ministry of Economy and Competitiveness/ Subprogram of Fundamental non-oriented research
IMDEA Energy Institute external funding: 140.400 €

International projects

Title/Acronym: New generation, High Energy and power density SuperCAPacitor based energy storage system/HESCAP

Partners: Centro de Estudios e Investigaciones Técnicas de GipuzKoa (CEIT) (Coordinator); IMDEA Energy Institute; CEA-LETI; Skeleton Technologies; National Technical University of Athens (NTUA); Yunasko (Ukraine)

Period: 2010-2012

Funding Institution/Program: European Union/ FP7-Cooperation. Call identifier: FP7-ENERGY-2009-1

IMDEA Energy Institute external funding: 311.465 €

Title/Acronym: ADvanced Electrolyser for hydrogen production with renewable energy sources/ADEL

Partners: HTceramix, S.A. (HTc) (Coordinator); Accelopment AG (ACCEL); Commissariat à l'Energie Atomique (CEA); Deutsches Zentrum für Luft und Raumfahrt e.V. (DLR);European Institute for Energy Research (EIFER); Eidgenössische Materialprüfungs-und Forschungsanstalt (EMPA); Hynergreen Technologies, S.A. (HG); HyGear B.V. (HYG); IMDEA Energy Institute; Joint Research Center (JRC); SOFCpower, SpA (SP); Topsoe Fuel Cell A/S (TOFC); Empresarios Agrupados Internacional, S.A. (EA)

Period: 2011-2013

Funding Institution/Program: European Union/ FP7-Cooperation Program-FCH JU. Call identifier: FCH-JU-2009-1

IMDEA Energy Institute external funding: 114.500 €

Title/Acronym: New materials for sorption-based thermal energy storage/ STOREHEAT

Partners: National Institute of Chemistry (Coordinator); IMDEA Energy Institute; Silkem d.o.o.

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/TCS-Power

Partners: Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR) (Coordinator); Siemens CSP (SCSP); Bühler AG (BUHL); Eramet et Comilog Chemicals, S.A. (RHM); IMDEA Energy Institute; Paul Scherrer Institute (PSI); Universität Siegen (USIEGEN)

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 (WARWICK); Eidgenössische Technische Hochschule Zürich (ETHZ); IMDEA Energy Institute (IMDEA); COMESSA; TORRESOL Energy Investments, S.A. (TORRESOL); European Powder & Process Technology (EPPT)
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: Training network in innovative polyelectrolytes for energy and environment/RENAISSANCE
Partners: University of the basque country (POLYMAT) (Coordinator); CNRS-University of Bordeaux I (LCPO); Max Planck Institute of Colloids and Interfaces (MPI CI); Linköping University (BIORGEL); University of Liege (Ulg); IMDEA Energy Institute; Kitozyme, S.A. (KITOZYME); Procter & Gamble Italia (P&G); Repsol-YPF (REPSOL)
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: Energy demand aware open services for smart grid intelligent automation/SmartHG
Partners: Sapienza University of Rome (Coordinator); Aarhus University; IMDEA Energy Institute; Joint Institute for Power and Nuclear Research; ATANVO GmbH; GridManager A/S; 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 €

Contracts with companies

Title/Acronym: Energy efficiency in systems for vibration testing
Company: IMV Corporation (Japan)
Period: 2010-2013
IMDEA Energy Institute external funding: 49.815 €

Title/Acronym: Technologies for the hotel of the future/THOFU
Company: Sacyr Vallerhermoso, S.A. (Spain)
Period: 2011-2012
Program: Industrial R&D Initiative-CENIT
IMDEA Energy Institute external funding: 100.013 €

Title/Acronym: Investigation potential for energy saving in capacitive deionization system for water purification
Company: UrWater (USA)
Period: 2011-2012
IMDEA Energy Institute external funding: 11.800 €

Title/Acronym: Innovative latent thermal energy storage system for concentrating solar power plants
Company: E.ON SE (Germany)
Period: 2011-2013
Program: EON International Research Initiative 2009-Announcement: “Heat storage for concentrating solar power”
IMDEA Energy Institute external funding: 120.066 €

Title/Acronym: Development of a modular central receiver concentrated solar power plant for decentralized power generation/CRISPTower
Company: Sunborne Energy Technologies Pvt. Ltd. (India)
Period: 2011-2013
IMDEA Energy Institute external funding: 81.320 €

Title/Acronym: Visualising the smart home: creative engagement with customer data
Company: E.ON SE (Germany)
Program: E.ON International Research Initiative 2012-Announcement: “Smart home a new customer relationship with energy”
Period: 2012-2013
IMDEA Energy Institute external funding: 75.771 €

Title/Acronym: FOTOCON-CO2
Company: REPSOL, S.A. (Spain)
Period: 2012-2014
IMDEA Energy Institute external funding: 205.800 €

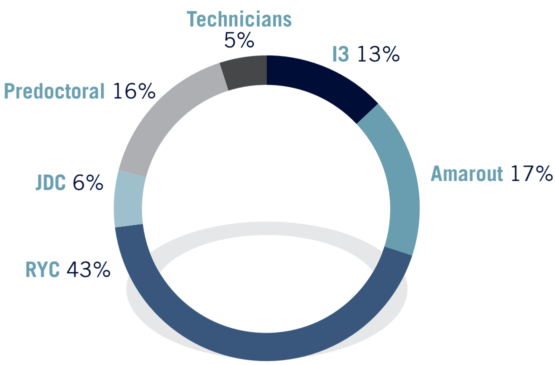
Title/Acronym: FLEXIBIORREFINERÍA
Company: REPSOL, S.A. (Spain)
Period: 2012-2013
IMDEA Energy Institute external funding: 110.000 €

Title/Acronym: Waste to Biofuel/WASBIO
Company: Befesa Gestión de Residuos Industriales, S.L. (Spain)
Period: 2012-2015
IMDEA Energy Institute external funding: 71.130 €

6.2. Researcher grants and mobility actions

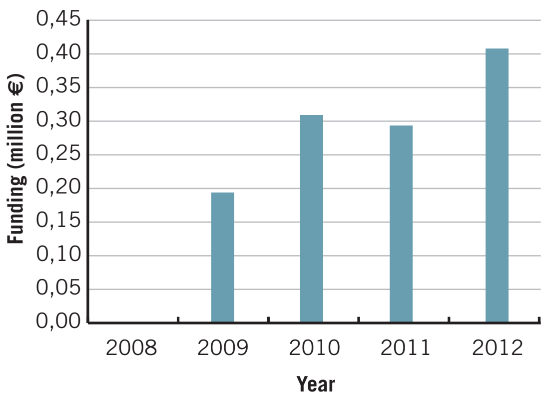
6.2.1. Researcher grants

Next figure shows the distribution of the total external funding obtained by the IMDEA Energy Institute from grants and fellowships since the beginning of its activity according to the type of fellowship, which accounts for 2.003.963 €. According to depicted data, the main source of external funding has been obtained from Ramón y Cajal (RYC) program (43%).



External funding obtained by IMDEA Energy Institute from grants and fellowships

The funding received every year associated to those fellowships and grants is illustrated in the next figure.



Annual external funding obtained by IMDEA Energy Institute through fellowships and grants during 2008-2012

The following grants have been obtained by researchers of IMDEA Energy between the years 2008-2012, and continue active in 2012:

Program: "Marie Curie" AMAROUT Europe. FP7-People Program. Call identifier: FP7-PEOPLE- 2007-2-3-COFUND
Period: 2009-2013
Funding Institution: European Union
IMDEA Energy Institute external funding: 244.229 €
Number of grants: 6
Dr. Yongxing Yang, Dr. Carlos Pérez, Dr. Fontina Petrakopoulou, Dr. Chandrasekaran Ramasamy, Dr. Milan Prodanovic and Dr. Selvan Bellan

Program: Contract for the support of research staff 2008
Project: Map interactions of proteins involved in the biosynthesis of iron-molybdenum cofactor of nitrogenase
Period: 2009-2013
Funding Institution: Comunidad de Madrid
IMDEA Energy Institute external funding: 68.250 €
Mr. A. David Moreno

Program: Ramón y Cajal 2008
Project: Materials and components for electrochemical energy storage
Period: 2009-2013
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 177.480 €
Dr. Raúl Díaz

Program: Ramón y Cajal 2008
Project: Development of active catalytic materials for the reduction of CO_2 with water under mild conditions. Removal and valorization of CO_2
Period: 2009-2013
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 177.480 €
Dr. Víctor A. de la Peña

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: Technical Support Staff 2010
Period: 2010-2013
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 37.800 €
Ms. M. Eugenia Di Falco

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: 70.408 €
Ms. Laura Collado

Program: Juan de la Cierva 2010
Project: Valorization of CO_2 with photocatalysis under mild conditions
Period: 2011-2013
Funding Institution: Ministry of Economy and Competitiveness
IMDEA Energy Institute external funding: 100.980 €
Dr. Prabhas Jana

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

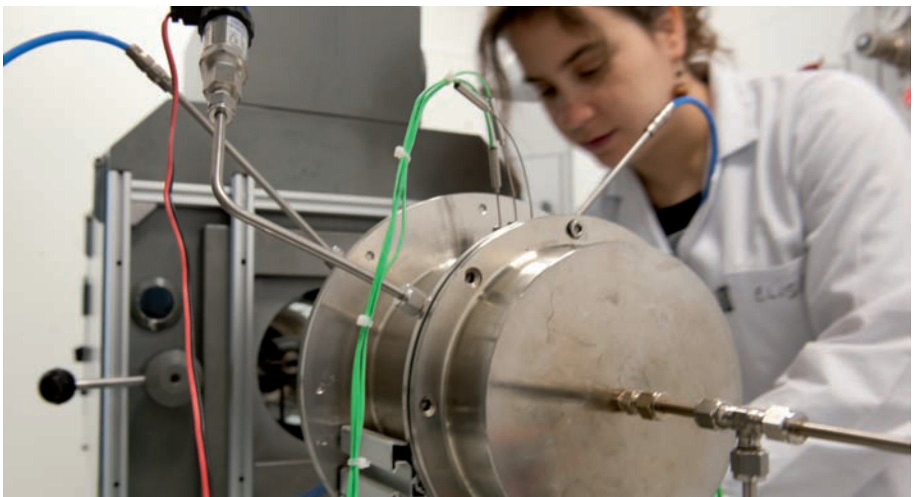
Program: II Call for research funding in energy and environment
Project: Environmental sustainability of energy systems for co-production of bioelectricity and biofuel using the Fischer-Tropsch process
Period: 2012-2013
Funding Institution: IBERDROLA Foundation
IMDEA Energy Institute external funding: 20.000 €
Dr. Diego Iribarren

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

Other grants recently approved and that will start in 2013, are as follows:

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: 635.039 €

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: 70.408 €



6.2.2. Mobility actions

Stay at Chalmers University of Technology (Sweden)
Program: FEBS Short-Term Fellowships
Period: 2 months, 2012
Funding Institution: Federation of European Biochemical Societies
Mr. Antonio D. Moreno

Stay at University of Warwick (United Kingdom)
Period: 3 months, 2012
Funding Institution: Ministry of Economy and Competitiveness (CAPSETA2 project)
Ms. Süheda Isikli

Stay at Imperial College London (United Kingdom)
Program: Sub-program FPI-MICINN (Call 2011)
Period: 3 months, 2012
Funding Institution: Ministry of Economy and Competitiveness
Ms. Laura Collado

Program: Access to Facilities-European Program SFERA
Project/Acronym: Thermal characterization of innovative ceramic absorbers for volumetric receivers/TH-CRABS
Period: 3 weeks, 2012
Funding Institution: European Union
Mr. Fabrisio Gómez

cooperation framework

7

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 2012.

Institution	Cooperation
Rey Juan Carlos University (URJC) (Spain)	Cooperation in projects and activities related to solar concentrating systems and the production of sustainable fuels (Projects: SOLGEMAC, RESTOENE LIGCATUP and ASBIOPLAT). Period: 2008-2014
Centre of Energy, Environmental and Technological Research (CIEMAT) (Spain)	Cooperation in projects and activities related to solar concentrating systems and the production of sustainable fuels (Projects: SOLGEMAC and RESTOENE). Joint Research Unit CIEMAT/IMDEA Energy from April 2011 Period: 2008-2014
Autonoma University of Madrid (UAM) (Spain)	Cooperation for research on the use of quinones applied to electrochemical storage devices (Project SOLGEMAC) and on the production of second generation biofuels (Project RESTOENE). Period: 2010-2013
National Technical University of Athens (NTUA) (Greece)	Cooperation within the framework of HESCAP project on supercapacitors. Period: 2010-2012
CEA-LETI (France)	Cooperation within the framework of HESCAP project on supercapacitors. Period: 2010-2012
Catalysis and Petrochemistry Institute (ICP-CSIC) (Spain)	Cooperation for the production of second generation biofuels (Project RESTOENE). Period: 2010-2013
National Institute of Aerospace Technique (INTA) (Spain)	Cooperation on integration of micro-turbines and Stirling engines on solar concentrating systems (Project SOLGEMAC). Period: 2010-2013
University of South Florida (USA)	Coordinator of the project funded by the company E.ON entitled "Innovative Latent Thermal Energy Storage System for Concentrated Solar Power Plants", as well as participation in the project funded by the company Sunborne Energy Technologies Pvt Ltd. Period: 2011-2013
Indian Institute of Technology Delhi/Center for Energy Studies (India)	Participation in the project funded by the company Sunborne Energy Technologies Pvt Ltd. Period: 2011-2013
University of Córdoba (Spain)	Cooperation within the framework of ADECAR project for the application of capacitive deionization to wastewater treatment. Period: 2011-2014

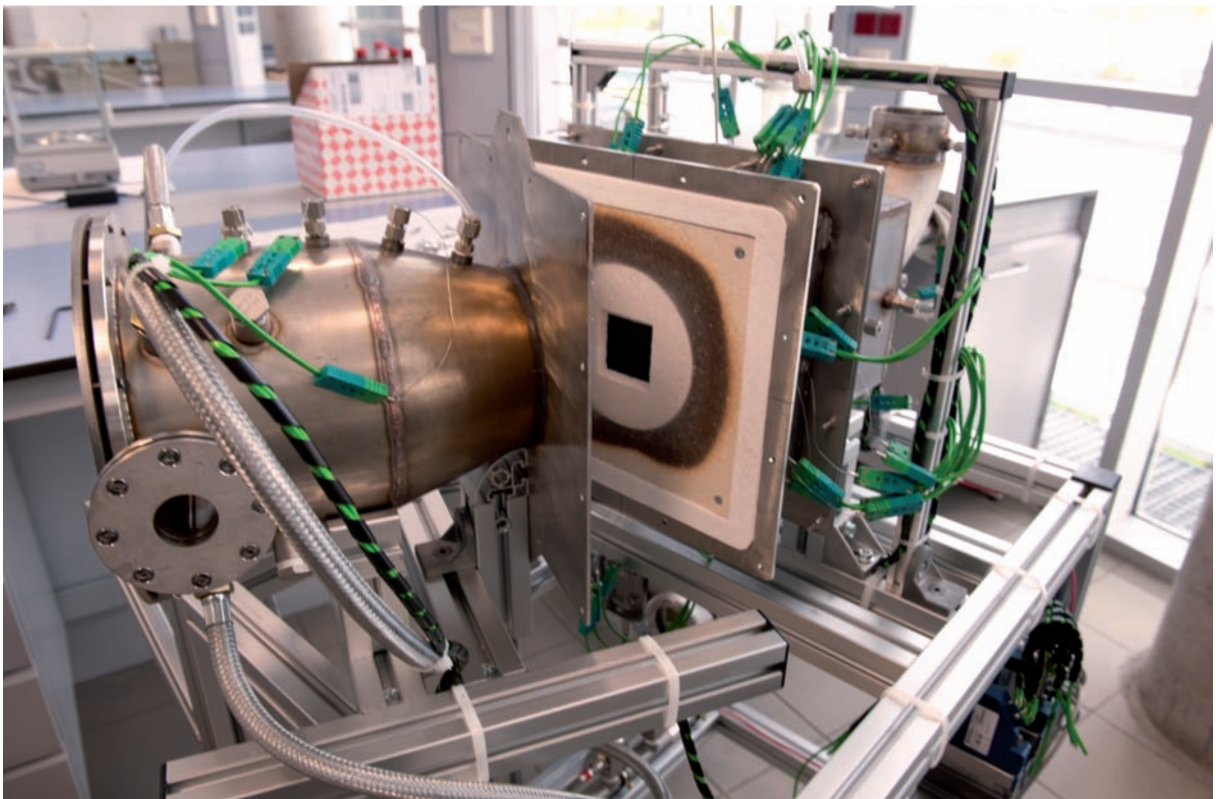
Institution	Cooperation
University of Seville (Spain)	Cooperation within the framework of SolH2 project for hydrogen production. Period: 2011-2013
University of Warwick (United Kingdom)	Cooperation within the framework of CSP2 project for solar concentrating systems. Period: 2011-2015
Centre National de la Recherche Scientifique (CNRS) (France)	Cooperation in projects related to solar concentrating systems (Project CSP2). Period: 2011-2015
Commissariat à l'Energie Atomique (CEA) (France)	Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-2013
Deutsches Zentrum für Luft und Raumfahrt e. V. (DLR) (Germany)	Cooperation within the framework of ADEL project for the production of hydrogen. Cooperation within the framework of TCSPower project related to solar concentrating systems. Period: 2011-2013
Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA) (Switzerland)	Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-2013
European Institute for Energy Research (EIFER) (Germany)	Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-2013
National Institute of Chemistry (Slovenia)	Cooperation in the project STOREHEAT for development of materials for thermal energy storage. Period: 2011-2014
Institute of Energy Technology (ETH-Zurich) (Switzerland)	Cooperation in the project funded by the company Sunborne Energy Technologies Pvt Ltd.and CSP2 project for solar concentrating systems. Period: 2011-2015
Istituto per la Microeletronica e Microsistemi-CNR (Italy)	Cooperation within the framework of CAPSETA2 project for the design of supercapacitors. Period: 2011-2014
Paul Scherrer Institute (PSI) (Switzerland)	Cooperation within the framework of TCSPower project related to solar concentrating systems. Period: 2011-2015
National Autonoma University of Mexico (UNAM) (Mexico)	Cooperation in joint research projects. Period: 2011-present
City University London (United Kingdom):	Cooperation in the project funded by the company E.ON for the developing user-oriented Smart Home services. Period: 2012-2013

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
Sapienza University of Rome (Italy)	Coordinator of the project SmartHG for smart grid intelligent automation. Period: 2012-2015

7.2. Cooperation with other IMDEA Institutes

The following table lists cooperation agreements established with other IMDEA Institutes, which have been active during 2012.

Name	Cooperation activities
IMDEA Software IMDEA Materials IMDEA Networks IMDEA Water IMDEA Food IMDEA Nanosciencia IMDEA Social sciences	Cooperation within the framework of AMAROUT Program. Period: 2009-2013



7.3. Cooperation with industry

The cooperation with industry has steadily grown in 2012, most of it related to projects and contracts for specific research activities. This fact is of special relevance for the IMDEA Energy Institute as one of its main goals is to work together with the industry sector to promote innovation and technology transfer. The following table lists the companies that have projects and contracts in collaboration with the IMDEA Energy Institute.

Name	Cooperation activities
Sacyr Vallerhermoso, S.A. (Spain)	Coordinator of the THOFU project. Period: 2010-2012
Acciona Infraestructuras, S.A. (Spain)	Cooperation on projects for capture and valorisation of CO_2 by photocatalysis (Project: FOTOVALCO2) Period: 2010-2012
Skeleton Technologies (Estonia)	Cooperation within the framework of HESCAP project on supercapacitors. Period: 2010-2012
Yunasko (Ukraine)	Cooperation within the framework of HESCAP project on supercapacitors. Period: 2010-2012
Abengoa Hidrógeno, S.A. (Spain)	Cooperation in projects and activities related to hydrogen production (Projects: SOLGEMAC, SolH2 and ADEL). Period: 2010-2013
Green Fuels (Spain)	Cooperation within the framework of RESTOENE project on second generation biofuels. Period: 2010-2013
IMV Corporation (Japan)	Cooperation on energy efficient processes. Period: 2010-2013
Abengoa Bioenergía (Spain)	Cooperation within the framework of RESTOENE project on second generation biofuels (Projects: RESTOENE and LIGCATUP). Period: 2010-2014
Torresol Energy Investments, S.A. (Spain)	Cooperation on solar concentrating systems (Projects: SOLGEMAC and CSP2). Period: 2010-2015
Empresarios Agrupados Internacional, S.A. (Spain)	Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-2013
E.ON SE (Germany)	Cooperation in projects on energy storage and smart homes. Period: 2011-2013
Accelopment AG (Switzerland)	Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-2013

Name	Cooperation activities
HTceramix, S.A. (Switzerland)	Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-2013
Bühler AG (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, S.A. (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
HyGear B.V. (Netherlands)	Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-2013
SOFCpower, SpA (Italy)	Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-2013
Sunborne Energy Technologies Pvt. Ltd. (India)	Coordinator of the project titled “Development of a Modular Central Receiver Concentrated Solar Power Plant for Decentralized Power Generation”. Period: 2011-2013
Topsoe Fuel Cell A/S (Denmark)	Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-2013
Silkem d.o.o (Slovenia)	Cooperation in the project STOREHEAT for development of materials for thermal energy storage. Period: 2011-2014
Isolux Ingeniería, S.A. (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
PROINGESA (Spain)	Cooperation on energy efficient processes for water treatment with capacitive deionization (Projects: REM and ADECAR). Period: 2011-2014

Name	Cooperation activities
Siemens Concentrated Solar Power, Ltd. (Israel)	Cooperation within the framework of TCSPower project related to solar concentrating systems. Period: 2011-2015
Algaenergy, S.A. (Spain)	Cooperation within the framework of LIGCATUP project for the production of second generation biofuels. Period: 2012-2014
REPSOL-YPF (Spain)	Cooperation for the production of second generation biofuels. (Projects: RESTOENE, LIGCATUP, FOTOCON-CO2, FLEXIBIORREFINERÍA). Period: 2012-2014
SAFT Batteries, S.L. (Spain)	Cooperation within the framework of CAPSETA2 project for the design of supercapacitors. Period: 2012-2014
Equipos Industriales de Manutención, S.A. (EINSA) (Spain)	Cooperation within the framework of CAPSETA2 project for the design of supercapacitors. Period: 2012-2014
Iberdrola (Spain)	Cooperation within the framework of SOLARO2 project for solar thermochemical processes based on manganese oxides. Period: 2012-2014
Novotec Consultores, S.A. (Spain)	Cooperation within the framework of ASBIOPLAT project for the production of biofuels. Period: 2012-2014
Abengoa Research (Spain)	Cooperation on projects for the production of second generation biofuels. Period: 2012-2015
Camelina Company España (Spain)	Cooperation on projects for the production of second generation biofuels. Period: 2012-2015
Befesa Gestión de Residuos Industriales, S.L. (Spain)	Cooperation in the project “Waste to Biofuel”. Period: 2012-2015

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 2012:

- Research Grouping of the Joint Undertaking on Fuel Cells and Hydrogen of the VII Framework Programme of the EC (N.ERGHY).
- Spanish Technology Platform on Hydrogen and Fuel Cells.
- Cluster on Sustainability and Renewable Energies of Madrid Network.
- Joint Programme on Energy Storage in the EERA (European Energy Research Alliance) with the objective to formulate proposals to the Strategic Energy Technology (SET) Plan of the European Union.
- Joint Programme on Bioenergy in the EERA (European Energy Research Alliance) with the objective to formulate proposals to the Strategic Energy Technology (SET) Plan of the European Union.
- Joint Programme on Concentrating Solar Power in the EERA (European Energy Research Alliance) with the objective to formulate proposals to the Strategic Energy Technology (SET) Plan of the European Union.
- Spanish Network of Life Cycle Assessment.
- Spanish Technology Platform on CSP technologies Solar Concentration.
- Alliance of Energy Research and Innovation (ALINNE) as members and at the Committee of Strategies.
- HIA30 of the International Energy Agency.
- International Solar Energy Society (ISES).

scientific results

8

The works published by researchers of the IMDEA Energy Institute during 2012 is listed below, as well as the communications to congresses.

8.1. Scientific publications

Scientific Journals

1. Aboudzadeh M.A.; Muñoz M.E.; Santamaría A.; Marcilla R; Mecerreyes D.
"Facile synthesis of supramolecular ionic polymers which combine unique rheological, ionic conductivity and self-healing properties".
Macromolecular Rapid Communication, **2012**, *33 (4)*, 314-318.

2. Botas, J.A.; Serrano, D.P.; García, A.; Vicente, J.; Ramos, R.
"Catalytic conversion of rapeseed oil into raw chemicals and fuels over Ni- and Mo-modified nanocrystalline ZSM-5 zeolite".
Catalysis Today, **2012**, 195, *1*, 59-70.

3. Chávez-Capilla, T.; Epifani, M.; Andreu, T.; Arbiol, J.; Palma, J.; Morante, J. R.; Díaz, R.
"Surface modification of metal oxide nanocrystals for improved supercapacitors".
Energy & Environmental Science, **2012**, *5*, 7555-7558.

4. Carro, P.; Torres, D.; Díaz, R.; Salvarezza, R. C.; Illas, F.
"Mechanism of defect generation and clustering in CH_3S self-assembled monolayers on Au (111)".
Journal of Physical Chemistry Letters, **2012**, *3 (16)*, 2159-2163.

5. D'Vries, R.F; de la Peña-O'Shea, V.A.; Snejko, N.; Iglesias, M.; Gutiérrez-Puebla, E.; Monge, M.A.
"Insight into the correlation between net topology and ligand coordination mode in new lanthanide MOFs heterogeneous catalysts: a theoretical and experimental approach".
Crystal Growth & Design, **2012**, 12 *(11),* 5535-5545.

6. Díaz, R.; Orcajo, M.G.; Botas, J.A. Calleja, G.; Palma, J.
"Co8-MOF-5 as electrode for supercapacitors".
Material Letters, **2012**, *68*, 126-128.

7. Dufour, J.; Iribarren, D.
"Life cycle assessment of biodiesel production from free fatty acid-rich wastes".
Renewable Energy, **2012**, *38 (1),* 155-162.

8. Dufour, J.; Serrano, D.P.; Gálvez, J.L.; González, A.; Soria, E.; Fierro. J.L.G.
"Life cycle assessment of alternatives for hydrogen production from renewable and fossil sources".
International Journal of Hydrogen Energy, **2012**, *37 (2)*, 1173-1183.

9. Escola, J. M.; Aguado, J.; Serrano, D. P.; Briones, L.; Díaz de Tuesta, J. L.; Calvo, R.; Fernandez, E.
"Conversion of polyethylene into transportation fuels by the combination of thermal cracking and catalytic hydroreforming over Ni-Supported hierarchical Beta zeolite".
Energy & Fuels, **2012**, *26 (6)*, 3187-3195.

10. Escola, J.M.; Aguado, J.; Serrano, D.P.; Briones, L.
"Hydroreforming over Ni/H-beta of the thermal cracking products of LDPE, HDPE and PP for fuel production".
Journal of Material Cycles and Waste Management, **2012**, *14 (4),* 286-293.

11. García, A.; Demessence, A.; Platero-Prats, A.; Heurtaux, D.; Horcajada, P.; Serre, C.; Chang, J.S.; Férey, G.; de la Peña-O'Shea, V.A.; Boissière, C.; Grosso, D.; Sánchez, C.
"Green microwave synthesis of MIL-100(Al, Cr, Fe) nanoparticles for thin-film elaboration".
European Journal of Inorganic Chemistry, **2012**, *32,* 5165-5174.
Special Issue: Organic-Inorganic Hybrid Materials: Design and Applications.

12. González-Fernández, C.; Ballesteros, M.
"Linking microalgae and cyanobacteria culture conditions and key-enzymes for carbohydrate accumulation".
Biotechnology Advances, **2012**, *30 (6)*, 1655-1661.

13. González-García, S.; Iribarren, D.; Susmozas, A.; Dufour, J.; R.J. Murphy, R.J.
"Life Cycle Assessment of two alternative bioenergy systems involving Salix spp. biomass: Bioethanol production and power generation".
Applied Energy, **2012**, *95*, 111-122.

14. Iribarren, D.; Dagá, P.; Moreira, M.T.; G. Feijoo, G.
"Potential environmental effects of probiotics used in aquaculture".
Aquaculture International, **2012**, *20*, 779-789.

15. Iribarren, D.; Moreira, M.T.; G. Feijoo.
"Life Cycle Assessment of aquaculture feed and application to the turbot sector".
International Journal of Environmental Research, **2012**, *6*, 837-848.

16. Iribarren, D.; Peters, J.F.; Dufour, J.
"Life Cycle Assessment of transportation fuels from biomass pyrolysis".
Fuel, **2012**, *97*, 812-821.

17. Iribarren, D.; Dufour, J.; Serrano, D.P.
"Preliminary assessment of plastic waste valorization via sequential pyrolysis and catalytic reforming".
Journal of Material Cycles and Waste Management, **2012**, *14*, 301-307.

18. Isikli, S.; Díaz, R.
"Substrate-dependent performance of supercapacitors based on an organic redox copule impregnated on carbon". Journal Power Sources, **2012**, *206*, 53-58.

19. Jana, P, de la Peña O'Shea, V. A., Coronado, J. M., Serrano, D.P.
"Mild temperature hydrogen production by methane decomposition over cobalt catalysts prepared with different precipitating agents".
International Journal of Hydrogen Energy, **2012**, *37 (8)*, 7034-7041.

20. Leonard, K.C.; Suyama, W.E.; Anderson, M.A.
"Evaluating the electrochemical capacitance of surface-charged nanoparticle oxide coatings".
Langmuir, **2012**, *28 (15)*, 6476-6484.

21. Leonard, K.C.; Tejedor-Anderson, M.I.; Anderson, M.A.
"Nanoporous oxide coatings on stainless steel to enable water splitting and reduce the hydrogen evolution overpotential".
International Journal of Hydrogen Energy, **2012**, *37 (24)*, 18654-18660.

22. Moreno, A.D; Ibarra, D.; Fernández, J.L; Ballesteros, M.
"Different laccase detoxification strategies for ethanol production from lignocellulosic biomass by the thermotolerant yeast Kluyveromyces marxianus CECT 10875".
Bioresource Technology, **2012**, *106*, 101-109.

23. Mora-Jaramillo, M.; Mendoza, A.; Vaquero, S.; Anderson, M.; Palma, J.; Marcilla, R.
"Role of textural properties and surface functionalities of selected carbons on the electrochemical behaviour of ionic liquid based-supercapacitors".
RSC Advances, **2012**, *2 (22)*, 8439-8446.

24. Petrakopoulou, F.; Tsatsaronis, G.; Morosuk, T.; Carassai A.
"Advanced exergoeconomic analysis applied to a complex energy conversion system".
Journal of Engineering for Gas Turbines and Power, **2012**, *134 (3)*, 031801.

25. Petrakopoulou, F.; Tsatsaronis, G.; Morosuk, T.
"Advanced exergoenvironmental analysis of a near-zero emission power plant with chemical looping combustion". Environmental Science and Technology, **2012**, *46 (5)*, 3001-3007.

26. Petrakopoulou, F.; Tsatsaronis, G.
"Production of hydrogen-rich fuels for pre-combustion carbon capture in power plants: A thermodynamic assessment".
International Journal of Hydrogen Energy, **2012**, *37 (9)*, 7554-7564.

27. Petrakopoulou, F.; Tsatsaronis, G.; Morosuk, T.; Paitazoglou, C.
"Environmental evaluation of a power plant using conventional and advanced exergy-based methods".
Energy, **2012**, *45 (1),* 23-30.

28. Platero-Prats, A.E.; de la Peña-O'Shea, V.A.; Proserpio, D.M.; Snejko, N.; Gutierrez-Puebla, E.; and Monge, A.
"Insight into the SBU condensation in Mg coordination and supramolecular frameworks: A combined experimental and theoretical study".
Journal of the American Chemical Society, **2012**, *134 (10)*, 4762-4771.

29. Romero, M.; Steinfeld, A.
"Concentrated solar thermal power and thermochemical fuels".
Energy & Environmental Science, **2012**, *5*, 9234-9245.

30. Santini, A.; Passarini, F.; Vassura, I.; Serrano, D.P.; Dufour, J. Morselli, L.
"Auto shredder residue recycling: mechanical separation and pyrolysis".
Waste Management, **2012**, *32*, 852-858.

31. Serrano, D.P.; García, R.A.; Linares, M.; Gil, B.
"Influence of the calcination treatment on the catalytic properties of hierarchical ZSM-5".
Catalysis Today, **2012**, *179 (1)*, 91-101.

32. Serrano, D.P.; Dufour, J.; Iribarren, D.
"On the feasibility of producing hydrogen with net carbon fixation by the decomposition of vegetable and microalgal oils".
Energy & Environmental Science, **2012**, *5 (3)*, 6126-6135.

33. Serrano, D.P.; Aguado, J.; Escola, J.M.
"Developing advanced catalysts for the conversion of polyolefinic waste plastics into fuels and chemicals".
ACS Catalysis, **2012**, *2 (9)*, 1924-1941.

34. Serrano, D.P.; Sanz, R.; Pizarro, P.; Moreno, I.
"Tailoring the properties of hierarchical TS-1 zeolite synthesized from silanized protozeolitic units".
Applied Catalysis A: General, **2012**, *435*, 32-42.

35. Vaquero, S.; Díaz, R.; Anderson, M.; Palma, J.; Marcilla, R.
"Insights into the influence of pore size distribution and surface functionalities in the behaviour of carbon supercapacitors".
Electrochimica Acta, **2012**, *86,* 241-247.

36. Yang, Y.; Ochoa-Hernández, C.; de la Peña-O'Shea, V.A.; Coronado, J.M.; Serrano, D.P.
"Ni_2P/SBA-15 as a hydrodeoxygenation catalyst with enhanced selectivity for the conversion of methyl oleate into n-octadecane".
ACS Catalysis, **2012**, *2 (4)*, 592-598.

37. Yang, Y.; Ochoa-Hernández, C.; Pizarro, P.; de la Peña-O'Shea, V.A.; Coronado, J.M.; Serrano, D.P.
"Synthesis of nickel phosphide nanorods as catalyst for the hydrotreating of methyl oleate".
Topics in Catalysis, **2012**, *55 (14-15)*, 991-998.

Patents

1. Application number P201230007, 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. Holder: Fundación IMDEA Energía. Inventors: González-Aguilar, J.; Romero, M. Country: Spain.

Books/Chapters of books

1. Mecerreyes D., Döbbelin M., Marcilla R. **2012**. Chapter: "Applications of ionic liquids in polymer industry". In: The Role of Ionic Liquids in the Chemical Industry. Ed.: Nova Publishers. ISBN: 978-1-62081-086-6.

2. Serrano, D.P.; Coronado, J.M.; Melero, J.A. **2012**. Chapter: "Conversion of cellulose and hemicellulose into platform molecules: Chemical routes". In: Biorefinery: from biomass to chemicals and fuels. Eds. Aresta, M.; Dibenedetto, A.; Dumeignil, F. Ed.: De Gruyter, pp.123-138. ISBN: 978-3-11-026023-6.

3. Dufour, J.; Martos, C.; Ruiz, A. **2012**. Chapter: Water Gas Shift Reaction. In: Hydrogen Production: Prospects and Processes. Ed.: Nova Publishers, New York, pp.175-200. ISBN: 978-1-62100-285-7.

patents
chapters of books
articules

Articules in general journals

1. de la Peña-O'Shea, V.A.; Coronado, J.M.; Serrano, D.P.
"CO_2 evaluation: Residue or raw material?"
DYNA Ingeniería e Industria, vol. 87, pp 145-148, March-April 2012.

2. Romero, M.; Palma, J. Serrano, D.P.
"New technologies for decarbonisation of transport".
Química e Industria, nº 600, pp 36-42, April-May 2012.

8.2. Congress communications

Invited lectures

1. Title: *On the search of efficient materials for photo-catalytic solar fuels production*
Speaker: de la Peña-O'Shea, V.A.
Congress: 2nd Kuwait Conference of Chemistry (KCC 2012) and 16th Arab Chemists Conference (16th ACC)
Venue: Kuwait
Date: 14-17 April 2012
Organizer: Kuwait Chemical Society (KCS); Union of Arab Chemists (UAC)

2. Title: *Renewable energy progress and development in Spain*
Speaker: Romero, M.
Congress: World Renewable Energy Forum & Exhibition, WREF-2012
Venue: Denver, Colorado, USA
Date: 13-17 May 2012
Organizer: American Solar Energy Society (ASES) and the World Renewable Energy Network (WREN)

3. Title: *Desarrollo y caracterización óptica de un helióstato para centrales eléctricas termosolares en India*
Speaker: Romero, M. (plenary conference)
Congress: XV Congreso Ibérico y X Congreso Iberoamericano de Energía Solar (CIES 2012)
Venue: Vigo, Spain
Date: 19-22 June 2012
Organizer: Asociación Española de Energía Solar

invited lectures

Oral communications

1. Title: *A demand based approach to optimisation of energy supply mix for smart*
Authors: Prodanovic M.; Gafurov, T.; Téllez M.B
Congress: 2012 IEEE PES Innovative Smart Grid Technologies Conference (ISGT 2012)
Venue: Washington, USA
Date: 16-20 January 2012
Organizer: Power and Energy Society

2. Title: *Contribution à la caractérisation thermique d'absorbeurs volumétriques en céramique pour des récepteurs de centrales solaires à tour*
Author: Gómez-García, F.
Congress: 13ème Journées des doctorants de PROMES
Venue: Odeillo, France
Date: 12-14 March 2012
Organizer: Laboratoire de Procédés, Matériaux et Energie Solaire (PROMES)

3. Title: *Transient numerical analysis of PCM-contained spherical capsules for heat storage in concentrating solar power plants*
Authors: Ramos, A.A.; Asselineau, C-A.; Gonzalez-Aguilar, J.; Rahman, M.M; Romero, M.; Goswami, D.Y.; Stefanakos, E.L.
Congress: The 12th International Conference on Energy Storage (Innostock 2012)
Venue: Lleida, Spain
Date: 16-18 May 2012
Organizer: University of Lleida, GREA Innovació Concurent

4. Title: *Hydroreforming of the product from LDPE thermal cracking over Ni supported hierarchical zeolite*
Authors: Aguado, J.; Serrano, D. P.; Escola, J. M.; Briones, L.
Congress: 19th International Symposium on Analytical and Applied Pyrolysis (Pyrolysis 2012)
Venue: Linz, Austria
Date: 21-25 May 2012
Organizer: Institute for Chemical Technology of Organic Materials

oral communications

5. Title: *Hydrogen production via methane decomposition promoted by pure silica materials*
Authors: Serrano, D. P.; Botas, J. A.; Pizarro, P.; Gómez, G.
Congress: World Hydrogen Energy Conference 2012 (WHEC 2012)
Venue: Toronto, Canadá
Date: 3-7 June 2012
Organizer: Canadian Hydrogen and Fuel Cell Association; Natural Resources Canada

6. Title: *Performance analysis of direct steam generation-central receiver systems*
Authors: Sanz-Bermejo, J.; Gonzalez-Aguilar, J.; Romero, M.
Congress: ASME Turbo Expo 2012
Venue: Copenhague, Denmark
Date: 12-15 June 2012
Organizer: ASME International Gas Turbine Institute

7. Title: *Study of synergy between silver nanoparticles and TiO_2 for enhancing hydrocarbon production in artificial photosynthesis process*
Author: de la Peña-O'Shea, V.A
Congress: 7th European Meeting on Solar Chemistry and Photocatalysis: Environmental Applications-SPEA7
Venue: Oporto, Portugal
Date: 17-20 June 2012
Organizer: Portuguese Chemical Society

8. Title: *Comparación del comportamiento óptico del campo vertical de helióstatos con respecto a los campos horizontales tradicionales*
Authors: González, A.; González-Aguilar, J.; Romero, M.
Congress: XV Congreso Ibérico y X Congreso Iberoamericano de Energía Solar (CIES 2012)
Venue: Vigo, Spain
Date: 19-22 June 2012
Organizer: Asociación Española de Energía Solar

9. Title: *Análisis óptico de un simulador solar de 42 kWe para el estudio de procesos a altos flujos de radiación y altas temperaturas*
Authors: González-Aguilar, J.; Zeaiter, H.; Romero, M.
Congress: XV Congreso Ibérico y X Congreso Iberoamericano de Energía Solar (CIES 2012)
Venue: Vigo, Spain
Date: 19-22 June 2012
Organizer: Asociación Española de Energía Solar

10. Title: *Sol-gel surface modification of titania nanocrystals with vanadium oxide species for improved supercapacitors*
Authors: Epifani, M.; Chávez-Capilla, T; Andreu, T.; Arbiol, J.; Palma, J.; Morante, J. R.; Díaz, R.
Congress: VIII Workshop Italiano Sol-Gel
Venue: Trento, Italy
Date: 21-22 June 2012
Organizer: CNR-University of Trento (Italy)

11. Title: *Removal of aromatic sulfur compounds from fuels using hierarchical TS-1 zeolites*
Authors: Sanz, R.; Serrano, D.P.; Pizarro, P.; Moreno, I.
Congress: Congreso Internacional de Ingeniería Química (ANQUE ICCE 2012)
Venue: Seville, Spain
Date: 24-27 June 2012
Organizer: ANQUE

12. Title: *Ordered mesoporous carbons as catalysts in methane decomposition reaction*
Authors: Botas, J.A.; Serrano, D.P.; Pizarro, P.; Gómez, G.
Congress: Congreso Internacional de Ingeniería Química (ANQUE ICCE 2012)
Venue: Seville, Spain
Date: 24-27 June 2012
Organizer: ANQUE

13. Title: *Novel $Zn_{1-x}Ga_xO$ nanostructures with Pt nanoparticles as water splitting photocatalyst*
Authors: Núñez, J.; de la Peña-O'Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: Congreso Internacional de Ingeniería Química (ANQUE ICCE 2012)
Venue: Seville, Spain
Date: 24-27 June 2012
Organizer: ANQUE

14. Title: *Determination of flow assurance problems due to asphaltene instability on crude oils*
Authors: Calles, J.A.; Dufour, J.; Marugán, J.M; Giménez-Aguirre, R.; Merino-García, D.; Sanz, P.; Peña, J.L.
Congress: Congreso Internacional de Ingeniería Química (ANQUE ICCE 2012)
Venue: Seville, Spain
Date: 24-27 June 2012
Organizer: ANQUE

15. Title: *Preparation of Fe_2O_3-SiO_2 composites as catalysts for high temperature WGS reaction*
Authors: Martos, C.; Dufour, J.; Ruiz A.; Lameiro, A.
Congress: Congreso Internacional de Ingeniería Química (ANQUE ICCE 2012)
Venue: Seville, Spain
Date: 24-27 June 2012
Organizer: ANQUE

16. Title: *The effect of Ni/P ratio on the hydrotreating performance of novel NixPy/SBA-15 catalysts*
Authors: Yang, Y.; Ochoa-Hernández, C.; de la Peña O'Shea, V.A.; Serrano, D.P.; Coronado, J.M.
Congress: International Symposium on "Catalysis for Clean Energy and Sustainable Chemistry" (CCESC2012)
Venue: Alcobendas, Madrid, Spain
Date: 27-29 June 2012
Organizer: EQS; Ibercat-soluciones catalíticas

17. Title: *Impregnación de un par redox orgánico sobre diferentes carbones para electrodos supercondensadores mejorados*
Authors: Isikli, S.; Díaz, R.
Congress: XXXIII Reunión del Grupo de Electroquímica de la RSEQ
Venue: Miraflores de la Sierra, Madrid, Spain
Date: 1-4 July 2012
Organizer: Grupo de Electroquímica de la RSEQ

18. Title: *Efficient anisole hydrodeoxygenation over Ni/TiO_2 and Ni/SBA-15 catalysts*
Authors: Yang, Y.; Ochoa-Hernández, C.; de la Peña O'Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: International conference on "Advances in catalysis for biomass valorization" (CAT4BIO)
Venue: Thessaloniki, Greece
Date: 8-11 July 2012
Organizer: University of Thessaloniki

19. Title: *Catalytic conversion of rapeseed oil for the production of raw chemicals, fuels and carbon nanotubes over Ni- modified nanocrystalline and hierarchical ZSM-5*
Authors: Botas, J. A.; Serrano, D. P.; García, A.; Ramos, R.
Congress: International conference on "Advances in catalysis for biomass valorization" (CAT4BIO)
Venue: Thessaloniki, Greece
Date: 8-11 July 2012
Organizer: University of Thessaloniki

20. Title: *Role of textural properties and surface functionalities of carbons in the performance of EDLCs*
Authors: Vaquero, S.; Palma, J.; Anderson, M.A.; Marcilla, R.
Congress: The 63rd Annual Meeting of the International Society of Electrochemistry
Venue: Praga, Czech Republic
Date: 19-24 August 2012
Organizer: International Society of Electrochemistry

21. Title: *Supercapacitors based on surface-modified metal oxide nanocrystals*
Authors: Chávez-Capilla, T; Epifani, M.; Arbiol, J.; Andreu, T.; Palma, J.; Morante, J.R.; Díaz, R.
Congress: XI International Conference on Nanostructured Materials
Venue: Rhodes, Greece
Date: 26-31 August 2012
Organizer: National Center for Scientific Research "Demokritos"

22. Title: *Hidrodesoxigenación de ésteres metílicos sobre materiales ácidos tipo SBA-15 impregnados con Ni y Co*
Authors: Ochoa, C.; Yang, Y.; de la Peña-O'Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: XXIII Congreso Iberoamericano de Catálisis
Venue: Santa Fe, Argentina
Date: 2-7 September 2012
Organizer: ISOCat; Sociedad Argentina de Catálisis; Universidad Nacional del Litoral

23. Title: *Estudio de la sinergia entre plata nanopartículas de Ag y TiO_2 para su empleo en el proceso de fotosíntesis artificial para la producción de hidrocarburos*
Authors: De la Peña-O'Shea, V.A.; Collado, L.; Sierra, B.; Jana, P.; Coronado, J.M.; Pizarro, P.; Serrano, D.P.
Congress: XXIII Congreso Iberoamericano de Catálisis
Venue: Santa Fe, Argentina
Date: 2-7 September 2012
Organizer: ISOCat; Sociedad Argentina de Catálisis; Universidad Nacional del Litoral

24. Title: *Solar hydrogen production by thermochemical processes: bioethanol reforming and thermochemical mixed-ferrite cycle*
Authors: Martín, M.; Gallardo, V.; Díaz, R.; Vidal, A.; Romero, M.; González-Aguilar J.; Ridao. M.A.;Tapia, E.; Gutiérrez Ortiz, F.J.; Vázquez, J.; Vega-Leal, A.P.
Congress: Euro-mediterranean Hydrogen Technologies Conference (EMHyTeC 2012)
Venue: Hammamet, Tunisia
Date: 11-14 September 2012
Organizer: ETRERA consortium

25. Title: *Coupling heat and electricity sources to intermediate temperature steam electrolysis*
Authors: Houaijia, A.; Monnerie, N.; Roeb, M.; Sattler, C.; Sanz-Bermejo, J.; Romero, M.; Cañadas, I.; Drisaldi, A.; Lucero, C.; Palomino, R.; Petipas, F.; Brisse, A.
Congress: SolarPACES 2012
Venue: Marrakech, Morocco
Date: 11-14 September 2012
Organizer: SolarPACES, MASEN, IRESEN

26. Title: *Analysis of shading caused by "Vertical Heliostat Fields" architecturally integrated into building facades*
Authors: González-Pardo, A.; Rodríguez, A.; González-Aguilar, J.; Romero, M.
Congress: SolarPACES 2012
Venue: Marrakech, Morocco
Date: 11-14 September 2012
Organizer: SolarPACES, MASEN, IRESEN

27. Title: *Thermal performance and residence time distribution determination in a solar reactor for chemical kinetics analysis*
Authors: Alonso, E.; González-Aguilar, J.; Pérez-Rábago, C.A.; Romero, M.
Congress: SolarPACES 2012
Venue: Marrakech, Morocco
Date: 11-14 September 2012
Organizer: SolarPACES, MASEN, IRESEN

28. Title: *Development and optical characterization of a carousel-type heliostat*
Authors: Pérez-Rábago, C.A.; González-Aguilar, J.; Prakash, R.; Sachant, S.; Goel, N.; Romero, M.
Congress: SolarPACES 2012
Venue: Marrakech, Morocco
Date: 11-14 September 2012
Organizer: SolarPACES, MASEN, IRESEN

29. Title: *The TCSPower Project – Thermochemical energy storage for concentrated solar power plants*
Authors: Wörner, A.; Binyamini, S.; Giger, F.; González-Aguilar, J.; Soupart, J.; Steinfeld, A.; Trettin, R.
Congress: SolarPACES 2012
Venue: Marrakech, Morocco
Date: 11-14 September 2012
Organizer: SolarPACES, MASEN, IRESEN

30. Title: *SolH$_2$- Solar-driven hydrogen production by bioethanol reforming and thermochemical mixed-ferrite cycle*
Authors: Diaz-Franco, R.; Gallardo Garcia-Orta, V.; González-Aguilar, J.; Gutiérrez-Ortiz, F.J.; Martín- Betancourt, M.; Pérez Vega-Leal, A.; Ridao-Carlini, M.A.; Romero-Álvarez, M.; Tapia, E.; Vidal-Delgado, A.; Vázquez, J.; Pérez, A.
Congress: SolarPACES 2012
Venue: Marrakech, Morocco
Date: 11-14 September 2012
Organizer: SolarPACES, MASEN, IRESEN

31. Title: *Factors influencing hydrogen production and sodium recovery in the NaOH-MnO thermochemical cycle*
Authors: Bayón, A.; de la Peña-O'Shea, V.A.; Serrano, D.P.; Coronado, J.M.
Congress: SolarPACES 2012
Venue: Marrakech, Marruecos
Date: 11-14 September 2012
Organizer: SolarPACES, MASEN, IRESEN

32. Title: *Gestión de energía en edificios inteligentes*
Authors: Gruber, J.K.; Prodanoviç, M.; Téllez Molina, M.B.; Gafurov, T
Congress: I Congreso Smart Grids
Venue: Madrid
Date: 22-23 October 2012
Organizer: Grupo Tecma Red S.L.

Poster communications

1. Title: *Laccase detoxification of steam-exploded wheat straw for ethanol production by SSF processes with the thermotolerant yeast Kluyveromyces marxianus*
Authors: Moreno, A.D.; Ibarra, D.; Ballesteros, I.; Ballesteros, M.
Congress: Advanced Biofuels in a Biorefinery Approach
Venue: Copenhague, Denmark
Date: 28 February - 1 March 2012
Organizer: University of Copenhague, Bio4Bio

2. Title: *Effect of laccases on bioethanol production from steam-exploded wheat straw at high solids loading*
Authors: Moreno, A.D.; Alvira, P.; Ibarra, D.; Ballesteros, M.
Congress: 34th Symposium on Biotechnology for Fuels and Chemicals (34th SBFC)
Venue: Nueva Orleans, USA
Date: 30 April - 3 May 2012
Organizer: ORNL, NREL

3. Title: *Laccase detoxification of steam-exploded wheat straw for ethanol production by SSF and PSSF processes with the thermotolerant yeast Kluyveromyces marxianus*
Authors: Moreno, A.D.; Ibarra, D.; Ballesteros, I.; Fernández-Rojo, J.L.; Ballesteros, M.
Congress: 34th Symposium on Biotechnology for Fuels and Chemicals (34th SBFC)
Venue: Nueva Orleans, USA
Date: 30 April - 3 May 2012
Organizer: ORNL, NREL

posters communications

4. Title: *Optical and energetic analysis of solar fields: mini- versus large-heliostats comparison*
Authors: González-Aguilar, J.; Romero M.
Congress: World Renewable Energy Forum 2012 (WREF 2012)
Venue: Denver, Colorado, USA
Date: 13-17 May 2012
Organizer: ASES, WREN, ISES, NREL, CRES

5. Title: *Assessment of copper-based electrolytes for redox flow batteries applications*
Authors: Sanz, L.; Palma, J.; Anderson, M. García-Quismondo, E.
Congress: The 12th International Conference on Energy Storage (Innostock 2012)
Venue: Lleida, Spain
Fecha: 16-18 May 2012
Organizer: University of Lleida; GREA Innovació Concurent

6. Title: *Influence of the synthesis method on the energy storage capacity of $Mn_{2-x}Co_xO_3$ materials*
Authors: Moya, J.; Bayón, A.; Jana, P.; Romero, M.; González-Aguilar, J.; de la Peña-O'Shea, V.; Serrano, D.P.; Coronado, J.M. J
Congress: The 12th International Conference on Energy Storage (Innostock 2012)
Venue: Lleida, Spain
Fecha: 16-18 May 2012
Organizer: University of Lleida; GREA Innovació Concurent

7. Title: *Life cycle assessment of hydrogen production via lignocellulosic biomass gasification*
Authors: Iribarren, D.; Susmozas, A.; Petrakopoulou, F.; Dufour, J.
Congress: 19th World Hydrogen Energy Conference 2012 (WHEC 2012)
Venue: Toronto, Canadá
Date: 3-7 June 2012
Organizer: Canadian Hydrogen and Fuel Cell Association; Natural Resources Canada

8. Title: *On the cumulative exergy demand of two processes producing biodiesel from algae*
Authors: Petrakopoulou, F.; Iribarren, D.; Dufour, J.
Congress: 2nd International Conference on Algal Biomass, Biofuels and Bioproducts
Venue: San Diego, USA
Date: 10-13 June 2012
Organizer: Elsevier

9. Title: *Asphaltene stability in high pressure tests with methane*
Authors: Dufour, J.; Calles, J.A.; Marugán, J.; Giménez-Aguirre, R.; Merino-Garcia, D.; Peña, J.L.; Carrier, H.
Congress: 13th International Conference on Petroleum Phase Behavior (Petrophase 2012)
Venue: St. Petersburg Beach, Florida, USA
Date: 10-14 June 2012
Organizer: University of Florida

10. Title: *Thermodynamic evaluation of the gasification of lignocellulosic biomass for hydrogen production*
Authors: Petrakopoulou, F.; Susmozas, A.; Iribarren, D.; Dufour, J.
Congress: 20th European Biomass Conference and Exhibition
Venue: Milán, Italy
Date: 18-22 June 2012
Organizer: European Commission

11. Title: *Well-to-wheels comparison of the environmental profile of pyrolysis-based biofuels*
Authors: Iribarren, D.; Peters, J.F.; Petrakopoulou, F.; Dufour, J.
Congress: 20th European Biomass Conference and Exhibition
Venue: Milán, Italy
Date: 18-22 June 2012
Organizer: European Commission

12. Title: *Thermodynamic evaluation of the gasification of lignocellulosic biomass for hydrogen production*
Authors: Petrakopoulou, F.; Susmozas, A.; Iribarren, D.; Dufour, J.
Congress: 20th European Biomass Conference and Exhibition
Venue: Milán, Italy
Date: 18-22 June 2012
Organizer: European Commission

13. Title: *Análisis de la influencia de la talla de los helióstatos en el rendimiento óptico-energético de campos solares*
Authors: González-Aguilar, J.; Goel, N.; Romero M.
Congress: XV Congreso Ibérico y X Congreso Iberoamericano de Energía Solar (CIES 2012)
Venue: Vigo, Spain
Date: 19-22 June 2012
Organizer: Asociación Española de Energía Solar

14. Title: *Environmental and thermodynamic comparison of post-combustion CO_2 capture systems*
Authors: Dufour, J.; Iribarren, D.; Petrakopoulou, F.; Susmozas, A.
Congress: Congreso Internacional de Ingeniería Química (ANQUE ICCE 2012)
Venue: Seville, Spain
Date: 24-27 June 2012
Organizer: ANQUE

15. Title: *Catalytic decomposition of light hydrocarbons over ordered mesoporous carbons*
Authors: Botas, J.A.; Serrano, D.P.; Pizarro, P.; Gómez, G.
Congress: International Symposium on "Catalysis for Clean Energy and Sustainable Chemistry" (CCESC2012)
Venue: Alcobendas, Madrid, Spain
Date: 27-29 June 2012
Organizer: EQS; Ibercat-soluciones catalíticas

16. Title: *Methane decomposition for CO_2-free H_2 formation with co-production of graphene over cobalt based catalyst*
Authors: Jana, P.; de la Peña O'Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: International Symposium on "Catalysis for Clean Energy and Sustainable Chemistry" (CCESC2012)
Venue: Alcobendas, Madrid, Spain
Date: 27-29 June 2012
Organizer: EQS; Ibercat-soluciones catalíticas

17. Title: *Catalytic cracking of rapeseed oil over hybrid zeolitic ordered mesoporous materials for the production of raw chemicals and fuels*
Authors: Serrano, D.P.; Botas, J.A.; García, A.; Linares, M.; Ramos, R.
Congress: International Symposium on "Catalysis for Clean Energy and Sustainable Chemistry" (CCESC2012)
Venue: Alcobendas, Madrid, Spain
Date: 27-29 June 2012
Organizer: EQS; Ibercat-soluciones catalíticas

18. Title: *Deoxygenation of methyl esters using alternative non-sulfided catalysts based on Ni and Co supported on acidic mesostrutured silicas*
Authors: Ochoa-Hernández, C.; Yang, Y.; de la Peña O'Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: International conference on "Advances in catalysis for biomass valorization" (CAT4BIO)
Venue: Thessaloniki, Greece
Date: 8-11 July 2012
Organizer: University of Thessaloniki

19. Title: *Supercapacitor electrode materials based on MOFs*
Authors: Orcajo, M. G.; Botas, J. A.; Calleja, G.; Díaz, R.; Palma, J.
Congress: MOF2012
Venue: Edinburgh, United Kingdom
Date: 16-19 September 2012
Organizer: DECHEMA

20. Title: *Gestión de energía en edificios inteligentes*
Authors: Gruber, J.K.; Prodanoviç, M.; Téllez Molina, M.B.; Gafurov, T
Congress: I Congreso Smart Grids
Venue: Madrid, Spain
Date: 22-23 October 2012
Organizer: Grupo Tecma Red S.L.

21. Title: *Aplicación de la DEsionización Capacitiva a Aguas Residuales (ADECAR)*
Authors: García, V.; Palma, J.; De Miguel, A.; Lavela, P.; Macías, C.
Congress: 11st Congreso Nacional del Medio Ambiente (CONAMA 2012)
Venue: Madrid, Spain
Date: 26-30 November 2012
Organizer: Conama Foundation

training and dissemination activities

9

annual report 2012

conferences and courses

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. e-Energy2012, Third International conference on future energy systems
Technical Programme Chair: Milan Prodanovic
Venue: Carlos III University, Leganés, Spain
Date: 9-11 May 2012
Organizer: IMDEA Networks Institute, Carlos III University

2. The 12th International conference on energy storage (Innostock 2012)
Member of Scientific Commitee: Raúl Díaz
Venue: Lleida, Spain
Date: 16-18 May 2012
Organizer: University of Lleida, GREA Innovació Concurent

3. International congress of chemical engineering (ANQUE ICCE 2012)
Member of Scientific Commitee: David Serrano
Venue: Seville, Spain
Date: 24-27 June 2012
Organizer: ANQUE

4. XXXIII Electrochemistry group meeting of RSEQ
Member of Scientific Commitee: Jesús Palma
Venue: Madrid, Spain
Date: 4-7 July 2012
Organizer: RSEQ; UAM; CSIC; IQFR; ISE

5. Workshop of Spanish network of Life Cycle Assessment
Technical Programme Chair: Javier Dufour
Venue: IMDEA Energy Institute, Móstoles, Spain
Date: 5 November 2012
Organizer: IMDEA Energy Institute

6. Course: Técnicas instrumentales, Análisis y Control de Procesos
Speakers: Coronado, J.; Jana, P.; Garcia, L.; Demuez, M.; de la Peña, V.; Marcilla, R.; González, J.; Iribarren, D.; Sanz, A.; Matatagui, P.; Serrano, D.; Picó, F.; Díaz, R.; Pizarro, P.
Venue: IMDEA Energy Institute, Móstoles, Spain
Date: 28-30 November 2012
Organizer: IMDEA Energy Institute

7. 1st Annual Workshop of Young Researchers of IMDEA Energy
Venue: IMDEA Energy Institute, Móstoles, Spain
Date: 14 December 2012
Organizer: IMDEA Energy Institute

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. Lecture: New Directions in Electrochemical Imaging: Structure-Activity at the Nanoscale
Speaker: Patrick Unwin (University of Warwick, United Kingdom)
Date: 22 March 2012

2. Lecture: Energía Solar: Tecnología y Aplicaciones
Speaker: Manuel Romero (IMDEA Energy Institute)
Date: 26 April 2012

3. Oral Presentation: Integration of CSP on building facades
Speaker: Aurelio González (IMDEA Energy Institute)
Date: 25 May 2012

4. Lecture: Power electronics – Circuits, Control and Applications
Speaker: Milan Prodanovic (IMDEA Energy Institute)
Date: 4 June 2012

5. Seminar on the preparation of European projects proposals
Speaker: Sara Alfonso and Arturo Menendez (Fundación madri+d)
Date: 15 June 2012

6. Lecture: Development of catalysts for thermo-chemical transformations of biomass into liquid fuels
Speaker: Juan Coronado (IMDEA Energy Institute)
Date: 22 June 2012

7. Oral Presentation: Professional Training Year at IMDEA Energy Institute
Speaker: Gabriel Casano (IMDEA Energy Institute)
Date: 2 July 2012

8. Lecture: Retos, mecanismos y control de la desactivación de catalizadores ácidos en procesos de la refinería sostenible
Speaker: Pedro Castaño (Basque Country University)
Date: 4 July 2012

9. Lecture: Sorption-based low-temperature heat storage: structure-property relationship in microporous aluminophosphate
Speaker: Natasa Zabukovec (National Institute of Chemistry, Ljubljana, Slovenia)
Date: 26 September 2012

10. Lecture: Nanowire and its futuristic application for devices
Speaker: Sachindranath Das (Burdwan Raj College, West Bengal, India)
Date: 4 October 2012

11. Lecture: Bioenergía: perspectivas
Speaker: Mercedes Ballesteros (IMDEA Energy Institute)
Date: 5 October 2012

lectures
and seminars

12. Oral Presentation: Novel Zn(1-x)GaxO nanostructures with Pt nanoparticles as water splitting photocatalyst
Speaker: Julio Núñez (IMDEA Energy Institute)
Date: 11 October 2012

13. Lecture: Decarbonization at crossroads: the cessation of the positive historical trend or a temporary detour?
Speaker: Nazim Muradov (Florida Solar Energy Center, USA)
Date: 13 November 2012

14. Oral Presentation: Role of textural properties and surface functionalities of carbons in the performance of Electrical Double Layer Capacitors (EDLCs)
Speaker: Susana Vaquero (IMDEA Energy Institute)
Date: 9 November 2012

15. Lecture: Energía eólica: tecnología on-shore y off-shore
Speaker: Enrique Soria (CIEMAT)
Date: 15 November 2012

16. Oral Presentation: Solar tower systems for hydrogen production through steam electrolysis
Speaker: Javier Sanz (IMDEA Energy Institute)
Date: 3 December 2012

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. Master in Renewable Energies and Environment
Module: Solar thermal power plants
Speaker: Romero, M. (Coordinator) and González-Aguilar, J.
Venue: UPM, Madrid, Spain
Date: 1 January-30 June 2012
Organizer: Polytechnic University of Madrid

2. Master in Renewable Energies and Energy Market
Module: Solar Energy
Speaker: Romero, M. (Coordinator), González-Aguilar, J. and Ballesteros, M.
Venue: EOI, Madrid, Spain
Date: 1 January-30 June 2012
Organizer: EOI

3. Master in Renewable Energies in the industry
Speaker: Ballesteros, M.
Venue: Zaragoza, Spain
Date: 7 February-3 March 2012
Organizer: San Jorge University (Zaragoza)

4. Course: Executive management program of renewable energy projects
Module: Energy from biomass and biofuels
Speaker: Serrano, D.P.
Venue: EOI, Madrid, Spain
Date: 17 February 2012
Organizer: EOI

5. Course: Executive management program of renewable energy projects
Conference: Future power networks
Speaker: Prodanovic, M.
Venue: EOI, Madrid, Spain
Date: 17 February 2012
Organizer: EOI

6. Master in Renewable Energies
Speaker: Ballesteros, M.
Venue: Zaragoza, Spain
Date: 9 March 2012
Organizer: University of Zaragoza-CIRCE

7. Master Executive on Renewable Energies
Module: Solar Thermoelectricity
Speaker: González-Aguilar, J.
Venue: Santo Domingo, Dominican Republic
Date: 26-30 March 2012
Organizer: PUCMM; EOI

8. Chalmers Energy Conference: Electricity for tomorrow
Conference: Concentrated Solar Power (CSP)-Technologies and challenges
Speaker: Romero, M.
Venue: Gothenburg, Sweden
Date: 28-29 March 2012
Organizer: Chalmers University of Technology

9. Invited conference at University of Stockholm
Conference: Catalysis for energy from fundamental to a sustainable energetic development
Speaker: De la Peña, V.A.
Venue: Stockholm, Sweden
Date: 5 April 2012
Organizer: University of Stockholm

10. Seminar: Introduction to research in energy engineering and chemistry
Speakers: Serrano, D.P.; Coronado, J.M.; Gruber J.K.; Prodanovic, M.; Palma, J.; González, J.; Ballesteros, M.; Dufour, J.
Venue: URJC, Móstoles, Spain
Date: 7-8 May 2012
Organizer: URJC; IMDEA Energy Institute

11. Workshop: Electrochemistry. Present and future
Conference: Systems and technologies for electrochemical energy storage
Speaker: García-Quismondo, E.
Venue: UAM, Madrid, Spain
Date: 11 May 2012
Organizer: Autonoma University of Madrid

12. Invited conference at Pontificia Universidad Católica de Chile
Conference: New electrochemical technologies for energy efficient storage and water treatment
Speakers: Palma, J.; Anderson, M.
Venue: Chile
Date: 22 May 2012
Organizer: Pontificia Universidad Católica de Chile

13. Workshop: 2nd Thematic Forum-EMIS forum on renewable solar energy
Conference: Advances in CSP technology: towards the next generation
Speaker: Romero, M.
Venue: Tunisia
Date: 25-26 June 2012
Organizer: The Mediterranean Innovation and Research Action (MIRA)

14. Master in engineering and environmental management
Module: Sustainability management
Conference: Thermal and thermoelectric power
Speaker: Romero, M.
Venue: EOI, Madrid, Spain
Date: 29 June 2012
Organizer: EOI

15. Summer School: Renewable energies today: promoting a more sustainable society
Conference: Solar thermal power plants
Speaker: Romero, M.
Venue: Pontevedra, Spain
Date: 2-4 July 2012
Organizer: UNED

16. Summer School: Air pollution. Climate effect and role of alternative energy
Conference: Renewable energies in the current energy situation and its potential in reducing air emissions
Speaker: Romero, M.
Venue: Ciudad Real, Spain
Date: 11-13 July 2012
Organizer: University of Castilla La Mancha

17. Summer School: The XXI century transportation with clean energy: electric vehicles and hydrogen fuel cell
Round table: Sustainable transport
Moderator: Romero, M.
Venue: Aranjuez, Spain
Date: 16 July 2012
Organizer: URJC Foundation

18. Summer School: The XXI century transportation with clean energy: electric vehicles and hydrogen fuel cell
Round table: The hybrid and electric vehicle
Moderator: Palma, J.
Venue: Aranjuez, Spain
Date: 16 July 2012
Organizer: URJC Foundation

19. Summer School: Technologies to combat climate change. CO_2 capture and storage
Conference: Transformation of CO_2 by artificial photosynthesis in search of the sangrail
Speaker: De la Peña, V.A.
Venue: La Granja, Spain
Date: 25 July 2012
Organizer: Polytechnic University of Madrid

20. Science Month 2012. Renewable energies
Conference: Solar energy
Speaker: Romero, M.
Venue: Institut français of Spain, Madrid, Spain
Date: 8 November 2012
Organizer: Ambassade de France en Espagne

21. Master on Renewable Energies, Hydrogen and Fuel Cells
Module: Solar energy
Speakers: Romero, M. (Coordinator) and González-Aguilar, J.
Venue: Madrid, Spain
Date: 20 November-21 December 2012
Organizer: CSIC-UIMP

9.4. Participation in science dissemination activities

The main science dissemination events in which the IMDEA Energy Institute has been involved in 2012 are listed below:

1. GENERA 2012: Workshop on public research capacities in the Comunidad de Madrid in Renewable Energies
Conference: The electric car and energy storage
Speaker: Prodanovic, M.
Venue: IFEMA, Madrid, Spain
Date: 23-25 May 2012
Organizer: Madri+d Foundation

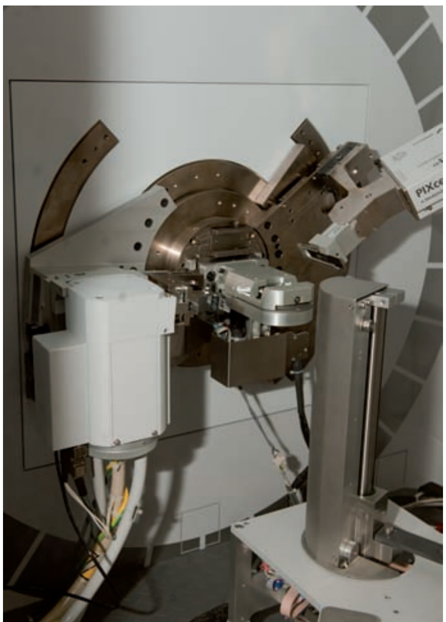
2. GENERA 2012: Infoday on R&D European funding in Energy and Environment
Conference: TCSPower project: Thermochemical Energy Storage for Concentrated Solar Power Plants
Speaker: Romero, M.
Venue: IFEMA, Madrid, Spain
Date: 23-25 May 2012
Organizer: Madri+d Foundation

3. Researchers' night 2012
Activity: On tour in science
Date: 28 September 2012
Venue: IMDEA Energy Institute, Móstoles, Madrid
Organizer: IMDEA Energy Institute

4. Researchers' night 2012
Round table on life science researchers
Conference: Science is my life
Speaker: Prodanovic, M.
Venue: Madrid, Spain
Date: 28 September 2012
Organizer: Madri+d Foundation

5. Science Week of Comunidad de Madrid (2012)
Activity: GYMKANA: In search of a sustainable world
Partners: HTPU, ECPU, SAU, TCPU
Venue: IMDEA Energy Institute, Móstoles, Madrid
Date: 6 and 8 November 2012
Organizer: IMDEA Energy Institute

6. Science Week of Comunidad de Madrid (2012)
Activity: Lectures. Energy, environment and sustainable development
Partners: BTPU, ELSU
Venue: Móstoles, Spain
Date: 12-13 November 2012
Organizer: IMDEA Energy Institute; URJC



science dissemination activities

9.5. Undergraduated students. Training

1. Mr. Abajo, Pablo
M. Sc. in renewable energy, fuel cells and hydrogen, Menéndez Pelayo International University and CSIC
Project title: Optical adjustment and characterization of a carrousel-type heliostat under real operating conditions
Supervisor: Dr. José González, HTPU
Date of defense: June 2012

2. Mr. Abajo, Pablo
Internship work: Participation in operation and maintenace activities of a carrousel-type heliostat
Supervisor: Dr. José González, HTPU
Period: March 2012-June 2012

3. Ms. Aguilar, Alexandra
M. Sc. in Technology and Energy Resources, Rey Juan Carlos University
Project title: Design of a solar thermal installation
Supervisor: Dr. Javier Dufour, SAU
Date of defense: July 2012

4. Mr. Arteche, Alberto
M. Sc. in renewable energy, fuel cells and hydrogen, Menéndez Pelayo International University and CSIC
Project title: Optical analysis and design of an optical mixer for its installation in a high-flux solar simulator
Supervisor: Dr. José González, HTPU
Date of defense: June 2012

5. Mr. Arteche, Alberto
Internship work: Participation in theoretical and experimental characterization of radiation in a high-flux solar simulator
Supervisor: Dr. José González, HTPU
Period: April 2012-July 2012

6. Mr. Blanco, Víctor
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Thermal analysis of commercial manganese oxides for thermochemical storage in concentrating solar power plants
Supervisor: Dr. José Gonzalez (HTPU) and Dr. Javier Marugán
Date of defense: January 2012

7. Mr. Casano, Gabriel
Internship work: Developing user interface and control platforms for smart energy integration laboratory
Supervisor: Dr. Milan Prodanovic, ELSU
Period: September 2011-August 2012

8. Ms. De Francisco, Olga
M. Sc. in renewable energy and environment, Polytechnic University of Madrid
Project title: Thermodynamic analysis of solar receivers for direct steam generation
Supervisor: Dr. Manuel Romero and Mr. Javier Sanz, HTPU
Date of defense: September 2012

9. Ms. Del Hoyo, Maria Orfila
Internship work: Redox cycles for thermochemical energy storage
Supervisor: Dr. Juan Coronado, TCPU
Period: January 2012-July 2012

10. Mr. Fernández, Fernando
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Development of a methodology for the estimation of emergy of hydrogen obtained from bioethanol
Supervisor: Dr. Javier Dufour (SAU) and Dr. Juan A. Botas
Date of defense: January 2012

11. Mr. Gallo, Alessandro
Internship work: Development of software for energy analysis on integration of renewable energies in buildings. Internship for a Leonardo da Vinci Trainee
Supervisor: Dr. José González, HTPU
Period: January 2012-May 2012

12. Mr. Gurpegui, Félix
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Ni/ZSM-5 catalysts with hierarchical porosity
Supervisor: Ms. Cristina Ochoa (TCPU) and Dr. Marta Paniagua
Date of defense: June 2012

13. Mr. Köhl, Maximilian
Internship work: Optimization of bioethanol synthesis from microalgae
Supervisor: Dr. Javier Dufour and Dr. Diego Iribarren, SAU
Period: August 2012-February 2013

14. Ms. López, María
M. Sc. in Technology and Energy Resources, Rey Juan Carlos University
Project title: FTIR monitoring of water adsorption on MOF's and ALPO's for seasonal heat storage
Supervisor: Dr. Juan Coronado and Dr. David Serrano, TCPU
Date of defense: June 2012

15. Mr. Lucas, Antonio C.
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Design, assembly and commissioning of a laboratory-scale test bed for analyse hydrogen production using concentrating solar energy
Supervisor: Dr. José Gonzalez (HTPU) and Dr. Juan A. Botas
Date of defense: June 2012

16. Mr. Martín, Mario
Internship work: Environmental assessment of geothermal systems
Supervisor: Dr. Javier Dufour and Dr. Diego Iribarren, SAU
Period: October 2012-January 2013

17. Mr. Martínez, Graciano
M. Sc. in Engineering of Chemical and Environmental Processes, Rey Juan Carlos University
Project title: Influence of relative humidity of reactive gases on the efficiency of PEMFCs
Supervisor: Dr. Javier Dufour, SAU
Date of defense: September 2012

18. Ms. Mata, Cristina
Internship work: Water splitting
Supervisor: Dr. Víctor de la Peña and Dr. Prabhas Jana, TCPU
Period: September 2012-December 2012

19. Mr. Mendoza, Álvaro
M. Sc. in Chemical and Environmental Engineering Processes, Rey Juan Carlos University
Project title: Development of supercapacitors based on activated carbon electrodes and ionic liquid electrolyte
Supervisor: Dr. Rebeca Marcilla, ECPU
Date of defense: January 2012

20. Mr. Miroslavov, Veselin
Internship work: Prototyping electrodes for electrochemical reactors (supercapacitors, metal-air batteries) by coating technique, from laboratory up to pilot plant scale
Supervisor: Dr. Enrique García-Quismondo, ECPU
Period: June 2012-December 2012

21. Mr. Mora, Mauricio
M. Sc. in Technology and Energy Resources, Rey Juan Carlos University
Project title: Use of ionic Liquids as electrolytes in Electrical Double Layer Capacitors (EDLC)
Supervisor: Dr. Rebeca Marcilla, ECPU
Date of defense: January 2012

22. Mr. Moya, Javier
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Synthesis of Mn_2O_3 doped with Co for thermochemical storage at high temperature
Supervisor: Dr. Juan Coronado (TCPU) and Dr. Javier Marugán
Date of defense: June 2012

23. Ms. Moyano, Edelweiss
Internship work: CO_2 valorisation by photocatalytic processes
Supervisor: Dr. Víctor de la Peña, TCPU
Period: September 2012-December 2012

24. Mr. Nieva, David
Internship work: Assembly and characterization of supercapacitors (SC's) based on activated carbons
Supervisor: Dr. Rebeca Marcilla, ECPU
Period: June 2012-December 2012

25. Ms. Pastor, Belén
Internship work: Application of emergy methodology to energy systems
Supervisor: Dr. Javier Dufour, SAU
Period: June 2012-December 2012

26. Ms. Rodríguez, Almudena
M. Sc. in renewable energy and environment, Polytechnic University of Madrid
Project title: Analysis of solar shading caused by "Vertical Heliostats Fields" architecturally integrated into building façades
Supervisor: Dr. Manuel Romero and Mr. Aurelio José González, HTPU
Date of defense: September 2012

27. Mr. Sahuquillo, Carlos
M. Sc. in Technology and Energy Resources, Rey Juan Carlos University
Project title: Energy storage systems for power networks: NAS battery application
Supervisor: Dr. Milan Prodanovic, ELSU
Date of defense: September 2012

28. Ms. Santos, Cleis
Internship work: Analyze of the electric work during asymmetric charge-discharge processes on a Capacitive Deionization (CDI) reactor
Supervisor: Dr. Enrique García-Quismondo, ECPU
Period: November 2011-May 2012

29. Ms. Sierra, Blanca
B. Sc. in Chemical Engineering, Rey Juan Carlos University
Project title: Synergy between metal nanoparticles and semiconductors in Au/TiO_2 and Ag/TiO_2 photocatalysts for CO_2 valorisation
Supervisor: Dr. Víctor de la Peña and Dr. Patricia Pizarro, TCPU
Date of defense: January 2012

30. Ms. Susmozas, Ana I.
M. Sc. in Technology and Energy Resources, Rey Juan Carlos University
Project title: Environmental and exergy assessment of hydrogen production through biomass gasificaction
Supervisor: Dr. Javier Dufour and Dr. Diego Iribarren, SAU
Date of defense: July 2012

31. Mr. Tello, Rodrigo
Internship work: Review of economical correlations for cost estimation of equipments
Supervisor: Dr. Javier Dufour, SAU
Period: June 2012-December 2012

32. Ms. Zazo, Lidia
Internship work: Study on the feasibility of using microvawe-based treatments for the transformation of lignocellulosic biomass into bio-oils with simpler and more convenient composition than those obtained in conventional fast pyrolysis
Supervisor: Dr. Juan Coronado, TCPU
Period: December 2012-June 2013

scientific highlights

10

annual report

2012

Integration of High Temperature Electrolyzers in Concentrating Solar Power Plants

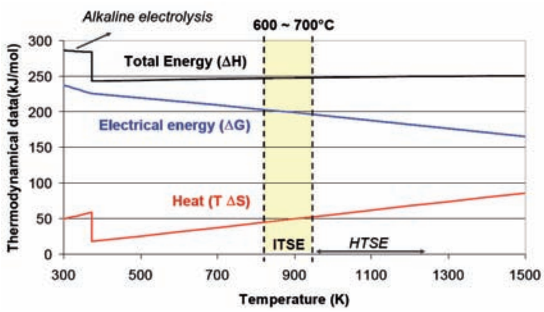
Worldwide hydrogen demand is projected to increase 4.1 % annually through 2016 to 286 billion cubic meters. This projection is based on current demand processes such as low-sulphur fuels production, chemical manufacturing applications, and production of semiconductors, float glass, metal components and food processing. Nevertheless, if the cost reduction goal for fuel-cell vehicles is reached, the transportation sector may ultimately run with hydrogen. This will result in an increase of hydrogen demand one/two orders of magnitude for the next decades [1].

Current hydrogen production is based mainly in methane reforming and conventional electrolysis processes. The first process consumes fossil fuels and releases greenhouse gases into the atmosphere. Thus negligible environmental advantages can be expected from the use of hydrogen as an energy carrier. Nevertheless, solar and wind energy sources couple with electrolysis systems have great potential to cover future hydrogen demand. Conventional water electrolysis is a well-established technology, where integration with renewable energy sources such as wind power and photovoltaics has been proved in several projects since the early nineties [2]. However, commercial liquid water electrolysis consumes great amount of electricity: Proton exchange membrane (PEM) electrolysers require 6.7 kW_e/Nm^3 of hydrogen and Alkaline electrolysers 4.9 kW_e/Nm^3 of hydrogen [3].

Steam electrolysis through Solid-Oxide Electrolysis Cell (SOEC) coupled with renewable energy sources stands up for a promising system [4]. This technology uses the same system than Solid-Oxide Fuel Cell (SOFC) but in reverse mode. SOEC technology shows great advantages in comparison with liquid water electrolysis. Main advantages of operating at the temperature range of 800-1000 ºC are the reduction of electricity requirements by around 30 %, yielding to 3.2 kW_e/Nm^3 of hydrogen (see the free energy water split diagram in Figure 1); and the capacity of working at higher current density which increases the hydrogen production per cell area. However, these high temperatures enhance chemical species evaporation and diffusion, and decreases mechanical stability of main components, which reduces electrolyser performance and lifetime [5]. Therefore, following the trends in SOFC cells, last experiences on SOEC technology have been focused on the development of the so-called Intermediate Temperature SOEC (IT-SOEC), also called ITSE or Intermediate Temperature Steam Electrolyzer, which works in the range of 600-700 ºC (Figure 1). Current research is aimed at optimising the electrolyser life time by decreasing its operating temperature while maintaining satisfactory performance level and high energy efficiency.

IMDEA Energy Institute is working on optimizing the integration of an IT-SOEC system into concentrating solar power (CSP) plants and hybrid biomass-PV plants. This research is carried out within the framework of the collaborative research project ADEL (ADvanced ELectrolyser for Hydrogen Production with Renewable Energy Sources), that focuses on the development of cost-competitive, energy efficient and sustainable hydrogen production based on renewable energy sources (http://www.adel-energy.eu/). ADEL is co-funded by the European Commission`s 7th Framework Programme (FP7) via the Fuel Cells and Hydrogen Joint Undertaking (FCH-JU).

Among commercial CSP technologies, central receiver systems (Figure 2) and linear Fresnel collectors have been selected as excellent candidates, because of the high performance of the first one and the simplicity and low cost of the second [6]. The research is aimed at optimizing the integration of both systems, and analysing the capabilities of the hybrid plant for hydrogen supply and electric grid management. Concerning the first objective, several flow diagrams have been analysed focusing on the re-utilization of hot rejected streams from the electrolyser unit to enhance solar power block performance. Regarding the second goal, operational modes for stationary and transient conditions have been developed to optimize the integration of the hybrid plant into the electric grid.



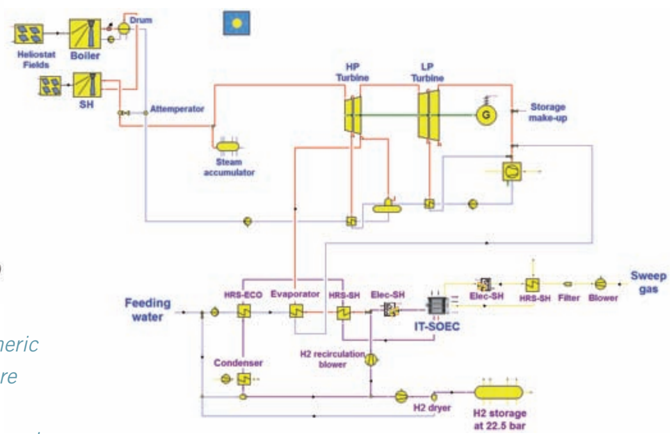


Figure 1. (top) Free energy water split diagram at atmospheric pressure. High Temperature Steam Electrolyzers (HTSE) are applied above 700ºC.
Figure 2. (right) Flow diagram of a direct steam generation solar central receiver system and IT-SOEC unit

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[1] "World Hydrogen: Industry Study with Forecasts for 2013 & 2018," Cleveland, OH, USA, 2010.
[2] Gahleitner, G. "Hydrogen from renewable electricity: An international review of power-to-gas pilot plants for stationary applications," *International Journal of Hydrogen Energy*, 2013, 38 (5), 2039–2061.
[3] "Hydrogenics," 2013. [Online]. Available: http://www.hydrogenics.com. [Accessed: 12-Mar-1BC].
[4] Jacobson, A. J. "Materials for Solid Oxide Fuel Cells," *Chemestry of materials*, 2010, 22 (3), 660–674.
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[6] Romero M. and González Aguilar J. "Solar thermal power plants: from endangered species to bulk power production in sun-belt regions". Chapter 3. Energy & Power Generation Handbook," edited by K.R. Rao. ASME Three Park Avenue, New York, NY 10016-5990, USA, 2011.

strategies to deve

competitive supercapacitors

Strategies to Develop Commercially Competitive Supercapacitors

Electrochemical capacitors, also called supercapacitors (SCs), are electrochemical energy storage systems that meet applications requiring high power values for short periods (ten seconds) and defined by a very high number of charge/discharge cycles (millions) [1,2]. Their energy density (about 5 Wh kg^{-1}) is lower than in batteries, but a much higher power delivery or uptake (10 kW kg^{-1}) can be achieved for shorter times (a few seconds). Therefore, they can complement or replace batteries in electrical energy storage and harvesting applications, when high power delivery or uptake is needed.

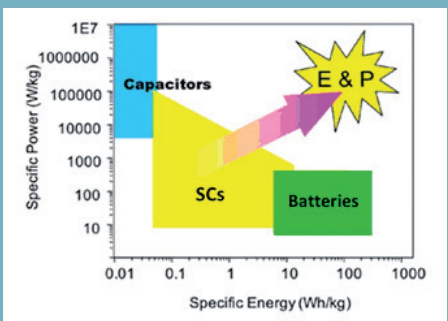

Figure 1 (left): Ragone plot of several electrochemical energy storage systems.

Thus, if energy densities of supercapacitors could be increased keeping low costs and their typical high power densities and long cycling life, they could become the high performance electrical energy storage which are expected to be necessary for renewable energy implementation [3]. These devices may be of use to smooth out the intermittency of renewable energy production, or to make possible the electrification of transportation. For example, some estimates suggest that in 2020 we will have about 8 million Hybrid and Electric Vehicles (according to the International Energy Agency). The demand for higher performance electrochemical energy storage technologies is becoming more and more critical due to the emergence of these two related issues; need for harvesting renewable energy effectively ("smart grid concept") and the development of hybrid and electric vehicles.

Several types of SCs can be distinguished, depending on the charge storage mechanism as well as the active materials used. Electrical Double-Layer Capacitors (EDLCs), the most common devices at present, store energy by electrostatic forces using carbon-based active electrode materials with high surface area [4, 5]. A second group of SCs, known as pseudo-capacitors uses fast and reversible surface or near-surface electrochemical oxidation-reduction reactions for charge storage. Transition metal oxides as well as electrically conducting polymers are examples of pseudo-capacitive active electrode materials. Conducting polymers can be more conductive than the inorganic battery materials and consequently have greater power capability. Moreover, conducting polymers possess greater diversity that metallic oxides because of the wide variety of organic molecular structures. On the downside, conducting polymers swell and contract substantially on charge and discharge suffering from poor cycle-life. Finally, hybrid capacitors combine a capacitive electrode with a battery electrode such as lithium to benefit from both the capacitor and the battery properties.

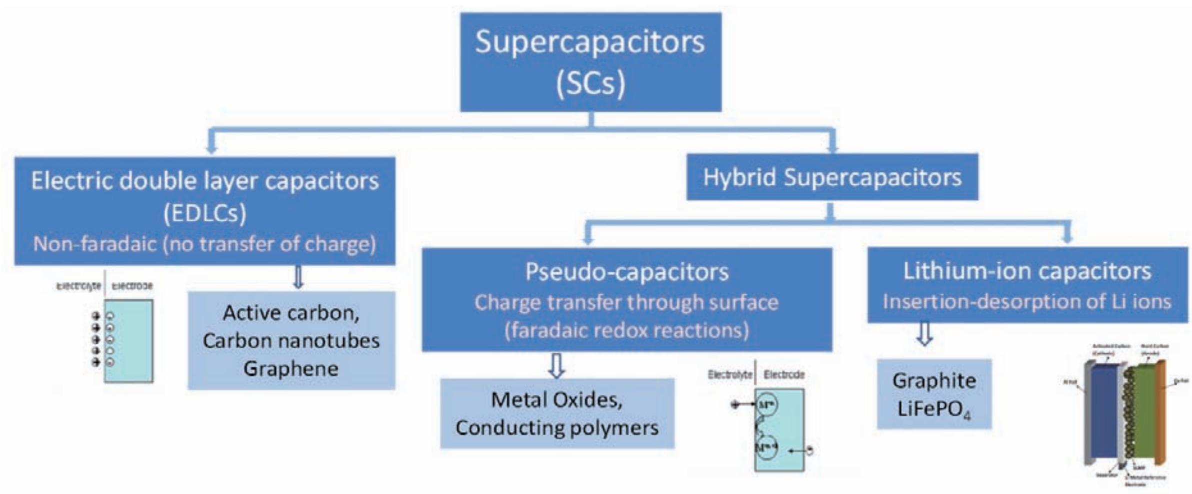

Figure 2 (right): Types of Supercapacitors

Thus, taking into account the diversity of SC technologies, and as nowadays the main challenge in SC technology is to improve the energy density delivered by present SCs, limited to few watt hours per kilogram, without sacrificing power density, cycle life and safety, several different approaches are pursued. Nevertheless, as the energy density of a SC is determined by the intrinsic capacitance of electrode material (C) and by the operating voltage (V) following this equation; $E=1/2CV^2$, all these strategies pursue an improvement of C, V, or both.

The Electrochemical Processes Unit of IMDEA Energy Institute investigates both approaches. Thus, as the main drawbacks of current pseudocapacitive electrode materials are the low electrical conductivities and/or the short cycling life, research in our group is focused on the development of strategies which may overcome these limitations. Recently, we have developed a strategy of surface modification leading to new pseudocapacitive-based electrode materials with enhanced electrical conductivity, capacitance and operating voltage which also keep fair cycling stability and power density [6]. In addition, the use of pseudocapacitive organic materials is also pursued [7], and strategies for further improvements are currently being developed.

Moreover, as a promising avenue for reaching higher operating voltages, our group is investigating the use of ionic liquids as electrolytes. While aqueous or organic-based electrolytes typically used in SCs reach around 1 and 2.5 V respectively, and the use of solvents such as acetonitrile rise environmental and safety concerns, ionic liquids are green and safe electrolytes which can attain voltages of 3.5 V and even higher, which would mean a six-fold increase on the energy stored by current SCs. Research on the use of ionic liquid-based electrolytes is still in its infancy, but interest is rapidly growing worldwide. Our recent research has focused on preliminary studies on the influence of several properties of SCs based on carbon-based electrode materials and ionic liquid electrolytes [8] which has allowed us to pursue further improvements optimizing the interactions between electrolyte and electrode materials.

The development of new functional materials and design concepts such as those pursued in our group are envisaged as key instruments to build electrochemical energy storage devices exhibiting higher performance which may reach the market in time to fuel the incoming renewable energy revolution.

References

[1] Conway, B. E. "Electrochemical supercapacitors: scientific fundamentals and technological applications". Plenum Pub Corp: 1999.

[2] Simon, P.; Gogotsi, Y., Nature Materials, 2008, 7 (11), 845-854.

[3] Yang, Z.; Zhang, J.; Kintner-Meyer, M. C. W.; Lu, X.; Choi, D.; Lemmon, J. P.; Liu, J., Electrochemical Energy Storage for Green Grid. Chemical Reviews, 2011, 111.

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[6] T. Chávez-Capilla, M. Epifani, T. Andreu, J. Arbiol, J. Palma, J. R. Morante, R. Díaz. "Surface modification of metal oxide nanocrystals for improved supercapacitors". Energy Environ. Sci., 2012, 5, 7555-7558.

[7] S. Isikli, R. Díaz. "Substrate-dependent performance of supercapacitors based on an organic redox couple impregnated on carbon". J. Power Sources, 2012, 206, 53-58.

[8] Mora-Jaramillo, M.; Mendoza, A.; Vaquero, S.; Anderson, M.; Palma, J.; Marcilla, R. "Role of textural properties and surface functionalities of selected carbons on the electrochemical behaviour of ionic liquid based-supercapacitors". RSC Advances, 2012, 2 (22), 8439-8446.

residential en

awareness and creation of new services

Residential Energy Demand Awareness and Creation of New Services

In recent years research activities in the field of residential energy consumption have been intensified both by the scientific communities and the industrial sector. This interest is a result of several factors, including the massive integration of intermittent renewable energy sources, increasing energy demand, limitations imposed by the existing infrastructure for energy generation and distribution etc. In particular, the energy demand awareness is seen as an opportunity to facilitate the creation of new services with an added value for both the energy companies and the end-users. By taking advantage of knowing the total energy demand in more detail, advanced control and management strategies can be applied to achieve better matching between energy generation and consumption and to improve the security of energy supply that has been compromised by higher penetration of distributed generation resources. All this can be achieved without any significant reduction of comfort for the end-users.

The availability of affordable smart meters and the continuing efforts for establishing appropriate legal frameworks in many countries enforced the deployment of smart meters in many areas. These smart meters collect measurements of energy consumption and provide good estimates of overall demand in each individual household. Utilities, network operators, retailers and companies not directly related to the field of energy production and distribution already expressed their interest in the collected end-user data with an intention to offer services and applications with an advanced functionality to various participants in a widely deregulated energy market.

Unresolved privacy issues concerning the collection of household measurements and the lack of more detailed data on the profiles and consumption of appliances severely restrict the options for development and validation of these services and applications. Substantial efforts are being made by researchers in analysing residential energy demand and studying user profiles and behaviour [1]. The adverse conditions of dealing with coarse residential energy consumption data can be avoided to some extent by generating and using artificially generated data based on statistical data and usage patterns [2].

An example of the energy demand of a household with a defined set of household appliances and a photovoltaic panel is given in Figure 1.

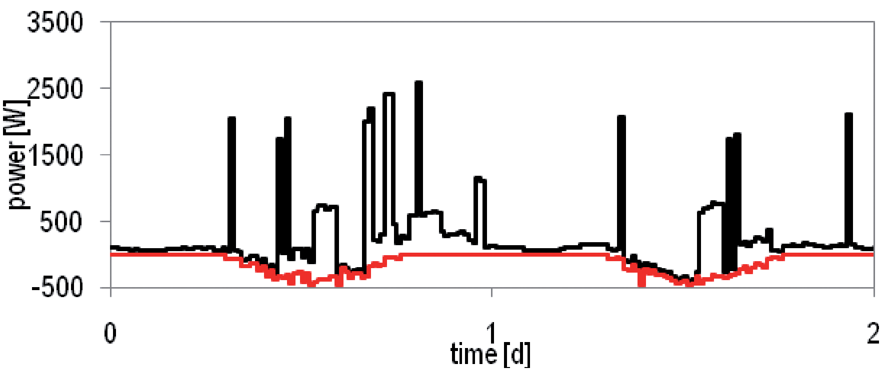

Figure 1. Artificially generated overall power demand of a household (black: overall power demand, red: generation of photovoltaic panel).

The domestic demand variations in combination with intermittent generation lead to considerable differences between the daily profiles of generation and demand. Traditional energy sources based on fossil or nuclear fuels can only be regulated within certain limits to cover the corresponding demand. However, up-regulation of most renewable energy sources is not possible and can cause possible deficiencies and failures in energy supply. Optimization of domestic energy demand offers an opportunity of reducing load variations by shifting some energy consumption activities from peak to off-peak periods. An example given in Figure 2 shows what effects on daily demand curve in a household can have the washing appliances when their use was restricted to certain hours [2].

Diurnal and seasonal fluctuations in energy demand as well as the intermittent nature of some renewable energy sources contribute to variations in wholesale energy prices as shown in Fig. 3 (see the Iberian Energy Market, www.omie.es). However, residential end-users are still charged fixed rates for their electricity consumption and any variations in the wholesale electricity prices are normally not passed on to the customer. By using detailed knowledge of residential energy consumption patterns it will be possible in future to consider the application of real-time pricing schemes with an intention of establishing stronger links between the wholesale and retail market prices [4]. Real-time pricing can be then introduced by utilities, network operators and retailers as an additional tool for incentivising customers to reduce their peak-time consumption [5] and to cover the actual costs of generation, transmission and distribution.

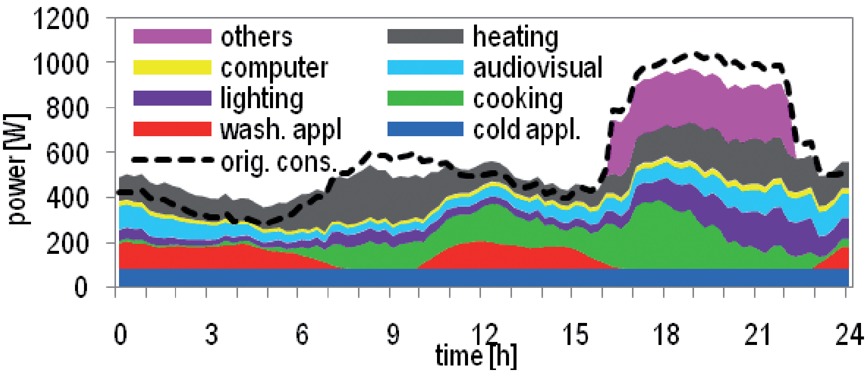

Figure 2. Daily average energy demand of a household after restricting the use of washing appliances to certain hours.

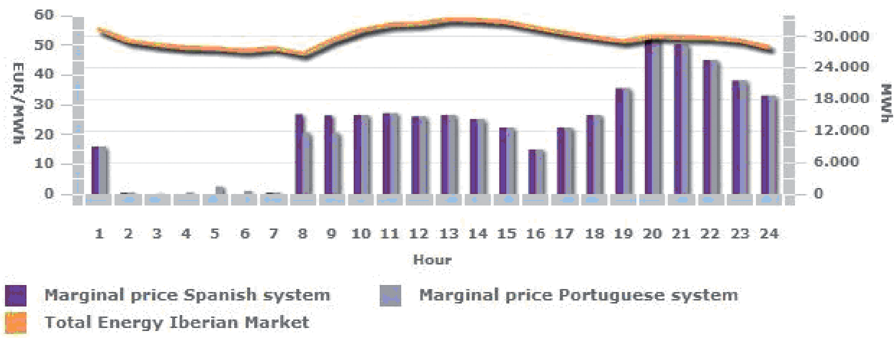

Figure 3. Electricity wholesale prices in the Iberian Energy Market on 8th March 2013 (source: OMIE-OMEL).

Consequently, real-time pricing and demand side management represent typical approaches used in demand optimisation strategies where detailed knowledge of individual and aggregated demand profiles are both necessary. An important field of study for the Electrical Systems Unit of the IMDEA Energy Institute is the development of novel, demand-aware services offered to energy end-users, system operators and energy providers.

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sun heat o

Sun Heat on Demand: Developing Micro and Mesoporous Materials for Thermochemical Energy Storage at low and high Temperature

developing micro and mesoporous materials for ...

Recently, energy roadmaps have placed great emphasis on the development of efficient thermal energy storage systems (TES), as a key factor to minimize the mismatch between energy supply and energy demand, for both domestic and industrial thermo solar applications. The concept is simple: the excess of heat generated by the solar radiation is stored throughout the day and then used during off-sun periods [1] [2].

There are three different types of thermal energy storage systems: sensible, latent and thermochemical [3]. Energy can be stored by means of sensible heat by increasing the temperature of a storing medium that could be either liquid (water, molten salts) or solid (concrete, rocks, sand). The stored heat per mass unit is directly proportional to its heat capacity and the temperature difference between its initial and final state. Sensible heat storage (SHS) is on an advanced stage of development and it has been already implemented in concentrated solar power (CSP) plants allowing a 24 hour energy production during many months of the year [4].

Latent heat storage (LHS) systems imply the phase change (crystallization, melting…) of the storage medium. Usually this type of TES can store more energy than the (SHS) as both specific and latent heat participate in the storing process. Materials used for LHS are called phase change materials (PCMs), like paraffin or eutectic salts, and can be packed in tubes, capsules or wall boards.

The third type of process, thermochemical heat storage (TCS), is based on reversible chemical reactions (e.g. reduction-oxidation) or reversible physicochemical processes (sorption-desorption). Both consist of three steps: charge, storage and discharge.

$$A + \text{heat} \leftrightarrow B + C \quad (1)$$

In the case of the former, during the charge, the energy provided by the sun is used to carry out an endothermic reaction. The reaction products are stored independently and finally combined during discharge in order to release the stored energy, through an exothermic reaction.

The main advantage of TCS is its higher energy storage density, compared with the two other types, which implies a smaller volume of storage medium, involving almost no energy losses during the storing period. A second advantage is the wide variety of chemical reactions and processes that can be used, resulting in a broad interval of temperatures at which energy can be stored. This flexibility allows choosing the right material for the relevant working conditions, from low to high temperatures.

Of particular interest for domestic applications are the systems based on reversible water adsorption on porous solids. By applying heat, water can be desorbed from these materials. After this charging stage both components can be stored separately. Then, during the discharge, water and sorbent are brought together again resulting in a heat release. This process can be easily implemented and it is suitable for seasonal storage as the dry solid can be stowed for long periods at low relative humidity.

These reasons make TCS a promising concept to boost the efficiency of solar thermal and CSP technologies. For this purpose, the TCP Unit of IMDEA Energy is working on the development of porous materials for low and high temperature energy storage.

Low temperature heat storage research is carried out at IMDEA Energy in collaboration with National Chemistry Institute of Slovenia (project STOREHEAT, MATERA-ERA-NET), is based on water sorption-desorption processes of microporous materials. Among them, aluminophosphates (ALPO) and metalorganic-framework (MOF) materials (Figure 1) have been proposed as suitable candidates for this application. Both have been subjected to water adsorption-desorption cycles, under different conditions of temperature (50-200 ºC) and humidity, in order to check their stability during several charge-discharge loops.

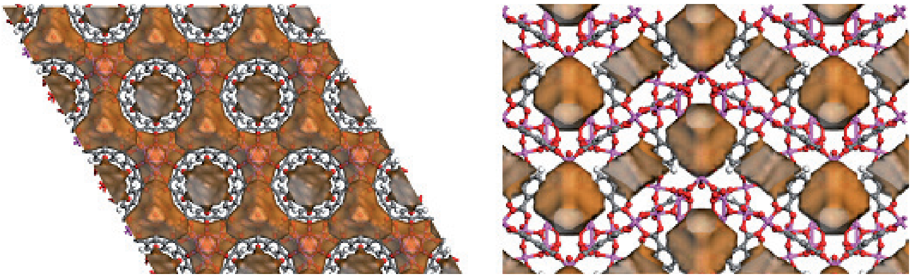

Figure 1. Different views of the structures of MOF MIL-96 showing in brown color the volume accessible to water molecules.

High temperature energy storage is focused on reduction-oxidation reactions of meso-porous metal oxides. In particular, Mn_2O_3 has been selected as a feasible material due to its inexpensive cost, low toxicity and favorable thermodynamics, as the redox reactions occur in the 600 – 1000 ºC temperature range (TCSPower). This interval will match the operation conditions of future CSP plants with central air receivers.This material stores and releases energy through the following reversible reaction[5]:

$$6Mn_2O_3 \underset{\leftarrow \text{ Discharge (oxidation)}}{\overset{\text{Charge (reduction) } \rightarrow}{\leftrightarrow}} 4Mn_3O_4 + O_2 \quad (2)$$

In spite of this redox couple meets some of the requirements to be a TCS material, others like kinetics and cycle stability must be improved in order to guarantee its complete feasibility. For this reason, the influence of the synthesis route on the reaction rate and the cyclability are subject of study as Figure 2 depicts. Results have demonstrated the very promising characteristics of these materials for TCS purposes.

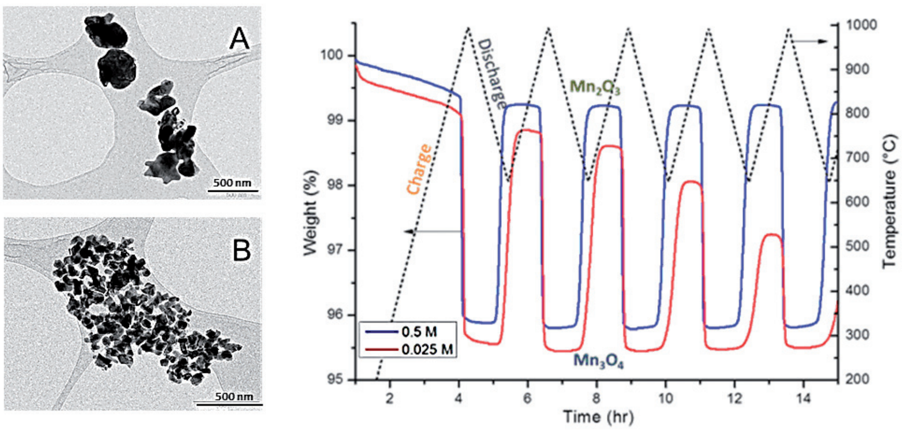

Figure 2. TEM images of Mn_2O_3 (left) showing the different particle size distribution of the samples prepared from 0.5 (A) and 0.025 (B) M precursor solution and the different stability of the Mn_2O_3-Mn_3O_4 redox cycles assays in air (right).

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Microalgae Carbohydrates Profile: Control of Cultivation Operational Parameters

Algae offer many advantages as feedstock for biofuels production since the land required and water fingerprint of microalgae for biofuel purposes is much lower than the required by traditional crops [1, 2]. Another advantage of microalgae versus energy crops includes faster growth due to their efficient solar conversion into biomass. This conversion is in the range of 1% for conventional energy crops (corn and sugarcane) while this value increase to 5 and 10% for green microalgae and blue-green microalgae, respectively [3]. Overall, the high productivity yield of microalgae implies less land requirement and hence decreases implementation costs. For all these reasons, microalgae are set to eclipse all other biofuel feedstocks. However, much effort on research and development is still necessary to reduce the uncertainty associated with the algae-to-biofuels process before it can be commercialized.

Bioethanol production is a promising technology for energy recovery from microalgal biomass. Second generation biofuels feedstock such as sugarcane bagasse, olive tree pruning or wheat straw resulted in similar bioconversion yields as microalgae [4]. In this manner, during these last years the potential of microalgae as an efficient source for bioethanol production is highlighted and great research efforts are devoted to this goal. Research studies are evaluating the potential of microalgae to accumulate carbohydrates (one of the most important sources of energy). Carbohydrate profile relies on its cell location, namely exopolysaccharides, intracellular and cell wall. The carbohydrates cell location is of crucial importance for bioethanol production since an effective and easy fermentation is dependent on sugars composition and pretreatment required for sugars extraction. The profile of neutral sugars (mannose, rhamnose, glucose, galactose, arabinose and xylose) and energy storage compounds is species€, strain€ and stage€specific. Green microalgae cell walls are quite resistant to pretreatment methods employed for disruption [5] while cyanobacteria normally present a peptidoglycan-based cell wall much easier to disrupt [6].

Up to now, research studies on microalgae for biofuels, conclude that the processes are not economically viable. Overcoming drawbacks such as low growth and photosynthesis rate, cell wall hardness of some strains and the prevailing accumulation of target macromolecules, are necessary to improve biofuel conversion efficiency. Research studies are devoted to "domesticate" algae to favor the production of a desired product, i.e. carbohydrates. The Research Unit of Biotechnological Processes for Energy Production studies the effect different parameters employed in the cultivation of microalgae to prevail carbohydrates accumulation. Changes in carbon allocation by genetic modifications normally involve some disadvantageous side effects, such as delayed growth rate or even cell death. Another way to manipulate carbon allocation is alteration of the environmental conditions in such a way that microalga regulatory systems produce the desired metabolites. Carbon allocation may be driven toward a non-natural flow by environmental and operational parameters applied during microalgae growth [7, Fig.1]. Additionally, the Research Unit is focus on the elucidation of potential inhibitors that may hinder sugars fermentation and the production of alternative energy forms (biogas) from the spent biomass.

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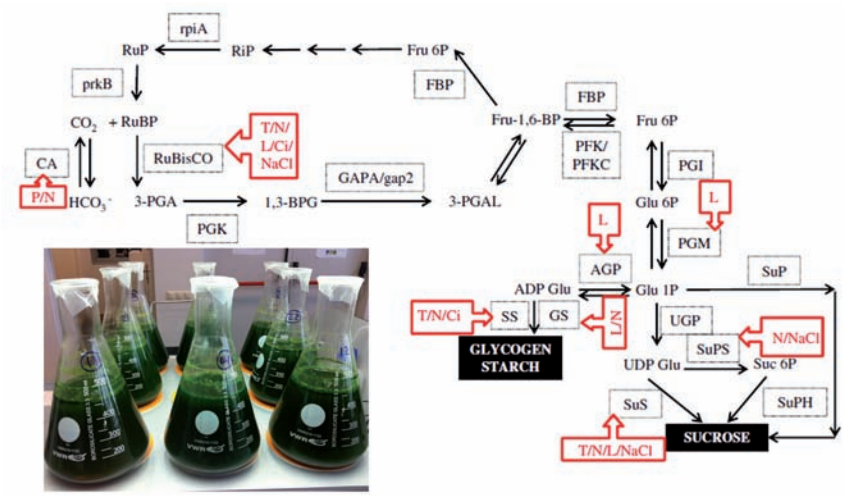

Figure 1. Key-enzymes (squares) and metabolites involved in the accumulation of starch, sucrose and glycogen in eukaryotic and prokaryotic microalgae. Enzymes abbreviation correspond to CA: carbonic anhydrase, RuBisCO: Ribulose-1,5-bisphosphate carboxylase/oxygenase, PGK: phosphoglycerate kinase, GAPA /gap2: dehydrogenase, FBP: fructose-1,6-biphosphatase, rpiA: ribose 5-phosphate isomerase, prkB: phosphoribulokinase, PFK/PFKC: phosphofructokinase, PGI: phosphoglucose isomerase, PGM:phosphoglucomutase, AGP: ADP-glucose pyrophosphorylase, SuP: sucrose phosphorylase, SuPS: sucrose phosphate synthase, SuPH: sucrose-phosphate hydrolase , SuS: sucrose synthase, SS: starch synthase, and GS: glycogen synthase. Red boxes correspond to identified operational parameters affecting enzymatic activity. (L: light, Ci: inorganic carbon, T: temperature, NaCl: salt, N: nitrogen and P: phosphorus).

modelling pyroly

prediction of yields and compositions

Modelling Pyrolysis for Reliable Prediction of Yields and Compositions

A model for the simulation of biomass pyrolysis processes along with upgrading of bio-oils through hydrotreating has been developed. The pyrolysis section includes the pre-treatment (drying and grinding) of biomass, pyrolysis reactor, recovery of products, along with a char combustor to supply the energy required and making the process to be self-sustained, without external energy inputs. The reactor is modelled in three sub-reactors to undertake the different pyrolysis phases: decomposition of biomass, main pyrolysis reactions, and secondary reactions. The simulation is based on the kinetics of the pyrolysis reactions and calculates the products as function of the biomass composition (elemental and fractional –cellulose, hemicellulose and lignin- ones) and the reactor operating conditions (temperature and residence time). The model allows a predictive simulation and its application to different types of biomass without available experimental data. In this way, different reactors can be implemented, once the operation variables are known. The reactions implemented were taken from literature [1-5]. The results were contrasted with different raw materials and reaction conditions, showing good fits.

The products are recovered at the output of the reactor by means of cyclones (char), quenching (bio-oil condensation) and flash (separation of gases from bio-oil). The quench is carried out with part of the bio-oil cooled down. Since the biomass is modelled by 30 compounds, from C_2 to C_{18}, including secondary elements (N, S and Cl), the compositions and yields of products (bio-oil, gas and char) are realistic.

Figure 1 shows the results for the pyrolysis of pine wood (PW) and wheat straw (WS) for different temperatures and residence times. A maximum is obtained for the liquid fraction at temperatures of 500 ºC and short times (typical conditions for fast pyrolysis). Longer residence times lead to higher char productions. As well, the differences between raw materials can be observed, pine wood gives larger liquid fraction and lower char than straw.

The bio-oil is deoxygenated by a two-phases catalytic hydrotreatment. Bio-oil is pressurized at 170 bar and mixed with hydrogen. Then, the mixture is heated and goes into the first reactor where it is stabilized at mild conditions (250 ºC and 170 bar). The catalyst is based on Co-Mo. Since the product of this reactor still has oxygen contents around 30-35%, it is fed to a second reactor (340 ºC, 170 bar and same catalyst) where this content is lowered down to contents about 1%. The hydrocarbons mixture is separated from water by cooling down and flashing, where water is eliminated. Since the hydrotreating reactions are exothermic, the external cooling is used to generate steam at 20 bar and 310 ºC that can be employed for electricity production in a turbine. Reactors are modelled with an iterative algorithm of linear regression, adapting an initial range of products to the composition of the input stream. The product is modelled with 40 components (from C_1 until C_{18}), using chrysene as reference compound for the heaviest fraction.

The organic product is fractionated in the distillation and hydrocracking section to give naphta, diesel and heavy residue streams. The latter goes into hydrocracking to yield lighter fractions. Before distilling, the inlet stream is fed to a flash separation to recover hydrogen.

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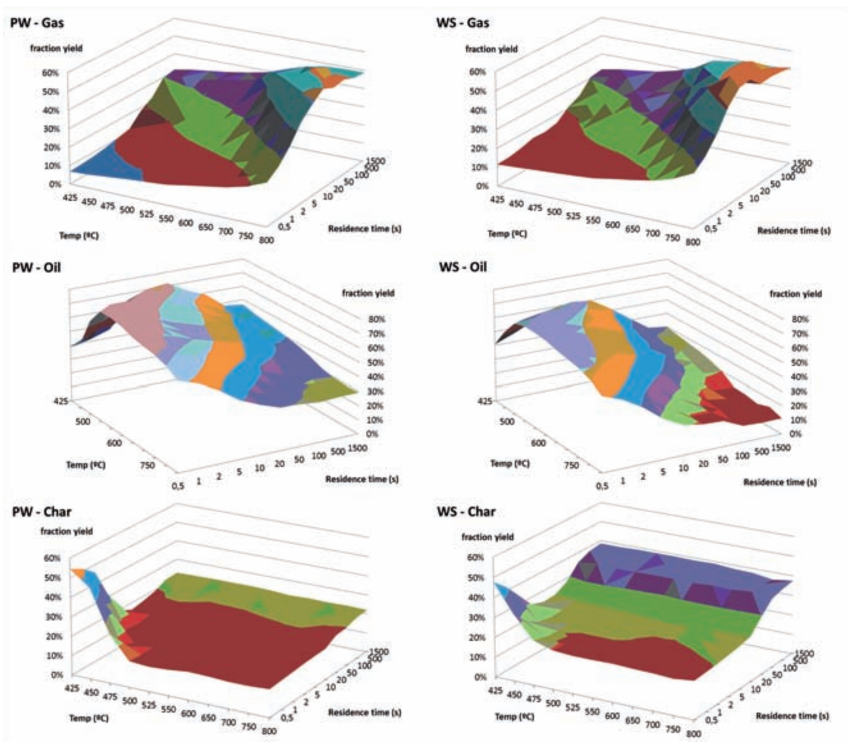

Figure 1. Products from biomass pyrolysis under different reaction conditions.

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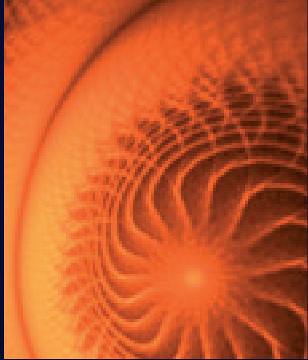

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