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# annual report
# 2011

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# annual report 2011

# foreword

**David Serrano**
Director of the IMDEA Energy Foundation

Móstoles, May 2012

I am pleased to present this 2011 Annual Report of the IMDEA Energy Institute, summarizing our main activities and achievements. The Institute was created in 2006 by the Regional Government of "Comunidad de Madrid" as a private Foundation, which has been an essential aspect for establishing a very efficient and flexible management system.

IMDEA Energy is an R&D institution focused on clean energy and renewable energy technologies. Our main goal is to get new developments that may help in the progress towards a low-carbon energy system. In this way, the research topics addressed by IMDEA Energy cover a wide range of subjects with high current interest and relevance, such as 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. These topics are mainly investigated with an experimental approach, although conceptual and theoretical analyses are also applied based on LCA tools and energy/exergy balances, allowing different alternatives to be compared in terms of both energy efficiency and environmental impact.

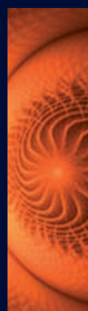
The researchers at IMDEA Energy are integrated in six different research units, all of them now in full operation. In order to reinforce the activities performed within the field of bioenergy, a new unit was created in 2011 as a joint initiative with CIEMAT: the Unit of Biotechnological Processes for Energy Production. By the end of 2011 a total of 42 researchers were working at the Institute, more than half of them holding a Ph.D degree. The progressive consolidation of the research units has been reflected in a significant increase of the scientific outputs, as denoted by the 44 articles and 5 books and book chapters being elaborated and published. Likewise, a wide variety of scientific dissemination actions have been performed by the IMDEA Energy researchers through their participation in a high number of events, allowing our activities and goals to be communicated to the society. Thus, 54 works have been presented in a variety of congresses, 32 of them as oral communications, whereas 19 invited lectures in courses, masters and technical seminars have been contributed in 2011. Moreover, the Institute has been involved in the organization of 9 conferences, congresses and workshops.

On the other hand, the construction works of the definitive headquarters of IMDEA Energy have progressed along 2011, being finished by the end of the year. Indeed, at the moment of writing this foreword, we are already working at phase I of the IMDEA Energy building located in the Technological Park of Móstoles. This has led to a very important enhancement in the quality of the working environment for scientists, technicians and administrative personnel. The availability of modern laboratories and pilot plants is having also a very positive effect in the efficiency of using our equipment and resources.

The success in getting approved new research projects has continued during 2011. Thus, a total of 20 research projects funded by public administrations and 9 contracts with companies have been under development in this year. Likewise, up to 14 personnel grants have been active in IMDEA Energy along 2011. These facts have had a very positive impact in the external funding received, allowing 45% of the total operational costs of the Institute to be funded with these external resources. In the current difficult economical context, this aspect is especially relevant as it demonstrates the ability of IMDEA Energy in achieving and receiving a significant proportion of funding from competitive calls. Moreover, the development of all these projects is fostering the collaboration of our researchers with an increasing number of research institutions, universities and private companies. Collaborations have been established with 26 research and education institutions and with 33 private companies for the development of collaborative projects. We are completely convinced that the establishment of collaborations with the industrial sector is especially important, as it may contribute to an effective transfer of technology and knowledge, which is really necessary for Spain as one of the key factors to reach a more sustainable and economically competitive structure. In this way, it must be highlighted that IMDEA Energy has filed 2 new patents in 2011.

In summary, I am proud of stating that by the end of 2011 IMDEA Energy has become a well-known and respected energy research institute at both national and international levels. Being aware of our recent successes, our ambition is to pursue this pathway by expanding our activities and improving the quality and impact of our scientific and technological outputs.





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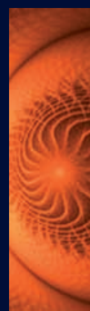


# 1

# general presentation

The IMDEA Energy Institute is a Research Centre created by the Regional Government of "Comunidad de Madrid" to develop world-class R&D on clean and renewable energy. The Scientific Programme of the IMDEA Energy Institute has been outlined with the aim of 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 expected to strength and to have 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.

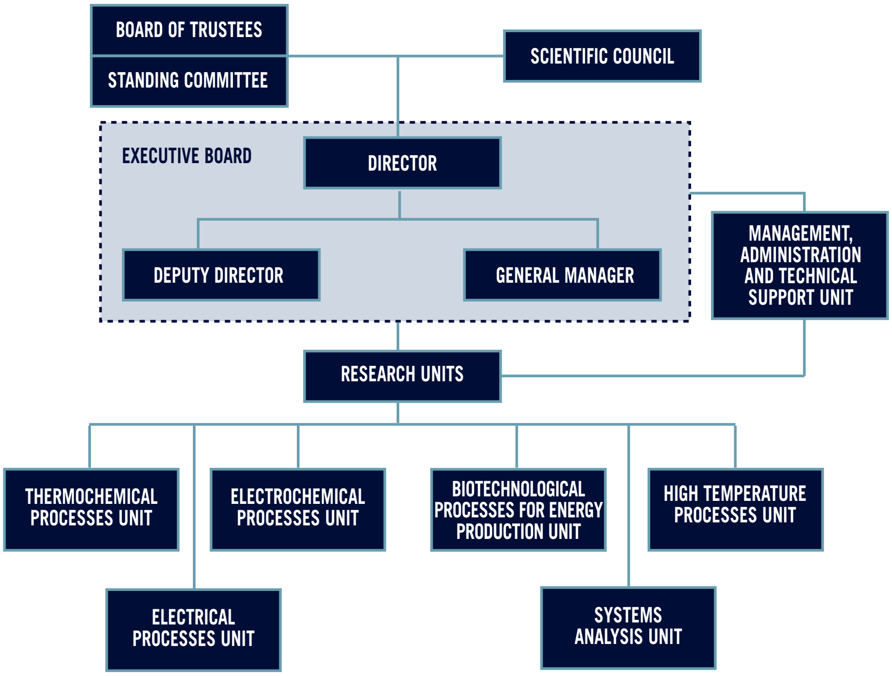
Research topics addressed at the IMDEA Energy Institute are concentrated within the following six areas:

- 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: fuel cells and poly-generation.
- 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.

# 2 governing bodies and functional structure

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, 2011 is listed below:

- Mr. Jon Juaristi Linacero, Chairman
- Mr. Jorge Sainz González
- 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. Likewise, the Scientific Council is responsible for assessing that the activities scheduled for each year have been carried out and that the four-year goals have been achieved. The Scientific Council has participated actively during the definition of the contents of the Strategic Programme of the Institute, already approved by the Trust. In addition, members of the Scientific Council have evaluated the CV of all candidates to the senior and postdoc researchers positions offered since 2008.

## SCIENTIFIC COUNCIL

**Prof. Dr. Martin Kaltschmitt**
*Director of the 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. Amable Liñán Martínez**
*Emeritus Professor*
*Polytechnic University of Madrid, Spain*

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

**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*

**Dr. Michael Epstein**
*Head of the Solar Research Facilities Unit*
*Weizmann Institute of Science, Israel*

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

## 2.3. Executive Board

The Executive Board is composed of 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-to-day running activities of the different Research Units and administration staff of the Institute. The General Manager is also in charge of elaborating the general budget draft, which is submitted annually for approval by the Board of Trustees.

## 2.4. Research units

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 2011:

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

## 2.5. Management, Administration & Technical Support Unit

By the end of 2011 the Management, Administration and Technical Support Unit of IMDEA Energy is formed by 8 persons, whose main function is to perform 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, *Chief.*
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, *Chief*
Ms. Eloísa Mateos Sevilla

Their main responsibilities are as follows:

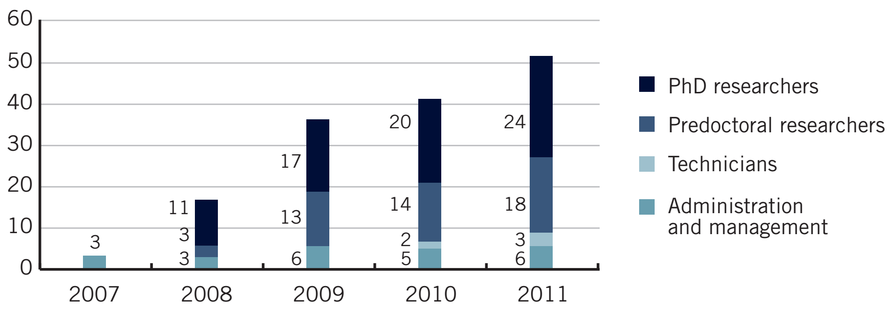
- R&D project management and support.
- Identification and dissemination of R&D funding opportunities (regional, national and international calls).
- Preparation of proposals to be submitted to public R&D calls.
- Contracts with companies and agreements assessment.
- Intellectual property rights management.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

## 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 during 2011 there are the following: analysis 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 analyses.

The next figure illustrates the growth undergone along the past five years in the numbers of persons working in the IMDEA Energy Institute.




*Evolution in the staff working in the IMDEA Energy Institute.*

# 3 research lines

The research lines addressed at the IMDEA Energy Institute follow 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, served as technology and market drivers. In most cases Spanish companies were 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 and, therefore, the transport sector is responsible in a large extent for the greenhouse gases emissions. Accordingly, the development of alternative and environmentally friendly fuels is of high interest. Within this research line two different areas are considered:

### Second Generation Biofuels

Biofuels are usually considered as 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 oils into green diesel.

- Optimization and improvement of catalytic hydrodeoxygenation and hydrodecarboxylation processes for upgrading bio-oils. Research should concentrate on the development of very active and selective catalysts and the integration of biomass treatment 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 our 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.

- Development of hydrogen production via thermo-chemical 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.

## 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 nanoporous materials may improve the performance of these systems and on the application of electrochemical storage systems to renewable power plants, 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

The forthcoming decades will see further deployment of renewable energy sources and distributed generation in electricity networks and will only emphasise the extraordinary importance of the development of new architectures and management algorithms. 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. 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.

- 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 requires 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 is a topic 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 or chemical reactors and 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 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, confinement in form of carbonates and solid carbon, etc. 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. 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.

# 4 scientists and research units

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 processes) and biofuels (biomass hydrotreatment process). It is also active in $CO_2$ valorization (photochemical 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 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 Processes (ELPU).** This unit deals mainly with the R&D activities related to the smart management of electricity demand, and related topics like integration of renewables in distributed generation systems, design and control of microgrids, industrial energy saving and power network simulation.

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

# 4.1. Thermochemical Processes Unit

## Research activities

One of the main 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, one of the most promising approaches is water splitting by means of thermochemical cycles coupled to solar concentrating power. 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.

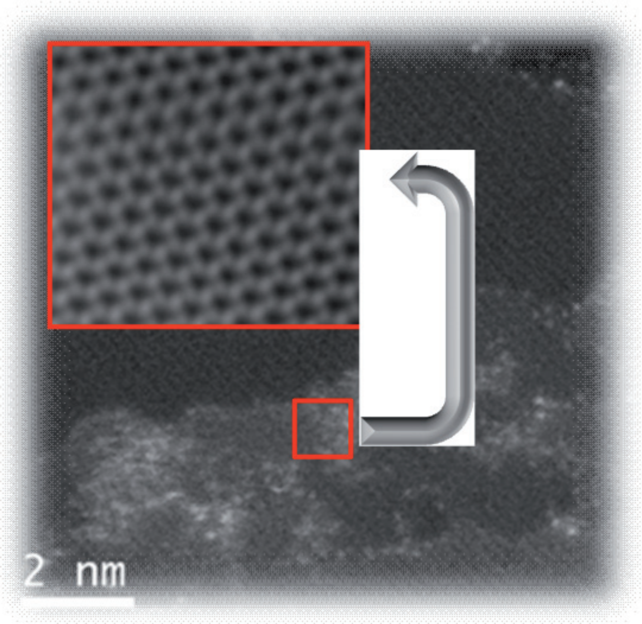
The possible utilization of residues as feedstock for fuel production, as well as the development of second generation biofuels, are also strategic research lines of the TCPU. In this way, the hydrotreating of bio-oils obtained either from flash pyrolysis of agro-forestry wastes or triglycerides extracted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

thermochemical

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 monitored, 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 the TCPU group 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.




*Graphene production by catalytic methane decomposition*

# 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, production of fuels from plastic wastes and hydrogen production free of $CO_2$ emissions. He has been involved in about 45 research projects funded by both public and industrial partners. He is author of about 115 publications in scientific journals, 5 patents and of 4 books. Besides he has presented more than 150 communications in scientific conferences. He has supervised 14 Ph.D. theses.

## Dr. Juan M. Coronado

Senior Researcher

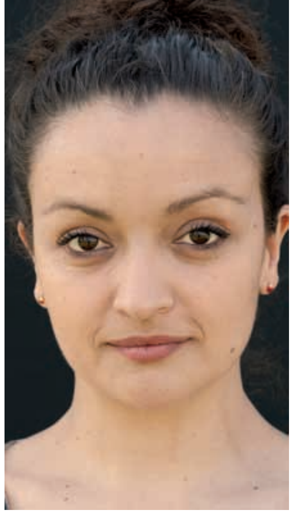
He received his Ph.D. in Chemistry from the Complutense University of Madrid in 1995. In 1997 he was awarded a grant of the "Marie Curie" EU program and spent two years as a postdoctoral fellow at the University of Dundee (UK). He was a "Ramón y Cajal" researcher at the ICP-CSIC. From 2005 he was a tenured scientist at CIEMAT. In 2009 he was appointed as senior researcher at IMDEA Energy. His scientific activity is been mainly focused on the development of enhanced nanostructured photocatalysts, and he is now also interested in biofuels upgrading. He has published more than 70 research papers, he has presented more than 60 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 Barcelona University 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 41 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. 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.

## Julio Nuñez
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.

## 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.

## Dr. Yongxing Yang
Postdoctoral Researcher

He has recently joined the TCPU. 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.

## 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.

## 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



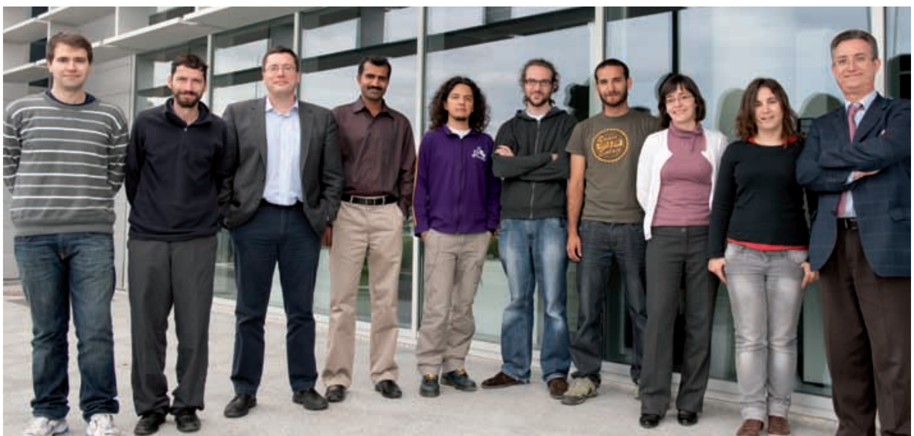
# 4.2. High Temperature Processes Unit

## 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 those 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 worldclass 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.

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. In 2011 the solar-driven reductions from $Mn_2O_3$ to $Mn_3O_4$ and from $Mn_3O_4$ to MnO have been tested thanks to a mobility action providing thermogravimetric desorption at the 50 kW solar simulator of Paul Scherrer Institute (Switzerland).

# 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 from 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 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

Ph.D. in Engineering by 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.




### 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.

### Charles-Alexis Asselineau
Predoctoral Researcher

Graduated in Mechanical Engineering by Ecole des Mines d'Albi (EMAC, Albi, France). Master of thermal engineering from Tsinghua University (Beijing, China). Predoctoral researcher working on thermal storage for concentrating solar power plants.

*Front view of 150-m$^2$ carousel-type heliostat developed by IMDEA Energy Institute in joint cooperation with the companies Sunborne Energy and TitanTracker within the framework of the project CRISPTower.*

# 4.3. Electrochemical Processes Unit

## 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 to be developed by the ECPU shall be applied both to renewable energies and to the electrification of transport.

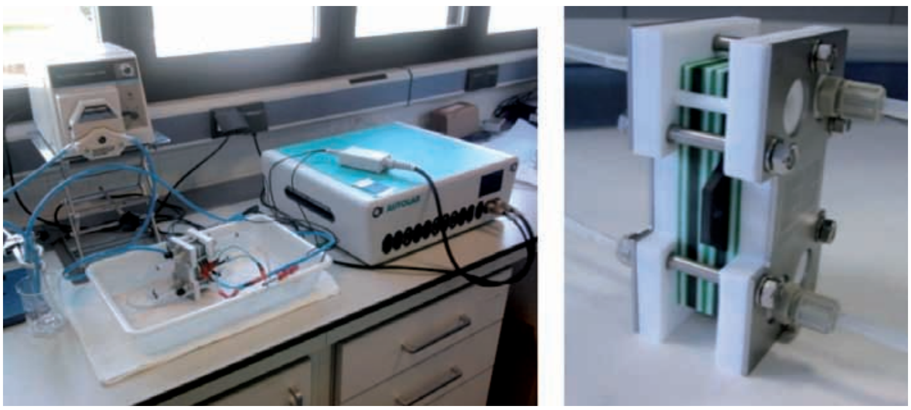
Energy storage is becoming a critical issue in electric grids in which a large contribution of renewable sources is creating a mismatch between generation and demand. In this way, bulk storage technologies enable utilities and system operators to harvest the full potential of intermittent renewable power 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, in the ECPU we work 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, 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.

*Left, setup for flow battery laboratory tests at Electrochemical Processes Unit. Right, detail of the electrochemical laboratory reactor.*



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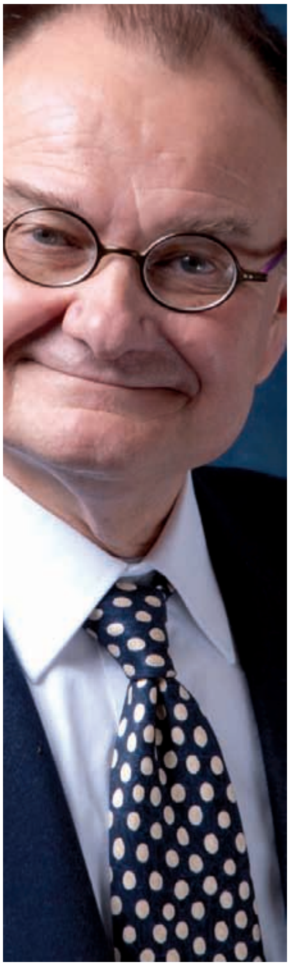


## Prof. Marc A. Anderson

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 Técnicas 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. Raúl 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

PhD in Chemistry by the University of the Basque Country in 2006. After her PhD she joined the Technological Center CIDETEC (Centre for Electrochemical Technologies) and performed two research stays at the Eindhoven University of Technology (Chemical Engineering and Chemistry-Polymer Chemistry) and at the University College London (London Center for Nanotechnology). Her main research interest is the development of electrochemical energy storage devices by using new IL-based electrolytes. She is co-author of more than 30 scientific papers in international journals and 2 patents.

## Dr. Chandrasekaran Ramasamy
Senior Assistant Rercher

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.

## 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.

## Laura Sanz
Predoctoral Researcher

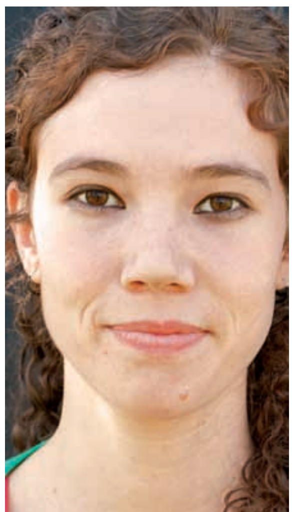
Graduated in Chemical Engineering by Rey Juan Carlos University. Master in Electrochemistry: Science and Technology by Autonoma University of Madrid. Predoctoral researcher working on redox flow batteries.

## 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.

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

## Research activities

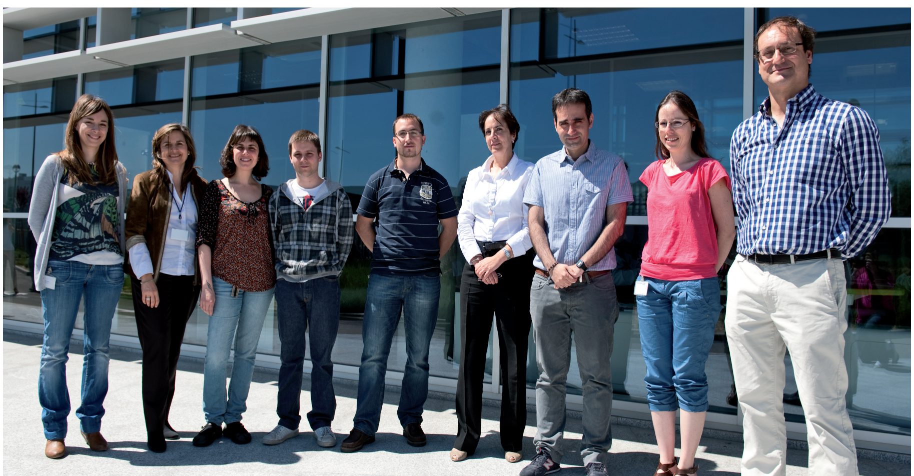
This unit is engaged in the development of novel processes for biofuels production. Since 2011 its activities have been focused on the development of technologies to convert biomass (lignocellulosic biomass, algae, and other biological material) into biofuels. The BTPU researches are working to improve 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.

The Joint Research Unit was created on March 2011 with researchers from IMDEA Energía 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 biotechnological processes.

The activities in 2011 have been focused on the definition of the research lines to be developed in the Joint Unit. These activities can be summarized as:

- Isolation and characterization of new microorganisms and their enzymatic complexes to transform lignocellulosic biomass into biofuels.
- Obtention of biofuels and other added-value products from microalgae.
- Genetic modification of metabolic pathways in hydrolytic and fermentative microorganisms to produce new biofuels.

In addition, the main activities in 2011 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 at the IMDEA Energy building.



# scientists

## Dr. Mercedes Ballesteros

Research Professor
Head of the Unit

PhD 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 since January 2011. 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 by biotechnological processes. 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). Participant as a 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. Participation in more than 50 R&D projects on biomass research, 10 of them financed by the European Commission. She has published above 40 papers in SCI journals and 3 chapters in technical handbooks. Co-author of 3 patents and reviewer for the European Commission, the Iberoamerica Science and Development (CYTED) Comission and the Spanish Ministry of Science, among others. External consultant for ECLAC of United Nations and the Spanish Agency for International Cooperation (AECID).

## Dr. Cristina González

Senior Assistant Researcher

PhD in Chemical Engineering and Environmental Technology by the University of Valladolid (2008). After her PhD, 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 20 scientific publications. Additionally, she has been involved in European and national funded research projects, as well as projects with private companies.

### 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 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.

### 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 PhD 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. David Ibarra
Associated Researcher

PhD by Complutense University of Madrid (2006). In 2007 he was awarded a postdoctoral grant at Royal Institute Technology, Sweden. In 2010 he joined the Biofuels Unit of CIEMAT with a Juan de la Cierva contract. His expertise refers to the use and characterization of lignocellulosic materials. He has published 24 papers in journals. In addition, he has presented more than 40 communications to national and international conferences. He has participated in 8 national and international research projects. He is also co-author of a national patent with international extension and exploitation license by industrial sector.

### 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.

*General view of new laboratory and equipment of the IMDEA Energy / CIEMAT Joint Unit*

# 4.5. Electrical Processes Unit

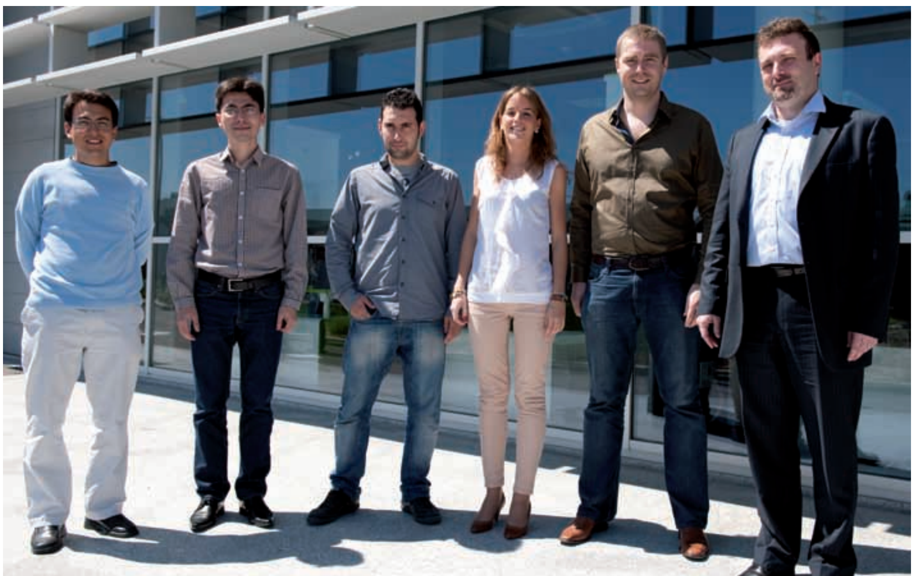
## Research activities

The main objective of the Electrical Processes Unit is to engage and participate in the design of management algorithms for future power networks, as the conventional methods of how energy generation, transmission and distribution operated until now cannot provide any longer 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 the intelligent algorithms for control of future power networks and participation in future real-time energy markets.

“Smart buildings” and “Smart Homes”, 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.

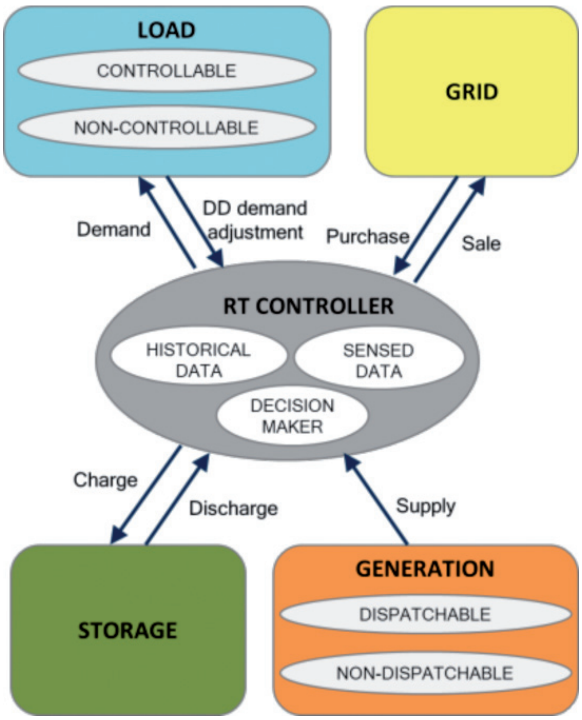
Improving energy efficiency in industrial applications is one of the principal activities of the research unit. By detail modelling of the consumption profiles and patterns along the nominal modes of operation, the potential for energy saving is investigated. The main



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 of the energy consumption patterns.




*Information exchange in real-time control for smart management of power demand*

# scientists

## Dr. Milan Prodanoviç

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. He 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. Among others, he had industrial collaboration projects with ABB, EDF Energy, EON, Repsol, IMV Japan, TurboGenset UK. He authored several journal and conference papers and is holder of 3 international patent applications in the area of energy efficiency and converter control. His research interests lie in design and control of power electronic systems, real-time simulation of power networks, decentralised control of distribution power networks and microgrids and energy efficient industrial applications.

## 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 on improving energy efficiency in industrial applications, renewable integration and future energy markets.

## Mª Belén Téllez

Predoctoral Researcher

Engineering Degree in Electronics and Telematics from University of Málaga. Master in Energy Engineering by Polytechnic University of Madrid. Predoctoral researcher working on development of intelligent algorithms for management of future power networks.

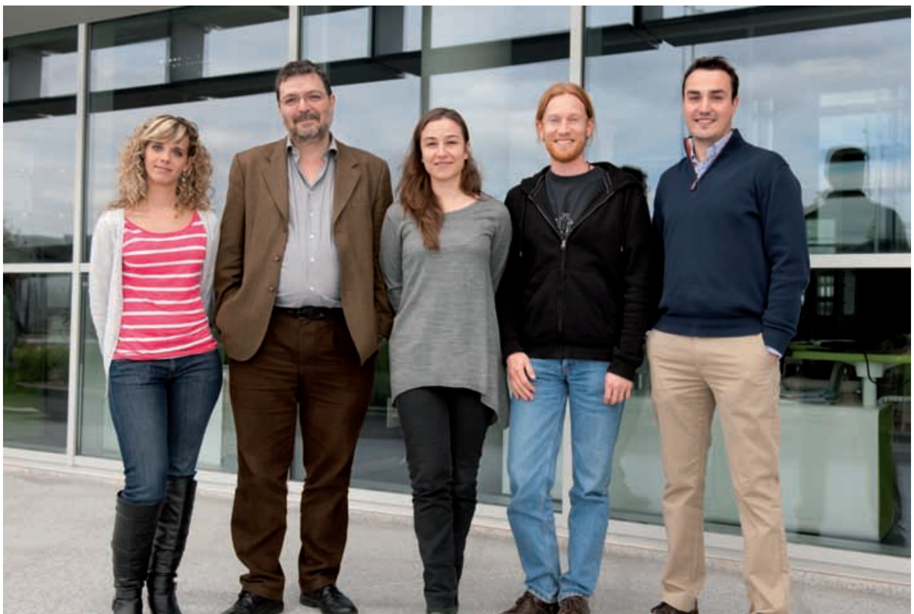
systems analysis

# 4.6. System Analysis Unit

### Research activities

Life cycle management of clean fuels has been the first research line started in the Research Unit. It is focused on two topics. The first one is hydrogen manufacturing through low impact processes such as light hydrocarbons decomposition, water photo-splitting, solar thermochemical cycles and biomass gasification. The latter involves the selection of the most appropriate raw materials and technologies, their simulation and optimization and, finally, their life cycle assessment and costing. The second research topic in this line is related to second-generation biofuels production. Their obtaining from animal and poultry fats, waste cooking oils (WCO) and sewage waste-oils was studied, showing that WCO are the most promising alternative. As well, the manufacturing of "green" diesel through biomass pyrolysis and upgrading of the bio-oil generated is being analyzed. Connecting with this line, the synthesis of high-density biofuels through platform molecules obtained from depolymerized lignocellulosic sugars has been initiated. Finally, the processing of microalgae has been also studied. The aim is to optimize their whole life cycle to attain a positive energy balance since the first studies published showed NER below 0.1.

The ASBIOPLAT project was awarded to the Unit by the Spanish Ministry of Science and Innovation (currently, Ministry of Economy and Competitiveness) and was kicked off at the beginning of 2012. It deals with the assessment of high energy density fuels and will be developed in collaboration with the Chemical and Environmental Engineering Group of Rey Juan Carlos University.

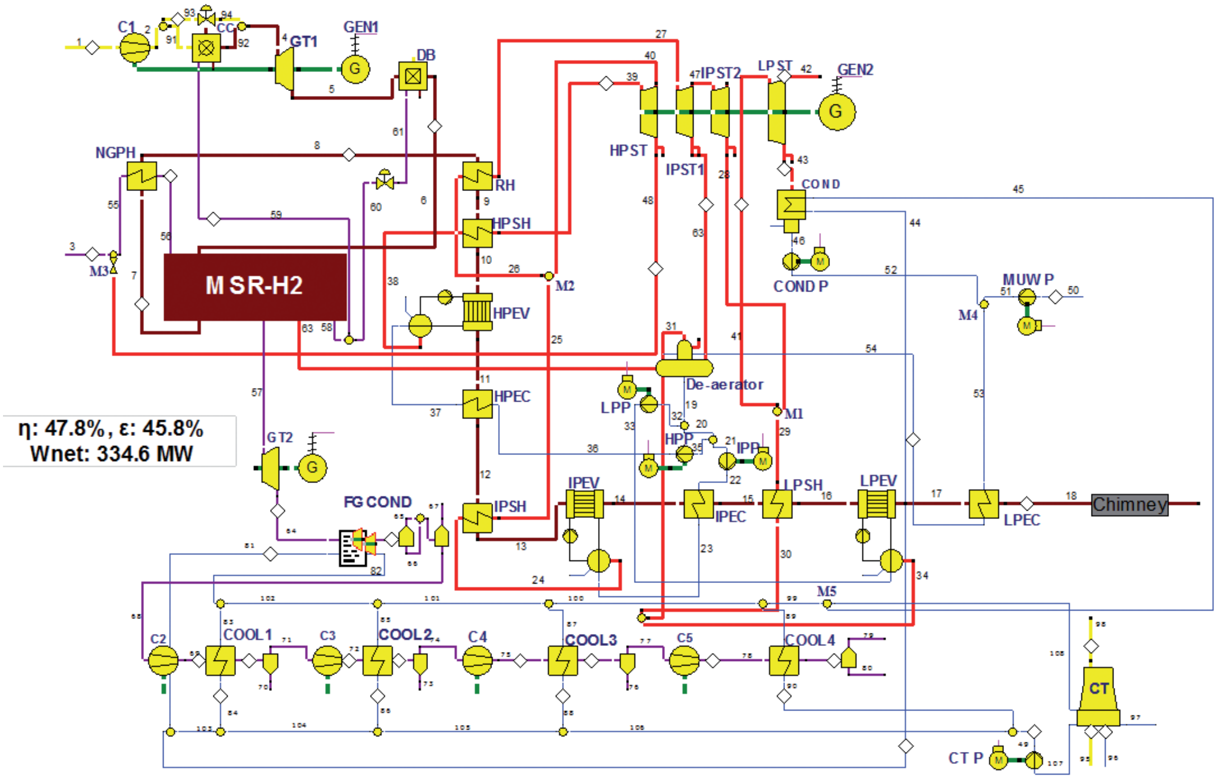


A second research line dedicated to capture and valorization of $CO_2$ has been also launched. A first study has been carried out about the life cycle assessment of the most usual post-combustion capture techniques: absorption, PSA, and membrane and cryogenic separations. As well, oxycombustion and coal gasification were alternatives being studied. Currently, two research contracts are under negotiation: the first one aims to determine the carbon footprint of refinery products and the latter will be also carried out in collaboration with the Thermochemical Processes Unit and deals with the photo-valorization of $CO_2$ and the manufacturing of "renewable" hydrogen.

Other research activity is a collaboration with the High Temperature Processes Unit to study the hybridization of solar technologies with other renewable energy sources within the framework of the Project ADEL.

The development of a software package for exergy component-based calculations to be coupled to commercial simulation software (AspenPlus or Ebsilon) is the cross-cutting action started up along this time.

*Detailed simulation with code Ebsilon® of a thermal power plant with $CO_2$ capture*



# scientists

### Dr. Javier Dufour

Senior Researcher

Head of the Unit

He is Head of the Energy Systems Analysis Unit (SAU). BSc (1990) and PhD (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.

He joined Rey Juan Carlos University in 2003, where he is currently Associate Professor. Currently, he is Coordinator of the PhD Programme on Chemical and Environmental Engineering at the Rey Juan Carlos University. His 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 (4 international), being the principal researcher in 14 of them.

### 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 author of 2 book chapters and 15 papers. She has participated in 27 international conferences and workshops.

### Dr. Sergei Levchenko
Visiting Researcher

He joined IMDEA Energy for three months, since October till December, 2011. He is Leading Senior Scientist of the Joint Institute for Nuclear and Power Research-Sosny, National Academy of Sciences, Minsk, Belarus. His scientific activity has been focused on subjects related to energy analysis and planning based on systems approach, environmental engineering and IT. He has been involved in about 25 research projects. He has more than 115 papers published in scientific journals and in proceedings of conferences, including a book.

### 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. She is developing her PhD research on biomass gasification.

# 5 facilities and scientific infrastructures

## 5.1. Temporary facilities

During the period 2008-2011 the Institute has developed its administration, management and research activities in temporary facilities. The provisional headquarters, for management and administration, of IMDEA Energy were located in the space assigned to this purpose by Rey Juan Carlos University in the building of the Technology Support Centre at the Móstoles Campus. This space housed the Directorship, Management and Administration staff of the Institute. In addition the Institute had four laboratories housing the research activities of the six Research Units. Three of them, with a space of 160 $m^2$ each, were located in the Campus of Móstoles of Rey Juan Carlos University (URJC). The fourth one housed until February 2011 in the Institute of Biotechnology and Plant Genomics in the Montegancedo Campus of Polytechnic University of Madrid (UPM). Infrastructural support from URJC during this period has been remarkable, providing not only the referred space and laboratories, under the framework of a cooperation agreement, but also the access to general services of the Campus, internet, library, workshop, large scientific equipment, meeting rooms, in similar conditions than those of the university staff.



## 5.2. Definitive headquarters

The definitive 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 has been ceded in 2008 by the Municipality of Móstoles. Design and construction of the building has been conceived in two consecutive phases.

The first phase of the construction was commissioned by July 2011 and represents approximately one third of the total project, 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. Phase 2 was awarded in December 2010 and construction has been commissioned by December 2011, with 3,180 $m^2$ of surface built above ground level and 1,000 $m^2$ underground involves the central hub, with central services, working area for two more research groups and definitive premises for administration and management. Also Phase 2 includes at the rear part of the building 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 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 definitive headquarters has been mainly built thanks to the funding coming from different sources: actions for Scientific and Technological Parks of the Ministry of Science and Innovation, an agreement established among Ministry of Science and Innovation, Community of Madrid and IMDEA Energy and European Union Structural Funds.

## 5.3. 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 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 analysis. 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 followed by: Thermal Conductivity Detector (TCD) or Mass Spectrometry) Micromeritics Autochem II.
- XRD diffractometer X'Pert Pro 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.

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 kWe 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, gas analysis test bed ($H_2$, $O_2$, CO, $CO_2$, $CH_4$), 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, one 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, three ovens (one with vacuum), and a rotary evaporator.

- Electrochemical Processes Unit: one multipotentiostat, booster, Z potential meter, dip coater, hydraulic press, oscilloscope, glove box, drying stove, precision potentiostat, routine potentiostat, drying oven, testing oven, vacuum oven, climatic chamber, an automatic film applicator and 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.

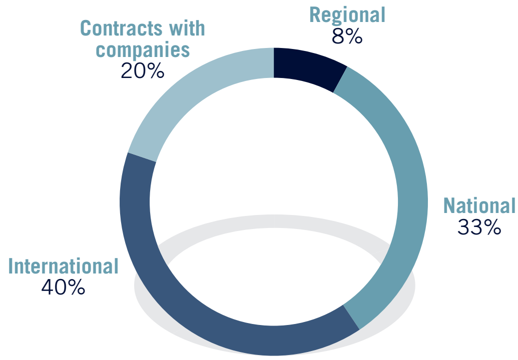
Likewise, the following software for scientific and technical applications is available:

- Software HSC Chemistry 6.1
- VAPS 5.2
- CFD programmes- Star CCM+ and COMSOL
- Simapro 7.2 Professional
- MATLAB-ALL and Simulink
- Trace Pro
- TRNSYS 16 and 17
- Aspen Plus
- Solidworks premium
- LABVIEW
- Ebsilon Professional

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.

# 6 R&D projects, grants and contracts

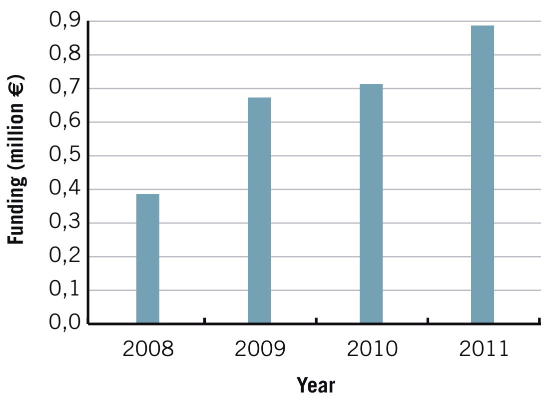
The total external funding obtained by IMDEA Energy Institute from R&D projects and contracts since the beginning of its activity, according to the funding source, has been the amount of 5.141.867 €. According to the data in the figure below, the main source of external funding has been obtained from international programs (40%), following by projects corresponding to calls of the national programs (33%). Significant funding has been also obtained from research contracts with companies (20%) and, in a lesser extension, from regional calls (8%).




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

The external funding obtained by IMDEA Energy Institute from R&D projects and contracts during 2011, according to the funding source, has been the amount of 878.190 €. The main source of external funding in 2011 has been obtained from research contracts with companies (47%), following by projects corresponding to calls of the international programs (27%), national programs (15%) and finally from regional calls (11%).

Next figure shows the evolution of the external funding achieved and spent in R&D activities in the period 2008-2011. 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. The self-funding ratio has been kept with values in the range 40-50%.




*External funding from R&D projects and contracts achieved and spent during 2008-2011*

## 6.1. R&D projects and contracts

The following list shows the R&D projects and contracts active during 2011:

### 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; Hynergreen Technologies, 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: Water purification through capacitive deionization/TAPCAP
Partners: IMDEA Energy Institute (Coordinator); PROINGESA; IMDEA Water Institute
Period: 2008-2010. Extension 2011
Funding Institution/Program: Ministry of Industry, Tourism and Commerce/ Strategic Action on Energy and Climate Change
IMDEA Energy Institute external funding: 161.702 €

Title/Acronym: Thermochemical cycles / HyTower
Partners: Hynergreen Technologies, S.A. (Coordinator); Abengoa Solar New Technologies, S.A.; AICIA/University of Seville; Rey Juan Carlos University; IMDEA Energy Institute; CIDAUT Foundation
Period: 2009-2010. Extension 2011
Funding Institution/Program: Ministry of Science and Innovation/ Strategic Singular Project
IMDEA Energy Institute external funding: 32.500 €

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 Science and Innovation/ Subprogram of Fundamental not-oriented research
IMDEA Energy Institute external funding: 149.556 €

Title/Acronym: Biosynthesis of the iron-molybdenum cofactor of nitrogenase/FEMOCO
Partners: IMDEA Energy Institute (Coordinator); Newbiotechnic, S.A.
Period: 2010-2011
Funding Institution/Program: Ministry of Science and Innovation/ Subprogram of Fundamental not-oriented research
IMDEA Energy Institute external funding: 51.719 €

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 Science and Innovation/ Sub-program INNPACTO 2010
IMDEA Energy Institute external funding: 131.359 €

Title/Acronym: Tailored semiconductor nanocrystals for supercapacitors/CAPSETA
Partners: IMDEA Energy Institute (Coordinator); SAFT Batteries, S.L.; EINSA
Period: 2011
Funding Institution/Program: Ministry of Science and Innovation/ Subprogram of Fundamental not-oriented research
IMDEA Energy Institute external funding: 14.520 €

Title/Acronym: Production of hydrogen via solar driven high temperature process/SolH2
Partners: HYNERGREEN TECHNOLOGIES (Coordinator); IMDEA Energy Institute; University of Seville; CIEMAT
Period: 2011-2013
Funding Institution/Program: Ministry of Science and Innovation/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 Science and Innovation/ Sub-program INNPACTO 2011
IMDEA Energy Institute external funding: 222.649 €

The following national projects have been approved during 2011 and will start in 2012:

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 Science and Innovation/ Subprogram of Fundamental not-oriented research
IMDEA Energy Institute external funding: 145.200 €

Title/Acronym: Oxygen generation and transport 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 Science and Innovation/ Subprogram of Fundamental not-oriented research
IMDEA Energy Institute external funding: 205.700 €

Title/Acronym: Development of novel catalytic systems for the production of 2nd-generation biofuels by deoxygenation of lignocellulosic biomass processes/LIGCATUP
Partners: IMDEA Energy Institute (Coordinator); URJC; Repsol YPF, S.A.; Abengoa Bioenergía; Algaenergy, S.A
Period: 2012-2014
Funding Institution/Program: Ministry of Science and Innovation/ Subprogram of Fundamental not-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 Science and Innovation/ Subprogram of Fundamental not-oriented research
IMDEA Energy Institute external funding: 71.390 €

## International projects

Title/Acronym: Towards the optimization of hydrogen production by nitrogenase/TOHPN
Partners: IMDEA Energy Institute
Period: 2008-2011
Funding Institution/Program: European Research Council/ FP7-Ideas Program-Starting Grant. Call identifier: ERC-2007-StG
IMDEA Energy Institute external funding: 856.610 €

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: 2010-2013
Funding Institution/Program: European Union/ FP7-Cooperation. Call identifier: FP7-ENERGY-2009-1
IMDEA Energy Institute external funding: 397.400 €

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: 109.920 €

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/TCSPower
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 (IMDEA); 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: 436.417 €

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 €

## Contracts with companies

Title/Acronym: Study of integrated thermochemical cycles with high temperature solar energy for hydrogen production/CONSOLIDA
Company: Hynergreen Technologies, S.A. (Spain)
Period: 2008-2011
Program: Industrial R&D Initiative-CENIT
IMDEA Energy Institute external funding: 250.000 €

Title/Acronym: Efficient and intelligent technologies aimed at health and indoor comfort/TECNOCAI
Company: Acciona Infraestructuras, S.A. (Spain)
Period: 2010-2011
Program: Industrial R&D Initiative-CENIT
IMDEA Energy Institute external funding: 93.456 €

Title/Acronym: Water purification system using capacitive processes/SPACAP
Company: PROINGESA (Spain)
Period: 2010-2011
Program: Agencia para el Desarrollo (ADE), Junta de Castilla y León
IMDEA Energy Institute external funding: 159.984 €

Title/Acronym: Energy efficiency in systems for vibration testing
Company: IMV Corporation (Japan)
Period: 2010-2012
IMDEA Energy Institute external funding: 33.659 €

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

Title/Acronym: Current status of energy storage technologies applied to transport
Company: REPSOL (Spain)
Period: 2011
IMDEA Energy Institute external funding: 5.450 €

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 €

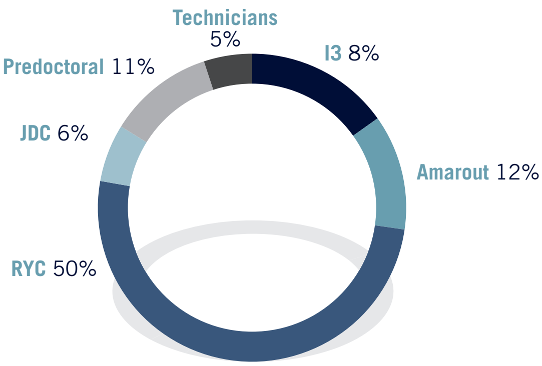
Title/Acronym: Innovative latent thermal energy storage system for concentrating solar power plants
Company: E.ON AG (Germany)
Period: 2011-2013
Program: EON International Research Initiative 2009-Announcement: "Heat Storage for Concentrating Solar Power"
IMDEA Energy Institute external funding: 120.066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

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 €

## 6.2. Researcher grants and mobility actions

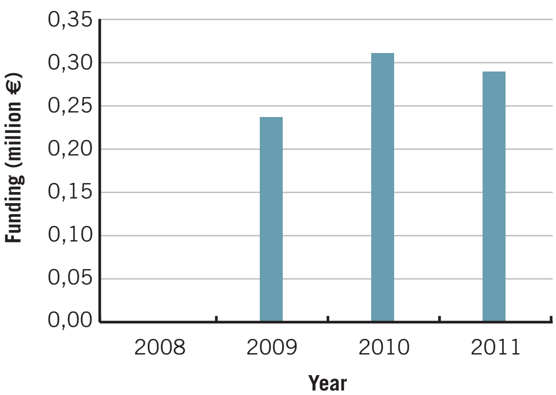
### 6.2.1. Researcher grants

Next figure shows the total external funding obtained by IMDEA Energy from grants and fellowships since the beginning of its activity according to the type of fellowship. The total funding got by IMDEA Energy has been the amount of 1.733.876 €. According to depicted data, the main source of external funding has been obtained from Ramón y Cajal-RYC program (50%).




*External funding obtained by IMDEA Energy Institute from grants and fellowships*

Next figure shows the funding received and spent every year associated to those fellowships and grants.




*External funding obtained by IMDEA Energy through fellowships and grants during 2008-2011*

The following grants have been obtained by researchers of IMDEA Energy between the years 2008-2011, and continue active in 2011:

Program: "Marie Curie" AMAROUT Europe. FP7-People Program. Call identifier: FP7-PEOPLE- 2007-2-3-COFUND
Period: 2009-2012
Funding Institution: European Union
IMDEA Energy Institute external funding: 703.845 €
Number of grants: 5
**Dr. Yongxing Yang, Dr. Carlos Pérez, Dr. Fontina Petrakopoulou, Dr. Chandrasekaran Ramasamy and Dr. Milan Prodanovic**

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: 68.104 €
**D. A. David Moreno**

Program: Ramón y Cajal 2008
Project: Materials and components for electrochemical energy storage
Period: 2009-2013
Funding Institution: Ministry of Science and Innovation
IMDEA Energy Institute external funding: 192.480 €
**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 Science and Innovation
IMDEA Energy Institute external funding: 192.480 €
**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 Science and Innovation
IMDEA Energy Institute external funding: 192.480 €
**Dr. José González**

Program: Technical Support Staff 2010
Period: 2010-2013
Funding Institution: Ministry of Science and Innovation
IMDEA Energy Institute external funding: 37.800 €
**Dª. M. Eugenia Di Falco**

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

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

Program: Predoctoral Research Grant (FPI)
Project/Acronym: Biosynthesis of the iron-molybdenum cofactor of nitrogenase/FEMOCO
Period: 2010-2011
Funding Institution: Ministry of Science and Innovation
IMDEA Energy Institute external funding: 5.710 €
**D. Alessandro Scandurra**

Program: Predoctoral Research Grant (FPI)
Project/Acronym: $CO_2$ Valorization by photocatalytic processes/ FOTOVALCO2
Period: 2010-2014
Funding Institution: Ministry of Science and Innovation
IMDEA Energy Institute external funding: 60.252 €
**Dª. Laura Collado**

Other grants recently approved and that will start in 2012, are as follows:

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Program: Ramón y Cajal 2011
Project: Intelligent power interfaces for real-time management of future power networks
Period: 2012-2016
Funding Institution: Ministry of Science and Innovation
IMDEA Energy Institute external funding: 183.600 €
**Dr. Milan Prodanovic**

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Program: Ramón y Cajal 2011
Project: Application of ionic liquid-based materials in high performance supercapacitor
Period: 2012-2016
Funding Institution: Ministry of Science and Innovation
IMDEA Energy Institute external funding: 183.600 €
**Dr. Rebeca Marcilla**

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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: 2012-2015
Funding Institution: Ministry of Science and Innovation
IMDEA Energy Institute external funding: 60.252 €

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### 6.2.2. Mobility actions

Program: Access to Facilities-European Program SFERA
Project/Acronym: Thermal and calorimetric characterization of new metallic and ceramic Materials for atmospheric AIR VOlumetric Receivers/MAIRVOR
Period: 2 weeks, 2011
Funding Institution: European Union
**D. Fabrisio Gómez**

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Program: Access to Facilities-European Program SFERA
Project/Acronym: Analysis of chemical kinetics of the $Mn_3O_4$/MnO reduction reaction in high-temperature/high-solar-radiation fluxes conditions/MANOKIN
Period: 2 weeks, 2011
Funding Institution: European Union
**Dr. José González and Dª. Elisa Alonso**

7

# cooperation framework

## 7.1. Cooperation with research institutions and universities

The following table lists cooperation agreements established with Research Institutions and Universities that have been active during 2011.

| Institution | Cooperation |
|---|---|
| Rey Juan Carlos University (URJC) (Spain) | Cooperation for the use of infrastructures and laboratories at the Campus of Móstoles.<br>Cooperation in projects and activities related to hydrogen production, solar concentrating systems and the production of sustainable fuels (Projects: CENIT-CONSOLIDA; PSEH2RENOV; SOLGEMAC and RESTOENE).<br>Period: 2008-present |
| Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT) (Spain) | Cooperation in projects and activities related to solar concentrating systems and the production of sustainable fuels (Projects: SOLGEMAC and RESTOENE).<br>Cooperation within the framework of CENIT-CONSOLIDA and SolH2 projects for hydrogen production.<br>Joint Unit CIEMAT/IMDEA Energy from April 2011<br>Period: 2008-present |
| Polytehcnic University of Madrid (UPM) | Cooperation for use of infrastructures and laboratories at the Campus of Montegancedo for biological production of hydrogen.<br>Cooperation with the Institute of Biotechnology in the FEMOCO project.<br>Period: 2008-2011 |
| 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).<br>Period: 2010-present |
| National Technical University of Athens (NTUA) (Greece) | Cooperation within the framework of HESCAP project on supercapacitors.<br>Period: 2010-present |
| CEA-LETI (France) | Cooperation within the framework of HESCAP project on supercapacitors.<br>Period: 2010-present |
| Instituto de Catálisis y Petroleoquímica-CSIC (ICP-CSIC) (Spain) | Cooperation for the production of second generation biofuels (Project RESTOENE).<br>Period: 2010-present |
| Instituto Nacional de Técnica Aeroespacial (INTA) (Spain) | Cooperation on integration of micro-turbines and Stirling engines on solar concentrating systems (Project SOLGEMAC).<br>Period: 2010-present |
| University of South Florida (USA) | Coordinator of the project funded by the company E.ON titled «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.<br>Period: 2011-present |

| Institution | Cooperation |
|---|---|
| University of Córdoba (Spain) | Cooperation within the framework of ADECAR project for the application of capacitive deionization to wastewater treatment. Period: 2011-present |
| University of Seville (Spain) | Cooperation within the framework of SolH2 project for hydrogen production. Period: 2011-present |
| University of Warwick (United Kingdom) | Cooperation within the framework of CSP2 project for solar concentrating systems. Period: 2011-present |
| Centre National de la Recherche Scientifique (CNRS) (France) | Cooperation in projects related to solar concentrating systems (Project CSP2). Period: 2011-present |
| Commissariat à l'Energie Atomique (CEA) (France) | Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-present |
| 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-present |
| Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA) (Switzerland) | Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-present |
| European Institute for Energy Research (EIFER) (Germany) | Cooperation within the framework of ADEL project for the production of hydrogen. Period: 2011-present |
| National Institute of Chemistry (Slovenia) | Cooperation in the project STOREHEAT for development of materials for thermal energy storage. Period: 2011-present |
| 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-present |
| Istituto per la Microeletronica e Microsistemi-CNR (Italy) | Cooperation within the framework of CAPSETA2 project for the design of supercapacitors. Period: 2011 |
| Paul Scherrer Institute (PSI) (Switzerland) | Cooperation within the framework of TCSPower project related to solar concentrating systems. Period: 2011-present |
| National Autonoma University of Mexico (UNAM) (Mexico) | Cooperation in joint research projects. Period: 2011-present |

Postgraduate education agreements

| Name | Cooperation activities |
|---|---|
| Rey Juan Carlos University (URJC) (Spain) | Official Master in Engineering of Chemical and Environmental Processes |
| Menéndez Pelayo International University and CSIC (Spain) | Master on Renewable Energy, Hydrogen and Fuel Cells |
| Escuela de Organización Industrial-EOI (Spain) | Master in Renewable Energies and Energy Market |
| Autonoma University of Madrid (Spain) | Master in Energies and Fuels for the Future |

## 7.2. Cooperation with other IMDEA Institutes

The following table lists cooperation agreements established with other IMDEA Institutes, which have been active during 2011.

| Name | Cooperation activities |
|---|---|
| IMDEA Water | Cooperation within the framework of TAPCAP project on energy efficient processes for water treatment with capacitive deionization. Period: 2008-2011<br>Cooperation within the framework of Researchers' night 2011 project. Period: 2011 |
| IMDEA Software<br>IMDEA Materials<br>IMDEA Networks<br>IMDEA Water<br>IMDEA Food<br>IMDEA Nanoscience<br>IMDEA  Water<br>IMDEA Social Sciences | Cooperation within the framework of AMAROUT Program. Period: 2009-2012 |

## 7.3. Cooperation with industry

The cooperation with industry has steadily grown in 2011, 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 |
|---|---|
| Hynergreen Technologies, S.A. (Spain) | Cooperation in projects and activities related to hydrogen production (CENIT-CONSOLIDA; PSERENOVH2; SOLGEMAC, SolH2 and ADEL).<br>Period: 2008-present |
| Green Fuels (Spain) | Cooperation within the framework of RESTOENE project on second generation biofuels.<br>Period: 2010-present |
| IMV Corporation (Japan) | Cooperation on energy efficient processes.<br>Period: 2010-present |
| Newbiotechnic, S.A. (Spain) | Cooperation on projects for the biosynthesis of the iron-molybdenum cofactor of nitrogenase for hydrogen production (Project FEMOCO).<br>Period: 2010-2011 |
| Sacyr Vallerhermoso, S.A. (Spain) | Coordinator of the THOFU project.<br>Period: 2010-present |
| Skeleton Technologies (Estonia) | Cooperation within the framework of HESCAP project on supercapacitors.<br>Period: 2010-present |
| Torresol Energy Investments, S.A. (Spain) | Cooperation on solar concentrating systems (Projects: SOLGEMAC and CSP2).<br>Period: 2010-present |
| APCT (Ukraine) | Cooperation within the framework of HESCAP project on supercapacitors.<br>Period: 2010-present |
| Abengoa Bioenergía (Spain) | Cooperation within the framework of RESTOENE project on second generation biofuels (Projects: RESTOENE and LIGCATUP).<br>Period: 2010-present |
| Acciona Infraestructuras, S.A. (Spain) | Cooperation on projects for capture and valorisation of $CO_2$ by photocatalysis (Projects: FOTOVALCO2 and CENIT-TECNOCAI).<br>Cooperation within the framework of SA2VE project on electrochemical energy storage with supercapacitors.<br>Period: 2010-present |
| Accelopment AG (Switzerland) | Cooperation within the framework of ADEL project for the production of hydrogen.<br>Period: 2011-present |
| Bühler AG (Switzerland) | Cooperation within the framework of TCSPower project related to solar concentrating systems.<br>Period: 2011-present |

| Name | Cooperation activities |
|---|---|
| COMESSA (France) | Cooperation in projects related to solar concentrating systems (Project CSP2).<br>Period: 2011-present |
| Empresarios Agrupados Internacional, S.A. (Spain) | Cooperation within the framework of ADEL project for the production of hydrogen.<br>Period: 2011-present |
| Equipos Industriales de Manutención, S.A. (EINSA) (Spain) | Cooperation within the framework of CAPSETA2 project for the design of supercapacitors.<br>Period: 2011 |
| E.ON (Germany) | Coordinator of the project titled «Innovative Latent Thermal Energy Storage System for Concentrated Solar Power Plants».<br>Period: 2011-present |
| Eramet et Comilog Chemicals, S.A. (Belgium) | Cooperation within the framework of TCSPower project related to solar concentrating systems.<br>Period: 2011-present |
| European Powder & Process Technology (Belgium) | Cooperation in projects related to solar concentrating systems (Project CSP2).<br>Period: 2011-present |
| HTceramix, S.A. (Switzerland) | Cooperation within the framework of ADEL project for the production of hydrogen.<br>Period: 2011-present |
| HyGear B.V. (Netherlands) | Cooperation within the framework of ADEL project for the production of hydrogen.<br>Period: 2011-present |
| Isolux Ingeniería, S.A. (España) | Cooperation within the framework of ADECAR project for the application of capacitive deionization to wastewater treatment.<br>Period: 2011-present |
| Nanoquimia (España) | Cooperation within the framework of ADECAR project for the application of capacitive deionization to wastewater treatment.<br>Period: 2011-present |
| PROINGESA (Spain) | Cooperation on energy efficient processes for water treatment with capacitive deionization (Projects: TAPCAP, REM and ADECAR).<br>Period: 2011-present |
| Siemens Concentrated Solar Power, Ltd. (Israel) | Cooperation within the framework of TCSPower project related to solar concentrating systems.<br>Period: 2011-present |
| Silkem d.o.o (Slovenia) | Cooperation in the project STOREHEAT for development of materials for thermal energy storage.<br>Period: 2011-present |
| SOFCpower, SpA (Italy) | Cooperation within the framework of ADEL project for the production of hydrogen.<br>Period: 2011-present |

| Name | Cooperation activities |
|---|---|
| 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".<br>Period: 2011-present |
| Topsoe Fuel Cell A/S (Denmark) | Cooperation within the framework of ADEL project for the production of hydrogen.<br>Period: 2011-present |
| Algaenergy, S.A. (Spain) | Cooperation within the framework of LIGCATUP project for the production of second generation biofuels.<br>Period: 2012-2014 |
| REPSOL-YPF (Spain) | Cooperation for the production of second generation biofuels. (Projects: RESTOENE and LIGCATUP).<br>Period: 2012-2014 |
| SAFT Batteries, S.L. (Spain) | Cooperation within the framework of CAPSETA2 project for the design of supercapacitors.<br>Period: 2012-2014 |
| Iberdrola (Spain) | Cooperation within the framework of SOLARO2 project for solar thermochemical processes based on manganese oxides.<br>Cooperation within the framework of SA2VE project on electrochemical energy storage with supercapacitors.<br>Period: 2008-2014 |
| Novotec Consultores, S.A. (Spain) | Cooperation within the framework of ASBIOPLAT project for the production of biofuels.<br>Period: 2012-2014 |

## 7.4. Cooperation with networks and associations

IMDEA Energy, 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, establishing new links with companies and research institutions and gaining updated information on the initiatives being planned and launched related to the different energy topics. The following list provides the main associations in which IMDEA Energy has been participating as a member in 2011:

- 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.
- Alliance of Energy Research and Innovation (ALINNE) as members and representation at the Committee of Strategies.
- HIA30 of the International Energy Agency.
- International Solar Energy Society (ISES).

# 8

# scientific results

scientific journals

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

## 8.1. Scientific publications

### Scientific Journals

1. De la Peña O'Shea, V.A.; Álvarez Galván, M.C.; Platero Prats, A.E.; Campos-Martín, J.M.; García-Fierro, J.L. "Direct evidence of the SMSI decoration effect: the case of Co/$TiO_2$". Chemical Communications, **2011**, *47*, 7131-7133.

2. Dufour, J.; Serrano, D.P.; Gálvez, J.L.; Moreno, J.; González, A.
"Hydrogen production from fossil fuels: Life Cycle Assessment of technologies with low greenhouse gas emissions".
Energy & Fuels, **2011**, *25 (5)*, 2194-2202.

3. Escola, J.M.; Aguado, J.; Serrano, D.P.; García, A.; Peral, A.; Briones, L.; Calvo, R.; Fernández, E.
"Catalytic hydroreforming of the polyethylene thermal cracking oil over Ni supported hierarchical zeolites and mesostructured aluminosilicates".
Applied Catalysis B: Environmental, **2011**, *106 (3-4)*, 405-415.

4. Guil-López, R.; Botas, J.A.; Fierro, J.L.G.; Serrano, D.P.
"Comparison of metal and carbon catalysts for hydrogen production by methane decomposition".
Applied Catalysis A-General, **2011**, *396 (1-2),* 40-51.

5. Hara, Y.; Tejedor-Tejedor, M.I.; Brzozowski, L.J.; Lara, K.; Lubin, D.; Severseike, D.J.; Anderson, M.A.
"Adsorption isotherms in defining performance of dye-sensitized solar cells with photoelectrodes of $TiO_2$ and ZnO".
Journal of the Electrochemical Society, **2011**, *158 (11)*, B1417-B1422. Impact factor: 2.427.

6. Hernández-Alonso, M.D.; Tejedor-Tejedor, I.; Coronado, J.M; Anderson, M.A.
"Operando FTIR study of the photocatalytic oxidation of methylcyclohexane and toluene in air over $TiO_2$-$ZrO_2$ thin films: influence of the aromaticity of the target molecule on deactivation".
Applied Catalysis B: Environmental, **2011**, *101 (3-4)*, 283-293.

7. Hernández-Alonso, M.D.; García-Rodríguez, S.; Sánchez, B.; Coronado, J.M.
"Revisiting the hydrothermal synthesis of titanate nanotubes: new insights on the key factors affecting the morphology".
Nanoscale, **2011**, *3 (5),* 2233-2240.

8. Hernández-Alonso, M. D., García-Rodríguez, S., Suárez, S., Portela, R., Sánchez, B., Coronado, J. M.
"Highly selective one-dimensional $TiO_2$-based nanostructures for air treatment".
Applied Catalysis B: Environmental, **2011**, *110*, 251-259.

9. Hernández, J.A.; Phillips, A.H.; Erbil, W.K.; Zhao, D.; Demuez, M.; Zeymer, C.; Pelton, J.G.; Wemmer, D.E.; Rubio, L.M.
"A sterile alpha motif domain in NafY targets Apo-NifDK for FeMo-cofactor delivery via a tethered domain".
Journal of Biological Chemistry, **2011,** *286 (8)*, 6321-6328.

10. Huelsz, G.; Gómez, F.; Piñeirua, M.; Rojas, J.; de Alba, M.; Guerra, V.
"Evaluation of refrigerator/freezer gaskets thermal loads".
HVAC&R Research, **2011**, *17 (2),* 133-143.

11. Iribarren, D.; Hospido, A.; Moreira, M.T.; Feijoo, G.
"Benchmarking environmental and operational parameters through eco-efficiency criteria for dairy farms". Science of the Total Environment, **2011**, *409 (10)*, 1786-1798.

**12.** Jana, P.; de la Peña-O'Shea, V.A.; Coronado, J.M.; Serrano, D.P.
"Co-production of graphene sheets and hydrogen by decomposition of methane using cobalt based catalysts".
Energy & Environmental Science, **2011**, *4 (3)*, 778-783.

**13.** Leonard, K.C.; Suyama, W.E.; Anderson, M.A.
"Improvement of electrochemical capacitor electrodes using $SiO_2$ nanoparticles".
Electrochimica Acta, **2011**, *56 (27)*, 10137-10144.

**14.** Martínez-Noel, G.; Curatti, L.; Hernández, J.A.; Rubio, L.M.
"NifB and NifEN protein levels are regulated by $ClpX_2$ under nitrogen fixation conditions in Azotobacter vinelandii".
Molecular Microbiology, **2011**, *79*, 1182-1193.

**15.** Miranda-García, N.; Suárez, S.; Sánchez, B.; Coronado, J.M.; Malato, S.; Maldonado, M.I.
"Photocatalytic degradation of emerging contaminants in municipal wastewater treatment effluents using immobilized $TiO_2$ in a solar pilot plant".
Applied Catalysis B: Environmental, **2011**, *103 (3-4)*, 294-301.

**16.** Morales, G Paniagua, M.; Melero, J.A.; Vicente, G.; Ochoa, C.
"Sulfonic acid-functionalized catalysts for the valorization of glycerol via transesterification with methyl acetate". Industrial and Engineering Chemistry Research, **2011**, *50*, 5898–5906.

**17.** Polo, J.; Zarzalejo, L.F.; Cony, M.; Navarro, A.A.; Marchante, R.; Martín, L.; Romero, M.
"Solar radiation estimations over India using Meteosat satellite images".
Solar Energy, **2011**, *85*, 2395-2406.

**18.** Sanz, R.; Serrano, D.P.; Pizarro, P.; Moreno, I.
"Hierarchical TS-1 zeolite synthesized from $SiO_2$-$TiO_2$ xerogels imprinted with silanized protozeolitic units".
Chemical Engineering Journal, **2011**, *171 (3)*, 1428-1438.

**19.** Serrano, D.P.; García, R.A.; Vicente, G.; Linares, M.; Prochazkova, D.; Cejka, J.
"Acidic and catalytic properties of hierarchical zeolites and hybrid ordered mesoporous materials assembled from MFI protozeolitic units".
Journal of Catalysis, **2011**, *279 (2)*, 366-380.

**20.** Serrano, D.P.; Aguado, J.; Escola, J.M.; Moreno, J.; González, A.
"Synthesis of hierarchical ZSM-5 by silanization and alkoxylation of protozeolitic units".
Catalysis Today, **2011**, *168 (1)*, 86-95.

**21.** Shi, J.; Starr, M.B.; Xiang, H.; Hara, Y.; Anderson, M.A.; Seo, Jung-Hun; Ma, Zhenqiang; Wang, Xudong.
"Interface engineering by piezoelectric potential in ZnO-Based photoelectrochemical anode".
Nano Letters, **2011**, *11 (12)*, 5587-5593.

**22.** Suárez, S.; Arconada, N.; Castro, Y.; Coronado, J.M.; Portela, R.; Durán, A.; Sánchez, B.
"Photocatalytic degradation of trichloroethylene in dry and wet air conditions with $TiO_2$ porous thin films".
Applied Catalysis B: Environmental, **2011**, 108-109, 14-21.

**23.** Vázquez-Rowe, I.; Iribarren, D.; Hospido, A.; Moreira, A.T.; Feijoo, G.
"Computation of operational and environmental benchmarks within selected Galician fishing fleets (NW Spain)".
Journal of Industrial Ecology, **2011**, *15 (5)*, 776-795.

**24.** Díaz, R.; Orcajo, M.G.; Botas, J.A. Calleja, G.; Palma, J.
"Co8-MOF-5 as electrode for supercapacitors".
Material Letters, accepted.

**25.** Dufour, J.; Iribarren, D.
"Life cycle assessment of biodiesel production from free fatty acid-rich wastes".
Renewable Energy, accepted.

**26.** 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, accepted.

**27.** 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, accepted.

**28.** Hernández-Alonso, M.D.; García-Rodríguez, S.; Suárez, S.; Portela, R.; Sánchez, B.; Coronado, J.M.
"Operando DRIFTS study of the role of hydroxyls groups in trichloroethylene photo-oxidation over titanate and $TiO_2$ nanostructures".
Catalysis Today, accepted.

**29.** Iribarren, D.; Dagá, P.; Moreira, M.T.; G. Feijoo, G.
"Potential environmental effects of probiotics used in aquaculture".
Aquaculture International, accepted.

**30.** Iribarren, D.; Moreira, M.T.; G. Feijoo.
"Life Cycle Assessment of aquaculture feed and application to the turbot sector".
International Journal of Environmental Research, accepted.

**31.** Iribarren, D.; Peters, J.F.; Dufour, J.
"Life Cycle Assessment of transportation fuels from biomass pyrolysis".
Fuel, accepted.

**32.** Isikli, S.; Díaz, R.
"Substrate-dependent performance of supercapacitors based on an organic redox copule impregnated on carbon".
Journal Power Sources, accepted.

**33.** 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, accepted.

**34.** 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, accepted.

**35.** 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, accepted.

**36.** Petrakopoulou F., Tsatsaronis G., Morosuk T.
"Application of an advanced exergoenvironmental analysis to a near-zero emission power plant with chemical looping combustion".
Environmental Science and Technology, accepted.

**37.** 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, accepted.

**38.** Petrakopoulou F., Tsatsaronis G., Morosuk T., Paitazoglou C.
"Environmental evaluation of a power plant using conventional and advanced exergy-based methods".
International Journal of Energy, accepted.

**39.** 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, accepted.



**40.** Romero, M.; Steinfeld, A.
"Concentrated solar thermal power and thermochemical fuels".
Energy & Environmental Science, accepted.

**41.** Santini, A.; Passarini, F.; Vassura, I.; Serrano, D.P.; Dufour, J. Morselli, L.
"Auto shredder residue recycling: mechanical separation and pyrolysis".
Waste Management, accepted.

**42.** 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, accepted.

**43.** 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, accepted.

**44.** 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, accepted.

## Books and chapters of books

**1.** Romero, M. and González-Aguilar, J. **2011**. Chapter 3: "Solar thermal power plants: from endangered species to bulk power production in sun-belt regions". In: "Energy & Power Generation Handbook". Ed. K.R. Rao. ASME, 3 Park Avenue, New York, NY 10016-5990, USA. ISBN: 978-0-7918-5955-1.

**2.** Dufour J., Martos, C., Ruiz, A. "Catalytic applications of magnetite: hydrogen production through WGS reaction". **2011**. In: "Magnetite: structure, properties and applications", Nova Science Publishers, New York (USA). ISBN: 978-1-61761-839-0.

**3.** Dufour, J.; Moreno, J.; Rodríguez, R. **2011**. "Life Cycle Assessment of biodiesel production from microalgae oil: effect of algae species and cultivation system". In: "Towards Life Cycle Sustainability Management", Springer. ISBN: 978-94-007-1898-2.

**4.** Petrakopoulou F.; Tsatsaronis G.; Piancanstelli C.; Gallio I.; Morosuk, T. **2011**. "Exergetic and exergoeconomic analyses of an oxy-fuel power plant with $CO_2$ capture" in: "Advances in energy research", Vol. 6, (Morena J. Acosta), Nova Publishers, pp. 229-242, ISBN: 978-1-61122-075-9.

**5.** Serrano, D.P.; Aguado, J.; Escola, J.M. **2011**. "Hierarchical zeolites: materials with improved accessibility and enhanced textural properties". In: RSC catalysis series. Ed. Royal Society of Chemistry (Cambridge, United Kingdom). ISBN: 978-1-84973-277-2.

## Patents

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

**2.** Application number: P201131383, title: "Campo vertical de heliostatos". Date of application: 12/08/2011 (O.E.P.M). Holder: IMDEA Energy Institute. Inventors: González, A.; Romero, M.; González-Aguilar, J.

books
chapters of books
patents

## 8.2. Congress communications

### Invited lectures

**1.** Title: *Experimental characterization of 3-D heat flux distribution of a 7kWe solar simulator*
Author: Gómez, F.
Congress: 7th SOLLAB Doctoral Colloquium
Venue: Grindelwald, Switzerland
Date: 21-23 March 2011
Organizer: ETHZ

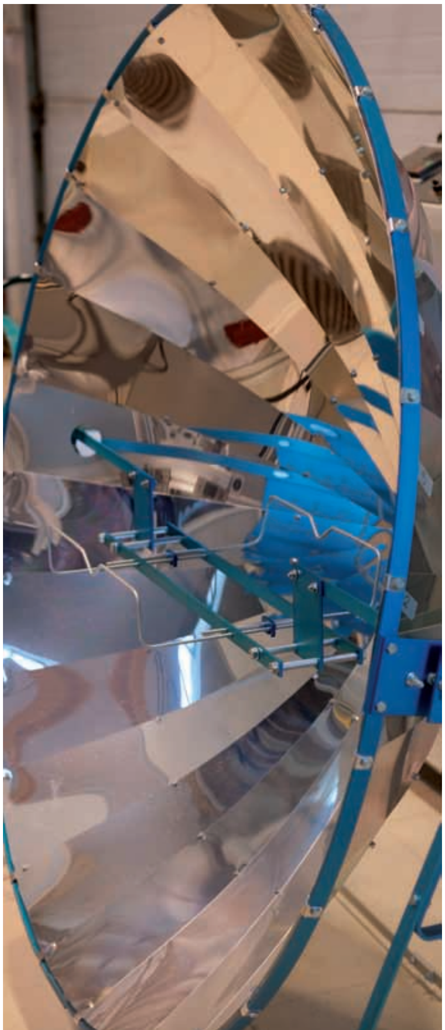
**2.** Title: *Energie solaire à haute température: de la curiosité de laboratoire à son implantation actuelle dans le marché de l'électricité, la thermique et la chimie*
Author: Romero, M. (plenary)
Congress: Congreso Francés de Energía Solar Térmica SFT2011
Venue: Perpignan, France
Date: 24-27 May 2011
Organizer: CNRS

**3.** Title: *Advances in thermochemical transformations of biomass for improving liquid biofuel production*
Author: Coronado, J.M.
Congress: Use of agro-forest and oily residues to produce clean transportation fuels - Workshop RESTOENE
Venue: Residencia la Cristalera, Miraflores de la Sierra, Madrid, España
Date: 8-10 June 2011
Organizer: ICP-CSIC

**4.** Title: *Emmagatzematge d'energia: situación actual i reptes de la clau de l'èxit de la implementació de les energies renovables*
Authors: Díaz, R.
Congress: XXVII Trobades Científiques de la Mediterrània
Venue: Maón, Spain
Date: 29 September-1 October 2011
Organizer: Societat Catalana de Física i Institut Menorquí d'Estudis

**5.** Title: *Hierarchical zeolites: singular properties, novel applications*
Author: Serrano, D.P.
Congress: 4th Slovenian - Croatian Symposium on Zeolites
Venue: Ljubljana, Slovenia
Date: 17-18 October 2011
Organizer: National Institute of Chemistry, Slovenia

**6.** Title: *Towards a sustainable energy system: technology challenges*
Authors: Serrano, D.P. (plenary)
Congress: 12th Mediterranean Congress of Chemical Engineering
Venue: Barcelona, Spain
Date: 15-18 November 2011
Organizer: SEQUI; Fair of Barcelona; Expoquimia



## Oral communications

**1.** Title: *Asimetric Capacitive Deionization (CDI), an emerging technology for water treatment in small communities*
Authors: Lado, J.; Wouters, J.; Tejedor, M.I.; Anderson, M.; García-Calvo, E.
Congress: 3rd International Congress Smallwat11 on Wastewater in Small Communities
Venue: Seville, Spain
Date: 25-28 April 2011
Organizer: Centro de las Nuevas Tecnologías del Agua (CENTA)

**2.** Title: *Synthesis of $TiO_2/V_2O_5$ core/shell nanocrystals for supercapacitors*
Authors: Chávez-Capilla, T.; Epifani, M.; Andreu, T.; Zamani, R.; Palma, J.; Arbiol, J.; Siciliano, P.; Morante, J. R.; Díaz, R.
Congress: *E-MRS 2011 Spring Meeting, IUMRS ICAM 2011 & E-MRS/MRS Bilateral Conference on Energy*
Venue: Niza, France
Date: 9-13 Mayo 2011
Organizer: European Materials Research Society

**3.** Title: *Optimizing the yield of one-dimensional $TiO_2$ nanostructures for air treatment applications*
Author: Coronado, J.M.
Congress: International Conference on Structure-Performance Relationships in Functional Materials Catalysis, Electrochemistry and Surfactants
Venue: Fuengirola, Spain
Date: 18-20 May 2011
Organizer: UMA; ICP-CSIC

**4.** Title: *Influence of the calcination treatment on the catalytic properties of hierarchical ZSM-5*
Authors: Serrano, D.P.; García, R.A.; Linares, M.; Gil, B.
Congress: The 4th Czech-Italian-Spanish (CIS-4) workshop on Molecular Sieves and Catalysis
Venue: Liblice, Czech Republic
Date: 15-18 June 2011
Organizer: J. Heyrovsky Institute of Physical Chemistry of the ASCR

**5.** Title: *Thermal and optical analysis of a 100 kWth multi-tubular reactor for hydrogen production based on a two-step thermochemical cycle integrated in a solar tower*
Authors: Betancourt, M.M.; García€Orta, V.G.; Pardo, A.G.; Aguilar, J.G.; Romero, M.; Iranzo, A.; Salva, A.; Tapia, E.
Congress: 2011 International Conference on Hydrogen Production (ICH2P-2011)
Venue: Thessaloniki, Greece
Date: 19-22 June 2011
Organizer: CPERI/CERTH

**6.** Title: *N and Cu-doped ZnO as $CO_2$ photoreduction catalyst*
Authors: Núñez, J.; de la Peña O'Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: 11th International Conference on Carbon Dioxide Utilization
Venue: Dijon, France
Date: 27-30 June 2011
Organizer: Institut de Chimie Moléculaire de l'Université de Bourgogne (ICMUB)

**7.** Title: *Influence of $Na_xMnO_{2+‰}$ synthesis on the hydrogen production stage of the $Mn_2O_3/MnO$ thermochemical cycle*
Authors: Bayón, A.; Sandoval, Martín-Betancourt, M.; Coronado, J.M.; de la Peña-O´Shea, V.A.; Serrano, D.P.
Congress: III Iberian Symposium on Hydrogen, Fuel Cells and Advanced Batteries (HYCELTEC 2011)
Venue: Zaragoza, Spain
Date: 27-30 June 2011
Organizer: LITEC-CSIC; University of Zaragoza

**8.** Title: *Hydrogen production by methane decomposition using cobalt based catalyst prepared by precipitation method in ethylene glycol*
Authors: Jana, P.; de la Peña-O´Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: III Iberian Symposium on Hydrogen, Fuel Cells and Advanced Batteries (HYCELTEC 2011)
Venue: Zaragoza, Spain
Date: 27-30 June 2011
Organizer: LITEC-CSIC; University of Zaragoza

**9.** Title: *Reaction studies of catalytic decomposition of methane over mesostructured carbons*
Authors: Serrano, D.P.; Botas, J.A.; Pizarro, P.; Gómez, G.; Martín, J.
Congress: III Iberian Symposium on Hydrogen, Fuel Cells and Advanced Batteries (HYCELTEC 2011)
Venue: Zaragoza, Spain
Date: 27-30 June 2011
Organizer: LITEC-CSIC; University of Zaragoza

**10.** Title: *Advanced electrolysers for hydrogen production with renewable energy sources*
Authors: Bucheli, O.; Lefebvre-Joud, F.; Brisse, A.; Martin Roeb, M.; Romero, M.
Congress: Europen Fuel Cell Forum 2011
Venue: Lucerne, Switzerland
Date: 28 June-1 July 2011
Organizer: European Fuel Cell Forum AG

**11.** Title: *Hidrodesoxigenación de ésteres metílicos sobre materiales tipo SBA-15 impregnados con Ni, Co y Cu*
Authors: Ochoa, C.; Yang, Y.; Coronado, J.M.; de la Peña-O´Shea, V.A.; Serrano, D.P.
Congress: SECAT 2011 – La catálisis ante la crisis energética y ambiental
Venue: Zaragoza, Spain
Date: 29 June-1 July 2011
Organizer: University of Zaragoza

**12.** Title: *Producción de hidrógeno por descomposición catalítica de metano sobre carbones mesoestructurados*
Authors: Botas, J.A.; Serrano, D.P.; Pizarro, P.; Gómez, G.
Congress: SECAT 2011 – La catálisis ante la crisis energética y ambiental
Venue: Zaragoza, Spain
Date: 29 June-1 July 2011
Organizer: University of Zaragoza

**13.** Title: *Improvement of the hierarchical TS-1 properties by silanization of protozeolitic units in presence of alcohols*
Authors: Serrano, D.P.; Sanz, R.; Pizarro, P.; Moreno, I.; Peral, A.
Congress: $5^{th}$ International FEZA Conference
Venue: Valencia, Spain
Date: 3-7 July 2011
Organizer: ITQ-CSIC

**14.** Title: *Kinetic modelling of asphaltene aggregation by FBRM®: evaluation of inhibitors performance*
Authors: Marugán, J.; Dufour, J.; Calles, J.A.; Giménez-Aguirre, R.; Merino-García, D.; Sanz, P.; Peña, J.L.
Congress: Petrophase 2011
Venue: Londres, UK
Date: 10-14 July 2011
Organizer: Institute of Physics

**15.** Title: *$Ni_2P$/SBA-15: a new type of nonsulfide hydrotreating catalyst for green diesel production*
Authors: Yang, Y.; Ochoa, C.; de la Peña-O´Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: EuropaCat X
Venue: Glasgow, Reino Unido
Date: 28 August-2 September 2011
Organizer: University of Glasgow

**16.** Title: *Vertical reflector fields: feasibility of optical and geometrical arrangements for CSP integration in façades*
Author: González, A.
Congress: ISES Solar World Congress 2011
Venue: Kassel, Germany
Date: 28 August-2 September 2011
Organizer: International Solar Energy Society

**17.** Title: *Diferentes estrategias de destoxificación con lacasas para la producción de etanol a partir de biomasa lignocelulósica*
Authors: Moreno, A.D.; Ibarra, D.; Fernández-Rojo, J.L.; Ballesteros, M.
Congress: XIV Red Temática en Biotecnología de Materiales Lignocelulósicos
Venue: Madrid, Spain
Date: 5-6 September 2011
Organizer: CIEMAT

**18.** Title: *Effect of cobalt source on $H_2$ production by catalytic methane decomposition*
Authors: Jana, P.; de la Peña-O´Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: 4th World Hydrogen Technologies Convention (WHTC2011)
Venue: Glasgow, United Kingdom
Date: 14-16 September 2011
Organizer: University of Glasgow

**19.** Title: *Preliminary identification of environmental and economical hotspots of hydrogen production from renewable energy sources: the case of solar thermal processes*
Authors: Dufour, J.; Gálvez, J.L.; Martínez, G.
Congress: 4th World Hydrogen Technologies Convention (WHTC2011)
Venue: Glasgow, United Kingdom
Date: 14-16 September 2011
Organizer: University of Glasgow

**20.** Title: *Analysis of a sustainable process to obtain hydrogen from biogas: environmental comparison with traditional manufacture*
Authors: Dufour, J.; Serrano, D.P.; Espada, J.J.
Congress: 4th World Hydrogen Technologies Convention (WHTC2011)
Venue: Glasgow, United Kingdom
Date: 14-16 September 2011
Organizer: University of Glasgow

**21.** Title: *Effect of cobalt instead copper as promoter of ht-water gas shift catalysts*
Authors: Martos, C.; Dufour, J.; Ruiz, A.
Congress: 4th World Hydrogen Technologies Convention (WHTC2011)
Venue: Glasgow, United Kingdom
Date: 14-16 September 2011
Organizer: University of Glasgow

**22.** Title: *Accessory enzymes in the 2nd generation bioethanol: hemicellulases and laccases*
Authors: Ibarra, D.; Moreno, A.D.; Alvira. P.; Ballesteros, M.
Congress: EERA bioenergy workshop: sugar platform
Venue: Toulouse, France
Date: 19-20 September 2011
Organizer: EERA

**23.** Title: *Optical-Energetical optimization of heliostat fields for pilot and commercial decentralized power generation in India*
Authors: González, A.; González-Aguilar, J.; Goel, N.; Romero, M.; Abraham, J.
Congress: SolarPACES 2011
Venue: Palacio de exposiciones y congresos de Granada, Granada, Spain
Date: 20-23 September 2011
Organizer: SolarPACES; PSA CIEMAT

**24.** Title: *Experimental analysis of $Mn_3O_4$ /MnO reduction in a packed-bed type solar reactor: Oxygen partial pressure influence*
Authors: Alonso E.; Gómez, F.; González-Aguilar, J.; Romero, M.
Congress: SolarPACES 2011
Venue Palacio de exposiciones y congresos de Granada, Granada, Spain
Date: 20-23 September 2011
Organizer: SolarPACES; PSA CIEMAT

**25.** Title: *Heliostat testing at a new facility in Sonora, Mexico*
Authors: Arancibia-Bulnes, C.A.; Peña-Cruz, M.I.; Marroquín-García, D.; Cabanillas, R.E.; Pérez-Rábago, C.A.; Riveros-Rosas, D.; Hinojosa J. F.; Estrada, C.A.
Congress: SolarPACES 2011
Venue: Palacio de exposiciones y congresos de Granada, Granada, Spain
Date: 20-23 September 2011
Organizer: SolarPACES; PSA CIEMAT

**26.** Title: *Concentration image profiles of the high-flux solar furnace of CIE-UNAM in temixco, Mexico. First Stage*
Authors: Riveros-Rosas, D.; Pérez-Rabago, C.A.; Arancibia-Bulnes, C.A.; Ricardo Perez-Enciso, R.; Estrada, C.A.
Venue: Palacio de exposiciones y congresos de Granada, Granada, Spain
Date: 20-23 September 2011
Organizer: SolarPACES; PSA CIEMAT

**27.** Title: *Preliminary assessment of plastic waste valorization via sequential pyrolysis and catalytic reforming*
Authors: Dufour, J.; Serrano, D.P.; Iribarren, D.
Congress: 6th International Symposium on Feedstock Recycling of Polymeric Materials (ISFR2011)
Venue Toledo, Spain
Date: 5-7 October 2011
Organizer: Rey Juan Carlos University; IMDEA Energy Institute

**28.** Title: *Hydroreforming of LDPE thermal cracking waxes over Ni/h-beta catalysts with different Ni particle size obtained from different Ni precursors*
Authors: Aguado, J.; Serrano, D.P.; Escola, J.M.; Briones, L.
Congress: 6th International Symposium on Feedstock Recycling of Polymeric Materials (ISFR2011)
Venue Toledo, Spain
Date: 5-7 October 2011
Organizer: Rey Juan Carlos University; IMDEA Energy Institute

**29.** Title: *Catalytic cracking of polyethylene over hierarchical H-ZSM-5 zeolites with different proportion of micro- and mesoporosity*
Authors: Serrano, D.P.; Aguado, J.; Escola, J.M.; Peral, A.
Congress: 6th International Symposium on Feedstock Recycling of Polymeric Materials (ISFR2011)
Venue Toledo, Spain
Date: 5-7 October 2011
Organizer: Rey Juan Carlos University; IMDEA Energy Institute

**30.** Title: *Hydroreforming over Ni/h-beta of the thermal cracking products of LDPE, HDPE and PP for fuel production*
Authors: Aguado, J.; Serrano, D.P.; Escola, J.M.; Briones, L.
Congress: 6th International Symposium on Feedstock Recycling of Polymeric Materials (ISFR2011)
Venue Toledo, Spain
Date: 5-7 October 2011
Organizer: Rey Juan Carlos University; IMDEA Energy Institute

**31.** Title: *Laccase detoxification of steam-exploded wheat straw for ethanol production by thermotolerant yeast Kluyveromyces marxianus*
Authors: Moreno, A.D.; Ibarra, D.; Fernández-Rojo, J.L.; Ballesteros, M.
Congress: XIX International Symposium on Alcohol Fuels: Development and utilization of alcohol fuels to promote sustainability (ISAF)
Venue: Verona, Italy
Date: 10-14 October 2011
Organizer: University of Verona

**32.** Title: *An integrated approach to optimization of energy supply mix in smart buildings*
Authors: Gafurov, T.; Téllez M.B; Prodanovic M.
Congress: IEEE PES Innovative Smart Grid Technologies 2011 Europe (ISGT-EUROPE 2011)
Venue: Manchester, United Kingdom
Date: 5-7 December 2011
Organizer: University of Manchester

## Poster communications

**1.** Title: *Catalytic hydrotreating of vegetable oils and bio-oils for upgraded biofuels production*
Authors: Ochoa, C.; Yang, Y.; Infantes-Molina, A.; de la Peña-O´Shea, V.A.; Pawelec, B.; García-Fierro, J.L.; Coronado, J.M.; Serrano, D.P.
Congress: Use of agro-forest and oily residues to produce clean transportation fuels - Workshop RESTOENE
Venue: Residencia la Cristalera Miraflores de la Sierra, Madrid, Spain
Date: 8-10 June 2011
Organizer: ICP-CSIC

**2.** Title: *Different laccase detoxification strategies for ethanol production from lignocellulosic biomass by thermotolerant yeast Kluyveromyces marxianus*
Authors: Moreno, A.D; Ibarra, D.; Fernández-Rojo, J.L.; Ballesteros, M.
Congress: Use of agro-forest and oily residues to produce clean transportation fuels - Workshop RESTOENE
Venue: Residencia la Cristalera Miraflores de la Sierra, Madrid, Spain
Date: 8-10 June 2011
Organizer: ICP-CSIC

**3.** Title: *Insights into the influence of pore size distribution and surface functionalities in the behaviour of carbon supercapacitors*
Authors: Vaquero, S; Marcilla, R.; Díaz, R.; Anderson, M.A.; Palma, J.
Congress: 2nd International Symposium on Enhanced Electrochemical Capacitors - ISEE'Cap2011
Venue: Poznan, Polonia
Date: 12-16 June 2011
Organizer: Technological University of Poznan

**4.** Title: *Estudio de las condiciones de operación óptimas para la producción de olefinas ligeras en procesos de craqueo catalítico de aceites vegetales*
Authors: Serrano, D.P.; Botas, J.A.; García, A.; Ramos, R.
Congress: SECAT 2011 – La catálisis ante la crisis energética y ambiental
Venue: Zaragoza, Spain
Date: 29 June-1 July 2011
Organizer: University of Zaragoza

**5.** Title: *Modificación de materiales tipo MCM-41 mediante la incorporación de hierro*
Authors: Collado, L.; Jana, P.; de la Peña-O´Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: SECAT 2011– La catálisis ante la crisis energética y ambiental
Venue: Zaragoza, Spain
Date: 29 June-1 July 2011
Organizer: University of Zaragoza

**6.** Title: *Hydroreforming of the LDPE thermal cracking product over Ni supported hierarchical and commercial HZSM-5*
Authors: Aguado, J.; Serrano, D.P.; Escola, J.M.; García, A.; Peral, A.; Briones, L.; Calvo, R.; Fernández E.
Congress: 5th International FEZA Conference
Venue: Valencia, Spain
Date: 3-7 July 2011
Organizer: ITQ-CSIC

posters communications

**7.** Title: *Hydrodeoxygenation of methyl esters over Ni-Beta zeolite with hierarchical porosity*
Authors: Ochoa, C.; Yang, Y.; Coronado, J.M.; de la Peña-O`Shea, V.A.; Serrano, D.P.
Congress: 5th International FEZA Conference
Venue: Valencia, Spain
Date: 3-7 July 2011
Organizer: ITQ-CSIC

**8.** Title: *Synthesis of hierarchical ZSM-5 zeolite from silanized seeds employing silylated polymers as organosilanes*
Authors: Pinnavaia, T.J.; Serrano, D.P.; Aguado, J.; Kim, S.S.; Peral, A.
Congress: 5th International FEZA Conference
Venue: Valencia, Spain
Date: 3-7 July 2011
Organizer: ITQ-CSIC

**9.** Title: *Kinetic study of hydrogen production by catalytic decomposition of methane over mesostructured carbons*
Authors: Serrano, D.P.; Botas, J.A.; Pizarro, P.; Gómez, G.; Martín, J.
Congress: 5th International FEZA Conference
Venue: Valencia, Spain
Date: 3-7 July 2011
Organizer: ITQ-CSIC

**10.** Title: *Acidic and catalytic properties of hierarchical zeolites and hybrid ordered mesoporous materials assembled from MFI protozeolitic units*
Authors: Serrano, D.P.; García, R.A.; Vicente, G.; Linares, M.; Prochacková, D.; Cejka, J. D.P.
Congress: 5th International FEZA Conference
Venue: Valencia, Spain
Date: 3-7 July 2011
Organizer: ITQ-CSIC

**11.** Title: *Indirect determination of asphaltene stability by thermogravimetric analysis*
Authors: Dufour, J.; Marugán, J.; Calles, J.A.; Giménez-Aguirre, R.; Merino-García, D.; Sanz, P.; Peña, J.L.
Congress: Petrophase 2011
Venue: Londres, United Kingdom
Date: 10-14 July 2011
Organizer: Institute of Physics

**12.** Title: *Life cycle assessment of biodiesel production from microalgae. Minimizing the impact of drying process*
Authors: Dufour, J.; Serrano, D.P.; Moreno, J.; Rodríguez, R.
Congress: 1st International Conference on Algal Biomass, Biofuels and Bioproducts
Venue: St. Louis, Missouri, USA
Date: 17-20 July 2011
Organizer: Elsevier

**13.** Title: *Catalytic hydrodeoxygenation of methyl oleate as a model for microalgae oil upgrading*
Authors: Ochoa, C.; Yang, Y.; de la Peña-O`Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: 1st International Conference on Algal Biomass, Biofuels and Bioproducts
Venue: St. Louis, Missouri, USA
Date: 17-20 July 2011
Organizer: Elsevier

**14.** Title: *Application of life cicle assessment methodology to methane production from solid waste*
Authors: Dufour, J.; Serrano, D.P. Espada, J.J.
Congress: Life Cycle Management Conference 2011
Venue: Berlín, Germany
Date: 28-31 August 2011
Organizer: TU Berlin; Volkswagen

**15.** Title: *Computation of operational and environmental benchmarks for dairy farms through the five-step LCA+DEA method*
Authors: Iribarren, D.; Hospido, A.; Moreira, M.T.; Feijoo, G.
Congress: Life Cycle Management Conference 2011
Venue: Berlín, Germany
Date: 28-31 August 2011
Organizer: TU Berlin; Volkswagen

**16.** Title: *Life cycle assessment of biodiesel production from microalgae oil: effect of algae species and cultivation system*
Authors: Dufour, J.; Moreno, J.; Rodríguez, R.
Congress: Life Cycle Management 2011
Venue: Berlín, Germany
Date: 28-31 August 2011
Organizer: TU Berlin; Volkswagen

17. Title: *Life cycle assessment of biodiesel production from cardoon (Cynara Cardunculus) oil obtained under Spain conditions*
Authors: Dufour, J.; Arsuaga, J.M.; Moreno, J.; Torrealba, H.
Congress: Life Cycle Management 2011
Venue: Berlín, Germany
Date: 28-31 August 2011
Organizer: TU Berlin; Volkswagen

18. Title: *Environmental profile and sustainability of hydrogen production technologies: the PHISICO2 program*
Authors: Dufour, J.; Serrano, D.P.; Gálvez, J.L.; Martínez, G.
Congress: Life Cycle Management 2011
Venue: Berlín, Germany
Date: 28-31 August 2011
Organizer: TU Berlin; Volkswagen

19. Title: *Cobalt based catalysts prepared by nanoreplication using SBA-15 as template*
Authors: Jana, P.; de la Peña-O´Shea, V.A.; Coronado, J.M.; Pizarro, P.; Serrano, D.P.
Congress: EuropaCat X
Venue: Glasgow, United Kingdom
Date: 28 August-2 September 2011
Organizer: University of Glasgow

20. Title: *Effect of the synthesis procedure in the physico-chemical properties of mesostructured cobalt based catalysts*
Authors: Jana, P.; de la Peña-O´Shea, V.A.; Coronado, J.M.; Pizarro, P.; Serrano, D.P.
Congress: EuropaCat X
Venue: Glasgow, United Kingdom
Date: 28 August-2 September 2011
Organizer: University of Glasgow

21. Title: *Parametric study of a latent thermal storage module*
Author: Ramos, A.; Sarada, K.; Rahman, M.; Yogi, G.; Stefanakos, E.; González-Aguilar, J.; Romero, M.
Congreso: ISES Solar World Congress 2011
Venue: Kassel, Germany
Date: 28 August-2 September2011
Organizer: International Solar Energy Society

22. Title: *On the search of efficient materials for solar fuels production from $CO_2$ photovalorization*
Autores: Sierra, B.; Collado, L.; Núñez, J.; Jana, P.; de la Peña-O´Shea, V.A.; Coronado, J.M.; Serrano, D.P.
Congress: Artificial Photosynthesis: Faraday Discussion 155
Venue: Edinburgh, United Kingdom
Date: 5-7 September 2011
Organizer: Royal Society of Chemistry

23. Title: *Metal Organic Frameworks for supercapacitors*
Authors: Díaz, R.; Orcajo, M. G.; Botas, J. A.; Calleja, G.; Palma, J.
Congress: 62$^{nd}$ Annual Meeting of the International Society of Electrochemistry
Venue: Niigata, Japan
Date: 11-16 September 2011
Organizer: International Society of Electrochemistry

24. Title: *Composite supercapacitor electrodes through surface adsorption of an organic redox couple on carbon*
Authors: Isikli, S.; Díaz, R.
Congress: 62$^{nd}$ Annual Meeting of the International Society of Electrochemistry
Venue: Niigata, Japan
Date: 11-16 September 2011
Organizer: International Society of Electrochemistry

25. Title: *Experimental 3D heat flux distribution of a 7 kWe-solar simulator*
Authors: Gómez, F.; González-Aguilar, J.; Romero, M.
Congress: SolarPACES 2011
Venue: Palacio de exposiciones y congresos de Granada, Granada, Spain
Date: 20-23 September 2011
Organizer: SolarPACES; PSA CIEMAT

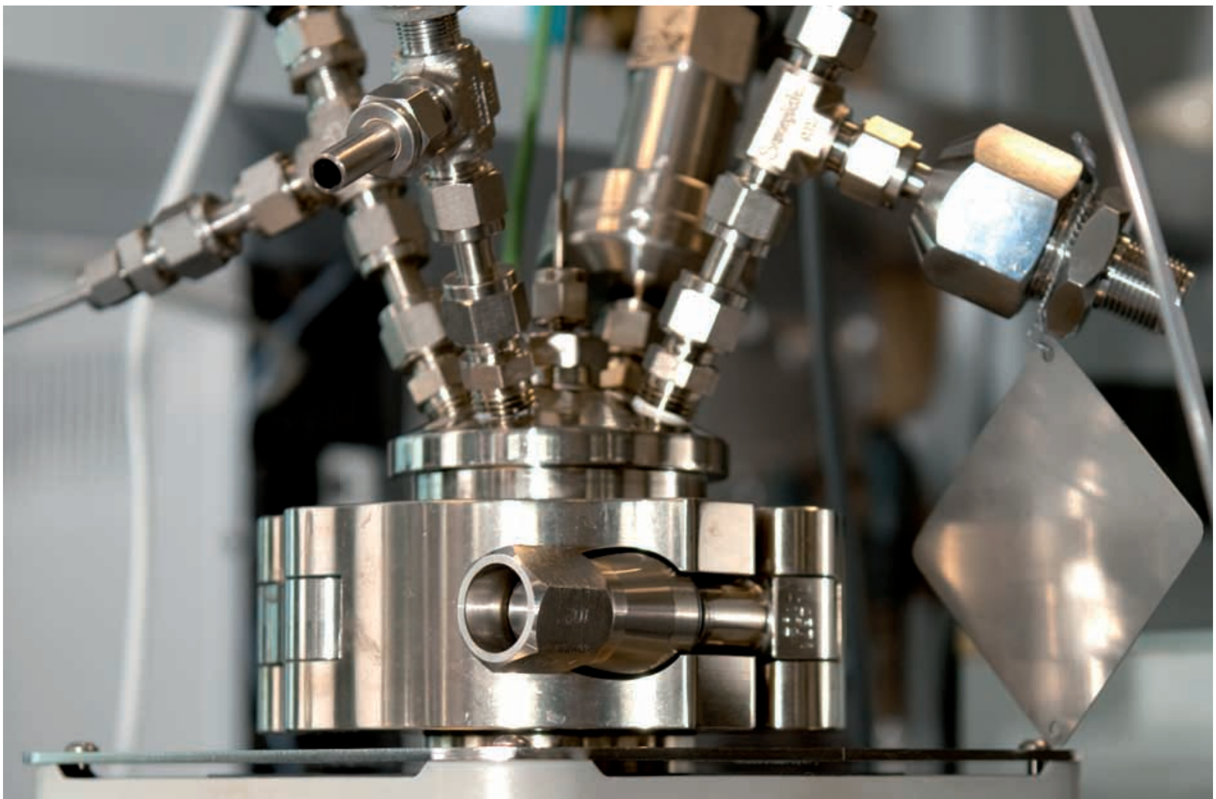
**26.** Title: *Experimental analysis of $Mn_3O_4$ /MnO reduction in a packed-bed type solar reactor: Oxygen partial pressure influence*
Authors: Alonso E.; Gómez, F.; González-Aguilar, J.; Romero, M.
Congress: SolarPACES 2011
Venue Palacio de exposiciones y congresos de Granada, Granada, Spain
Date: 20-23 September 2011
Organizer: SolarPACES; PSA CIEMAT

**27.** Title: *Control system for the high-flux solar furnace of the CIE-UNAM in Temixco, Mexico. First stage.*
Authors: Pérez-Rábago, C. A., Guzmán-Galán, R., Flores-Guzmán, N., Brito, E., Marroqui-García, D., Pérez-Enciso, R., Riveros-Rosas, D., Arancibia-Bulnes, C.A., Estrada, C.A.
Congress: SolarPACES 2011.
Venue: Palacio de exposiciones y congresos de Granada, Granada, Spain
Date: 20-23 September 2011
Organizer: SolarPACES; PSA CIEMAT

**28.** Title: *Proactive control for energy systems in smart buildings*
Authors: Gafurov, T.; Téllez M.B; Prodanovic M.
Congress: IEEE PES Innovative Smart Grid Technologies 2011 Europe (ISGT-EUROPE 2011)
Venue: Manchester, United Kingdom
Date: 5-7 December 2011
Organizer: University of Manchester

**29.** Title: *Hydrocarbon production through hydrodeoxygenation of methyl esters over Ni and Co supported on SBA-15 and Al-SBA-15*
Authors: Ochoa-Hernández, C.; Yang, Y.; Coronado, J.M.; de la Peña-O'Shea, V.A.; Serrano, D.P.
Congress: Catbior 2011 - 1st International Congress on Catalysis for Biorefineries
Venue: Torremolinos, Málaga, Spain
Date: 2-5 October 2011
Organizer: CSIC; University of Málaga (UMA)





# 9

# training and dissemination activities

conferences

## 9.1. Organization of conferences, courses and seminars

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

**1.** Conference: Liquid Fuels from Water, $CO_2$, and Solar Energy
Speaker: Steinfeld, A.
Venue: EOI, Madrid, Spain
Date: 4 April 2011
Organizer: EOI; IMDEA Energy Institute

**2.** Congress: Sociedad Española de Catálisis, SECAT 2011
Member of the Scientific Committee: Serrano, D.P.
Venue: Zaragoza, Spain
Date: 29 June - 1 July 2011
Organizer: University of Zaragoza

**3.** Congress: 5$^{th}$ International FEZA Conference
Member of the Organizer Committee: Serrano, D.P.
Venue: Valencia, Spain
Date: 3-7 July 2011
Organizer: ITQ-CSIC

**4.** Congress: International Solar Energy Society (ISES)
Member of the Scientific Committee: Romero, M.
Venue: Kassel, Germany
Date: 28 August-2 September 2011
Organizer: International Solar Energy Society

**5.** Congress: International Conference in Polygeneration Strategies (ICPS11)
Member of the Scientific Committee: Serrano, D.P.
Venue: Vienna, Austria
Date: 30 August -1 September 2011
Organizer: Vienna University of Technology

**6.** Congress: SolarPACES 2011
Member of the Scientific Committee: Romero, M.
Venue: Granada, Spain
Date: 20-23 September 2011
Organizer: SolarPACES; PSA CIEMAT

**7.** Congress: 6$^{th}$ International Symposium on Feedstock Recycling of Polymeric Materials, ISFR2011
Chairman: Serrano, D.P.
Member of the Scientific Committee: Dufour, J.
Venue: Toledo, Spain
Date: 5 -6 October 2011
Organizer: Rey Juan Carlos University; IMDEA Energy Institute

**8.** Workshop: Expoquimia 2011: El papel de la Química en el desarrollo de la energía solar termoeléctrica
Member of the Scientific Committee: Romero, M.
Venue: Barcelona, Spain
Date: 18 November 2011
Organizer: Rey Juan Carlos University; IMDEA Energy Institute

**9.** Congress: HYdrogen – POwer THeoretical and Engineering Solutions International Symposium (Hypothesis 2011)
Member of the Scientific Committee: Dufour, J.
Venue: San José, Costa Rica
Date: 12-15 December 2011
Organizer: Instituto Tecnológico de Costa Rica

## 9.2. 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: Renewable Energy and Environment
Module: Solar thermal power plants
Speaker: Romero, M.
Venue: Polytechnic University of Madrid, Madrid, Spain
Date: 1 January-30 June 2011
Organizer: Polytechnic University of Madrid

**2.** Conference: Grids of the future
Speaker: Prodanovic, M.
Venue: Móstoles, Madrid, Spain
Date: 3 February 2011
Organizer: CETINIA-Rey Juan Carlos University

**3.** Course: Executive management program of renewable energy projects
Speakers: Serrano, D.P.; Romero, M.; Prodanovic, M.
Venue: Madrid, Spain
Date: 25 February-10 June 2011
Organizer: EOI

**4.** Conference: Renewable energies in the current energy context
Speaker: Romero, M.
Venue: Cervantes Institute, Bremen, Germany
Date: 29 March 2011
Organizer: Cervantes Institute

**5.** Seminar: Presentation of the book: "Polímeros conductores: su papel en un desarrollo energético sostenible"
Speaker: Marcilla, R.
Venue: ETSI de Telecomunicación- Universidad Politécnica de Cartagena, Spain
Date: 19 May 2011
Organizer: Universidad Politécnica de Cartagena

**6.** Workshop: Use of agro-forest and oily residues to produce clean transportation fuels
Panel discussion: Present and future of the production of fuels from biomass via thermochemical processes.
Speaker:
Date: 9 June 2011
Organizer: CSIC; Autonoma University of Madrid

**7.** Summer School: SECAT 2011
Conference: Preparation and catalytic applications of ordered mesoporous materials
Speaker: Serrano, D.P.
Venue: University of Zaragoza, Spain
Date: 27-28 June 2011
Organizer: University of Zaragoza

**8.** Summer School: $CO_2$, Problem or resource? New vision of his capture, processing and use
Conference: Environmental study of the processes of capture, storage and recovery of $CO_2$: analysis of life cycle
Speaker: Dufour, J.
Venue: Aranjuez, Spain
Date: 8 July 2011
Organizer: Rey Juan Carlos University

**9.** Course: Management and waste treatment, discharges and emissions for sustainable development
Module: The atmosphere: composition and chemistry
Speaker: Dufour, J.
Date: 4-29 July 2011
Organizer: Complutense University of Madrid

courses

# seminars

**10.** Summer School: Air pollution, climate impact 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
Fecha: 13-15 July 2011
Organizer: University of Castilla-La Mancha

**11.** Seminar: New nanomaterials for clean technologies
Conference: Co-production of hydrogen and carbon materials by catalytic decomposition of methane and other hydrocarbons
Speaker: Serrano, D.P.
Venue: Alicante, Spain
Date: 12-13 September 2011
Organizer: University of Alicante

**12.** Seminar: Chemical Engineers at the energy challenge: new challenges and solutions
Conference: Biomass and biofuels
Speaker: Serrano, D.P.
Venue: Valencia, Spain
Date: 13 September 2011
Organizer: Polytechnic University of Valencia

**13.** Summer School: Utilization of biomass for the production of chemicals or fuels. The concept of biorefinery comes into operation
Conference: Conversion of cellulose and hemicellulose into platform molecules: chemical routes
Speaker: Serrano, D.P.
Venue: Lecce, Italy
Date: 18-24 September 2011
Organizer: Consortium of EuroBioRef Project

**14.** Workshop: Era-Net project "STOREHEAT"
Conference: Solid-Gas reactions for solar heat storage at low and high temperatures
Speaker: Coronado, J.M.
Venue: Ljubljana, Slovenia
Date: 17-18 October 2011
Organizer: Consortium of STOREHEAT Project

**15.** Conference: Design of polymeric ionic liquids and its role in Electrochemistry
Speaker: Marcilla, R.
Venue: MEET - Münster Electrochemical Energy Technology, Munster, Germany
Date: 18 October 2011
Organizer: MEET - Münster Electrochemical Energy Technology

**16.** Course: Decontamination and disinfection of water and air by solar advanced oxidation processes
Conference: Advanced Photocatalytic Materials
Speaker: Coronado, J.M.
Venue: Madrid, Spain
Date: 24-26 October 2011
Organizer: CIEMAT

**17.** Seminar: Technical conference on sanitation and treatment
Conference: Valorización energética de los fangos de EDARs mediante la producción de hidrógeno a través de procesos de descomposición catalítica
Speaker: Coronado, J.M.
Venue: Murcia, Spain
Date: 16-17 November 2011
Organizer: Esamur; Consejería de Agricultura and Agua de la región de Murcia

**18.** Webinar: Concentrated Solar Power vs Photovoltaic
Speaker: Romero, M.
Venue: on line
Date: 7 December 2011
Organizer: Irsolav; Geónica, S.A.

**19.** Conference: Waste recovery and renewable energy
Conference: Vision of renewable energy in Spain
Speaker: Dufour, J.
Venue: Móstoles, Spain
Date: 20 December 2011
Organizer: Rey Juan Carlos University




## 9.3. Participation in science dissemination activities

The main science dissemination events in which IMDEA Energy has been involved in 2011 are listed below:

**1. Researchers´ Night 2011**

Workshop 1: Biofuels production
Workshop 2: Smart grids
Venue: IMDEA Energy Institute, Móstoles, Spain
Date: 23 September 2011
Organizer: IMDEA Energy Institute

**2. XI Science Week of Comunidad de Madrid (2011)**

Workshop 1: Photocatalysis applied and biofuels
Workshop 2: Electrochemical energy storage
Workshop 3: Power grids
Workshop 4: The competition of the environmental impacts
Workshop 5: Concentrating solar power
Venue: IMDEA Energy Institute, Móstoles, Spain
Date: 7-20 November 2011
Organizer: Comunidad de Madrid

# science dissemination activities

# 10 scientific highlights

# New concentrating solar energy developments in metropolitan areas



For the first time in mankind history, the world population living in urban areas has surpassed population inhabiting rural regions and it is expected a continuous growth from 3.3 billion in 2008 to about 5.2 billion in 2035. The contribution will be especially important in non-OECD countries. Distributed generation and energy management in metropolitan areas and access to robust and reliable energy in isolated rural areas will become major challenges [1].

Energy management in urban areas will surely need substantial improvements in energy efficiency of buildings, promoting the use of heat and even electricity and heat generation. In fact, the Directive on Buildings of the European Union (2002/91/EC) states that «for new buildings with a total useful floor area over 1 000 $m^2$, Member States shall ensure that the technical, environmental and economic feasibility of alternative systems such as decentralized energy supply systems based on renewable energy, and combined heat and power, is considered and is taken into account before construction starts". In order to face up to this growing energy demand using poly-generation and small distributed systems in rural and metropolitan areas, the contribution of technologies based on concentrating solar power may be relevant. Indeed, the higher the starting temperature of the polygeneration system, the greater the number of potential electricity generation stages and opportunities for heat usage. Besides, the overall efficiency of the process will increase if energy losses in the processing chain are properly controlled. The concentrating solar power allows achieving these high temperatures.

In the last three decades several theoretical works have analyzed this idea; let us cite McDonald [2], who in 1986 proposed a parabolic disk based solar-fossil fuel cogeneration plant led to supply the demand of small urban and/or industrial centers or Romero et al.[3], who in 1999 described the MIUS (Modular Integrated Utility Systems) concept combining polygeneration systems using central receiver systems (CRS) equipped with a gas turbine. More recently, in 2007, Buck and Friedman [4] analyzed a central receiver plant in trigeneration systems. In practice, the European Union has supported the development of hybrid solar-gas CRS plants with a turbine of 100 kW through the project SOLHYCO (2006-2010) and recently the Aora Solar company (http://aora-solar.com) sells a solar/combustion hybrid CRS plant using similar electric power. Simultaneously, new concepts have been proposed in the field of CR concentrating solar power plants based on small area heliostats (from 1 to 7 $m^2$), such as eSolar (http://esolar.com) or BrigthSource Energy (www.brightsourceenergy.com) companies, which allow great modularity, not necessarily aimed at managing low thermal capacities (less than 10 $MW_{th}$), as depicted in figure 1.

ng solar energy



*Figure 1. Different modular central receiver concentrating solar plants. (a) eSolar; (b) Wilson Solar Power; and (c) Aora Solar (images from their respective websites).*

Modularity concepts make it possible to integrate CSP technologies in metropolitan areas. So far there are initiatives for installation in commercial buildings, such as Wilson Solar Power in the U.S. (www.wilsonsolarpower.com), which proposes using the malls roofs to this purpose. This approach follows a route traced by solar thermal and solar photovoltaics and, more recently, concentrating photovoltaics (Chemisama, 2011) or concentrating solar parabolic trough and Fresnel technologies. According to this evolution, it may be expected to continue solar technologies integration in buildings by incorporating new features that combine passive functions (for instance, in the energy management and lightning) and aesthetic roles, from the architectural point of view.

IMDEA Energy Institute analyzes the integration of Central Receiver concentrating solar systems in buildings, for example in their façades, and their contribution within polygeneration schemes. Before the deployment of real facilities based on these concepts takes place, numerous research works will be necessary, for instance: analyzing the evolution of the solar resource and its management by non-horizontal heliostat fields, identifying and characterizing relevant materials for these applications and compatible with constraints related to be located in metropolitan areas, examining the visual impact associated to the use of reflective materials and high irradiated surfaces and optimizing the energy resources in order to meet the best fitting to demand of certain buildings.

## References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the search of l

## The search of larger batteries for sustainable transport and electric grids

for sustainable transport and electric grids

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 usual approach to these technological challenges is to build larger batteries, but the energy density of the current commercial batteries is so limited that huge batteries would be necessary. This is certainly an unviable approach in terms of volume, weight and cost.

Redox flow batteries are an attractive alternative to the conventional approach because their capacitiy does not relies on the battery size but the amount of stored electrolyte and this could make a notorious difference in overall costs [1,2]. Unfortunately, there are not fully commercial flow batteries and still they have to implement important technological advances [3,4].

The flow battery technology closest to commercialization is the vanadium redox battery. This is made of two aqueous electrolytes containing soluble vanadium ions; V(II) – V(III) in the negative electrode and V(IV) ) – V(V) in the positive [5]. A schematic representation is shown in Figure 1. This battery has the great advantage of using exclusively soluble redox couples; in consequence all the energy is stored in the electrolytes, while the battery itself is just the place where the electrolytes are reduced or oxidized. Therefore, the power of the battery depends on the size and number of electrodes while its capacity depends on the volume and concentration of the electrolytes [6]. One of the big weaknesses of this battery comes from the toxicity and high cost of the vanadium that is the main component of the electrolytes. Another weakness arises from the fact that, despite its efficiency is around 80%, this value is far from the round trip efficiency of lithium-ion batteries (over 90%) and electrochemical capacitors (over 95%) [7]. The final effect is that the total cost per kWh stored is too high to make the technology competitive for massive application.

The approach from IMDEA Energy Institute is to focus on the research of new redox chemistries that shall fulfill the following requirements: lower toxicity and cost than vanadium; high solubility of all redox species involved, in spite of the battery's state-of-charge; and high reversibility of all the redox reactions during charge and discharge of the battery. The combination of these characteristics will reduce the cost per kWh stored and make a more environmentally friendly battery.

arger batteries

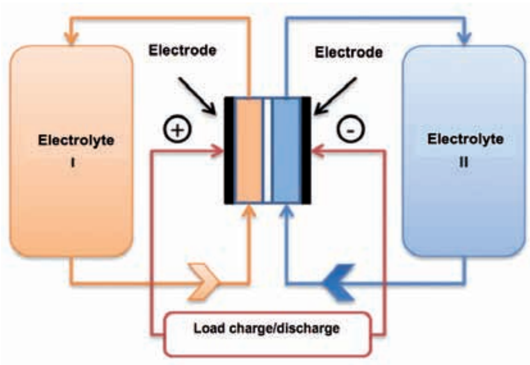


*Figure 1. Schematic representation of a Redox Flow Battery.*

At present the work carried out has proven that it is possible to substitute the vanadium electrolyte at the positive electrode by soluble redox couples based on iron or copper, while the negative vanadium electrolyte can be substituted by soluble natural organic molecules. In both cases, highly concentrated solutions have been stabilized and better reversibility than that of vanadium electrolytes has been reached.

In the next step, both half reactions will be combined to build a full cell in which vanadium is not required anymore. Further work will involve the scale up of the cell to a size adequate for the construction of a pilot prototype in which operational parameters will be selected and technical feasibility of the battery will be assessed.

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of smart buildings and neighbourhoods



## Meeting Energy Demand of Smart Buildings and Neighbourhoods

The term "Smart Buildings" normally refers to various control techniques used for integration of renewable energy sources to buildings, energy efficiency improvement, reduction of greenhouse emissions and application of demand side management. In addition to the buildings, a new term "Smart Neighbourhoods" has been recently introduced that refers to integrated management of energy generation, storage and demand on a district or neighbourhood level. However, results of various studies on incorporation of renewable energy technologies into buildings reveal in many cases lack of a holistic approach to investigation and optimisation of small energy supply systems. The two main drawbacks are absence of analysis of end-use energy demand and pre-definition of energy system structure in initial phases of building design.

Incorporation of hybrid energy systems consisting of renewable energy sources is seen as a way to reduce the carbon footprint of a building (or a neighbourhood) and potentially provide its self-sustainability. Such mixed designs are encouraged by recent advances in energy technologies and also by the fact that the end-use energy demand in buildings is not homogeneous and comprises thermal and electrical loads. An example end-use daily profile is shown in Fig. 1 for two different months. As the electrical demand

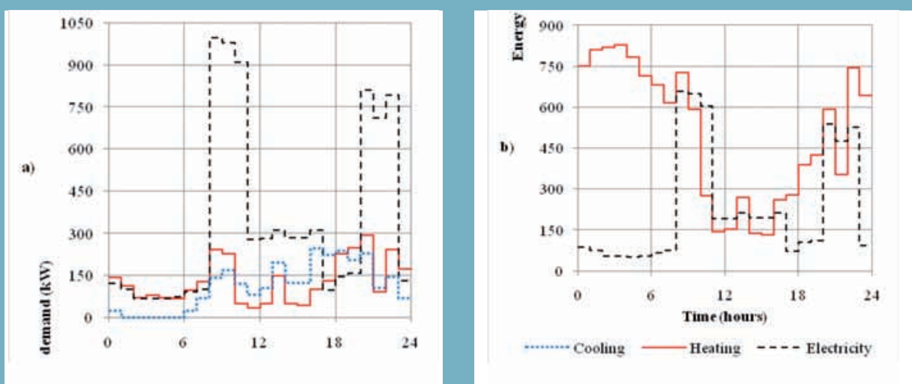


*Fig. 1. Daily end-use energy demand profiles of a building in July (a) and December (b)*

# ergy demand

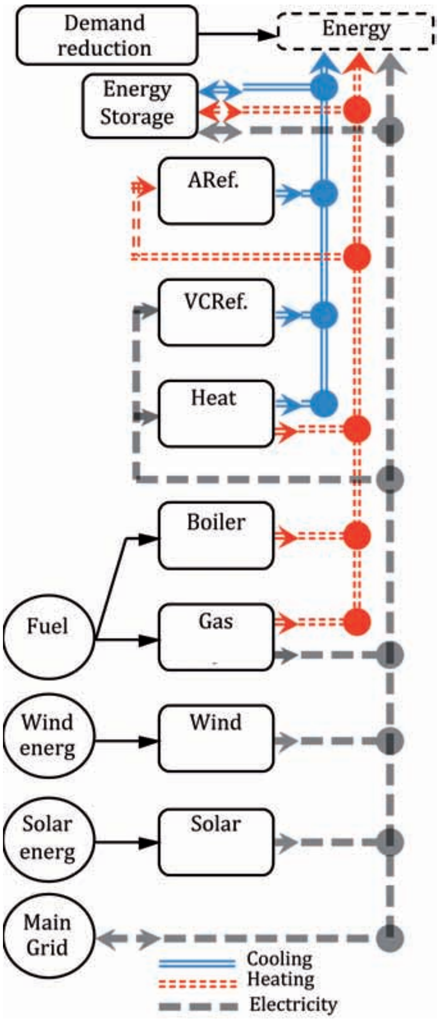


*Fig. 2. Example of a hybrid system superstructure (ARef. – Absorption Refrigerator, VCRef. – Vapor Compression Refrigerator)*

and the electrical supply represent only a part of the total energy demand and supply, it is essential to consider integration of smart grid technologies together with other energy technologies used in residential and non-residential buildings and industrial estates [1].

Hybrid energy supply systems have been increasingly considered as a preferred choice to meet electricity, cooling and heating demand of new buildings. Providing optimal hybrid energy system mix is one of the most important tasks in this all inclusive approach where the end-use energy demand, primary energy sources and available storage technologies of the small energy system are analysed simultaneously. The developed methodology consists of the following three stages: input data definition, creating the energy system superstructure and domain scanning. The final solution represents the optimal energy system mix. An example of what are the inputs to this optimisation process is shown in Fig. 2.

Once the energy supply mix has been determined, further advances can be achieved through resource management [2, 3]. Most of the existing management techniques applied to "Smart Buildings" depend substantially on a stiff grid connection to control real-time energy balance. Yet, recent advances in energy storage technologies, demand side management techniques, on-site CHPs, intelligent appliances along with development of sensor networks and information technology suggest that near real-time optimal dispatch of all installed resources is possible [4, 5]. New hierarchical methods for proactive management of multiple energy sources to meet total energy demands of a small, local scale energy system are being under investigation (as depicted in Fig. 3) [6]. In order to propose and develop management systems capable of taking strategic decisions, all the relevant control aspects need to be considered such as

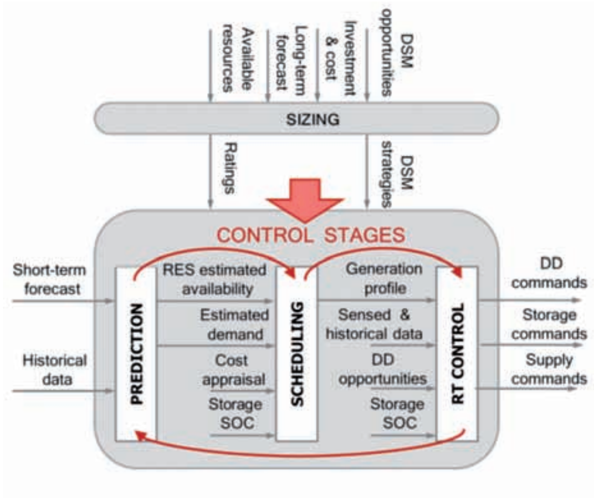


*Fig. 3. Hierarchical control steps*

prediction, scheduling and real-time control for installed generation and demand resources (including demand side management and demand dispatch). Energy storage devices and energy exchange with external power supplies play an important role in these new schemes as they add more options in management of installed energy sources by accommodating for their different dynamic properties and by providing for any supply or demand uncertainties.

A scheme that enables further improvements in management of real-time (RT) energy balance is based on an overall system optimization and application of frequent prediction updates so that the system becomes more robust in dealing with various dynamic uncertainties: intermittent renewable energy generation (solar radiation, wind speed…), demand profiles, changing prices, efficiency, etc. This RT control strategy, with some preliminary results shown in Fig. 4, is conceived for integration of multi-energy sources to future buildings operating in either gridconnected or full standalone (islanded mode).

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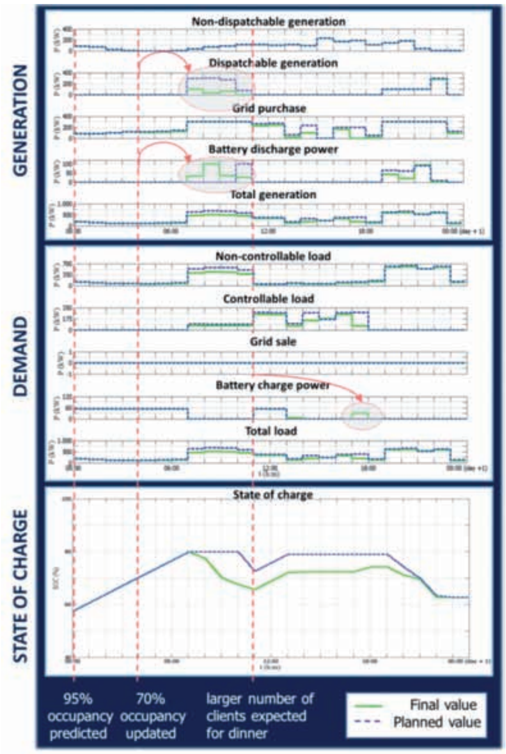


*Fig. 4. Example of a hierarchical proactive management of installed resources*

# on the road to a new

## On the road to a new generation of biofuels: from vegetable oils to renewable diesel

from vegetable oils to renewable diesel

Despite being an exhaustible fossil resource, oil is currently the main source of primary energy and chemical products world-wide. At present, more than 80 million barrels of oil a day are required to meet the global needs, but most likely consumption will reach higher levels in the coming years. Most of the crude extracted (70-80%) is intended to meet the high demand of the transportation sector, which constitutes almost one third of the total energy consumed in the world [1]. This strong dependence on a feedstock which is unevenly distributed, together with the increase in the global car park have prompted the introduction of alternative fuels.

Nowadays, bioethanol and biodiesel are the most widely consumed liquid fuels produced from renewable sources. Thus, the annual production of ethanol was ca. $7.7 \cdot 10^{10}$ L (2011), while the biodiesel generated was $1.7 \cdot 10^{10}$ L (2009). The raw materials used for the production of this first generation biofuels come, in the case of bioethanol from sugar cane or cereals (mainly maize), while vegetable oils (with high content of triglycerides), such as canola and soya in USA and Argentina, palm in Malaysia and rape in Europe are used for manufacturing biodiesel [2]. These crops can compete with food production and require an extensive use of land, and this fact can threatens biodiversity, especially in tropical areas. To prevent these social and environmental concerns and also to contribute to reduce the cost of these fuels, the utilization of alternative feedstocks such as waste oils, or dedicated energy crops with high productivity and limited cultivation requirements like jatropha, camelina or microalgae are being investigated. These new resources are called to constitute a second generation biofuels with enhanced sustainability.

However, the future development of biofuels does not only require a change in the resources, but also a shift in the way they are processed as to improve their properties. In this respect biodiesel already present certain advantages over conventional diesel such as low-sulfur content, high biodegradability and lower emissions of carbon monoxide, unburned hydrocarbons and solid particles. Nevertheless, biodiesel contributes to increase $NO_x$ emissions, and it is slightly corrosive for rubbers and other polymeric components so it can damage non-adapted vehicles. For these reasons, biodiesel is commercialized in the form of mixture with conventional diesel: B20 (containing 20% v/v of biodiesel). Additionally up to 7% v/v of biodiesel (B7) can be used in conventional engines without any modifications [3]. Another important factor to consider is that the energy density of a fuel decreases with the increase in the presence of oxygen, and accordingly biodiesel, which is chemically constituted by fatty acid methyl esters ($CH_3$-O-CO-$C_nH_{2n-m}$), presents lower energy density than diesel of fossil origin: 38 versus 43 MJ/Kg. In order to circumvent these drawbacks, triglycerides can be treated to eliminate the oxygen and yield a renewable fuel with features more similar to conventional petro-diesel. A scheme of both processes for manufacturing biofuels from triglycerides can be seen in Figure 1. When vegetable oils react with hydrogen at high pressure, triglycerides are hydrogenated and fragmented into several intermediate (monoglycerides, diglycerides and carboxylic acids). Subsequently, these molecules are converted into paraffin and isoparaffins through three different routes: decarboxylation, decarbonylation and hydro-deoxygenation. In parallel, propane, water, carbon monoxide and carbon dioxide and methane are produced as by-products. Hydrotreating process involves working with high pressure of hydrogen (20-70 bar), moderate reaction temperature (300 - 350 °C) and the presence of adequate metal supported catalysts. Thus, the obtained fuel, known either as *green or renewable diesel* or *HVO (from Hydrotreated Vegetable Oil),* can be mixed with diesel without affecting its calorific power is obtained as a final product [4].

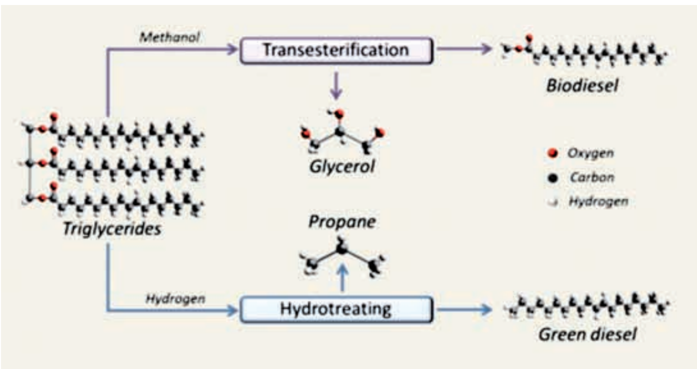


*Figure 1. Scheme showing the process of biodiesel and green diesel production from vegetable oils*

The process of obtaining biodiesel requires less severe reaction conditions and, therefore, it has lower operational costs. However, the conditions used in the process of hydrotreating are very similar to the ones used in hydrodesulfurization (HDS) units, which facilitates the possibility of feeding a mixture of triglycerides and fractions of the oil in existing refineries. This fact implies a lower cost of implementation and constitutes an important advantage over the process of manufacturing biodiesel. First commercial plants producing HVO have been installed, among other countries, in Finland and USA.

Catalysts development is crucial to produce cost-effective renewable diesel because milder operation conditions and more efficient hydrogen use, along with the utilization of low cost material are beneficial for both the throughput and the economy of the process. In addition, further upgrading of the obtained fuel to improve properties such as lubricity or cold start capacity will require the design of multifunctional catalyst with improved performance. This topic constitutes one of the research lines of the TCP Unit of IMDEA Energy Institute. In this way recent investigation has allowed inexpensive catalysts to be synthetized showing a remarkable selectivity for the hydrodeoxygenation products, as it is shown in Figure 2. These results are very relevant as they can contribute to the future implementation of these advanced biofuels [5].

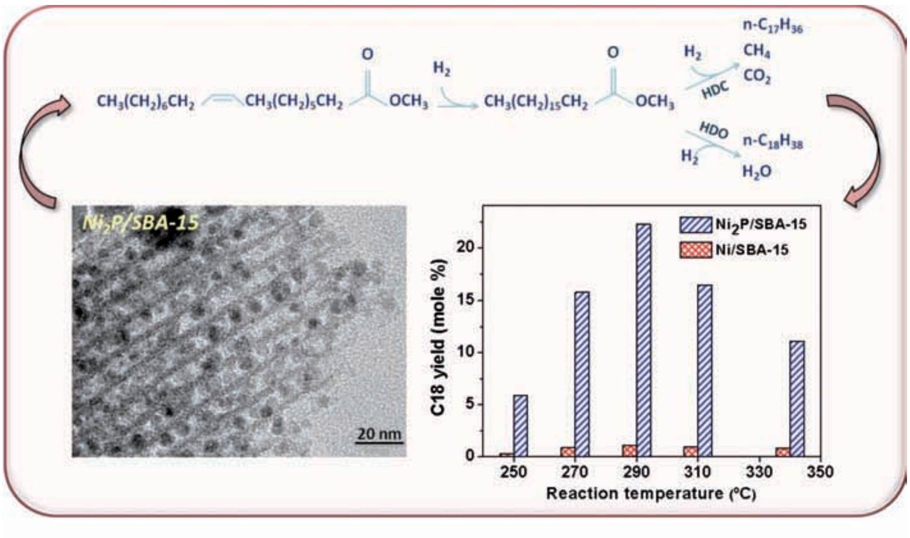


*Figure 2. TEM image of a Ni2P/SBA-15 catalyst and selectivity to n-octadecane in the hydrotreating of methyl oleate, in comparison with a conventional Ni/SBA-15 catalyst [5].*

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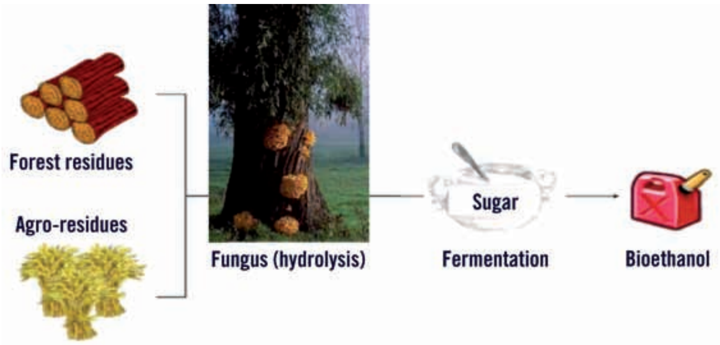
## Production of ethanol by fermentation of lignocellulosic biomass

Lignocellulosic biomass, including agriculture residues, forest products or energy crops, represents one of the most abundant and low cost resources for ethanol production. Its use could significantly decrease fossil fuel consumption and contribute to a greenhouse gas emissions reduction [1]. The process is based on the conversion of carbohydrates contained in lignocellulosic materials to their monomer sugars and its fermentation by microorganisms to ethanol. Among different conversion processes, enzymatic hydrolysis is a promising method. Unfortunately, due to the lignocellulosic complex structure, the cellulose accessibility to enzymes is limited. Thus, a preliminary pretreatment step is required to improve the enzymatic hydrolysis and increase the fermentable sugars yields [2]. Steam explosion, a process that combines high pressures and temperatures, is one of the most commonly used pretreatment methods. During this process, extensive lignocellulosic structure alteration is produced. Lignin is redistributed and hemicellulose is partially hydrolyzed and solubilized, making cellulose more accessible to enzymes. In contrast, this pretreatment generates some soluble inhibitory compounds, derived from a partial sugars and lignin degradation, which can affect enzymatic hydrolysis as well as fermentation steps [3]. The nature and concentration of these toxic compounds depend on the raw material and the harshness of the pretreatment. They are classified according to their chemical structure and include furan derivates (furfural and 5-hydroxymethylfurfural derived from pentose and hexose sugars degradation, respectively), weak acids (mainly acetic acid) and phenolic compounds from lignin (aromatic acids, alcohols and aldehydes). Several methods have been studied to reduce the effects of inhibitory compounds. Usually, the whole slurry obtained after steam explosion process is filtered and washed before enzymatic hydrolysis. However, from an economical and environmental point of view, the filtration and washing steps should be avoided since they increase both operational costs and wastewater. Moreover, the use of the whole slurry can increase the fermentable sugars concentration, obtaining a higher ethanol production [4]. For these reasons, other detoxification methods have been explored, including the use of enzymes such as laccases. Laccases are multicopper-containing oxidases with phenoloxidase activity, which catalyze the oxidation of substituted phenols, anilines and aromatic thiols, at the expense of molecular oxygen [5]. They have been mainly used to detoxify prehydrolysates (effluents from whole slurry filtration step) from different steam-exploded biomasses. Compared to other detoxification methods, the use of laccases involves substrate-specific reactions under mild conditions, fewer toxic sub-products and low energy requirements. In spite of the knowledge gained on the use of laccases for prehydrolysate detoxification, little information is available for whole slurry.




The Research Unit for the Production of Energy by Biotechnological Processes studies the effect of lacasses from *Pycnoporus cinnabarinus* and *Trametes villosa* on the removal of toxic compounds present in steam-exploded wheat straw. Laccase treatments are carried out before or after saccharification step at different substrate loadings [6]. A substantial removal of phenolic compounds by laccases reduced the inhibitory effects of slurry from steam-exploded wheat straw. It led to improve the fermentation performance of *K. marxianus* strain used, shortening its lag phase and enhancing the ethanol yields, and increase the substrate loadings of saccharification and fermentation broths. These enhancements are more significant when laccase treatment is carried out before enzymatic hydrolysis, in spite of decreased glucose recovery. According to this study, detoxification by laccases could reduce costs of lignocellulosic ethanol process through the use of partially detoxified whole slurry and increasing higher fermentation rates and ethanol yields.

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# sustainable

from lignocellulosic biomass

## Sustainable energy from lignocellulosic biomass

Progressive depletion of fossil resources and the raising concern on global warming have led to increased efforts to find alternative energy sources. In particular, biofuels are a renewable energy source capable of directly substituting fossil fuels in the currently oil-dependent road transport sector [1]. Nevertheless, since feedstock production for current first generation biofuels such as bioethanol and biodiesel requires intensive agricultural practices and large land areas, special attention has to be paid to the life-cycle sustainability and the energy efficiency of bioenergy systems [2]. The availability of second generation biofuels is a key issue of a future sustainable biofuel production. In this respect, biofuels based on lignocellulosic feedstocks could contribute an important share in the future fuel mix. A life-cycle perspective is needed to evaluate and to ensure the environmental suitability of these systems. Therefore, Life Cycle Assessment (LCA) was used to study all of them [3].

Biological conversion of biomass into energy products, such as biofuels, still faces economic and efficiency challenges. Liquid biofuels, especially bioethanol, provide one of the few options for the substitution of fossil transport fuels in the short to medium term, being strongly promoted in the European Union. Bioethanol has usually been produced from starch and sugar crops but can be also produced by biochemical conversion (saccharification and fermentation) of lignocellulosic biomass feedstocks in ‘second generation’ systems.

Combustion, pyrolysis and gasification are the three main thermochemical conversion methods for biomass feedstocks. While in combustion processes the heat generated must be used directly, both the synthesis gas (syngas) from biomass gasification and the pyrolysis-derived bio-oil can be stored and used later in different applications.

With gasification, biomass is converted into a gaseous fuel (syngas, also called biosyngas) through heating in the presence of a gasifying agent (typically air, oxygen and/or steam). Syngas contains CO, $CO_2$, $H_2$, $CH_4$, water and traces of other components, such as tars and dust. It can be used in a large number of applications, including electricity and/or heat generation and the synthesis of other energy products, such as hydrogen or diesel through the Fischer-Tropsch process.

Comparing the production of bioethanol and bioelectricity, Figure 1 (cumulative energy demand (CED), global warming (GWP), ozone layer depletion (ODP), photochemical oxidant formation (POFP), land competition (LC), acidification (AP) and eutrophication (EP)) shows that the bioelectricity scenario potentially entails a better global warming performance than the bioethanol scenario. However, the bioelectricity alternative is linked to a much higher non-renewable energy demand. Based on the lower heating value of the bioethanol product, the biofuel scenario potentially produces 557.3 GJ per ha of willow (assuming a 35% engine efficiency), while the energy input corresponded to 292.7 GJ. Therefore, the net energy balance for the biofuel scenario resulted in 264.6 GJ. This positive balance indicates that the bioethanol scenario is feasible from an energy perspective. Similarly, the bioelectricity scenario produces 1,273.6 GJ per ha of willow and consumes 1,171.5 GJ. Hence, the energy balance for this scenario resulted in 102.0 GJ. This positive balance suggests that the bioelectricity scenario is also feasible from an energy perspective. Nevertheless, the energy balance of the biofuel scenario is more than two times that of the bioelectricity scenario. Global warming and energy parameters led to opposite conclusions regarding the most convenient processing pathway for willow chips. When the emphasis is placed on the energy performance, the bioethanol scenario seems to be the best choice. However, where the global warming performance is the decisive factor, the bioelectricity scenario arises as a more suitable option.

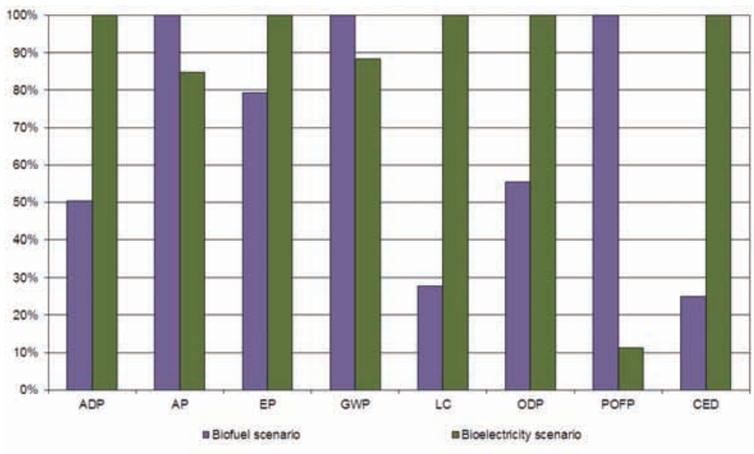


*Figure 1. Comparative environmental impacts for the biofuel and bioelectricity scenarios*

Nonetheless, the identification of the most environmentally appropriate scenario strongly depends on the impact categories to be considered.

Concerning the production of hydrogen, it was considered the gasification of poplar in a low-pressure char-indirect gasifier, catalytic tar destruction, cold-wet gas cleaning and syngas conversion to hydrogen through steam methane reforming and water gas shift followed by PSA purification (Figure 2). The exergy efficiency of the plant was found to be 48 %. Since efficiencies of approximately 49 % have been reported for the production of hydrogen via coal gasification, the biomass gasification system can be considered an attractive alternative as long as environmental advantages are associated with this system.

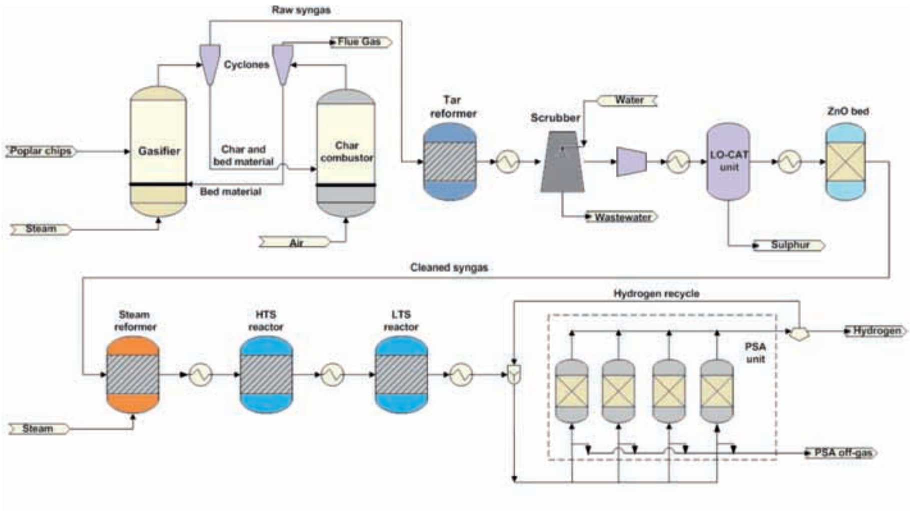

*Figure 2. Process for the gasification of biomass.*

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