Institut de Recerca en Energies de Catalunya (IREC)

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Director General: Ramon Garriga

IREC Tarragona:
Head of the Bioenergy and Biocombustibles Section, Dr. Joan Salvadó

1. Introduction

The Catalonia Institute for Energy Research, the IREC (Institut de Recerca en Energia de Catalunya), was funded in July 2008, began its R+D activities in January 2009 and finished the organization of the laboratories and infrastructures in 2011-12. In the 2013 the Catalan Institute for Energy Research has achieved its consolidation in both European projects and industrial projects, After five years, it has built a stable team of valuable individuals who are committed to the scientific and technological growth of the center, resulting in cutting-edge research and a constantly increasing flow of income.

Mission

Its Mission is to contribute to the sustainable development of society and to greater industrial competitiveness, generating science and building technology.

Target

The target of its research activity is to become a center of excellence and an international benchmark organization in the energy sector, through research, technology development and innovation.

Orientation

The Institute works with a dual approach:

– Applied and technological research, aimed at generating knowledge within groups of the Institute, with a medium or long-term application in mind.

– Technological research and Technical development, focused on collaboration with Industry to create new products and new technical solutions, in the short and medium-term.

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

IREC collaborates with the Government, Universities and Industry, and this is reflected in the structure of its Board of Trustees.

Estrategic Goals

• Maintenance and enhancement of international connection to promote scientific ideas that boost the industrial sector energy.

• Generating own specific knowledge aimed at providing novelties and innovations to companies, for the development of its strategic medium and long term plans.

• Empowering knowledge transfer to the market either with direct collaborations with companies, generating and licensing of patents, spin-off's, etc.

To get the maximum efficiency for achieving these objectives, the institute is organized to total cost based management focused to have maximum basal resources devoted to the research and technological activities.

Highlights

The following is a selection of the highlights for IREC in 2013:

– The implementation of competitive and industrial projects for a total income of 4,2 million euros, with income from competitive projects of 2,8 million euros (66%) and income from industrial projects for 1.4 million euros (34%). Most competitive projects come from European tenders.

– European leadership in research into thin-film photovoltaic materials based on "Calcopirites" and "Kesterites", leading to being coordinators of three FP7 projects, *Scalenano, Inducis and Kestcells projects*.

– We are also coordinators of two new FP7 projects. One of them is in the field of the intelligent LEDs with the aim of developing a number of spectrally tunable light engines with integrated intelligence, low-cost and low-consumption, *HiLed project*. The second one belongs to the field of development of simulation tools to evaluate the energy performance of different technical solutions integrating energy efficiency strategies, *Renew IT project*.

– A part from these coordinated projects led, the Institute participates as partner to 28 FP7 European projects from different calls: Nanotechnologies, Advanced Materials and Production (NMP), Information and Communication

Technologies (ICT), ENERGY, Fuel Cells and Hydrogen (FCH), SMARTCITIES, TRANSPORT, Marie Curie Actions and also from others programs like: MED Program, Competitiveness and Innovation Framework Program (CIP).

- In 2013 there has been a significant increase of industrial project contracts, with a high added value for the energy industry.
- In 2013, IREC empowered its first spin-off, Omicron Lighting, S.L. (Ledmotive, S.L. in 2014).
- We are a founder member of "KIC InnoEnergy" of the European Institute of Innovation and Technology (EIT), which is a body of the European Union, for innovation actions in the field of the Energy. At the moment IREC participates in seven other KIC Projects.
- Leading the Connect-EU Energy group with the aim of promoting, encouraging and conveying Catalan R+D and innovation interests from more than 100 related entities of the energy sector to Europe.
- Leading the XaRMAE (Network of the Generalitat de Catalunya on the Advanced Materials for Energy).
- The publication of 94 indexed publications with an average impact factor of 4.33.
- Getting relevant recruitment subsidies of research personnel; ''ICREA'' from Generalitat de Catalunya, as well as ''Ramon y Cajal'', ''Técnico de Apoyo'' and other fellow positions from Ministerio de Economia y Competitividad and Marie Curie Program.
- • The organization of an international conference on energy challenges in collaboration with Massachusetts Institute of Technology (MIT), with the participation of the enterprises represented on the IREC Board of Trustees.
- The organization of the 17th International Conference on Solid–State Sensors, Actuators and Microsystems and Eurosensors XXVII.
- The organization of the International Conference on Nuclear Fusion (XI International Symposium ISFNT 2013).

2. Organizational structure

2.1. Board of Trustees

The IREC Board of Trustees has the following members:

(Updated December 2013)

Catalan Ministry of Enterprise and Labor, Government of Catalonia
(Generalitat de Catalunya)
Felip Puig i Godés Minister of Enterprise and Labor

Pere Palacín i Farré
Director General for Energy, Mines and Industrial Safety

Maite Masià i Ayala
Director of the Catalan Institute of Energy (ICAEN)

Andreu Mas-Colell
Catalan Ministry of Economy and Knowledge, Government of Catalonia
(Generalitat de Catalunya)

Antoni Castellà i Clavé
Secretary General for Universities and Research

Josep Maria Martorell i Rodon
Director General for Research

CIEMAT (Centro Investigaciones Energía y Materiales)
(Organization of the Spanish Ministry of Economy and Competitiveness)
Carmen Vela Olmo
Chairman of CIEMAT and Secretary of State for Research

Cayetano López Martínez
Director of CIEMAT

José Ignacio Cruz Cruz
Wind Energy Unit

IDAE (Instituto Diversificación Ahorro Energético)
(Organization of the Spanish Ministry of Industry, Energy and Tourism)
Alberto Nadal Belda Chairman of IDAE and Secretary of State for Energy

Fidel Pérez Montes
Director of IDAE

Consuelo Lozano Sánchez
Director of the Area of Companies and Investment

University of Barcelona
Dídac Ramírez i Sarrió
Rector of University of Barcelona

UPC (Polytechnic University of Catalonia)
Enric Fossas i Colet
Rector of UPC-BarcelonaTech

URV (Universitat Rovira i Virgili), Tarragona
Josep Anton Ferré Vidal
Rector of URV

ENDESA Servicios S.L.
Josep Maria Rovira Vilanova
Director General ENDESA in Catalonia

Gas Natural SDG, S.A.
Juan Puertas Agudo
Director of Gas Network, Energy Efficiency & Renewables

Fundación REPSOL
Arturo Gonzalo Aizpiri
Director of Institutional Relations and Corporate Responsibility

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

Compañía Logística de Hidrocarburos CLH, S.A.
Basilio Navarro
Director of Resources

ALSTOM Wind, S.L.U.
Josep Prats i Mustarós
VP Advanced Technology

2.2. Members of the Executive Committee:

Chairman of the Executive Committee:

Josep Maria Martorell i Rodon

Director General for Research, Ministry of Economy and Knowledge, Government of Catalonia (Generalitat de Catalunya)

Secretary of the Executive Committee:

Pere Palacín i Farré

Director General for Energy, Mines and Industrial Safety, Ministry of Enterprise and Labour Government of Catalonia (Generalitat de Catalunya)

Committee Members:

José Ignacio Cruz Cruz

Wind Energy Unit, CIEMAT.

Consuelo Lozano Sánchez

Area Director of Companies and Investment, IDAE.

Jordi Alberch i Vié, Vice-Chancellor of Research, University of Barcelona, UB.

Francesc Xavier Grau i Vidal

Rector, Rovira i Virgili University, URV.

Ana Isabel Pérez Neira

Vice-Rector of Research and Innovation, Polytechnic University of Catalonia, UPC – BarcelonaTech.

Josep Maria Rovira Vilanova

Director of Innovation and Technology, Endesa.

Juan Puertas Agudo

Director of Gas Network, Energy Efficiency & Renewables, Gas Natural Fenosa.

Juan Andrés Díez de Ulzurrun Moreno

Engineering, Technology and Purchasing General Manager, Enagas

Josep Prats i Mustarós

VP Advanced Technology, Alstom Wind

Fernando Temprano Posada

Director of Technology, Repsol

Basilio Navarro Sánchez

Director of Resources, CLH

2.3. Scientific Advisory Board

The Scientific Advisory Council, appointed by the Board of Trustees, serves as an advisory body for the Institute's scientific strategy, assisting in the evaluation of its activities and members.

The Scientific Advisory Board members are as follows:

Prof. Esteban Chornet
Chairman of the Board
Emeritus Professor of Sherbrooke University, Quebec, Canada

Prof. John A. Kilner
Materials Department, Faculty of Engineering, Imperial College London, U.K.

Prof. Johan Driesen
Associate Professor, U.K. Leuven, Belgium.

Prof. Matthias M. Schuler
Adjunct Professor of Environmental Technologies, Graduate School of Design, Harvard University, U.S.A.

Mr. Jürgen Kröning
Managing Director of DEWI-OCC at Cuxhaven, Onshore and Offshore Wind Business, Netherlands

Prof. Konstantinos Papamichael
Co-Director, California Lighting Technology Center, University of California, Davis, U.S.A.

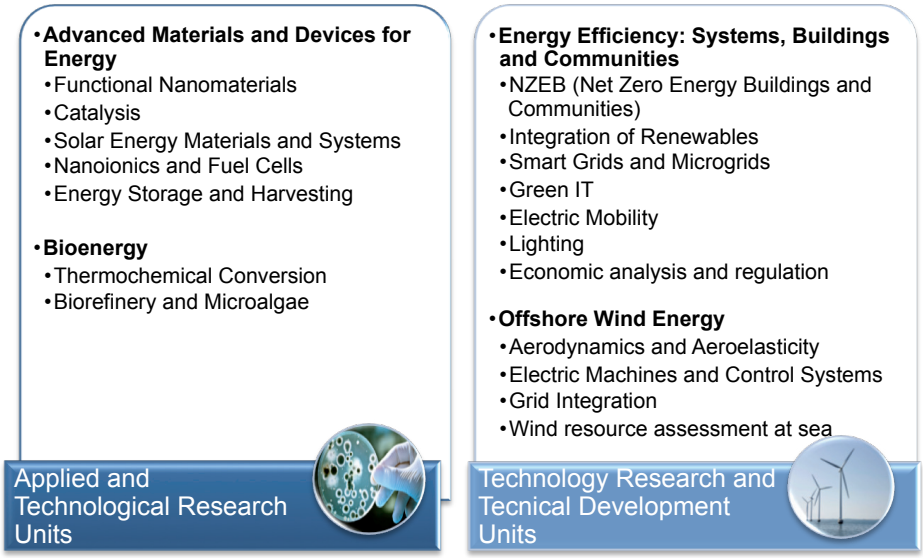
2.4. CERCA - Research Centres of Catalonia

IREC is a member of the CERCA Institution, the Catalan institution created by the Catalan Government to supervise, support and facilitate research to the Catalan research centers.

IREC is one of the 47 research centers of Catalonia, specifically focused on energy research of Catalonia.

2.5. Functional organization

The Institute is focused on the subjects listed in the following illustration:



The current research groups and their leaders are as follows:

Applied and Technological Research Units

Advanced Materials and Devices for Energy Area	Prof. Dr. Joan Ramon Morante
Functional Nanomaterials	Dr. Andreu Cabot
Catalysis	Prof. Dr. Narcís Homs
Solar Energy Materials and Systems	Prof. Dr. Alejandro Pérez
Nanoionics and Fuel Cells	Dr. Albert Tarancón
Energy Storage and Harvesting	Prof. Dr. Joan Ramon Morante

Bioenergy Area	Prof. Dr. Joan Salvadó
Thermochemical Conversion	Dr. Daniel Montané
Biorefinery and Microalgae	Prof. Dr. Joan Salvadó

Technology Research and Technical Development Units

Energy Efficiency: Systems, Buildings and Communities Area	
Thermal Energy and Building Performance	Dr. Jaume Salom
Lighting	Dr. Josep Carreras
Electrical Engineering3	**Deputy Mr. Manel Sanmartí**
Electrical Machines, Control Systems and Grid Integration for Wind Energy	Dr. Oriol Gomis
Smart Grids and Microgrids	Dr. Andreas Sumper
Fusion Programme	Mr. Manel Sanmartí
Offshore Wind Energy Group	
Aerodynamics and Aeroelasticity	Mr. Frieder Schuon

IREC Current Staff

The following table indicates the distribution of IREC's staff by administrative and research areas, and according to their functional status.

	IREC TOTAL STAFF PER DEDICATION, AT 31st DECEMBER 2013					
	Permanent	Temporary and Tenure Track	Fellowships	Third Parties	TOTAL	
Advanced Materials for Energy	5,5	17,0	18,0	4,0	44,5	37%
Electrical Engineering	6,8	7,9	3,0	2,0	19,7	16%
Bioenergy and Biofuels	1,4	1,0	1,0	2,0	5,4	5%
Energy Efficiency	11,8	13,9	4,0	2,0	31,7	26%
Offshore Wind	1,0	3,0	0,0	0,0	4,0	3%
Fusion b_FUS	0,2	1,0	0,0	0,0	1,2	1%
TOTAL R+D	**19,9**	**35,9**	**23,0**	**8,0**	**86,8**	**72,4%**
Technical Support Staff	**11,2**	**9,6**	**0,0**	**0,0**	**20,8**	**17,4%**
Management Staff	**11,3**	**0,0**	**0,0**	**1,0**	**12,3**	**10,2%**
TOTAL IREC	**42,3**	**45,5**	**23,0**	**9,0**	**119,8**	**100%**
%	**35,3%**	**38,0%**	**19,2%**	**7,5%**	**100%**	

National Origin of IREC Staff members, 2013

In 2013 IREC had staff and researchers from different nationalities: Germany, Argentina, Austria, Belgium, Byelorussia, China, Colombia, Cuba, USA, France, India, Iran, Italy, Mexico, Serbia, Turkey and Uruguay.

3. Research Lines

Irec Research Lines

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

In this framework, the European Strategic Energy Technology Plan (SET-Plan), establishes a first reference about the strategic energy technology policy for Europe. It is addressed to accelerate the development and the deployment of cost-effective low carbon technologies and new energy generation, transport, distribution and end-users models.

The proposed strategic road-map stresses the importance of fostering basic and applied science as a way to obtain breakthrough for future emerging technologies, and as a source of fundamental problem solving during technology development and innovation implementation. The action plan comprises also measures related to planning, implementation, resources and international cooperation in the field of energy technology and innovation.

Under these boundaries, the most interesting topics, where European research would be the most effective for improving the industrial competitiveness, are about basic materials science, physical chemistry of processes, heat and mass transfer phenomena, dedicated powerful tools to characterize materials and energy devices and systems, especially, on large scale facilities and engineering capabilities for transferring knowledge and understanding from science and technology to disruptive innovations for relevant novel energy systems and energy management models increasing efficiency of the energy use.

Therefore, the main IREC research lines at 2013 can strategically be summarized in three:

- Energy Efficiency: Systems, Buildings and Communities Area.
- Bioenergy.
- Advanced materials, processes and devices for novel and improved energy systems.

These research lines have taken to the organization of the activities of the groups and laboratories in two functional branches:

- Applied research and technology.
- Technology development and technical applications.

Energy Efficiency:

The EU is aiming at a 20% cut in Europe's annual primary energy consumption by 2020. The Commission has strengthened measures to increase efficiency at all stages of the energy chain: generation, transformation, distribution and final consumption. These measures focus on the public transport building and industrials sectors.

In this field, IREC's strategy focused on:

- Electric mobility: improved integration of electric mobility into the grid including advanced grid functionalities of electric vehicles and charging infrastructure.
- Net Zero Energy buildings and districts: design, modeling, study and optimization of buildings, districts and their interaction with energy networks in order to achieve work on zero or nearly zero energy concept.
- Green IT: advanced energy efficiency and renewable integration concepts in IT Data Centers and efficiency in IT equipment in office buildings.

– Advanced lighting systems: Intelligent control of LED based illumination systems considering spectral response, photometric theory and measurements, optical and thermal simulations. Rapidp prototyping lab.

– Photonics for energy: Use of photonic and nano-photonic elements to increase efficiency and throughput. Light energy harvesting.

– Energy efficient solutions for refurbishment of the building stock and increasing knowledge towards the minimization of the gap between energy modeling and real energy performance.

– Smart grid and micro grids: development of power technologies for increasing flexibility, quality and feasibility of the electrical network together with new monitoring and control capabilities. Likewise, development of power technologies for increasing renewable, energy storage and electric mobility penetration.

– Design and implementation of higher efficient power unities, especially for wind energy, electrical mobility and energy storage.

– Energy efficiency in Communities: energy sustainability design and use applied to Communities, Cities and Industrial Parks.

Bioenergy and Biofuels:

Bioenergy is a renewable energy made available from materials derived from biological sources. Its main target is to use the stored sunlight energy in the form of chemical energy as biomass, which requires processes and transformations for obtaining useful biofuels.

In this field, IREC's strategy has been addressed on:

a) Micro algae's: development of microalgae's growth processes involving higher efficiencies for improving energy balance and cost.

a) Development and use of catalysts and reactors for biomass processing: new concepts in the design of reactors considering biogas production and reforming of bio alcohols.

Advanced materials, processes and devices for energy applications:

The aim is to promote generic materials developments having a potential for high efficiency energy applications including innovative approaches for the synthesis and assembly of nanomaterials for devices and systems. Furthermore, the group is also interested in exploring functional materials with promising properties; in particular those related to heat, mass and/or charge transport or catalysis properties. Special attention is paid to establishing sound strategies to eliminate bottlenecks to the exploitation of these phenomena, at the nanoscale level, in energy applications.

Besides developing cross-cutting multiscale tools for energy materials and processes applied to the study of materials, and processes and systems considered as a whole

or to their individual components or constitutive behaviors, we aim at developing testing and assessment platforms for materials and devices, since they are considered essential for designing, developing and understanding new functional materials for energy applications and for understanding the relevant physic-chemical processes.

These aims focus on several strategic points oriented to systems for the conversion and storage of the energy:

- Electrochemical energy storage: new concepts and implementation in the field of flow redox batteries based on new electrode materials, new electrolyte concepts and membranes.
- Chemical energy storage: hydrogen and synthetic methane or C1 derived fine chemicals production including power to gas options. Special attention has been paid on sun fuels. Development of photo electrochemical reactors for artificial photosynthesis applications.
- New nanoionic applications for novel energy devices: development of integrated fuel cells as well as improved SOFC and SOEC systems offering higher durability.
- Thin film photovoltaic cells: based on chalcogenide compounds including advanced kesterites for low cost, high efficiency, high mass production photovoltaic systems.
- Nano energy: new approaches for the synthesis and assembly of nanomaterials for devices and systems for taking benefit of the mechanisms, properties and performances at the nano scale level. Special attention is driven on thermoelectricity, nano photovoltaics, multifunctional catalysis and modification of surface properties (super hydrophobicity, anti-icing, impinging strength).
- Harvesting systems: development of fully autonomous systems for monitoring and control of energy parameters in smart buildings, intelligent cities and advanced energy networks.
- New energy storage principles: new materials and processes for advanced energy storage cells such as thin film cells and new three dimensional nano based electrodes.

IREC activities also emphasize efforts to achieving corporate development and knowledge transfer, with the responsibility of promoting transfer of knowledge through technology development contracts with companies. These contracts are not part of competitive calls in which IREC participates, but private contracts between the company and the Institute for the development of applied or technological research. These efforts based on the interaction with IREC research groups, are oriented to leading cross-cooperation between groups to submit joint proposals in line with the synergy derived from different capabilities of the Institute.

In connection with dissemination, the Institute displays significant activity in several directions:

a) Presentation of our own projects by the Institute's researchers,

b) Seminars and workshops organized by the Institute with the participation of our researchers,

c) An annual international conference in collaboration with the Massachusetts Institute of Technology (MIT) in which we present our work through speakers and posters, and through open days to show our laboratories.

d) Participation and promotion of different Clusters and Associations for the support of collaborative innovation, and it advises public bodies such as municipal and regional entities.

e) Lead different actions for moving research results towards precompetitive and innovative products. In such direction IREC is leading XaRMAE, Connecteu-Energy and is an active research member of the Iberia CC-KIC of InnoEnergy.

Laboratories

IREC was founded in the second part of the year 2008 and its activity was launched in 2009. The establishment of its own laboratories in a provisional building located at Sant Adrià del Besos near of the future university campus has required some years and considerable effort, in which researchers have been closely involved. During this period, the activity has been compatible with the preparation of proposals and the realization of projects and publications. The laboratories of the Institute were set up between 2011 and 2012, except for the laboratory of Energy Integration, which started working in February 2013. Likewise, new laboratories have been inaugurated at IREC-Tarragona for the Areas Bioenergy and Thermal Energy.

Ongoing Projects

The implementation of competitive and industrial projects for a total income in 2013 of 4,2 million euros, with income from competitive projects of 2,8 million euros (66%) and income from industrial projects of 1 million euros (34%). Most of competitive projects come from European tenders.

Regarding current situation at the end December 2013, we show the amount and share of the ongoing projects portfolio.

Figures below show the expected income for the next years from the ongoing projects at the end of 2013:

Origin	Portfolio (€)	%	Nº Projects	€ / Project
EUROPEO	6.358.974,49	76,40%	26	244.575,94
INDUSTRIAL	747.413,03	8,98%	18	41.522,95
NACIONAL	1.217.053,01	14,62%	13	93.619,46
Total	8.323.440,53	100,00%	57	146.025,27

IREC Headquarters

The Institute has two centers, one in Barcelona (Sant Adrià del Besòs) and another in Tarragona.

The center in Barcelona is mainly involved in activities related with the areas of:

- Advanced Materials and Devices for Energy
- Energy Efficiency: Systems, Buildings and Communities Area

The center in Tarragona is mainly involved in activities related to the areas of:

- Bioenergy
- Energy Efficiency (laboratories)

4. Infrastructure Funding

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

- ERDF funding within the "Programa Operatiu Catalunya 2007-2013"; € 4,202,998.15 granted to finance the IREC's infrastructures at its Barcelona headquarters.
- ERDF funding within the "Programa Operatiu Catalunya 2007-2013"; € 1,853,449.83 granted to finance the IREC's infrastructures at its Tarragona headquarters.
- ERDF funding within the "Fondo Tecnológico Ministerio de Ciencia e Innovación"; € 304,490.29 awarded to finance the infrastructures of the IREC's offshore wind energy test station in Tarragona, advanced through the program "Innplanta 2010-2012 del Subprograma de Parques Científicos y Tecnológicos del Ministerio de Ciencia e Innovación".
- "Infraestructuras Científico-Tecnológicas", from the Spanish Ministry of Science and Inno-vation, cofunded with ERDF funding, within the "Fondo Tecnológico Ministerio de Ciencia e Innovación", with a € 350,000.- grant to finance laboratory equipment in Barcelona.
- Funding of 2 million euros for IREC infrastructures in the 2009-2011 period from the 2009 Spanish State budget, pursuant to section 32 in the third additional ruling of the Statute of Autonomy, through the call made by the Spanish Ministry of Science and Innovation, with the support of the Ministry of Innovation, Universities and Enterprise of the Government of Catalonia.
- Funding of 3.1 million euros for IREC infrastructures in the 2010-2012 period from the 2010 Spanish State budget, pursuant to section 32 in the third additional ruling of the Statute of Autonomy, through the call made by the Spanish Ministry of Science and Innovation, with the support of the Catalan Ministry of Economy and Finance.

– Funding of 2.5 million euros for the IREC's offshore wind energy test station in Tarragona in the 2010-2012 period, from the 2010 Spanish State budget, pursuant to section 32 in the third additional ruling of the Statute of Autonomy, through the call made by the Spanish Ministry of Industry, Tourism and Commerce, with the support of the Ministry of Economy and Finance of the Government of Catalonia.

– Multiannual subsidy of 5 million euros awarded by the Generalitat de Catalunya to fund the IREC's infrastructures in the period 2010-2014.

– Nominal subsidy of € 100,000 for the 2010 fiscal year within a program for cooperation between the state administration and the autonomous communities, awarded by the Spanish Ministry of Science and Innovation.

– Loans totaling €12,296,685 through the "Acteparq 2009 y Innplanta 2010-2012, ambos programas de financiación del Subprograma de Parques Científicos y Tecnológicos del Ministerio de Ciencia e Innovación", for the financing of the IREC's scientific and technological infrastructures at its Barcelona and Tarragona headquarters.

5. Breakdown of Accounts

2013 has been a year of financial growth for the IREC, largely due to the strength of its research initiatives.

Income from R+D activities increased significantly from the previous year both in competitive and industrial projects. The increase of number and income from European projects is especially remarkable. Income from competitive projects increased 13% and income from industrial projects increased 28% with respect to the previous year.

Expenses in research-related supplies and in human resources rose accordingly, as all the IREC areas consolidated their activity.

In 2013 the Institute achieved positive results thanks to a reduction in overhead costs, an increase in industrial projects with high added value and significant economic volume, and the implementation of the actual indirect cost methodology both for industrial and European projects.

PROFIT AND LOSS ACCOUNT('000)	2012	2013
TOTAL REVENUE	**9.942**	**10.602**
INCOME FROM R+D ACTIVITIES	3.984	4.555
TRUSTEES FUNDING	2.464	2.498
GRANT ASSETS ASSIGNED	3.232	2.889
OTHER INCOME	262	660
OPERATING EXPENSES	**6.921**	**7.499**
EBITDA	**3.021**	**3.103**
AMORTIZATIONS	3.181	2.735
EBIT	**- 160**	**368**
FINANCIAL RESULT	- 292	- 287
PROFITS	**- 452**	**81**

Balance Sheet ('000)	2012	2013
ASSETS		
NON-CURRENT ASSETS	14.672	12.923
CURRENT ASSETS	50.988	31.908
TOTAL ASSETS	**65.660**	**44.831**
LIABILITIES		
NET EQUITY	18.580	16.606
NON-CURRENT LIABILITIES	21.382	13.052
CURRENT LIABILITIES	25.698	15.172
TOTAL LIABILITIES + EQUITY	**65.660**	**44.831**

6.Applied and Technological Research Units

Research and Technological Development Activities

Bioenergy and Biofuels

THE TEAM

(Permanent and temporary positions, tenure tracks and fellowships)

Prof. Dr. Joan Salvadó, Head of Bioenergy and Biofuels and Group Leader of Feedstocks

Prof. Dr. Daniel Montané, Group Leader of Biorefining and Termochemical Conversion

Dr. Sònia Abelló, Researcher

Dr. César Berrueco, Researcher

Dr. Carles Torras, Researcher

Dr. Ester Clavero, Laboratory Technician

Dr Jorgelina Cecilia Pascualino, Laboratory Technician

Maria Pilar Rey, Laboratory Technician

Claudia Nurra, PhD Fellowship

Javier Recari, PhD Fellowship

Vision and milestones

Bioenergy accounts for over 60% of renewable energy sources in Europe, and is poised to play an increasingly vital role in supplying power to Europe in the long-term. The Strategic Energy Technology (SET) plan has set a target whereby at least 14% of the EU's energy must come from biological sources by 2020. It has also pledged to cut the GHG emissions of biofuels and bio-liquids by 60%, in line with the sustainability criteria provided for in the new Renewable Energy Sources (RES) directive.

The EU and its member state governments are implementing various financial and regulatory instruments in order to facilitate the development of the industrial infrastructure required to reach the targets of the SET plan. At the same time, the implementation plan of the European Industrial Bioenergy Initiative (EIBI) has identified new generic value chains for increasing the contribution of bioenergy to the EU's energy targets for 2020 as part of its efforts to combat climate change. The value chains have been divided into thermochemical and biochemical pathways, complementary activities and measures.

The IREC's Bioenergy and Biofuels Area is made up of a multidisciplinary research team that develops advanced solutions for fuels and energy systems based on biomass, new materials and improved energy efficiency in the industry through the intensification of processes.

Its aims are to provide quality research and development, and to offer a rich and creative environment that delivers opportunities to private businesses for innovation and technology transfer.

6.1. Thermochemical Conversion Group

It concentrates its research efforts on bio-refining in order to develop thermochemical processes for the conversion of biomass and waste into synthetic liquid and gas fuels. Specifically, its areas of research are pyrolysis and gasification for the development of thermochemical processes for producing liquid and gas fuels using renewable resources. There is also a catalysis research line in which work is being carried out on the design, synthesis and characterization of new catalysts intended for the production of synthetic fuels using sources such as biomass and solid waste. The Group is currently focusing on hybrid Ferro catalysts for FT synthesis; zeolite, cracking and tar-reforming catalysts, material catalysts and adsorbents for removing traces of contaminants from syngas.

6.2. Feedstocks Group: Biorefinery and Microalgae

This work is focused on the use of microalgae for producing biofuels and other high added value compounds, within the field of bio-refining. Work is being conducted on microalgae cultures (up to 1200L); harvesting using various techniques such as sedimentation/flocculation, membranes and centrifugation; the breakdown of cell walls; the extraction of lipids; and trans-esterification.

The group also has a membranes technology laboratory that concentrates on the following activities: synthesis of compound polymer membranes, flat membranes and membrane reactors, the physical characterization of membranes (microscopy, mercury porosimetry, power loads, hydrophilicity, etc.) and the evaluation of the performance of membranes in conventional dynamic and micro-scale models on a pilot scale.

The area owns modern laboratories equipped with state-of-the-art technology and lab-scale process plants with enough dimension to scale up the results to an industrial process, allow carrying out the characterization, valorization and analysis of feed-stocks and fuels, as well other process components like catalysts and membranes.

This highly accurate equipment allows the complete evaluation of the resulting components of the processes under test, to enable correct modeling and obtaining results under test conditions.

The equipment of our laboratory enables us to obtain results in accordance with current regulations to let companies gain efficiency, competitiveness and improve their processes.

These above pointed out activities are developed around the implemented facilities infrastructures and experimental set-ups that are available in our laboratories that enhance our capabilities in the following aspects:

Fuel Characterization

This is a cutting-edge facility for the characterization of solid and liquid bio-fuels. The following parameters can be analyzed at present:

» Biomass and solid recovered fuels: Pretreatment (milling, cryogenic milling, sieving, etc.), particle size distribution, density and mechanical properties (pellets), high and low calorific values of the fuel, elemental composition (C,H,N,S,O), moisture, volatile matter and ash, ash fusibility, halogens (Ionic chromatography), metals (microwave digestion and ICP/EOS), biogenic carbon content (except 14C method), biological activity (dynamic spirometry).

» Biodiesel and diesel: derived cetane number, distillation curves, oxidative stability, iodine number, water content, high and low calorific values, biodiesel composition, cold fi lter plugging point, fl ash point (Pensky-Martens and closed cup method), acid index (Free fatty acid content), density, total contamination, copper strip corrosion, ash content, metals (Na, K, Mg, Ca, P), biodiesel in diesel, carbon residue, viscosity, lubricity.

Gasification and Thermal Conversion:

It provides a set of experimental units for the thermal conversion of biomass, solid recovered fuels and coal. In combination with the Fuel Characterization and the Catalysts for Synthetic Fuels facilities, it offers a complete platform to develop basic and applied research on advanced processes for the use of biomass in energy applications and the synthesis of second-generation biofuels. Several bench and laboratory-scale units are available to investigate the gasification and pyrolysis of solid fuels such as biomass, solid recovered fuels and coal (up to 1.5 kg/h of solids). The systems are fully automated computer-controlled units that are configurable for a variety of experimental conditions. On-line analyzers and sampling devices are available to obtain real time information of the reactions under study.

Synthesis and Characterization of Catalysts for Synthetic Fuels:

The Catalysts for Synthetic Fuels activity is focused on the design, synthesis and characterization of new catalysts aimed at the production of synthetic fuels from renewable biomass and assimilable resources.

The unit is currently focused on iron-based hybrid catalysts for FT synthesis, zeolites, catalysts for tar cracking and reforming, and catalysts and adsorbent materials for the removal of trace contaminants from syngas. The laboratory has up-to-date equipment for the synthesis, structural characterization and testing of catalysts, including two reactor units for high-pressure Fischer-Tropsch synthesis.

Membrane Technology:

The available modern equipment to synthesize, characterize and test membranes gives the Institute the capability to engage activities from micro to pilot scale; from commercial to own-designed modules; and to classic tangential cross-flow filtration to advanced dynamic systems which are useful to improve process performance, where fouling and concentration polarization is significant.

The main equipment includes an automatic applicator and a multi-thickness casting knife, a fully automated, multi-dispenser & multi-variable contact angle equipment, streaming potential analyzer for fl at sheets, mercury porosimeter and microscopes, analytical equipment (HPLC/GPC, particle size, GC, elemental analysis, etc.). For testing, the following setups are available:

» Set-up with 4 micro & lab-scale modules. Includes temperature and pressure control, volumetric and mass flow rate measurement, etc. Real-time variable monitoring and analytics.

» 2 pilot scale (up to 1.5 m2) dynamic set-ups: a multi-shaft rotatory and a vibratory system.

Microalgae Facilities:

This facility involves growing different plants from reach-in to walk-in growing chambers (up to 1200L) that allow us to control all the parameters to study the influence of each on the correct growth of the specimens in different environmental and nutritional conditions.

This facility laboratory not only owns equipment for microalgae culturing purposes (flow cytometer, plate reader, high accuracy particle size and counter analyzer, microscopes, TOC, elemental analyzer, TGA, etc.) but also for downstream processing (laboratory and pilot continuous centrifuges, membrane laboratory, cell disruption equipment, etc.).

Projects

ECO2CO2: Eco-friendly bio-refinery fine chemicals from CO2 photo-catalytic reduction Funding.

Title/ Acronym: Eco-friendly bio-refinery fine chemicals from CO2 photo-catalytic reduction (ECO2CO2) - NMP3-SL-2012-309701.

Partners: Politecnico di Torino (POLITO),Technische Universiteit Delft (TUD)

European Research Institute of Catalysis A.I.S.B.L. (ERIC),Centre Tecnològic de la Química de Catalunya (CTQC), Chemtex Italia Spa (CTXI), Avantium Chemicals BV (AVT), Solaronix S.A (SOLAR), Repsol YPF S.A (REPSOL), IREC.

Period:2012-2016

Funding Institution/Program: European Union - FP7- NMP-2012-SMALL-6.

MARECORE (Microalgae bio-refining: optimization of the harvesting and lipid recovery steps)**:** The Project investigates the microalgae culture for the production of energetic products. The Project analyses microalgae life-cycle, their growth process and the best treatment. The main goal of Marecore is to reduce the actual costs and make the process economically viable.

Title/Acronym: Microalgae bio-refining: optimization of the harvesting and lipid recovery steps. (ref. ENE2011-22761) - MARECORE.

Partners: IREC

Period: 2012-2014

Funding Institution/Program: MINECO / Proyectos de Investigación Fundamental No Orientada 2011.

PIOPE: The Project develops and optimizes process of growth of two types of micro-algae. This biomass should be used to obtain gas to produce energy.

Title/Acronym: Microalgae culture for the production of energetic products (PIOPE)

Period: 2011-2014

Funding Institution/Program: Industrial Project

VALDEGAL: Membranes screening, membranes characterization and other processes to transform them into bioethanol or a new product with hypertensive properties.

Title/Acronym: Membranes screening, membranes characterization and other processes to transform them into bioethanol or a new product with hypertensive properties. (VALDEGAL)

Period: 2012-2013

Funding Institution/Program: Industrial Project

SUMEM: Peptide separation in serum by membrane filtration processes

Title/Acronym: Peptide separation in serum by membrane filtration processes (SUMEM)

Period: 2013-2014

Funding Institution/Program: Industrial Project

CAFIP: Characterization and zeta potential in polymeric membranes for osmosis and nano-filtration

Title/Acronym: Characterization and zeta potential in polymeric membranes for osmosis and nano-filtration (CAFIP)

Period: 2013-2014

Funding Institution/Program: Industrial Project

PiB-GAS: Feasibility study of production of BioSNG via biomass gasification.

Title/Acronym: Feasibility study of production of BioSNG via biomass gasification (PiB-GAS)

Period: 2013

Funding Institution/Program: Industrial Project

EPXSteam: Evaluation of the XyloSteam process: Gasification of biomass for steam production

Title/Acronym: Evaluation of the XyloSteam process: Gasification of biomass for steam production (EPXSteam)

Period: 2013

Funding Institution/Program: Industrial Project

SyNaGa-P: Biomass gasification at a pilot plant.

Title/Acronym: Basic design of a pilot plant of BioSNG combining biomass gasification and syngas methanation (SyNaGa-P)

Period: 2013-2014

Funding Institution/Program: Industrial Project

SYN3 (Synthetic liquid fuels through gasification of SRF and biomass: novel catalytic systems for Fischer-Tropsch synthesis): The main objective is to determine the gas quality from the gasification of recuperated solids (CSR) and biomass.

Title/ Acronym: Synthetic liquid fuels through gasification of SRF and biomass: novel catalytic systems for Fischer-Tropsch synthesis (SYN3) - CTQ2011-22767.

Partners: IREC

Period:2012-2014

Funding Institution/Program: MINECO / Proyectos de Investigación Fundamental No Orientada 2011.

TEDECE: Technical assessment of EDAR samples characterization.

Funding: Industrial Project

TRADEBE: State of the art of industrial, demonstration and pilot technologies available to produce liquid biofuels from residual materials.

Funding: Industrial Project

EVALE: Evaluation of waste hydrocarbon sample for energy uses (EVALE).

Funding: Industrial project

Publications

Articles and Journals from ISI Database

Abelló, S.; Berrueco, C.; Montané, D. High-loaded nickel-alumina catalyst for direct CO2 hydrogenation into synthetic natural gas (SNG). *Fuel*. 2013, *113*, 598-609. [IF: 3,357]

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Leyva, C.; Ancheyta, J.; Berrueco, C.; Millan, M. Chemical characterization of asphaltenes from various crude oils. *Fuel Processing Technology*. 2013, *106*, (February 2013), 734-738. [IF: 2,816]

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Piroshka Terrazas-Bandala, L.; Gonzalez-Sanchez, G.; Garcia-Valls, R.; , Gumi, T.; Beurroies, I.; Denoyel, R.; Influence of humidity, temperature, and the addition of activated carbon on the preparation of cellulose acetate membranes and their ability to remove arsenic from water. *Journal of Applied Polymer Science*. (Accepted 2013). [IF: 1,395]

Purón, H.; Pinilla, J.L.; Berrueco, C.; Montoya De La Fuente, J.A.; Millán, M. Hydrocracking of maya vacuum residue with NiMo catalysts supported on mesoporous alumina and silica-alumina. *Energy and Fuels*. 2013, *27*, (7), 3952-3960. [IF: 2,853]

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Torres, C.M.; Ríos, S.D.; Torres, C.; Salvadó, J.; Mateo-Sanz, J.M.; Jiménez, L. Microalgae-based biodiesel: A multicriteria analysis of the production process using realistic scenarios. *Bioresource Technology*. 2013, *147*, (November 2013), 7-16. [IF: 4,75]

Torres, C.M.; Ríos, S.D.; Torras, C.; Salvadó, J.; Mateo-Sanz, J.M.Jiménez, L. Sustainability analysis of biodiesel production from Cynara Cardunculus crop. *Fuel*. 2013, *111*, 535-542. [IF: 3,357]

Doctoral Theses

Ongoing theses:

Thesis title: Biodiesel from Microalgae

PhD student: Sergio Daniel Ríos

PhD supervisors: Xavier Farriol, Joan Salvadó, Carles Torras

University: Universitat Rovira i Virgili

Thesis title: Pre-concentration strategies for microalgae harvesting as bio-refinery process chain

PhD student: Sema Sirin

PhD supervisors: Joan Salvadó

University: Universitat Rovira i Virgili

Thesis title: Separation processes in microalgae bio-refining

PhD student: Claudia Nurra

PhD supervisors: Carles Torras

University: Universitat Rovira i Virgili

Thesis title: Improvement on the synthesis gas produced by thermal gasification of biomass and SRFs

PhD student: Javier Recari

PhD supervisors: Xavier Farriol, César Berrueco

University: Universitat Rovira i Virgili