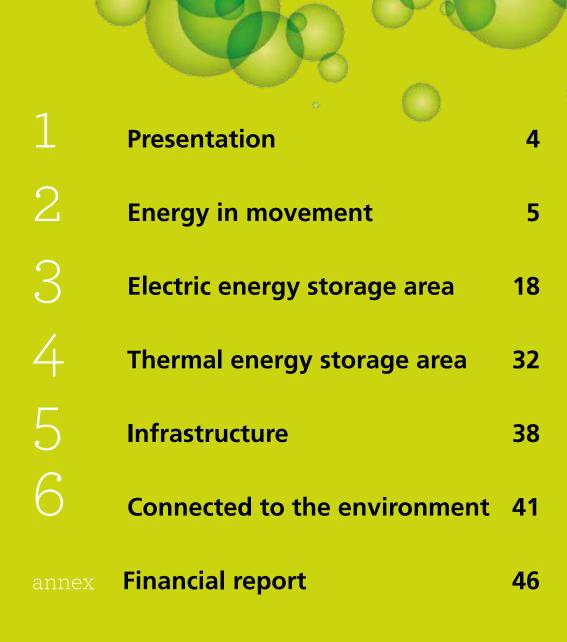


energy cooperative research centre

report **2013-14**

energy in movement



1 PRESENTATION



Jesús María Goiri CEO CIC Energigune

During these two years of intense activity, CIC Energigune has become one of the largest laboratories in Europe in its two areas of expertise: electrochemical and thermal energy storage.

Since the publication of the last Report, the research lines for the next years have been consolidated and we have increased our presence both in terms of publications, from 26 by the end of 2012, to over 100 at the end of 2014, as in the number of patents requested, having eight processes by the end of 2014. Another relevant aspect is hiring and the relationship with the industry world, which has implied the exploration of promising opportunities for the Centre with local companies and large multinationals who consider power storage as an essential opportunity for their future.

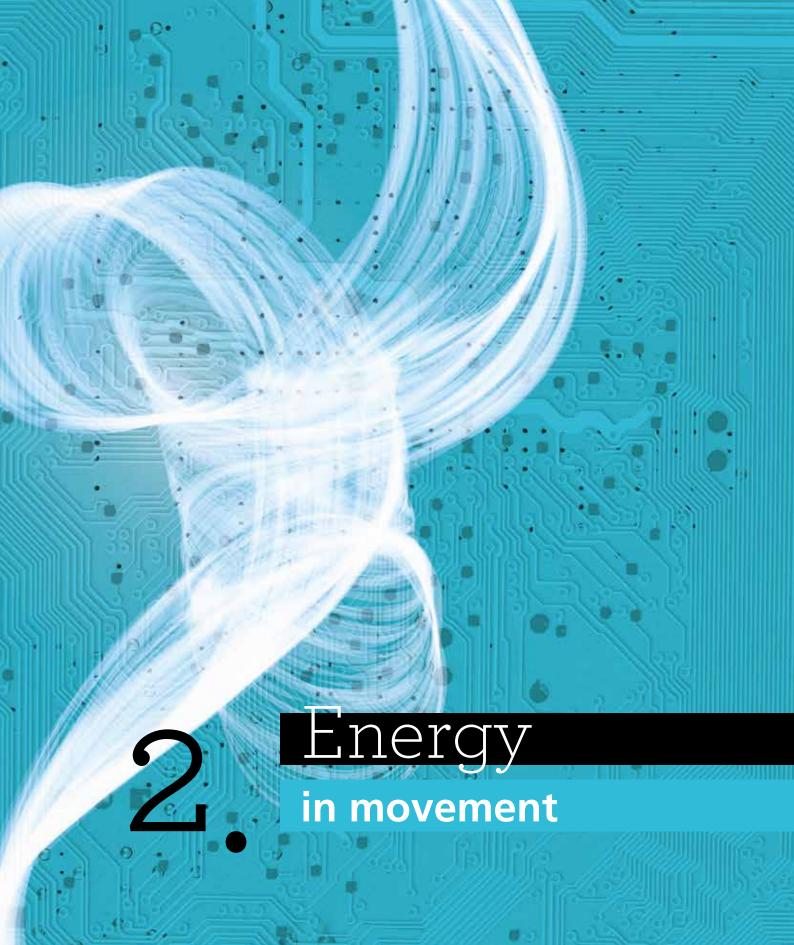
As regards the external financing process, it is important to mention the call for the EU H2020 programme, which was a ti-

tanic effort for the laboratory, since 17 proposals were entered for different calls, four of the thermal area and thirteen for the electrochemical area.

The growth limitations responding to the financial reality have not prevented certain degree of growth in research staff and centre management personnel, which has reached 68 people thanks to a larger diversification in our financing sources. Similarly, it was possible to approve the investment for the battery prototyping line that will bring CIC Energigune closer to the industry and consolidate its intellectual property for the potential development of entrepreneurial projects related to Electrochemical storage.

As a conclusion of this 2013-2014 phase, we can say that the CIC Energigune project is closer to reach a true creativity phase which will result in a research network in a field that will experience a great financial growth in the years to come throughout the world, such as power storage.

Lastly, we cannot forget the constant support of the Basque Government Department of Economic Development and Competitiveness, which has made it possible to create high projection research through CIC Energigune.



2.1 GENERAL OVERVIEW

TECHTIMES

California governor enacts new laws to boost use of electric cars, bikes

diario_responsable

Iberdrola y BMW lanzan el primer servicio de car sharing eléctrico corporativo en España

- Barrings

El vehículo eléctrico liderará el transporte urbano en 10 años

vozpopuli

CAF entra en Montenegro con el suministro de trenes eléctricos

LAVANGUARDIA

El bus eléctrico del grupo vasco Irizar ya circula en pruebas por Barcelona

what is

happening?

entrelineas

Empresas españolas construirán en Marruecos una de las mayores plantas solares de África

The Washington Post

The gamble on Tesla's gigafactory in the Nevada desert

energíadiario.com

Arabia Saudí finaliza su mayor planta solar que ahorrará al año 33.320 toneladas de CO2

AFRWEEKEND

Paris conference the key for climate change



ENERGY STORAGE A key to the future



our framework

Energibasque strategic plan

developed by the department of Economic Development and Competitiveness of the Basque Government

Set plans

developed by the European Commission

Smart specialisation policies

defined by the Basque Government, in which Power is one of the three main pillars that have been identified

our trajectory

2007

Formal foundation of CIC Energigune and initial strategy 2008-2012

2008

Launch of the project and identification of the strategic research lines

2010

Strengthening of talent search and start-up of the CIC building

2009

Definition of the operating model and talent search

2011

Opening of CIC Energigune and start of the research activities

2012

Increase of research, launch of new research lines and implementation of the extended CIC



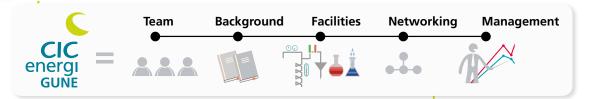
Vision

To become one of the 5 main research centres in Europe in the areas of expertise of CIC and the leader for the collective R&D effort for power development in the Basque Country, generating an impact that is measurable in the industry.

Mission

To play a leading role on the international scientific stage focused on basic research in energy- related materials oriented to storage applications, contributing to industrial competitiveness of Basque businesses, through:

- Excellent and breakthrough research
- Transfer of technology and knowledge to local industry
- Coordination of Basque technology and research efforts (in energy storage)



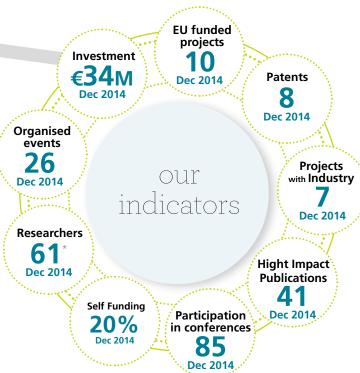


2013

- Graphene flagship launched
- · First industrial collaborations both national and international
- 1st Symposium on Na batteries
- Battery testing lab start-up with more than 300 channels for battery cycling
- Bruno D'Aguanno joins CIC Energigune as Thermal Storage Area's Scientific Director

2014

- Relevant increase of the number of patents pending (6)
- II Forum Power our Future 2014
- Prototyping line's Phase I endorsement
- Mineco's grant for Linabatt Project
- Publication of "BATTERIES & SUPERCAPS POST MORTEM ANALYSIS PLATFORM" Dossier



* Including Ikerbasque Researchers

2.2 RELEVANT MILESTONES

PROTOTYPING LINE

- Purchasing process of the Phase I Prototyping Line, balancing the development of the technologies of CIC Energigune and the relevance of advanced manufacturing.
- The prototyping line will allow us to further advance our work to revolutionise materials or systems at a greater level that is also closer to the industry's reality and reduce the technological risk, while expediting market placement.
- This infrastructure will have special incidence in research on Na-ion and Li /Low Temperature Na–S batteries, while covering a gap in the Basque S&T&I network (RVCTI), to turn it into an open Platform accessible to all of the network's agents.

INCORPORATION SCIENTIFIC DIRECTOR THERMAL STORAGE AREA

Bruno D'Aguanno became part of CIC Energigune in November 2013. The Italian researcher headed the Chemical Processes Department of CRS4 in Cagliari (Italy), gaining his PhD in Physics with the thesis titled: "Freezing of ionic liquids in correlation to hot-solid structure". He has extensive experience in the preparation of European projects, and has over 50 publications in the Thermal Storage field.

ORGANISATION OF CONGRESSES

October 2013. "1st Symposium on Na batteries". Palacio Villa Suso in Vitoria-Gasteiz. First global symposium on sodium batteries. 109 attendees, 17 universities, 11 keynote speakers, 18 research presentations and 30 posters exposed.

April 2014. II Forum Power our Future. Palacio Villa Suso in Vitoria-Gasteiz. 30 global experts as keynote speakers. 150 attendees. 40 informative posters.

July 2014 CIC Energigune is appointed as organiser of the ABAA8 Congress in Nara (Japan), the 8th International Conference on Advanced Lithium Batteries for Automobile Applications Congress 2015.

START OF #OPENLABS CYCLE

During 2014 the new #Openlabs cycle has been developed and launched to bring the science of CIC Energigune closer to society. In this first phase, the priority target population has been schools and universities around us.



PATENTS

During 2013 and 2014 one patent has been approved:



Besides, we have **6 more patents in process,** two of them with a positive International Research Report:

ELECTROCHEMICAL ENERGY STORAGE DEVICE (P201490064)

Authors: Ander Laresgoiti, Hisashi Tsukamoto, Laida Otaegui, Liya Wang and Lide M. Rodríguez

PROCESS FOR THE PREPARATION OF HIERARCHICALLY MESO AND MACROPOROUS STRUCTURED MATERIALS (PCT/EP2013/071705)

Authors: Mani Karthik, Abdessamad Faik and Stefania Doppiu

NEW HIGH CAPACITY MATERIALS BASED ON TRANSITION METALS OF OXYNITRIDES (PCT/EP2014/062412)

(PCT/EP2014/062412)

Authors: Montserrat Casas - Cabanas, Begoña Acebedo, Michel Armand and Montse Galceran Mestres

PROCESS FOR THE PREPARATION OF FLEXIBLE MESO AND MACROPOROUS CARBON FOAMS

(EP14382098.3)

Authors: Mani Karthik

HINDERED GLYMES FOR ELECTROLYTE COMPOSITIONS

(EP14382149.4)

Authors: Devaraj Shanmukaraj and Michel Armand

A SODIUM CERAMIC ELECTROLYTE BATTERY (EP14382393.8)

Authors: Michel Armand, Teófilo Rojo, Gurpreet Singh, Laida

Otaegui and Frederic Aguesse



AWARDS/RECOGNITIONS



Michel
Armand

2013 "CATALAN
SABATIER" AWARD
OF RSEQ



Teófilo Rojo
2013 AWARD TO
RESEARCH IN
THE INORGANIC
CHEMICAL AREA
OF RSEQ



Marine Reynaud 2014 BEST PHD UPJV-11TH EDITION

Recognition of the best posters presented at some of the Congresses we have attended.

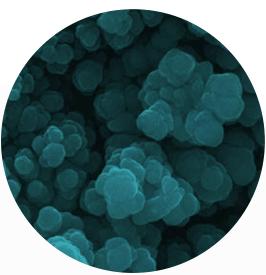


Euromar 2013 Juan Miguel López del Amo



STFC Batteries 2014 María José Piernas





EUROPEAN PROJECTS



SIRBATT

Call: FP7-ENERGY.2013.7.3.3

Title: Stable Interfaces for Re-

chargeable Batteries

Purpose: Development of microsensors to control internal temperature and pressure of lithium cells to maintain optimal performance conditions, which allows for a higher duration of batteries in their high-scale use in networks.

The results of this project could be used to develop electrodes with an optimised life cycle and stability.

Iberdrola leads the task of defining large scale applications.

CIC budget: €260k Total Grant: €3.2M



MAT4BAT

Call: FP7-2013-GC-Materials

Title: Advanced Materials for

Batteries

Purpose: Development of advanced materials for safer and more resistant ion-lithium batteries. The project will address critical ageing mechanisms related to Li-ion technology that have direct repercussions on the useful life of the product and safety from two main aspects: current performance of the battery and battery technologies. The project parts from a ground breaking NMC / liquid carbonate electrolyte / graphite technology that is marketed and is being incorporated in electric vehicles.

CIC budget: €442k Total Grant: €8.2M



GRAPHENE Flagship

Call: FP7-ICT-2013-FET-F

Title: Graphene-Based Revolutions in ICT and Beyond

Purpose: The purpose of the project is to research on graphene to obtain products that revolutionise multiple industries, from electronics to new power applications and new functional components.

The main scientific and technological goal is the development of ICT technological materials and identifies new devices with graphene technology and materials in graphene layers that offer new functionalities and areas of application.

CIC budget: €500k Total Grant: €54M

Marie Curie Grants

FP7-PEOPLE-2012-IOF

CIC Energigune and MIT. Dr. Nagore Ortiz.

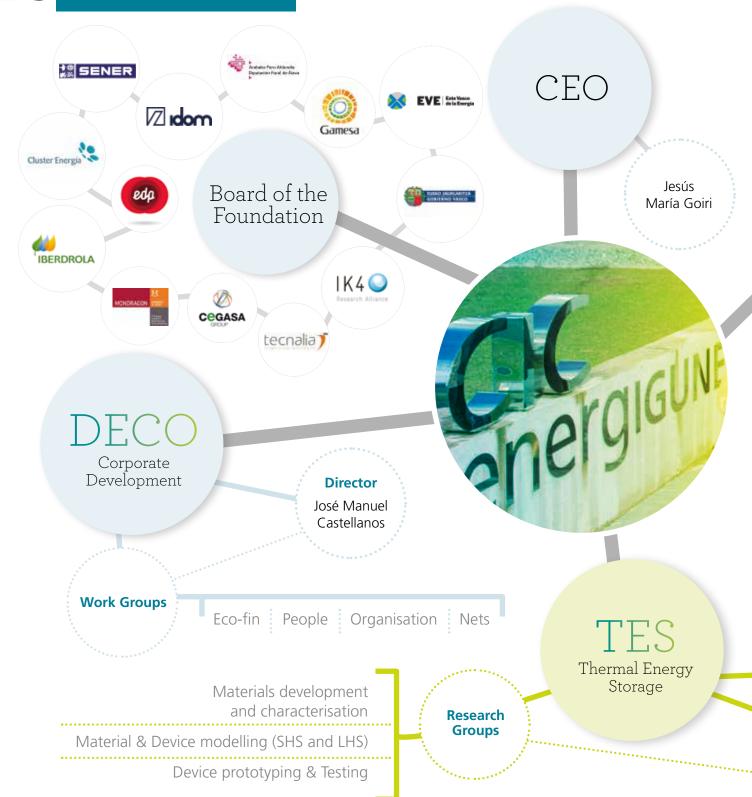
September 2013

FP7-PEOPLE-2011-CIG

Dr. Javier Carrasco.
September 2013

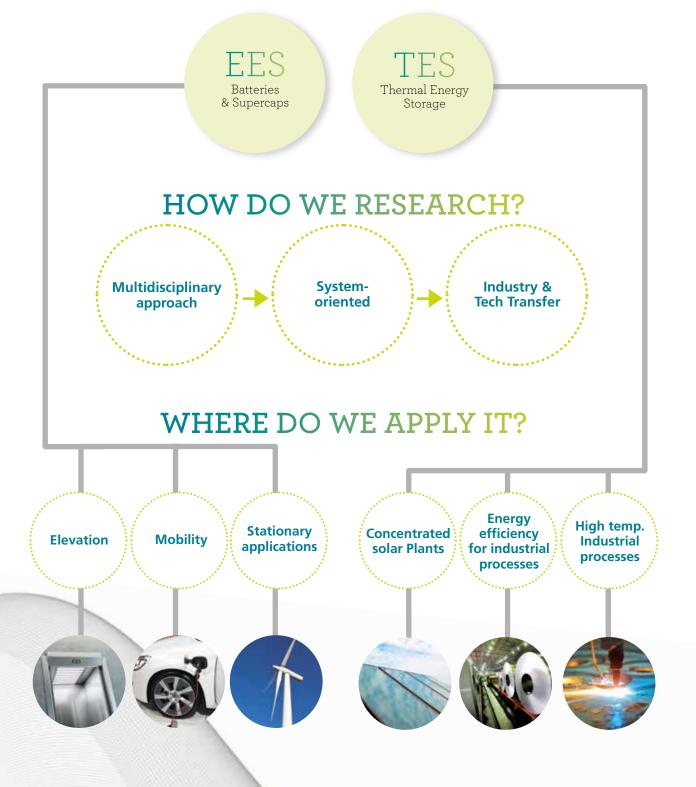


2.3 ORGANISATION





WHAT ARE WE RESEARCHING?



2.4 COLLABORATORS



2.5 OUR FIGURES

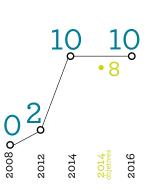
INVESTMENT

0 16 27 43 2008 2012 2014 2016

HIGH-IMPACT publications

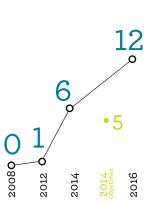


With industry

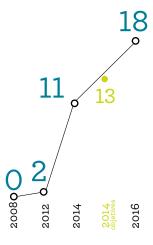


PROJECTS

European



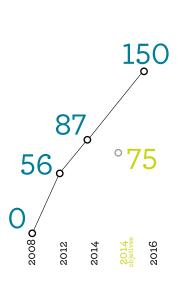
Research Competitive

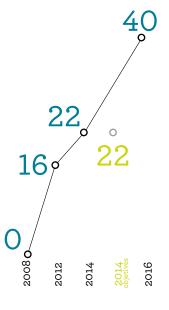


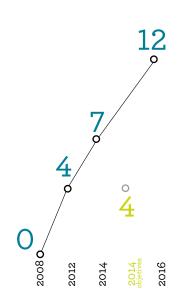
PARTICIPATION in conferences

EVENTS organised

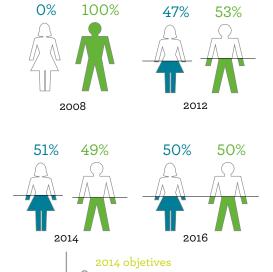
PATENTS





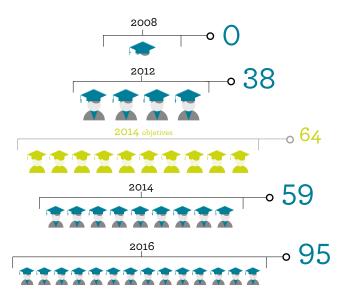


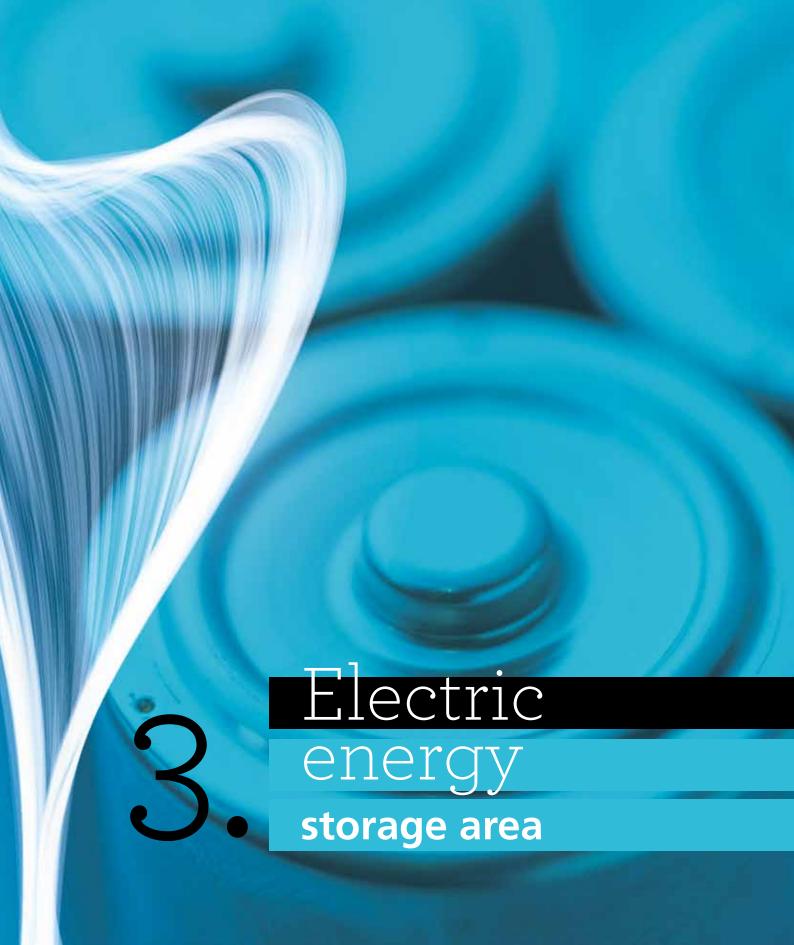
% WOMEN % MEN



50% 50%

RESEARCHERS on staff





3.1 STAFF



"Taking into account the critical need for energy transition from fossil fuels to more sustainable sources as well as the high demand for energy storage systems, the need for large scale electrochemical energy storage is urgently required."

2018

	Na-ion	Li-ion	Li-S	Polymer electrolytes	Ceramic electrolytes
OALS	Cost (€/kWh) < 215	Cost (€/kWh) < 200	Cost (€/kWh) (mass production) <250 Cell specific energy	Density 1.2 g/cm³	Density >93%
	Cell specific energy (Wh/kg) 130	Cell specific energy (Wh/kg) 270		Conductivity >0.1 mS/cm	Conductivity >0.1 mS/cm
	Cell energy density (Wh/l) 260	Cell energy density (Wh/l) 650	(Wh/kg) 500 Cell energy density	High electrochemical stability	Electrochemical stability moderate
	Anode capacity (mAh/g) 300	Anode capacity (mAh/g) 1000	(Wh/l) 500 Anode capacity (mAh/g) 3860	Operating temp range 60-70 °C Crate 1C	Operating temp range -10 °C-500 °C
	Cathode capacity (mAh/g) 180	Cathode capacity (mAh/g) 250	Cathode capacity (mAh/g) 650		Optimised garnet
	Cycles >200	Cycles >1000	Cycles >600	Development of	compositions.
<u> </u>	Operating temp RT	Operating temp range RT	Operating temp RT- 70 °C	novel synthetic polymers and preparation of self-standing polymer membranes. Thickness control of polymer membranes prepared by hot-pressing (from 15 µm to 500 µm). Integration of developed thin films into all-solid-state Li or Na batteries.	Optimised route of dense ceramics. Exploring routes of organic-inorganic solid electrolytes and thin films. Implementation of developed materials in solid state batteries.
TEGIES	Anode First cycle irreversible capacity. Electrode-electrolyte interactions. Avoid displacement reactions.	Anode Li ₄ Ti ₅ O ₁₂ Graphite Sn/Si-rGo composite Cathode Li-rich	Anode Best SoA anodes for G1 cell concept (developed materials) Anode alternatives Li thin film deposi-		
K	Cathode Select materials based on: Low cost / Safety / Avoid	Li-rich Li _{1,2} Mn _{0,6} Ni _{0,2} O ₂ Electrolyte LiPE6 in organic sol-	tion Li metal with protective layers		

/ Safety / Avoid electrolyte decomposition.

Alternative synthesis methods.

Electrolyte

Polymer electrolytes. Aqueous systems.

Other

Coin cell prototypes. Large pouch cells. Reaction mechanisms.

LiPF6 in organic solvent with additives **Ionic Liquids** Polymer

Other

Aqueous cell fabrication Robust interphase Coatings of C, ZrO, and Al₂O₃

Cathode

Best SoA cathode for concept development

Organosulfur cathode assessment C/S, other architectures

Additives and formulation optimisation

Electrolyte

Electrolyte chosen for G1 cell concept Polymer / ceramic / composite

2025 -

Na-ion	Li-ion	Li-S	Polymer electrolytes	Ceramic electrolytes
Cell level cost (€/ kWh) <100 Cell specific energy (Wh/kg) 160	Cost (€/kWh) <150	Cost (€/kWh) (mass	Density 1.0 g/cm³	Density >98%
	Cell specific energy (Wh/kg) 350	production) <120 Cell specific energy	Conductivity >1mS/cm	Conductivity >1 mS/cm
	Cell energy density (Wh/l) 800	(Wh/Kg) 600 Cell energy density	Stability High	Stability High
Cell energy density (Wh/l) 350	Anode capacity (mAh/g) 1400 Cathode capacity	(Wh/l) 600	Operating temp range 50-60 °C Crate 2C	Crate 1C
Anode capacity		Anode capacity (mAh/g) 3860 Cathode capacity (mAh/g) 850		Cycles >1000
(mAh/g) 500			Cycles >1000	Operating temperature
Cathode capacity (mAh/g) 210	(mAh/g) 300 Cycle >3000		-	-10 °C-500 °C
Cycles >3000	Operating temp range RT Anode Li metal Graphene Cathode LiNi _x Mn _{2-x} O ₄ Li-rich Multi electron cathode Electrolyte Ionic Liquids	Cycles >1000	Optimised synthetic routes of new polymers and block copolymers.	(pure ceramic elec- trolyte) RT-70 °C (hybrids)
Operating temp RT		Operating temp RT-70 °C		
Study of the performance of selected electrode materials and electrolyte in full cell. Search for second generation materials from previous expertise.		Materials and processing optimisation to deliver target capacity and cyclability. Proof of prototype in terms of reproducibility, performance, stability and viability.	Polymer membranes scale-up by extrusion technique for applications at pouch cell level. Integration of developed thin films into battery devices.	Optimised hybrid electrolytes and thin films. Thickness control of hybrid electrolyte membranes. Integration of developed thin films <1 µm) and thick layers (10-30 µm) into battery devices.
	Polymer			

Supercaps

Cost (€/Wh) <15

Cell specific energy (Wh/kg) 9 (25*)

Cell specific power (kW/kg) 15

Electrode capacitance (F/g) 350

Cycles >1,000,000

Operating temp range RT

Electrodes

Carbon materials including graphene;

Inorganic materials.

Carbon/inorganic or carbon/carbon composites.

Electrolyte

Application of commercially available aqueous and organic based electrolytes including ionic liquids.

Cell design / Configuration

Symmetric and asymmetric carbon cells both in organic and inorganic electrolytes.

Symmetric and asymmetric hybrid systems comprising two AC electrodes or an AC electrode and a battery type electrode.

Others

Post-mortem studies

Prototyping

Reach and improve the values obtained with the lab scale prototypes (coin cell) but at a pouch cell level + facility stabilisation and operation.

Electrodes

Decision on Electrode materials.

Cell Balancing/Formulations

Feedback to pouch cell

Pouch Cell Forecasting

Projection from small to large scale.

Risks

Change in SOA.

Scaling up of the materials.

Mitigation Plan

Formulations are in broken steps.

Collaborations/Suppliers.

Post-mortem

Protocols for disassembling and characterisations of Li-ion batteries.

Protocols for disassembling and characterisations of supercapacitors.

Diagnostic of aged cell.

Correlations between ageing parameters and cell components degradation.

System

Development and validation of protocols of various electrochcemical devices for Li-ion and supercaps.

Diagnostic of aged cells Development of predictive models for lifetime according to their applications.

Materials

Correlation between ageing parameter and materials degradation Development of predictive models of materials degradation.

Cell components

Correlation between ageing parameter and cell components degradations.

Development of predictive models of cell components degradation.

Modelling & Computational studies

Efficient screening and/or characterisation of cathode and anode materials. Target: crystalline materials with up to 4 constituent elements.

Efficient screening and/or characterisation of electrolytes. Target: cristalline solid electrolytes with up to 4 constituent elements.

Gain atomistic understanding of electrode/electrolyte interfaces. Target: solid/solid interfaces.

To apply state-of-the-art static DFT calculations and statistical mechanics techniques.

To develop advanced MD simulations combining DFT and IP approaches for effective sampling of complex configurational spaces.

^{*} hybrid cell configuration

Supercaps

Cost (€/Wh) <12

Cell specific energy (Wh/kg) 30 (50*)

Cell specific power (kW/kg) >15

Electrode capacitance (F/g) 500

Cycles >1,000,000

Operating temp range (°C) -40 to 60

Electrodes

Carbon materials including graphene.

Inorganic materials.

Carbon/inorganic or carbon/carbon composites.

Electrolyte

Development of aqueous and organic based electrolytes including ionic liquids.

Cell design/ Configuration

Symmetric and asymmetric Carbon cells both in organic and inorganic electrolytes.

Symmetric and asymmetric hybrid systems comprising two AC electrodes or an AC electrode and a battery type electrode.

Others

Prototyping & Post-mortem studies.

Extending temperature range.

Prototyping

Improve battery performance based on: Slurry Formulations, Electrode Formulations, Eletrolyte Formulations, Pouch Cell process optimisation, cell balancing.

Electrodes

Decision on Electrode materials.

Cell Balancing/ Formulations

Feedback to pouch cell.

Pouch Cell Forecasting

Projection from small to large scale.

Risks

Change in SOA.

Scaling up of the materials.

Mitigation Plan

Formulations are in broken steps.

Collaborations/Suppliers.

Post-mortem

Provide guidance for advanced materials and cell components.

Provide guidance for optimal use of a given device for best performance and extended lifetime.

Development and validation of protocols for Na-ion, Li-air and Li-S.

Provide guidance for fabrication and use of new-cell concept.

System

Extension to emerging technologies.

Materials

Provide guidance for materials properties suitable for ageing.

Cell components

Provide guidance for fabrication suitable for ageing.

Other

Provide guidance on laboratory prototype cells.

Modelling & Computational studies

Efficient screening of cathode and anode materials. Taget: amorphous and low dimensional materials.

Efficient screening of electrolytes. Target: polymers and liquid electrolytes.

Gain atomistic understanding of electrode/electrolyte interfaces. Target: solid/liquid interfaces.

Towards more realistic simulations. Target: approaching macroscopic length and time scales.

To develop high-throughput techniques and big data management for materials screening.

To develop IP MD simulations of solid/liquid interfaces containing several thousands of atoms.

To develop bottom-up multiscale approaches including multiphysics effects.

3.3 RESEARCH LINES

Na-ion

Purpose

To develop low-cost systems for stationary energy storage applications, through the synthesis, structural and electrochemical characterisation of new low cost materials at the anode, cathode and electrolytes with the appropriate sodium-ion chemistry.

Objectives

- To achieve a low cost (less than 215 €/KWh. (2018) less than 100 €/KWh (2025).
- To achieve improved safety.
- Robustness with a number of cycles greater than 3000.

Limitations and risks

- The range of materials to test is very wide.
- Competition with world wide research groups.

Results so far

- More than 20 invited and oral presentations at international conventions.
- 18 papers published in journals with a high impact factor.
- Two highly cited review articles.
- Two patent applications at the internal analysis stage.

Collaborators

Argonne National Lab, PSI, BCN Materials, University of Oxford, University of St Andrews, University of Sidney.

Ceramic electrolytes

Purpose

To develop solid electrolytes with high ionic conductivity in order to replace the liquid organic solvents that are currently used and give safer and more reliable batteries.

Objectives

Use of ceramic ionic conductors, to increase the safety and chemical and electrochemical stability of the systems, with the advantage that ceramic materials can be obtained with a wide range of stoichiometries, crystal structures and microstructures leading to a controlled range of electrochemical properties that can be used in these devices.

Limitations and risks

- The range of materials to test is very wide.
- There are many research groups in the world working in this field.

Results so far

- Ceramic electrolytes based on the Li₇La₃Zr₂O₁₂ garnet structure have been developed with total conductivities of >1 mScm-1
- Novel processing route for ceramic electrolytes has been developed.
- 7 Publications, 8 oral conference presentations: 15 total contributions.

Collaborators

Imperial College, PSI, Autonomous University of Barcelona and the Nagoya Institute of Technology.

Li-S **Purpose** To develop a lithium sulfur battery concept with properties capable of overcoming the limitations of current lithium-ion

Objectives

- Develop technical-economically feasible solid Lithium-Sulfur battery concepts
- Validate the achievements in terms of durability and safety under real application environments

technology for specific target applications. The main drivers are cost, safety and enhanced durability.

Demonstrate upscaling capability

Limitations and risks

Overcoming critical intrinsic issues of Li-S technology, such as durability, C-rate capability and volumetric energy density

Results so far

- Successful new materials preparation with preliminary enhanced stability
- Successful additives preparation that enhance volumetric energy density

Collaborators

IK4-Cidetec, Tecnalia.

Polymer electrolytes

Purpose

To develop safer and more reliable solid electrolytes with high ionic conductivity (>10-4 S/cm at room temperature) and a high transport number $(t+\rightarrow 1)$ through the replacement of currently used liquid organic solvents.

Objectives

- Develop cost effective solid electrolytes for Li and Na-based battery systems.
- Crate >1
- Improve the performance of polymer electrolytes at lower operating temperatures.

Limitations and risks

- Choice of polymers compatible for high voltage operation.
- Improving the properties of the polymer electrolyte with a combined property of high ionic conductivity, high transference number and mechanical stability.

Results so far

- 6 invited talks.
- One oral and one poster presentation at ANM 2014.
- Four papers and one review published in 2014.

Collaborators

Polymat, ICTP-CSIC, ICMM-CSIC, Deakin University, Huazhong University of Science and Technology, Wuhan, China, Hunter College of the City University of New York, Volkswagen, Bosch.

Li-ion

Purpose

Investigation of new Li-ion electrode materials and optimisation of existing ones through understanding electrochemistry/composition/(micro)structure and electrode formulation correlations. Elucidation of reaction and degradation mechanisms through physical-chemical characterisation of the electrode bulk and surface regions. Development of advanced tools for the characterisation of Li-ion battery materials.

Objectives

- To meet the market requirements in terms of energy density (270 Wh/kg), useful life and safety.
- To achieve attractive costs for practical applications (200 €/kg).
- To maintain the requirements regarding sustainability.

Limitations and risks

- Loss of focus due to expansion of activities
- Cross-contamination
- Difficulties to obtain the desired phase
- Lack of supply from partner or company
- Saturation of laboratory facilities

Results so far

- 1 patent
- 8 papers published in journals with a high impact factor
- 13 conference contributions
- 1 software program (FAULTS)
- 3 EU projects
- 1 National project

Collaborators

Nokia, SOLVAY, University of Liverpool, IMERYS, Karlsruhe Institute of Technology, University of Camerino, Johnson Matthey, SGL Group, Collége de France, Neutrons for Science, ICMAB, University of Illinois (Chicago), DirectaPlus.



Supercaps

Purpose

Optimise carbon materials and transition metal oxides/nitrides to obtain high energy and/or power density supercapacitors in both gravimetric and volumetric terms and maximise energy output through advanced asymmetric and hybrid cell configurations.

Objectives

- Synthesis of novel electrode materials for electrochemical capacitor application using cheaper and alternative precursors and/or providing higher capacitance values.
- Optimise and adjust nanoporous carbon from low-cost precursors and nitrogen-doped carbon to specific electrolytes.
- Explore and optimise pseudocapacitive materials and composites based on oxides/ nitrides of transition metals.
- Explore and adjust asymmetric and hybrid system configurations

Limitations and risks

- Limited porosity formation tunability, reducing non-accessible porosity. Strategy: Mixed physical/chemical activation, milder activation conditions.
- Limited power of hybrid cells, limited kinetic stability of electrolytes operating above their thermodynamic voltage window. Strategy: Appropriate carbon-electrolyte combinations, accurate mass balancing, oversizing batterytype electrodes.

Results so far

- One industrial collaboration
- 6 papers published in journals with a high impact factor
- Participation in the Graphene Flagship

Collaborators

CNRS/Thales (University of Nantes), the Surface Analysis Platform (Drexel University) and the Surface Analysis Platform (Paul Sabatier University).



Modelling & Computational studies

Purpose

To apply and develop atomistic models and simulations of electroactive materials using first-principle methods in order to guide the synthesis and characterisation of new compounds.

Objectives

- To develop and implement state-of-the-art computational approaches.
- To efficiently screen and characterise cathode, anode, and solid electrolyte materials.
- To gain molecular-level understanding of electrode/electrolyte interfaces.

Limitations and risks

- Limitations of the materials models to cope with complex, real materials.
- Insufficient computational resources.

Results so far

- 2 published papers.
- 1 Paper under revision in Energy & Environmental Science and 3 papers under preparation.
- 2 oral presentations.

Collaborators

BCAM, UPV/EHU, European projects within 7PM: SIRBATT (until 2016)

Post-mortem analysis

Purpose

To establish extensive knowledge base on failure roots and greater understanding of critical ageing mechanisms occurring in different electrochemical devices in order to propose behaviour and predictive models for battery performance and lifetime under various practical operating conditions.

Objectives

- To develop and validate protocols for analysing various electrochemical devices with various configurations.
- To diagnose aged cells and correlate ageing parameters and cell components degradation.
- To develop predictive models for electrochemical devices performance and lifetime according to their applications.
- To provide guidance for optimal use of a given device for best performance and extended lifetime.
- To extend post-mortem analysis to emerging technologies such as Li-S, Na-ion...

Limitations and risks

- Cells not delivered
- Insufficient battery degradation
- Contamination from other Research Lines
- Safety issues to study device with high current and voltage device

Results so far

- 1 Paper under revision
- 2 Papers under preparation
- Oral presentation in the 227th ECS meeting
- European projects within the 2020 horizon: MAT4BAT (until 2016)
- Industrial partners on a confidential basis.

Collaborators

CEGASA, IK4-Ikerlan, Argonne National Laboratory, Zentrum für Sonnenenergie- und Wasserstoff-Fors chung (ZSW).

Prototyping

Purpose

The purpose of the research line is to support the system-oriented research lines to bring the newly developed materials at the prototyping stage where the proof of concept can be demonstrated at the device level

Objectives

Improving cell performance by optimising process parameters and project the technical requirements from the coin cell level to the pouch cell level are the two main objectives of the research line.

Limitations and risks

Those are related to the respective limitations of the technology to be considered for this stage. Risks are related to the adaptation of the change in the state-of-the-art technology under consideration and the lack of scale up facilities for potential electroactive materials, which would be required for manufacturing larger format cells such as pouch or prismatic cells.

Results so far

Research line under development stage.

Collaborators

System-oriented research lines at CIC.



3.4 SCIENTIFIC HIGHLIGHTS



UPDATE ON NA-BASED BATTERY MATERIALS. A GROWING RESEARCH PATH

Verónica Palomares, Montse Casas-Cabanas, Elizabeth Castillo-Martínez, Man H. Han and Teófilo Rojo

This work presents up-to-date information on Na-based battery materials. On the one hand, it explores the feasibility of two novel energy storage systems: Na-aqueous batteries and Na-O₂ technology. On the other hand, it gathers the new advances on non-aqueous Na-ion systems. Although all of them can be placed under the umbrella of Na-based systems, aqueous and oxygen-based batteries are arising technologies with increasing significance in energy storage research, while non-aqueous Na-ion technology has become one of the most important research lines in this field. These systems meet different energy storage requirements: Na-aqueous batteries will have a determining role as a low cost and safer technology; Na-O₂ systems can be the key technology to overcome the need of high-energy-density storage devices; and non aqueous Na-ion batteries have applications in the field of stationary energy storage.

Energy & Environmental Science. DOI: 10.1039/c3ee41031e

Accepted 14th June 2013



HIGH TEMPERATURE SODIUM BATTERIES: STATUS, CHALLENGES AND FUTURE TRENDS

B. Hueso, Michel Armand and Teófilo Rojo

The progress in the research and development of high temperature sodium batteries suggests that all-solid-state batteries with inorganic or polymer solid electrolytes are promising power sources with a wide range of applications due to their high thermal stability, reliability, long-cycle lives and versatile geometries. Electrolytes play a fundamental role in terms of current (power) density, time stability, and battery safety and, as a result, their continuous improvement and innovation are indeed critical to success. In fact, inorganic solid electrolytes pave the way for improving the cost-effective development of rechargeable sodium batteries. This review describes a state-of-the-art overview of most of the Na⁺ conductors using electrolytes in sodium/sulphur and ZEBRA batteries. The emphasis of this article is on inorganic solid electrolytes, specially, ceramic and glass-ceramic electrolytes as a promising alternative applicable to all solid-state batteries. As part of a continuing effort to find new materials that operate at room temperature and moderate temperatures, NASICON electrolytes will be also considered. Polymer electrolytes based on poly(ethylene oxide) (PEO) are also very suitable for all solid-state batteries. Hence, the review focuses on ion transport based on the observed conductivity, electrolytes preparation, safety and environmental impact.

Energy & Environmental Science. DOI: 10.1039/c3ee24086j

Accepted 11th January 2013.

POLYMERIC SCHIFF BASES AS LOW VOLTAGE REDOX CENTRES FOR SODIUM ION BATTERIES

Elizabeth Castillo-Martínez, Javier Carretero-González and Michel Armand

The redox entity comprising two Schiff base groups attached to a phenyl ring (–N=CH-Ar-HC=N–) is reported to be active for Na-ion storage (Ar: aromatic). Electroactive polymeric Schiff bases were produced by reaction between non conjugated aliphatic or conjugated aromatic diamine block with a terephthaldehyde unit. Crystalline poly-Schiff bases are able to electrochemically store more than one sodium atom per azomethine group at potentials between 0 and 1.5 Volts vs Na+/Na. The redox potential can be tuned through conjugation of the polymeric chain and by electron injection from donor substitutes in the aromatic rings. Reversible capacities of up to 350mAh/g are achieved when the carbon mixture is optimised with Ketjen Black®. Interestingly, the "reverse" configuration (–CH=N-

2,0 X = Y = -CH₃
Z = -CH₃
X = XY,Z = -H
P6
P4
P3

0,0
0,0
0,5
1,0
1,5

x Na / monomer unit Ar-N=HC-) is not electrochemically active, though it is isoelectronic.

Simple poly-Schiff bases insert sodium at low potential with high capacities. More than one Sodium ion can be reversibly stored per /C=N bond in poly-Schiff bases with the active unit –N=CH-Ar-HC=N– that contains 10 π electrons.

Angewandte Chemie Int. ed. 2014 http://dx.doi.org/10.1002/anie.201402402

Article first published on-line: 22 APR 2014

NAO.67MN1-XMGXO2 (0 \leq X \leq 0.2): A HIGH CAPACITY CATHODE FOR SODIUM-ION BATTERIES

Juliette Billaud, Gurpreet Singh, Robert Armstrong, Elena Gonzalo, Vladimir Roddatis, Michel Armand, Teófilo Rojo and Peter G. Bruce

Earth-abundant $Na_{0,67}[Mn_1-xMg_x]O_2$ cathode materials with the P2 structure have been synthesised as positive electrodes for sodium ion batteries ($0 \le x \le 0.2$). $Na_{0,67}MnO_2$ exhibits a capacity of 175 mAhg⁻¹ with good capacity retention. A Mg content of 5% is sufficient to smooth the charge/discharge profiles without affecting the capacity, whilst further increasing the Mg content improves the cycling stability, but at the expense of a lower discharge capacity (150 mAhg⁻¹ for $Na_{0,67}Mn_{0,8}Mg_{0,2}O_2$). It was observed that the cooling process during synthesis, as well as Mg content, have an influence on the structure.

Energy & Environmental Science. DOI: 10.1039/c4ee00465e

Accepted 21st February 2014.

MOLECULAR SWITCHES FROM BENZENE DERIVATIVES ADSORBED ON METAL SURFACES

Wei Liu, Sergey N. Filimonov, Javier Carrasco and Alexandre Tkatchenko

Transient precursor states are often experimentally observed for molecules adsorbing on surfaces. However, such precursor states are typically rather short-lived, quickly yielding to more stable adsorption configurations. Here we employ first-principles calculations to systematically explore the interaction mechanism of benzene derivatives on metal surfaces, enabling us to selectively tune the stability and the barrier between two metastable adsorption states. In particular, in the case of tetrachloropyrazine molecules, two equally stable adsorption states are identified with a moderate and conceivably reversible barrier between them. We address the feasibility of experimentally detecting the predicted bistable behaviour and discuss its potential usefulness in a molecular switch.

Nature communications. DOI: 10.1038/ncomms3569

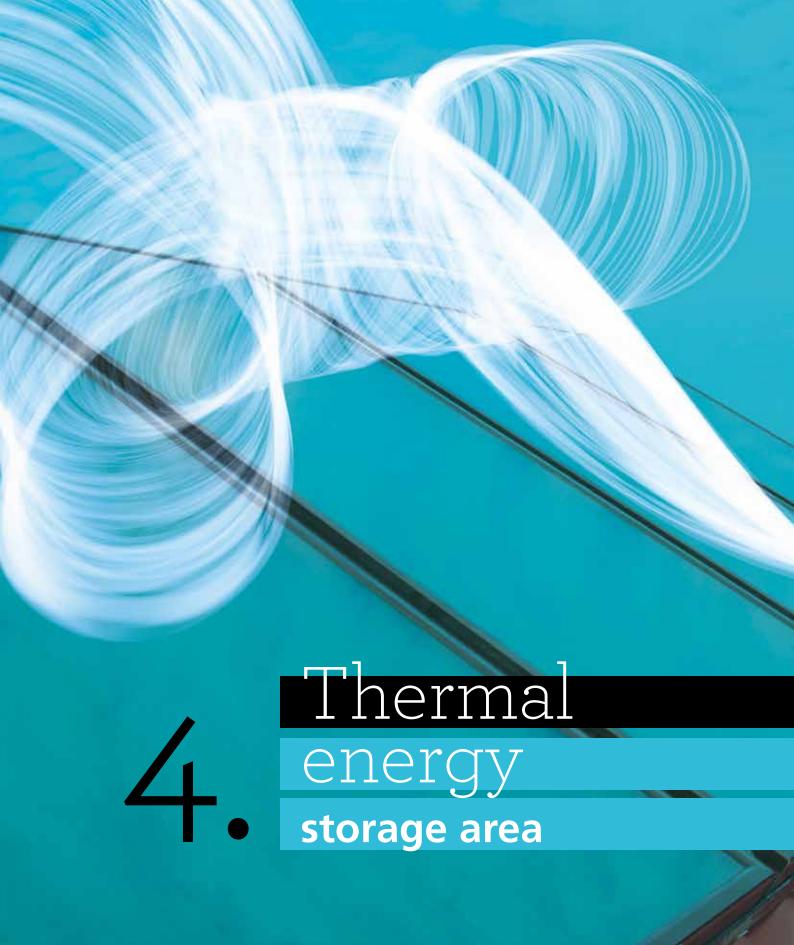
Accepted 5 Sep 2013. Published 25 Oct 2013.

COMPREHENSIVE INSIGHTS INTO THE STRUCTURAL AND CHEMICAL CHANGES IN MIXED ANION FEOF ELECTRODES BY USING PDF AND NMR SPECTROSCOPY

Kamila M. Wiaderek, Olaf J. Borkiewicz, Elizabeth Castillo-Martínez, Rosa Robert, Nathalie Pereira, Glenn G. Amatucci, Clare P. Grey, Peter J. Chupas and Karena W. Chapman

In-depth analysis of operando X-ray pair distribution function (PDF) data is combined with Li NMR spectroscopy to gain comprehensive insights into the electrochemical reaction mechanism of high performance iron oxyfluoride electrodes. While the full discharge capacity could be recovered upon charge, implying reversibility of the electrochemical reaction, the atomic structure of the electrode formed after cycling (discharge-charge) differs from the pristine uncycled electrode material. Instead, the "active" electrode that forms upon cycling is a nano-composite of an amorphous rutile phase and a nanoscale rock salt phase. Bond valence sum analysis, based on the precise structural parameters (bond lengths and coordination number) extracted from the in-situ PDF data, suggests that anion partitioning occurs during the electrochemical reaction, with the rutile phase being F-rich and rock salt phase being O-rich. The F- and O- rich phases react sequentially; Fe in a fluoride rich environment reacts preferentially, during both discharge and charge.

JACS. Journal of the American Chemical Society
Published: February 22, 2013



4.1 STAFF



"Better than other energy storage technologies, TES technologies can exploit cheap and eco-friendly storage materials, and can act as a driving factor for a new science of materials pushing them toward their thermophysical limits... TES Area is exploiting slag, stones, concretes, and innovative nano-fluid and nano-structured materials"

2018

Sensible heat storage

Enhance liquid thermal stability - Target parameter: $T \ge 800 \, ^{\circ}\text{C}$

Increase solar thermal efficiency by using salt with lower freezing T -Target parameter: T ≤ 250 °C

Decrease the amount of storage material by enhancing the heat capacity - Target parameter: Cp $\geq 1.5 \text{ J/g} \cdot \text{K}$

Decrease the pumping work to move the HTF - Target parameter: Viscosity \leq 0.012 Pa.s @ 300 $^{\circ}$ C

Improve the heat transfer from HTF and HSM -Target parameter: Thermal conductivity \geq 0.58W/m·K @800 °C

Reduce the cost of storage solid media - Target parameter: Specific cost ≈ 10 €/kWth

Reduce the cost of the storage systems - Target parameter: Specific cost ≈ 20 €/kWth

Development of microscopic simulation tools such as Classical MD and DFT MD

Thermo-physical characterisation of solid HSMs, and synthesis and characterisation of selected nano-salt mixtures

Development of new methods to synthesise nano-salt mixtures

Characterisation and shaping of slag from steel industry

Design and realisation of sensible heat storage lab-scale devices (T up to 800 °C); Use of CIC's heating-loop facilities

Latent heat storage

Development of metal alloys with transition temperatures in an extended range - Target parameter: $300 \le T \le 500$ °C

Enhance the latent heat - Target parameter: Enthalpy $\approx 160 \text{ kJ/kg}$

Decrease the amount of storage material by enhancing the heat density - Target parameter: Heat density $\approx 130 \text{ kWh/m}^3$

Increase the applicability of salt PCM by nano-encapsulation - Target parameter: nanocapsule diameter range 5-10 nm

Increase the applicability of metal alloy and salt PCM by micro-and macro encapsulation - Target parameter: capsule volume up to $\approx 0.5 \text{m}^3$

Reduce the cost of storage solid media - Target parameter: Specific cost ≈ 40 €/kWh

Reduce the cost of the storage systems - Target parameter: Specific cost ≈ 60 €/kWth

Development of simulation tools to describe the phase diagrams of simple mixtures

Development of new methods to synthesise metal alloys at laboratory scale

Development of protocols for metal alloy and salt PCM encapsulation

Compatibility study of metal alloy and salt PCM with different containment materials

Design and construction of metal alloys multi-tube storage/exchanger units up to 400 °C

GOALS

STRATEGIES

2025

Sensible heat storage

Enhance liquid thermal stability - Target parameter: T ≥ 1000 °C

Increase solar thermal efficiency by using salt with lower freezing T - Target parameter: $T \le 70 \, ^{\circ}\text{C}$

Decrease the amount of storage material by enhancing the heat capacity - Target parameter: Cp ≥3.75 J/g·K

Decrease the pumping work to move the HTF - Target parameter: Viscosity ≤ 0.004 Pa.s @ 300 °C

Improve the heat transfer from HTF and HSM -Target parameter: Thermal conductivity ≥ 0.58 W/m·K @1000 °C

Reduce the cost of storage solid media - Target parameter: Specific cost ≤ 8 €/kWth

Reduce the cost of the storage systems - Target parameter: Specific cost ≤ 18 €/kWth

Development of simulation tools to describe nano-fluids at all-length scale

Thermo-physical characterisation of solid HSMs, and synthesis and characterisation of selected nano-salt mixtures in an extended T range

Development of new methods to synthesise nano-salt mixtures in an extended T range

Characterisation and shaping of candidate waste materials for thermal storage

Design and realisation of improved sensible heat storage lab-scale devices (T up to 1000 °C); Use of CIC's heating-loop facilities; Use of SFERA facilities

Latent heat storage

Development of metal alloys with transition temperatures in an extended range - Target parameter: $300 \le T \le 800$ °C

Enhance latent heat - Target parameter: Enthalpy $\approx 200 \text{ kJ/kg}$

Decrease the amount of storage material by enhancing heat density - Target parameter: Heat density $\approx 200 \text{ kWh/m}^3$

Increase the applicability of salt PCM by nano-encapsulation - Target parameter: nanocapsule diameter range 0.5-10 nm

Increase the applicability of metal alloy and salt PCM by micro-and macro encapsulation - Target parameter: capsule volume up to $\approx 1 \text{m}^3$

Reduce the cost of storage solid media - Target parameter: Specific cost ≈ 25 €/kWh

Reduce the cost of the storage systems - Target parameter: Specific cost ≈ 30 €/kWth

Development of simulation tools to describe the phase diagrams of complex mixtures

Adaptation of new methods to synthesise complex systems at laboratory scale

Development of protocols to encapsulate more complex PCM

Development of protocol for metal alloy and salt PCM encapsulation

Design and construction of metal alloys multi-tube storage/exchanger units up to 800 °C

4.3 RESEARCH LINES

Sensible heat storage

Purpose

To develop efficient and reliable thermal energy storage systems based, on the one hand, on the valorisation of low cost by-product ceramic materials, while developing innovative materials with enhanced thermophysical properties such as heat capacity, thermal conductivity, viscosity (if in liquid phase) and single-phase temperature range.

Objectives

Development of stable liquid materials, mainly nanoparticle-salt mixtures, with high thermal capacity, high thermal conductivity, and low viscosity.

Development of stable solid materials with heat capacities very close to the Dulong and Petit classical limit, and with high thermo-mechanical ratcheting limits.

Development of cost effective thermal energy storage systems working at very high temperature up to 800 °C for next generation CSP power plants and waste heat recovery applications in different industrial processes.

Construction and testing of different sensible heat storage units at laboratory scale under real operation conditions.

Demonstration of upscaling capability via collaboration with industry in the realisation of pre-industrial pilot scale demonstrator.

Limitations and risks

The main risks may result in the discovery of low performances of the thermal energy storage system based on by-product ceramic materials.

Results so far

- Successful selection and characterisation of low cost by-product materials (slag) with desirable properties for TES application.
- Successful design of new nano-salt mixtures with enhanced thermophysical properties such as heat capacity and thermal stability.
- Successful development of some CFD models to simulate and optimise sensible thermal energy storage units.

Collaborators

IK4-Tekniker, Tecnalia, UPV, ArcelorMittal, IK4-Azterlan, NAVARGI, DLR, Fraunhofer, Friedrich Alexander University Erlangen-Nuremberg, ENEA, LCA, Soltigua, Enerray, CEA, ALSTOM, Optimum Cement, VTT, Tapojärvi company, PSI, Imperial College, MASEN, IRESEN

Latent heat storage

Purpose

To develop new concept thermal energy storage systems based on innovative materials showing solid-liquid phase transitions at requested temperatures, high volumetric storage capacity and high thermal conductivity values, being these characteristics dictated by the particular technological applications.

Objectives

Development of new binary and ternary metal alloys with end-user requested properties.

Development of innovative nano-cluster metal alloys for the generation of PCM materials with a cascade of transition temperatures.

Development of carbon foam-like material for PCM adsorption and/or encapsulation.

Development of high temperature thermal energy storage systems that are able to deliver a high amount of heat in a short time: high heat power.

Validation of the concept via the construction and testing, under real operation conditions, of different latent heat storage units at laboratory scale.

Demonstration of upscaling capability via collaboration industry in the realisation of pre-industrial scale pilot demonstrator.

Limitations and risks

 The elevated cost of this technology in comparison to the actual commercial molten solar salt two-tank storage system.

Results so far

- Successful new materials development with high volumetric storage capacities.
- Successful development of simulation tools which will allow to understand the enhancements of some thermophysical properties of the investigated materials.
- Successful development of CFD models to simulate different laboratory scale latent heat storage units.
- Promising results from the design, construction and testing of latent heat storage unit at laboratory scale.

Collaborators

IK4-Tekniker, Tecnalia, UPV, SENER, MASEN, IRESEN

4.4 SCIENTIFIC HIGHLIGHTS



Nicolas Calvet, Judith C. Gomez, Abdessamad Faik, Vladimir V. Roddatis, Antoine Meffre, Greg C. Glatzmaier, Stefania Doppiu and Xavier Py

This paper demonstrates the potential of a post-industrial ceramic commercially called Cofalit as a promising, sustainable, and cheap filler material in a molten salt direct thermocline storage system. This ceramic material, which comes from the industrial treatment of asbestos containing waste, demonstrates relevant properties to store thermal energy by sensible heat up to 1100 °C and is very inexpensive. In the present study, the compatibility of this ceramic material with two different molten salts - the conventional binary Solar salt and a promising ternary nitrate salt also called HITEC XL - is tested at medium temperature (500 °C) under static state. The objective is to develop a molten salt thermocline direct storage system using low-cost shaped ceramic as a filler material. It should significantly decrease the cost of parabolic trough storage systems and simultaneously increase the efficiency of the plants by producing superheated steam at higher temperature.

Applied Energy. www.sciencedirect.com/science/article/pii/S0306261913000056

Accepted 29 December 2012. Available on-line 8 February 2013

THERMODYNAMIC STUDY OF THE EUTECTIC MG49–ZN51 ALLOY USED FOR THERMAL ENERGY STORAGE

J. Rodríguez-Aseguinolaza, P. Blanco-Rodríguez, E. Risueño, M. J. Tello and S. Doppiu

The eutectic Mg49–Zn51 (mass %) alloy has been identified as a suitable material for latent heat thermal energy storage. Within this scope, the exhibited solid–solid and solid–liquid phase transitions have been carefully characterised. A detailed thermodynamic study focused on the specific heat of the investigated alloy is also provided. The Cp behaviour, very important in the thermal energy storage frame, is theoretically modelled and experimentally validated by quasi-isothermal modulated differential scanning calorimetry measurements. Different intermetal phases of the Mg–Zn binary system have also been successfully described within this approach in the complete temperature range.

Keywords: Differential scanning calorimetry (DSC), Specific heat, Phase transformations, Thermal energy storage, Mg–Zn binary alloys. Thermodynamics CIC Energigune will celebrate 8th International Conference on Advanced Lithium Batteries for Automobile Applications - ABAA8 - which will take place from 30th Sept to 2nd Oct 2015 in Bilbao – Basque Country (Spain), a 3-day event whose mission is to enhance global R&D of advanced lithium batteries for vehicles, accelerate the discussion and communication of R&D progress, and strengthen global collaboration in this field.

Journal of Thermal Analysis and Calorimetry. DOI 10.1007/s10973-014-3639-0 Accepted 04 January 2014. Published on-line 31 January 2014.

THERMOPHYSICAL CHARACTERISATION OF MG-51%ZN EUTECTIC METAL ALLOY: A PHASE CHANGE MATERIAL FOR THERMAL ENERGY STORAGE IN DIRECT STEAM GENERATION APPLICATIONS

P. Blanco-Rodríguez, J. Rodríguez-Aseguinolaza, E. Risueño, A. Faik, M. Tello and S. Doppiu

The possibility of using magnesium based eutectic metal alloys as phase change material (PCM) for thermal energy storage (TES) in concentrated solar power (CSP) applications is analysed. An extensive thermophysical characterisation of the Mg51%-Zn eutectic metal alloy between room temperature and melting temperature has been performed. The results are compared with some available data in the literature, and differences found are discussed. A comparison with pure, binary and ternary inorganic salts used as PCM is presented highlighting the advantages and disadvantages of the different systems. This alloy is proposed not only as a candidate for latent heat thermal energy storage for direct steam generation (DSG) in CSP applications but for high pressure and high energy steam processes as well. Reported data are essential for ensuing modelling and experimental reactor studies employing this alloy as a PCM for TES.

Energy. DOI: 10.1016/j.energy.2014.05.058 Accepted 15 May 2014. Available on-line 13 June 2014





5.1 THE BUILDING



4500 m²

+ 2000 m² of laboratory facilities









Interaction

Connected laboratories and platforms that are close to the work spaces of researchers

Large common areas

Sustainability

Committed to renewable energy sources

- biomass
- geothermal
- photovoltaic

Maximum power efficiency qualification





www.cicenergigune.com/visita-virtual/index.html

5.2 PLATFORMS



 $-\overline{\mathrm{NMR}}$ Nuclear magnetic resonance.

Is an analytical technique that makes the most of the magnetic properties of atomic nuclei to obtain structural, kinetic and thermodynamic information from a wide variety of materials. It has two magnets (500 and 200 Mhz).



 $-\mathsf{SAU}$ The surface analysis platform.

Offers a wide range of experimental techniques to characterise surface areas and interfaces that include the most up-to-date instrumentation in photoemission spectroscopy (XPS and UPS), low energy electron diffraction. (LEED), Auger microscope (SAM), sweep probe microscopes (STM and AFM) and optical spectroscopy (Raman and FTIR).



-EM Transmission electronic microscope (TEM) and sweep electronic microscope (SEM).



-Dry Room A dry room with a surface area of 55 m² and a dew point of -60 °C.

This room houses the prototyping line where materials are processed to turn them into laminated electrodes and where the prototype cells are assembled in pouch format



-X ray Diffraction techniques (XRD) and dispersion of X-rays at low angles (SAXS) make up the X-ray platform.

Acquisition of a new D8 thanks to the grant awarded by the Department of Education of the Basque Government.



 $-\mathsf{PPMS}$ Physical property measurement system.

Platform for studies on impedance, electric, thermal transport and magnetometry at variable temperatures and in different environments.



Thermal analysis platform

The prototyping lab has a large space for experimental testing on a laboratory scale (STA, DSC, LFA) and pre-demonstration of thermal energy storage systems.



-Testing Lab

Once the electrochemical cells have been assembled, their performance is tested by means of measuring the cyclical voltammetry and galvanometry and impedance spectroscopy in different operating conditions. To do this, CIC Energigune counts with a Testing Lab with six potentiostats, a climatic chamber and a battery tester with more than 300 channels.



6.1 #OPENLABS CICENERGIGUNE

A NEW INITIATIVE TO BRING OUR SCIENCE CLOSER TO SOCIETY

In a simple, attractive and didactic way

Promoting **scientific vocation** among the youth around us

Sharing the relevance of finding **new responses** to the challenges of the future, such as energy storage

7 sessions developed by + 12 scientists

of CIC Energigune to showcase our work





#openlabs 2014

- **April 2014.** Egibide. Congress: Power our Future. Villa Suso Conference Hall
- **April 2014.** Mondragon Unibersitatea. CIC Energigune
- May 2014. Mondragon Unibersitatea. CIC Energigune
- June 2014. Citizenship. European Power Week. Mendizorroza Pools in Vitoria-Gasteiz
- November 2014. Entrepreneurs. Álava Emprende. Villa Suso Conference Hall
- **November 2014.** Abetxuko Ikastola. CIC Energigune
- December 2014. Jesus Obrero. CIC Energigune

+ 500 people have experimented our

research endeavours

- University students
- Primary school students
- High-school students
- Entrepreneurs
- Professors
- Citizenship

6.2 MASTER AND PhD

Lectures at 5 University programmes

Collaborations with 2 local Universities

PhD

2013 — 11 2014 — 15





Interns stayed

at CIC Energigune

2013 - 2

2014 — 6



2014 — 10

- PhD in Physics and Materials Technology (UPV/EHU)
- PhD in Science and Materials Technology (UPV/EHU)
- PhD in Mechanical Engineering and Electric Power (MU)
- Master's Degree in New Materials (UPV/EHU)
- Master's Degree in Chemical Processes
 Engineering and Sustainable Development (UPV/EHU)
- Master's Degree in Energy and Power Electronics (MU)
- Degree in Power Engineering (MU)
- University of Caen (France)
- University of Picardie Jules Verne (France) -Master's Degree MESC

6.3 COMPANIES



6.4 CONGRESSES

I INTERNATIONAL SYMPOSIUM ON SODIUM BATTERIES

CIC Energigune organised the first global meeting to share the advances in the research on this sort of batteries in October 2013.

- 111 attendees from 13 different countries
 - Strong industrial representation: Fiamm, Iberdrola, Iberpotash, Renault Nissan, Saft, Solvay, Solvionic, Sumimoto Chemical, Toyota Motor Europe
 - 51% sponsorship by EVE, Argonne National Lab, Comercial Rafer, Solvionic, Fisher Scientific, Energy & Environmental Science and Basquetour
- 17 universities represented, 11 keynote speakers
- 18 presentations of different research projects
- 30 posters exposed

II POWER OUR FUTURE

Second edition of the international scientific congress organised by CIC Energigune in April 2014

- 136 attendees from 12 countries
- Strong industrial representation: Eika, ZSW, JME, Irizar, AEG power solutions, Cegasa
- 9% sponsorship by Bruker, Specs, Alava Ingenieros, AEG, Scharlab and Basquetour
- Novelties vs. POF 12:
 - On the occasion of the Congress, two tutorial sessions were held the day before (April 1st): Supercapacitors and Batteries.
 - Within the related activities on 31 March, the "Open Labs" cycle opened with the presentation of a group of 100 Egibide students.
 - During the days of the celebration of the Congress, several electric vehicles were exposed (Renault, Nissan and BMW) outside of the Palacio de Villa Suso.







annex FINANCIAL REPORT

2012 2013 2014 **EXPENDITURE** and **INVESTMENT** per year (thousands of Euros) 3,399.61 4,077.92 4,783.83 Expenditure Personnel Cost 1,841.88 2,410.27 2,881.99 General Expenses 1,557.73 1,667.65 1,901.84 1,426.61 910.80 Investment 824.97 4,826.22 5,694.63 **TOTAL BUDGET** 4,902.88 **INCOME** (thousands of Euros) Funds from Basque Government - Economic De-4.667,90 4.554,84 4.661,43 Funds from European Union 61.15 149.34 638.75 74.42 Other Public Funding 34.00 202.14 84.21 **Private Funding** 138.70 199.79 **TOTAL INCOME** 4,847.26 4,917.30 5,702.12



