Innovation Report / 2014-2015

IBERDROLA

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Letter from the Chairman

I am pleased to present to you a new edition of the Iberdrola Innovation Report, which describes the main initiatives and projects undertaken during 2014 and 2015 in the field of research, development and innovation (R&D&i).

The Iberdrola group views innovation as a strategic variable that constitutes the main tool for guaranteeing the sustainability, efficiency and competitiveness of the company. Our efforts in R&D&i aim to optimise operating conditions, improve safety and reduce the environmental impact of our activities.

During 2014-2015, our investments in R&D&i rose to €370 million, which represents more than 17% in 2015 compared to the previous year. As a result of our permanent commitment to human, economic and management-centred innovation, Iberdrola was recognised as the most innovative power utility in Spain and fourth in Europe according to the European Commission's ranking.

The company was also recognised in the internationalisation category of the 2015 National Innovation and Design Award conferred by the Spanish Ministry of the Economy and Competitiveness after appraising Iberdrola's worldwide wind leadership on the basis of a bold and innovative industrial project.

Our position as benchmark in innovation within the energy sector is based upon sustainable development, the fostering of renewable energies and emerging technologies as the driving forces behind the creation of value and social contribution.

Moreover, Iberdrola implements programmes to develop R&D&i through initiatives such as Perseo, our Corporate Venture Capital programme, dedicated to investing in innovative technologies and businesses that ensure the sustainability of the energy model. Turning to our support for entrepreneurs, in 2015 we launched the *Supplier Innovation Programme*, centred on three lines of action: providing access to the financing mechanisms, driving the joint creation of companies (spin-offs with suppliers) and fostering innovative purchases to small and medium-sized enterprises.

Anticipating the future

R&D&i will remain a key factor for successfully undertaking the new stage of growth at our company. We expect to invest €24,000 million in our strategic markets during the period comprising 2016-2020 in a favourable scenario for developing clean and efficient energy sources to meet the global emissions reduction targets committed in the Paris Climate Conference.

Innovation is a strategic variable that constitutes the main tool for guaranteeing the sustainability, efficiency and competitiveness of the company.

In anticipation of the energy transition, Iberdrola has committed to sustainable solutions that require greater electrification of the global economy: more clean energy, more storage capacity, more backup power, more and smarter grids, and more digitisation.

Going forward, our commitment to innovation will remain a priority to uphold Iberdrola in the vanguard of developing new products, services and business models that are transforming the sector. Ultimately, we will continue focusing our efforts on providing our customers with better and more efficient service while our innovative activities contribute to sustainable development everywhere we do business.

Ignacio S. Galán
Chairman of Iberdrola

Introduction

Governance Structure

The conjunction of companies making up Iberdrola had operations in over 40 countries in 2015, with its most relevant activities in Spain, the United Kingdom, the United States of America, Mexico and Brazil. These companies are integrated in the Iberdrola Group (the "**Group**"), whose parent company, as defined by law, is Iberdrola, S.A. (the "**Company**").

The corporate and governance structure of the Group is an essential part of the corporate governance system and comprises:

a) In its configuration as a *holding entity*, the Company's main function is to engage as the stakeholder of its *subholdings*.

b) The *subholding* companies in turn comprise, in every country where the Group has activities, a combination of holdings in the parent companies of the energy businesses operating in that area. The Group also has a *subholding* company for the parent companies of the non-energy businesses operating in several countries.

c) The parent companies of the businesses assume executive responsibilities in a decentralised manner, have the independence required to perform the ordinary and effective management of each business, and are also responsible for their ordinary control.

This Corporate Governance System structure, which is explained in greater detail in the *General Corporate Governance Policy* available at the Company's corporate website (www.Iberdrola.com), enables an agile and swift decision-making process on ordinary management depending on the parent companies of the businesses, and appropriate Group-level coordination through the oversight functions carried out by the *subholdings* and the Company itself.

The Group's corporate governance model distinguishes and duly separates the roles of ordinary and effective management from those of supervision and control. In this regard, the Company sets out the policies and strategies of the Group and corresponding to the *subholdings* insofar as the implementation of said policies, strategies and guidelines in the countries where they operate.

In this regard and in accordance with its permanent powers for drawing up, assessing and revising the corporate governance system, the Company's Board of Directors approved the *Innovation Policy* and *Knowledge Management Policy*, analysed respectively in sections 6.1 and 6.2 in this report.


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1.

Executive summary

1.1. R&D&i - Innovation oriented towards efficiency, sustainability and the development of new products and services

For the Iberdrola Group (hereinafter referred to as "Iberdrola" or "the Group"), innovation is the main tool to guarantee the Company's sustainability, efficiency and competitiveness. The efforts in R&D&i aim to optimise operating conditions, improve safety and reduce environmental impact. Moreover, through innovation, Iberdrola seeks new business opportunities that could arise in the energy sector.

Thanks to the human and economic efforts allocated to innovation, today Iberdrola stands at the vanguard in the development of new products, services and business models that are transforming the energy sector.

The 2015-2017 Innovation Plan encompasses the innovative strategy of the Company, which carries out projects in all its business areas in line with the future prospects of Iberdrola. During 2015, over €200 million was invested in R&D&i activities, mainly allocated to the initiatives involving smart grids, clean generation, offshore wind power and new business technologies and models. The company's world-wide leadership in renewable energies was recognised through the 2015 National Innovation and Design Award in the category of internationalisation.

As a result of an unwavering commitment to innovation, Iberdrola was recognised as the most innovative *utility* in Spain and fourth in Europe according to the European Commission's ranking.

A clear strategy laid out in the 2015-2017 Innovation Plan encompasses innovation as the main tool for guaranteeing the sustainability, efficiency and competitiveness of the company along three lines of action:

- **Efficiency**, oriented towards a constant optimisation of our operations, management of the useful service life of facilities and equipment, reduction in operation and maintenance costs, and decreased environmental impact to meet increasingly stringent environmental requirements, that motivates us to improve constantly in terms of not only technology but also our processes and operations. With the salient involvement of all Iberdrola Group employees, over 200 R&D&i projects are being developed that will affect the business in the short/medium term.

- **New products and services**, novel and competitive developments adapting to a market that is increasingly global and whose fundamental purpose is to satisfy the needs of customers. These are projects employing existing technology to create innovative business models geared to providing energy, equipment and technologies that are increasingly more efficient, sustainable and environmentally friendly. Salient amongst such projects are energy efficiency, electric vehicles, smart grids and distributed energy resources.

- **Disruptive technologies and business models** that enable us to take on the energy challenges of the future and adapt ourselves to the changes taking place in the electric sector. Through PERSEO, Iberdrola's corporate venture capital programme, we invest in disruptive technologies and new businesses that ensure the sustainability of the energy model.

Innovation at Iberdrola is part of an open and decentralised international R&D&i management model that bolsters collaboration with technology suppliers and the drive for innovation amongst employees. This model entails partnerships with companies, universities, technology centres, industrial organisations and public institutions through programmes and agreements. This cooperation enhances the competitiveness of the companies while generating wealth at both community and national levels.

In this line, Iberdrola launched a **Supplier Innovation Programme** in 2015 for promoting and accelerating the development of new products and services that provide solutions to the future needs of the Company while responding to the challenges facing the sector. The programme revolves around three central axes: facilitating access to financing mechanisms for suppliers and fostering the joint creation of companies (*spin-offs* with suppliers) through the Perseo fund and innovative purchasing of the developed products or services from small and medium-sized enterprises.

One of the main activities of this programme was the constitution of GDES Tech4Services, an agreement between Iberdrola and the Dominguis Group as technology partner to develop new operation and maintenance technologies in the electricity sector.

The company's Innovation Policy sets out the underlying principles driving this strategic variable, which affects all Group businesses and their activities. Leadership in innovation within the energy sector is based upon sustainable development, the fostering of renewable energies and emerging technologies as the driving forces behind the creation of value and social contribution. Some of the most prominent activities to provide reliable electricity and encourage sustainable development are given below, grouped into future strategic areas at the international level: renewable energy sources, clean generation technologies, smart grids, distributed energy resources, digitisation and other disruptive technologies in sustainable energy.

Renewable energy sources

Innovation activities in the renewable energies area focus primarily on improving the efficiency of existing technologies and their integration in the grid, in addition to developing new generation technologies and new designs or processes for projects in the pipeline or future projects mainly associated with offshore wind power.

The Company has become a global benchmark in the offshore sector, where it carries out the most cutting-edge and innovative projects. Innovation in **offshore** wind power projects is fundamental for reducing costs and limiting the risks in projects in the pipeline and future projects. An on-site campaign was conducted at the **WIKINGER** wind farm to validate the design of the jacket foundation piling (responsible for setting the foundations to the ground) because of the special characteristics of the seabed, with significant improvements achieved. Another salient project is **TLPWind**, which was conceived to design a next-generation floating wind turbine model. The **MARINEL** project entails an analysis of further alternatives for issues of this sort, such as installable substations. Another project of particular interest entails the replacement of offshore meteorological towers that require expensive foundations for their installation by floating stations with an alternative measurement system known as **LIDAR** (*Light Detection And Ranging*). The main objective of the **LEANWIND** project is to reduce costs during a wind farm's useful service life and throughout the entire supply chain through the application of "lean" principles and development of innovative solutions and tools. We are also participating in a European project (**BEST PATHS**) that entails the analysis of multi-terminal HVDC (*High Voltage Direct Current*) networks across different suppliers to observe the interactions with the power electronics in wind turbines for a scenario in which a large amount of offshore wind power will be connected to the grid.

Iberdrola develops R&D&i to improve the efficiency of wind farms, reduce operation and maintenance costs, and enhance production. In the energy resources field, projects such as **SEDAR, INNPACTO**

OPENFOAM and FP7 EERA DTOC are taking shape, and developments are still under way on an internal model for designing wind farms based on fluid dynamics and the use of supercomputers

Among the available tools for managing the running of wind farms, efforts are focused on the continuous optimization of the production forecasts to reduce deviations from real production (**METEOFLOW**). Operating tools such as CORE and DOMINA are also prominent.

Within the projects aimed at **improving the integration of renewable energies**, special mention should be given to the **SMARTWIND** project, which entails the creation of models and simulations for using wind farm storage sites to provide auxiliary services such as reducing deviations between offered and actual production figures. The **NEWPLAVOL** project focuses on photovoltaic power storage.

Last but not least, salient initiatives specifically conceived to address **sustainability** also merit particular mention, such as the **BRIO** project, which entails the analysis of wind farms that have reached the end of their useful service life and the assessment of components of wind turbine blades having an elevated added value.

Clean generation technologies

The efforts in the generation area focused on flexibility and operating efficiency, respect for the environment and the improvement of facility safety.

The **FILTRATIONS** project is particularly prominent and involves the development of a new method for efficiently inspecting water channels. Regarding the security of the facilities and guaranteeing the on the structural integrity of generation assets while maximising their life cycle, **INSROCA, SIRO and ECRIGEN** projects are currently in progress.

The **MIGRES and RESONUC** projects are particularly prominent in the nuclear power area. The former develops a new process of integrated management and control rod channels, which will allow a sustainable management of them. Within the framework of **RESONUC**, resonances are being monitored and characterised in critical systems to establish a solution that can guarantee optimum functionality as a significant element in the safety and reliability of nuclear power plants.

Iberdrola continues its commitment to reduce the environmental impact in generation plants, promoting the ambitious project **CO2FORMARE**, which provides a sustainable solution to the *macrofouling* issue in cooling systems of power plants and reduce the environmental impact not only in air emissions but also in the aquatic environment. The technical expertise generated in **COEBEN-II** project carried out at the Velilla del Rio Carrión Power Plant are being incorporated at Lada to adapt the facilities there to environmental requirements that are growing ever more restrictive, thus affording an alternative to high-cost commercial solutions.

Markets

As the market continues growing more global and competitive, requiring the optimisation of margins, control over risks and improved asset management, there is also an arising need for guaranteeing operational transparency in the markets where Iberdrola participates, which is the reason for embarking on developing the **REMIT** project. This project seeks to develop advanced tools for assuring transparency in *trading*, monitoring and oversight operations to guarantee that markets cannot be manipulated because of a disclosure or harbouring of privileged or non-public information and also the reporting of activities internally and to the pertinent European regulatory body.

Commercial Area - New products and services

Innovation is essential to commercial activities to be able to provide customers with products and services that best adapt to their needs. In this regard, Iberdrola has launched:

- **New products**: such as "Customised Plans", a new category of products that lets customers choose the plan that best suits their lifestyles with no need to change their consumption habits. With "Conect@" and the new customer

App, energy offers have been launched entirely online.

- **New services:** such as Iberdrola "Smart Solar", an integrated package that includes the design, assembly and commissioning of a custom solar facility, including financing, consulting, maintenance, management and supervision of the plant through internet tools and modern apps, inclusive of backup energy as required. The "Iberdrola Smart Home" project brings efficient heating management to our residential customers via a smart thermostat with internet connectivity that can be easily programmed and controlled from a mobile phone, helping them save up to 37% on their yearly heating expenses.

Moreover, Iberdrola continues working on its commitment to electric mobility in harmony with its strategy to support sustainable development and its commitment to innovation by developing new charging services and engaging in R&D&i programmes financed with European Community and Spanish Autonomous Community funds such as **REMOURBAN** and **AZKARGA**. We are also involved in **GRID4EU**, a European innovation project for smart grids to provide customers with a real-time reading of their electricity consumptions and flexible rates slots so they can manage their consumption more efficiently.

Smart Grids

Iberdrola continues its efforts in R&D&i, particularly regarding Smart Grids at the Spanish and European levels. The Group's R&D&i activities in electric power distribution focus on optimising the distribution network, particularly in the areas of occupational safety, environmental factors and the improvement in the supply quality.

In Europe, Iberdrola leads the **UPGRID** project, which seeks to reinforce its capacity as integrator of active demand and distributed generation in low voltage. Projects still making headway include **IGREENGrid** for developing precise methods for integrating renewable energies into electricity distribution grids, and **DISCERN**, a project for comparing different smart grid solutions to discover the ideal arrangement of architectures. Following the conclusion of the **ADVANCED and GRID+** projects, the European Commission opted to to continue this activity through the new **GRID++** project.

In Spain, Iberdrola finished the **PRICE** project at the beginning of 2015. The objective of this project was to cover the needs identified for developing a smart grid within a framework of efficiency, safety and sustainability. For the standardisation and maintenance of overhead lines, Iberdrola leads the **MATUSALEN** project for developing a tool to ascertain the ageing of medium-voltage cables in underground lines, and participates as partner in the **SILECTRIC** project, focusing on developing new insulators for overhead lines and high-voltage switchgear, and the **TABON** project for developing a technology for verifying and inspecting the earthing connections on overhead lines.

Along these same lines, projects are under way in the United Kingdom to shore up smart grids. Three significantly ambitious projects are currently in progress: **ARC**, seeking to accelerate the process for coupling renewable energies to the distribution grid, **FLEXNET**, developing solutions and technologies for improving and increasing grid capacities by 20%, and **VISOR**, which will implement a global monitoring system for the transmission network to ascertain its capacity and dynamic performance during scheduling and operation.

Innovation projects are ongoing in Brazil to develop new smart equipment and materials to improve the supply quality in the distribution grid such as an automatic low-voltage regulator or the smart analysis of grid images taken by an unmanned aerial vehicle, **IANT**.

The **FICS** project is a particularly salient solution in the United States for rendering interconnections more flexible and enabling the integration of distributed generation in the grid.

In Qatar, Iberdrola has an **R&D&i Technology Centre for smart grids**, where projects are under way in this area.

Systems

The Systems area has continued to honour its commitment to developing innovative projects that bring value to our businesses, enabling them to gain a competitive advantage in the market and thus increase their productivity and efficiency.

Iberdrola Distribución's new Geographical Information System (GIS) stands tall amongst the most prominent projects in Spain while modernisation of the CRM (Customer Relationship Management) system has begun across the pond in the United States of America. There are notable projects in Brazil such as the global corporate human resources process, and in Scotland where work continues on the new smart meter data management system and the Smart Foundation as a communication platform connecting smart meters to the UK retail network.

Meanwhile, Systems continues shorting up the development of innovation pilots in different areas and businesses, many of which are based on technologies such as geolocation, social media, working on the cloud, mobility solutions, digitisation, augmented reality and even 3D printing.

1.2. Iberdrola Ventures – PERSEO

Iberdrola Ventures - PERSEO is Iberdrola's Corporate Venture Capital programme, endowed with €70 million for investing in innovative technologies and business models that ensure the sustainability of the energy model. Since its creation in 2008, over €50 million have been invested in technology-developing startups and new businesses in the energy sector worldwide. Through this programme, Iberdrola can provide entrepreneurs, particularly in the United Kingdom, United States of America and Spain, with its support as investor, *expertise*, base of 32 million customers and over 45 GW in installed power capacity worldwide. We thus contribute to developing and boosting an innovative corporate fabric in the energy sector.

The company particularly prioritises innovation in the following areas:

- Customer-oriented Solutions: energy efficiency, demand management, green mobility…
- Distributed Energy Resources: innovative generation and storage solutions.
- Renewable Energies: technologies related to renewable energy generation (solar, wind power, offshore)…
- New technologies applied to the Operation and Maintenance of energy infrastructures: robotics, sensors, software, etc.

The current investment portfolio covers a broad and diversified range of projects under the Iberdrola Ventures-Perseo umbrella, which is joined by other financing programmes targeting technology providers and projects with an important social component.

Iberdrola Ventures - PERSEO holds stake in the following companies: renewable energies (*Oceantec, Morgan Solar and Hammerfest Strom*), Operation and maintenance technologies (*Arachnocopter*, *Atten2* and *GDESTech4Services*) and distributed energy resources (*Stem and Sunfunder*).

Recognition for Innovation at Iberdrola 2014-2015

Our unwavering commitment to innovation has earned Iberdrola acclaim through the following awards:

Recognition for Innovation at Iberdrola 2014-2015
Iberdrola was recognised as the most innovative Spanish utility and ranks fourth in Europe according to the European Commission's 2015 R&D Scorecard
2015 National Innovation and Design Award in the category of internationalisation, conferred by the Ministry of the Economy and Competitiveness
2014 Impulso Award for ICT in Spanish Companies, granted by AMETIC in 2015
Award for having one of the "100 Best Ideas of the Year" by Actualidad Económica magazine
Iberdrola was selected as a finalist for the Zayed Future Energy Prize in the category of "Large Corporation"
Best Innovation Scottish Green Energy Award for the ARC Project (Accelerating Renewable Connections) of SP Energy Networks
The Qatar power company Kahramaa has awarded Iberdrola for its support in promoting energy efficiency in the country
Computing Prize in the field of innovation and information technologies, conferred by Computing magazine
Award for best practices in Innovation granted by KPMG-El Confidencial
Recognition of the REGALIZ R&D&i project through the 'process award for sustainable development' in the European Business Awards for the Environment
ScottishPower recognised in the European Smart Meters Awards 2014 under the categories of "Innovation in Customer Service" and "Innovation in implementation"

2.

Innovation strategy

2.1. Vision

Iberdrola reached its current position as a result of the transformation undertaken by the company over the past fifteen years and thanks to a corporate vantage point capable of anticipating sector trends: acknowledgement that the intensely growing world energy demand cannot be satisfied with an inefficient and unsustainable model for the Environment based on fossil fuels. On the contrary, the shift towards a gradual decarbonisation of the economy, increase in the importance of electricity in the universal energy balance and growth of clean energies was relentless and irreversible.

Iberdrola is tackling the outlook for the immediate future in a scenario characterised by a sharp growth in the global energy demand from efficient, clean sources to cut global emissions and combat climate change.

At Iberdrola, we strongly believe that the current paradigm can continue advancing and we can move forward towards the far-reaching transformation envisioned for the energy section by continuously improvement and attaining greater efficiency in our processes and operations. Now, more than ever, we need to bolster innovation to turn it into the main implement in our search for the new opportunities that will enable us to progress towards a flexible, cheaper, balanced, more sustainable and less polluting energy model, while also creating jobs.

Iberdrola views innovation as the most important tool to guarantee sustainability, efficiency and competitiveness. The company conducts its efforts in R&D&i to optimise operating conditions, improve safety and reduce our environmental impact. Through innovation, Iberdrola also seeks new business opportunities that could arise in the energy sector.

2.2. Iberdrola innovation plan

The deployment of innovative strategy both in management and technology has converted Iberdrola into the world leader and benchmark in R&D&i, as a result of the successful implementation of a common model for all geographic and technological areas, collaboration with technology providers and the fostering of a culture of innovation.

The new Iberdrola 2015-2017 R&D&i Plan consolidates the research, development and innovation plans of the different Business Units during this period. In line with the Group's outlook, the Plan reinforces the commitment to sustainable development, promotion of renewable energy sources and emerging technologies.

Two basic pillars have been established to become world leaders in R&D&i in the energy sector:

R&D&i Management Benchmark, with a unique and global management model for all the countries in which the Company operates with a view to providing a common framework for promoting innovation and making the most of the results. The following goals have been set:

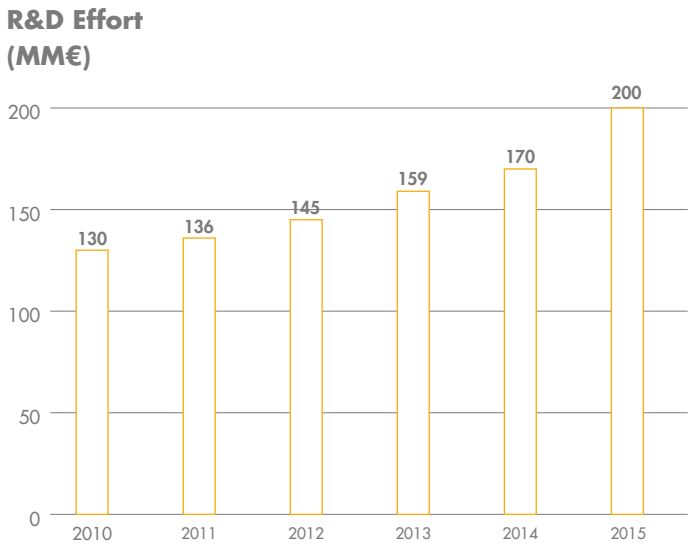
- Upholding our leadership in innovation management.
- Consolidation of the international organisation and management model (open and decentralised).
- Leaders in Innovation: positioning in indices.

The technology positioning of the Iberdrola Group by creating value at an international level with R&D&i initiatives and projects in key technology areas. The following goals are sought:

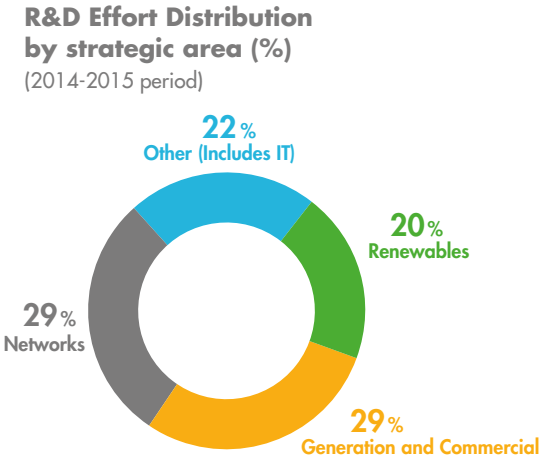
- Creation of value in businesses by undertaking R&D&i projects in key technology areas.
- PERSEO Consolidation- Corporate Venture Capital Programme
- Fostering innovation through the Supplier Innovation Programme
- Consolidation of the Technology Centre in Qatar

The company focuses its efforts on developing initiatives regarding smart grids, clean generation, offshore wind power and new business technologies and models. The company's world leadership in renewable energies was recognised through the 2015 National Innovation and Design Award in the category of internationalisation.

The unwavering commitment to innovation earned us recognition as the most innovative *utility* in Spain and fourth in Europe according to the European Commission's ranking. In 2015, the Group's R&D&i activities accounted for €200 million, 17% more than in the previous year.



From a technical point of view, strategic R&D&i areas have been addressed with international initiatives and projects, essentially in Spain, the United Kingdom, the U.S., Brazil and Mexico. The chart shows the expected percentages allocated to each technology area:



The project portfolio for Research, Development and Innovation (R&D&i) at Iberdrola comprises activities in four main areas, reflecting the company's strong commitment to sustainable development and the promotion of emerging technologies:

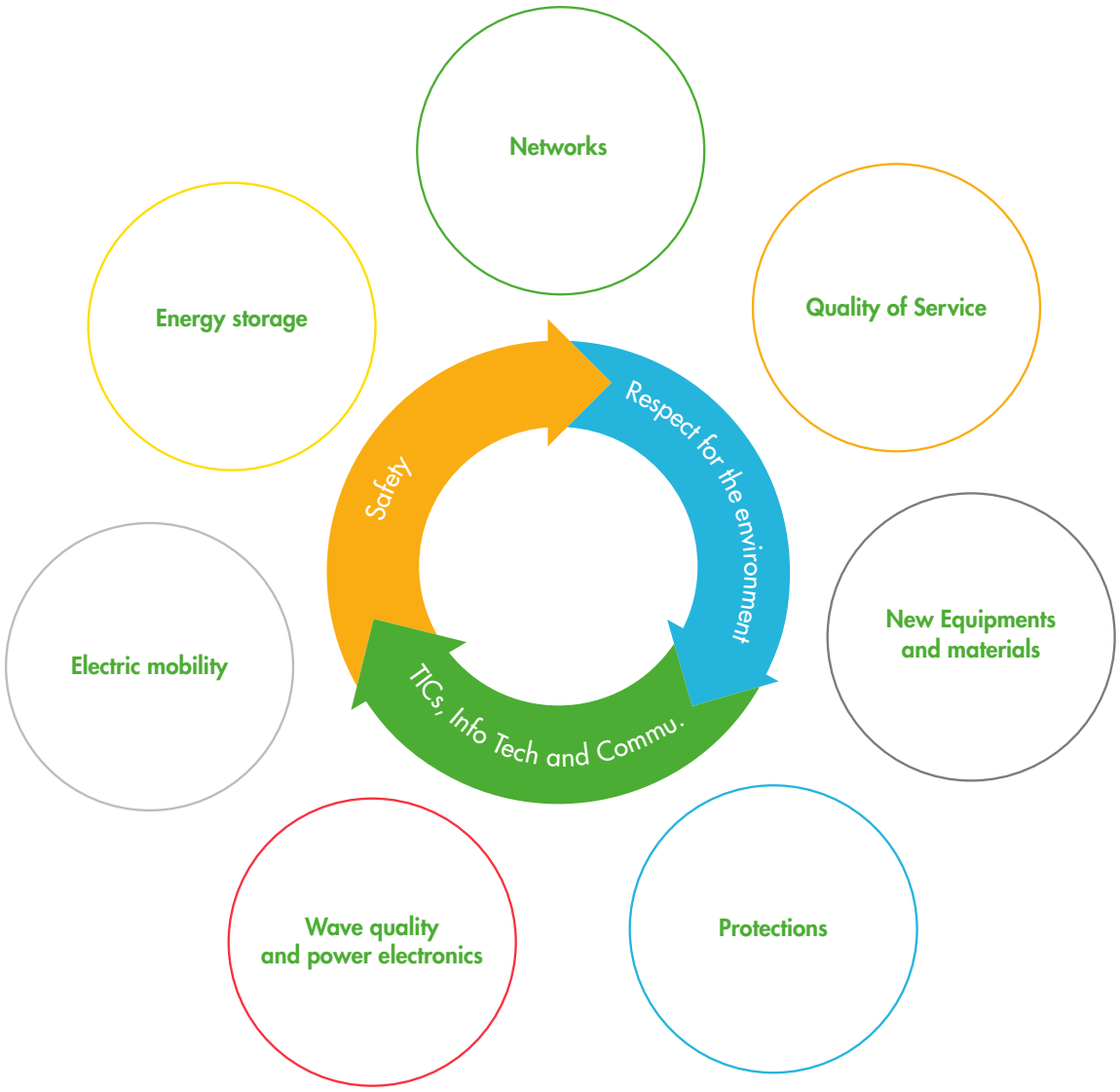
- Non-renewable sustainable generation.
  - Clean generation.
  - Energy efficiency.
- Networks for the future.
- Renewable energy sources.
- Cross-sector technologies: ICT, environment, electric mobility, digitisation, energy storage.

Sustainable generation

The efforts in the generation area focus on flexibility and operating efficiency, respect for the environment and the improvement of facility safety.

Networks of the future

The Group's R&D&i activities in electric power distribution focus on optimising the distribution network, particularly in the areas of occupational safety, environmental factors and the improvement in the supply quality



Renewable Energies

Innovation activities in the renewable energies area have centred around improving the efficiency of operational assets and integration of renewable energies in the offshore wind power field, and developing new designs or processes for ongoing and future projects associated with offshore wind power.

Cross-sector technologies

Including activities related to information and communications technologies (ICT), engineering and other cross-cutting areas such as electric vehicles, energy storage, environmental activities, digital transformation initiatives, etc.

It should be noted that all our R&D&i initiatives at Iberdrola have been and will continue to be in line with the Iberdrola commitment to sustainability and care for the environment, and thus contemplate criteria for biodiversity preservation and the reduction of environmental impacts.

3.

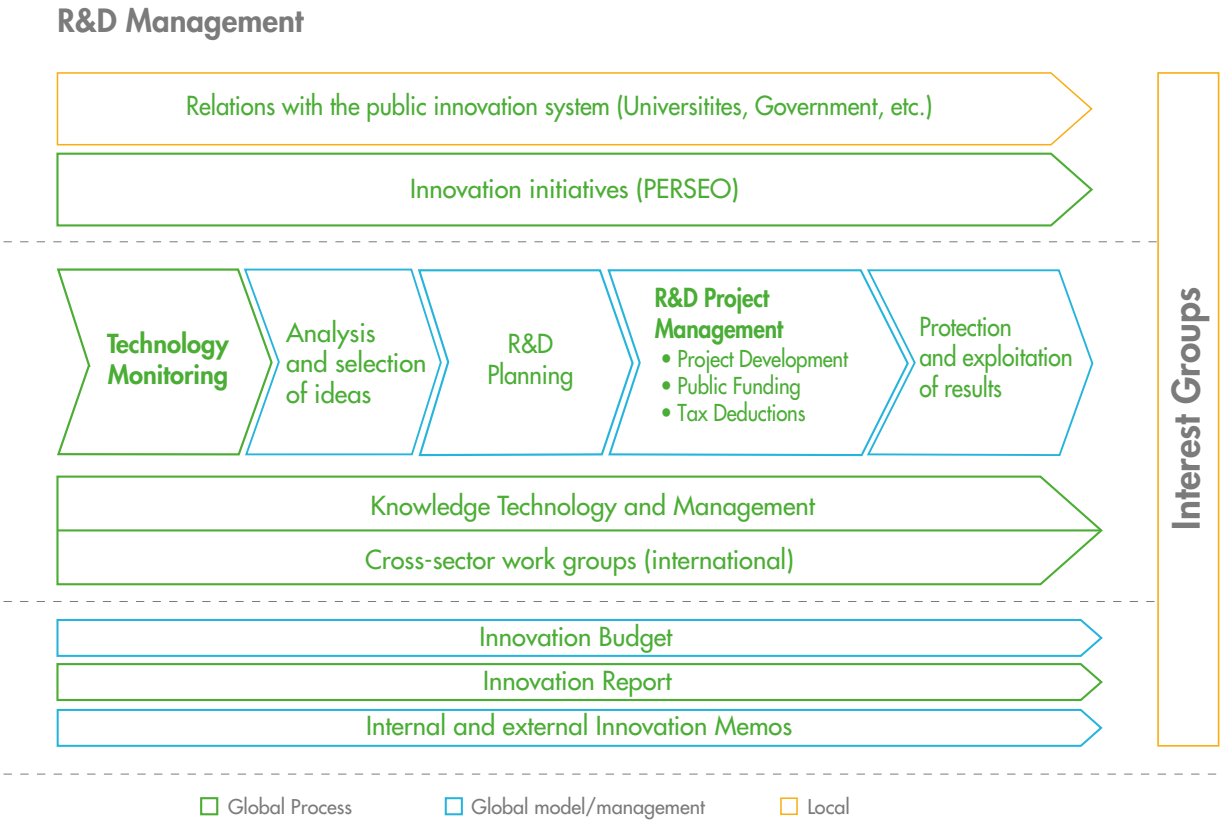
R&D&i management benchmarks

3.1. R&D&i Management System

Iberdrola is aware that innovation requires planning to ensure that all the R&D&i activities of all the businesses in the Group are coordinated and structured. For this reason, an R&D&i Management System was implemented in mid-2007 in accordance with standard UNE 166002:2014 and certified by AENOR, thus providing systematised and standardised criteria for R&D&i activities that can be implemented globally and efficiently.

Iberdrola has structured its R&D&i Management System so that the Innovation Division can provide Business Units with a global model, since we believe that there should be a single, standard and systematic innovation process for the entire organisation. The development of a specific structure for this management, such as R&D&i committees, has been fundamental for managing the innovative process from a perspective that is closer to them.

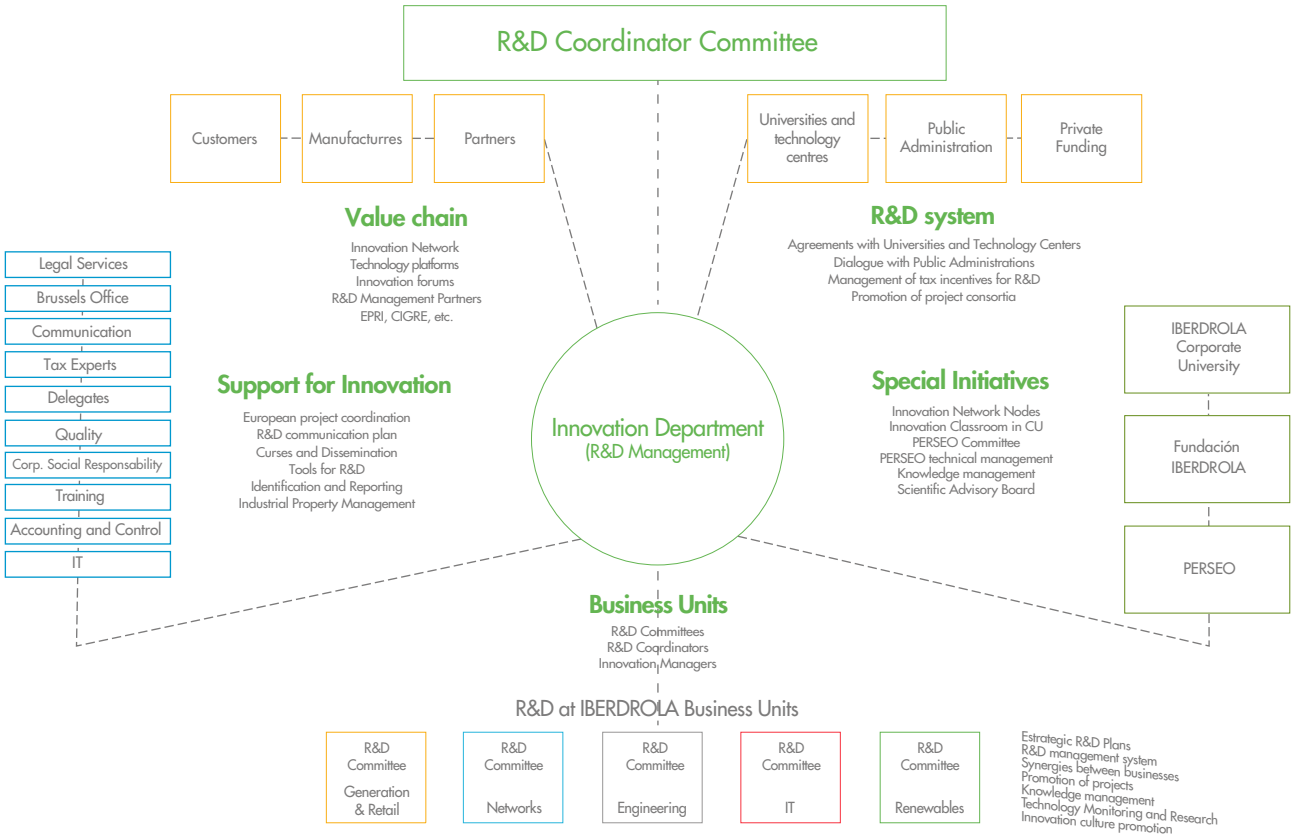
In short, the R&D&i Management System enables us to view innovation as a basic activity of a consistently and effectively managed organisation, according to a set of well-defined and well-documented processes with owners assigned to the various activities and a proper allocation of resources. The chart below shows the international process map for R&D&i management across the Iberdrola Group.



Iberdrola understands innovation as a decentralised and open process:

- **Decentralised** because the process is carried out independently in each business unit with the support and coordination of the Innovation Division.
- **Open**, because Iberdrola prides itself on being a technology-driven company and, as such, seeks to involve Group technology suppliers such as universities, technology centres and equipment manufacturers in the innovation process.

The chart below shows the different internal and external agents that form part of innovation at Iberdrola on a day-to-day basis:



- "Fundación Iberdrola: the Company, its Group and Fundación Iberdrola, have developed an appropriate framework for collaboration between the Company and its Group under which the Foundation coordinates and executes the Group's corporate social responsibility strategy insofar as it is consistent with its foundational purpose and as assigned by the Company's Board of Directors. The Foundation also coordinates the Group's general interest and corporate social responsibility activities in the countries in which it is present. Culture and innovation constitute one of the primary activity areas of Fundación Iberdrola."

- The **Innovation Division**: rigorously and efficiently managing the Iberdrola Group's innovation capabilities, providing the Group with the tools, resources and structures necessary for creating a suitable environment for cultivating innovation.

- **R&D&i Coordinator Committee**: responsible for innovation at the Iberdrola Business Units, sharing best practices at an executive level and monitoring compliance with the R&D&i Plan.

- **Business Units**: as a fundamental part of the decentralised innovation model, business units conduct R&D&i activities and projects. The Innovation Committees have been set up as a support and management structure. The work of our Innovation Coordinators is highly relevant at a management level, while the Innovation Manager provides support to all R&D&i promotion activities.

- **Support for innovation**: internal areas at Iberdrola for fostering innovation.

- **Special initiatives**: Iberdrola Corporate University, Fundación Iberdrola España and Iberdrola Ventures-PERSEO (corporate venture capital programme).

- **Value chain**: the company's stakeholders, clients, manufacturers and external partners.

- **R&D&i System**: universities and technological centres, government agencies.

3.2. Open innovation

Open innovation represents the management of collaboration contributing to maintain and renew structures for innovation and is essential for large collaborative groups as is the case of Iberdrola, with 30,000 employees in 40 countries. This management provides a forum for communication with the Group and the right tools to ensure that collaboration is successful and objectives are met.

The Company also implements programmes for developing R&D&i through special partnerships and providers.

Supplier Innovation Programme

Iberdrola launched its Supplier Innovation Programme for promoting and accelerating the development of new products and services that provide solutions to the future needs of the company while responding to the challenges facing the sector.

The programme revolves around three central axes: facilitating access to financing mechanisms, fostering the joint creation of companies (*spin-offs* with suppliers) and favouring innovative acquisitions from small and medium-sized enterprises.

The Ministry of the Economy and Competitiveness and Iberdrola will share good practices in innovative acquisition procedures, fostering innovation from the demand side and opportunities for co-investments within the framework of the INNVIERTE programme, which aims to promote innovation in entrepreneurships through support to the venture capital investment in innovative technology-based entrepreneurs.

This initiative will boost the pull effect that IBERDROLA exerts on the business sector in the areas where it has operations. It also ratifies its commitment to innovation, to which €200 million were invested in 2015.

Technology platforms, associations and institutes

The *European Technology Platforms* (ETP) are groups backed by the European Commission for the purpose of contributing to the definition of a strategic research and innovation agenda at the European level. The agenda brings together representatives from the industry, civil sector, research and development institutions, financial organisations, governments and the energy sector as a whole from Member States and the EU. Iberdrola is an active member of the following European platforms and associations:

European platforms

Name	Objectives
European Technology Platform Smart Grids (ETP *Smart Grids*)	This platform aims to contribute to the definition for researching and developing the technologies necessary for the future of smart grids in the EU. The platform members include distribution and transmission companies, the technology industry, research centres and universities, regulations and sector associations. Iberdrola is actively involved in this ETP's "Steering Committee" and various work groups.
Research, Innovation and Technology leaders group (TPWIND)	The purpose of this group is to identify realistic paths for R&D policies and technology development in the EU, priorities on the basis of reducing the social, environmental and technological costs with a view to contributing to achieving the targets of the EU in terms of onshore and offshore wind power generation. Iberdrola Renovables Energía, S.A. (Iberdrola Renovables) is a founding member, sits on both the Executive Committee and the Management Committee, and actively participates in 4 of the 5 established work groups.
Sustainable Nuclear Energy Technology Platform (SNE-TP)	This platform promotes the framing of a Strategic Research and Development Agenda for nuclear technology to preserve and shore up European leadership in technology. Iberdrola has been a member of SNE-TP since its creation in September 2007 and is a also member of the steering committee.
European Technology Platform on Industrial Safety (ETPIS)	This platform aims to contribute to streamlining research and coordinated implementation integrated in the field in industrial health and safety. The platform simplifies cooperation and enables a constructive exchange between industry, regulators in charge of safety and environmental protection, NGOs, labour unions and other social agents, and research and innovation community. Iberdrola is an active member of the ETPIS "High Level Group".

Other European associations

Name	Objectives
European Green Vehicles Initiative Association (EGVIA)	The association was created to streamline research, development and demonstration of technologies for developing sustainable mobility in the EU, including electric vehicles and the associated infrastructure dedicated to developing green vehicles and mobility system solutions. Iberdrola is a delegate member in the "*Smart Grids*" area.
European Association for Storage of Energy (EASE)	This association seeks to actively promote and support the deployment of energy storage as an essential instrument within the framework of the European energy and climate policy, and build a European platform for exchanging and disseminating information related to energy storage. It currently has 41 members, who represent the European electricity sector.

Name	Objectives
European Distribution System Operators (EDSO)	This organisation combines Europe's main Distribution System Operators (DSO). EDSO focuses on guiding R&D&i, EU policies and the regulation of Member States for supporting the development of smart grids. EDSO is the key element in the relationships between European DSOs and European institutions, promoting the broad-scale development and tests of new smart grid models and technologies, new market designs and regulations. Iberdrola is a founding member and holds the vice-chair of this association.
WindEurope (erstwhile EWEA)	Association that groups the main actors in the European wind power sector. Its main objectives include the promotion of research, development and innovation (R&D&i) in wind power for preserving European leadership in technology, improving the viability of wind power and assuring optimal use of European research funds and support to European university education, research institutes and industry. Iberdrola is a member of the board of directors and actively participates in the different work groups.
World Economic Forum (WEF)	The World Economic Forum is an International Organisation for Public-Private Cooperation. The Forum engages the foremost political, business and other leaders of society to shape global, regional and industry agendas. The "Digital Transformation of Industries" initiative is the Forum's multi-year project examining the opportunities and challenges that digitalisation is creating for business and society.
European Round Table of Industrialists (ERT)	This forum bringing together around 50 Chief Executives and Chairmen of major multinational companies of Europe's major multinational companies covering a wide range of industrial and technological sectors. The "digital economy" has become one of the top political priorities. A working group was created with this "digital single market" initiative. This Working Group provides high-level recommendations from a wide industry perspective on how to enable such digitisation in a timely way.
Eurelectric	This forum bringing together around 50 Chief Executives and Chairmen of major multinational companies of Europe's major multinational companies covering a wide range of industrial and technological sectors. The "digital economy" has become one of the top political priorities. A working group was created with this "digital single market" initiative. This Working Group provides high-level recommendations from a wide industry perspective on how to enable such digitisation in a timely way.

Spanish technology platforms

Name	Objectives
Plataforma Española de Seguridad Industrial (PESI - Spanish Industrial Safety Platform)	The basic objective of PESI is to provide a global and comprehensive vision of industrial safety. It works on the following areas: safety of products and facilities; health and safety at work; environmental safety; and company asset safety. Iberdrola chairs this platform and coordinates the work group in charge of advanced technologies for risk prevention, reduction and management.
Wind Technology Platform: REOLTEC.net	Integration and coordination of various research, development and innovation actions to meet the needs of the Spanish wind power sector. Consolidation of the Spanish wind power industry's technological positioning by shoring up and selectively coordinating scientific/ technological stages and selectively disseminating the results and experience obtained.
Spanish Fusion Technology Platform	This platform seeks to have Spain attain the industrial technologies and processes needed to participate competitively in both national and international fusion projects. Iberdrola is a member of the platform's Executive Committee.
Spanish Fission Platform (CEIDEN)	Coordination of various domestic R&D plans and programmes, and participation in international programmes, seeking to consistently direct the efforts of the organisations involved. Iberdrola is a member of the Management Board and an active participant in the Nuclear Industry Capabilities Project.
Spanish Electrical Grid Platform (FUTURED)	Integrate all the agents involved in the sector to define and boost strategies at a national level with a view to consolidating a more advanced grid capable of meeting future challenges. Iberdrola is a member of the governing board.
Spanish Energy Efficiency Platform	Innovation in energy efficiency technology, generating new solutions through the promotion of research and development of new techniques, products and services that contribute to the reduction of energy demand through energy efficiency. Iberdrola is a member of the Management Board of this platform and is actively involved in the coordination of its work groups.

EIT and KIC InnoEnergy

The European Institute of Innovation and Technology (EIT) seeks to strengthen and make the most of the innovative capabilities and resources present in Europe, in both industry and in research centres and universities.

To achieve these objectives, three consortia have been set up to focus on various areas of innovation: energy, ICT (information and communications technologies) and climate change.

Iberdrola is a member of the energy KIC (Knowledge and Innovation Communities) known as KIC InnoEnergy. This was launched in September 2010 under a 7-year agreement with the EIT. Its mission is to promote and fund innovation projects in the areas defined by the SET Plan: renewable energy sources, smart grids, energy efficiency, biofuels, clean coal and the integration of nuclear power with renewable energy. Six regional nodes have been established, each one tasked with coordinating the activities in one of the aforementioned areas.

Iberdrola pertains to the Iberian node, which coordinates renewable energy-related activities and integrates partners in Spain and Portugal, though Iberdrola can also participate in projects within any field.

Iberdrola participates in two projects in connection with Smart Grids. The ***Electric Energy Storage*** project is based on the implementation of technologies that enable the integration of renewable energy sources into smart grids (new equipment, control systems and the integration of storage systems). The ***Smart Power*** project develops and coordinates the application of innovative methods for designing and efficiently managing smart grids.

Iberdrola Energy Challenge

The Iberdrola Energy Challenge was conceived on the basis of a joint initiative between Iberdrola and KIC InnoEnergy, the European Union's benchmark innovation and technology centre. The objective entails enabling KIC InnoEnergy students to seek out groundbreaking ideas regarding the future of the energy sector to foster a more sustainable and energy efficient society.

To do so, we challenged a group of over 600 young people with an average age of 26 from over 29 countries to develop solutions in three fields: energy models accessible at the global level, new digital models that redefine the relationship between *utilities* and their customers and, thirdly, development of a social economy that makes energy more accessible.

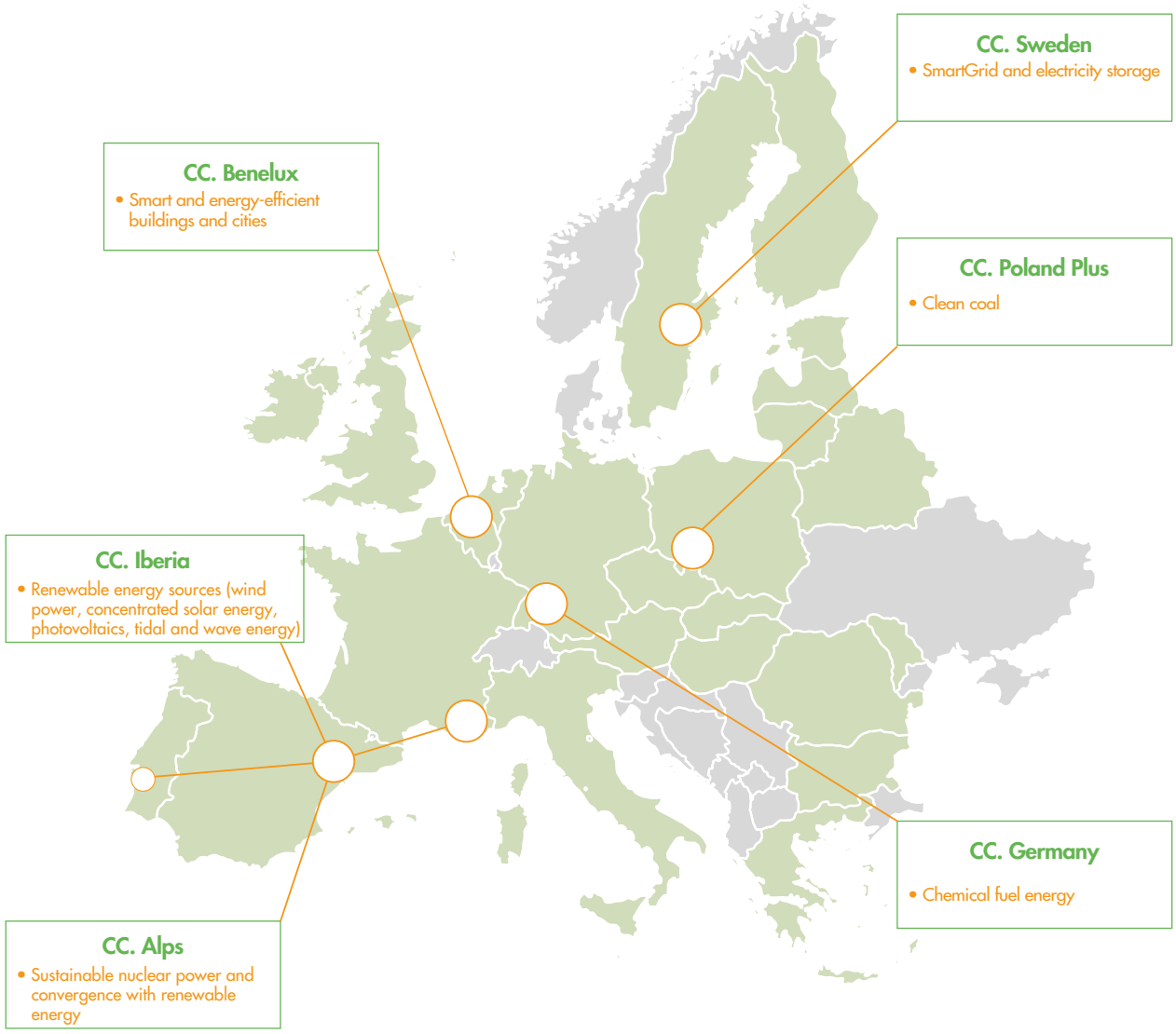
The winners were chosen following an electronic vote by the audience in attendance during the *2016 Digital Summit*, which was held at the Iberdrola building in Madrid.

The first prize in the Iberdrola Energy Challenge was given to the young people working on the 'Save to Donate' project, which proposed an initiative that would have Iberdrola customers reinvest in the electricity supply for disadvantaged regions. Doing so would encourage collaboration between the company and its customers to promote worldwide access to energy.

Second place was given to the '*DSO Controlled PV-Converters*' project. This initiative proposes a converter system for greater integration of residential solar panels in the electricity grid.

The projects selected for the third and fourth prizes were respectively '*Sharing Economy Concept in Electricity Grid*' and '*Eco-Sharing: Car-Sharing as Grid Storage*

Knowledge community map



EPRI

The Electric Power Research Institute (EPRI) is an independent non-profit public interest organisation established in 1973 to conduct research in energy and the environment. Its mission is to carry out collaborative R&D work by its members, who are electricity companies and other organisations in the energy sector.

As an international member, Iberdrola has been participating in the activities of the Non-Nuclear and Nuclear Generation Divisions of the EPRI since 1999, holding a position on the Boards of the Generation, Nuclear and *Power Delivery and Utilisation Division* (EPRI programmes concerning Electricity Distribution, Transmission and Retailing) and likewise participating in Renewable Energy programmes.

The innovations in the (Non-Nuclear) **Generation Area** focus on:

- Maintenance of Iberdrola's conventional thermal and combined-cycle plants to contribute to the reduction of operation and maintenance costs, and an improvement in equipment reliability and facility service life extension .
- Optimisation and improvement in planning and actions in energy markets through their market analysis, forecast of fundamental variables and optimisation and improvement of contracting models.
- Clean combustion technologies (clean coal, emission control, advanced coal plants, CO_2 capture and storage) and efficient operation of generation plants.
- Reliability of the main plant components (structural materials, advanced automation, gas turbines, heat recovery steam generators, etc.) and cybersecurity-related matters.

The R&D&i activities at EPRI in the **electricity distribution area** focus on:

- Tools and technologies to satisfy demand and centred on energy efficiency. This entails defining the technologies needed to adapt demand during peak periods to thus reduce the needs for generation.
- New distribution system configurations and advanced grid automation: grid automation poses new challenges and opportunities for grids and the IT systems that manage them. This project provides tools for managing the future development of advanced automation for distribution networks.
- Technology transfer and information systems: provides information on the future evolution of technology in distribution networks through the integration of traditional electricity distribution with the opportunities afforded by computing and sensors, thanks to new advances in communications via electricity grids (PLC) and other technologies. This is closely linked to the new smart meters (digital), which will become mandatory for all customers in Spain beginning in 2018. This is the most important project of the three and the foundation of the future of electricity distribution.

The Global Nuclear Programme, which the Spanish Electricity Industry Association (UNESA) has managed since 2006 within the framework of a global agreement between the Spanish nuclear sector and EPRI, has been particularly successful in the **Nuclear Generation Area**. This agreement has resulted in a very high number of engineering activities at Iberdrola's nuclear power plants and in projects related to material degradation, fuel reliability, nuclear asset management, advanced nuclear technology, waste, spent fuel, etc.

Iberdrola has also participated in some of the EPRI product user groups enabling technical assistance by EPRI specialists for problems at plants and the acquisition of essential technical material for the application of their products. This activity is reflected in over 20 specific projects applied to the facilities.

Iberdrola has kept its **technological training** in line with EPRI, which has entailed access to over 300 technical reports yearly, individual training for its technical staff through webcasts, specialised seminars and access to reports, estimated at over 20,000 hours of training in three years and an intangible value of over 30 million dollars. Several company employees also received international recognition with *7 EPRI Technology Transfer Awards*.

IBERDROLA has worked closely with EPRI in corporate and strategic innovation in the electricity sector through participation in drawing up strategic "Science and Technology" and "Technology Innovation" reports such as *Electricity Road Map 2030-2050, Reshaping the Electricity Industry in the Future, Intelligent Grid Program, Clean Coal Technology: "New Generation Fleet for tomorrow", Innovation Technology within the Electricity Industry, Distributed Resources Program, Emission Control*

Abatement Strategy, Role of Renewable Energy in Future Electricity Supply, etc.

Iberdrola is a member of the EPRI Generation and Distributed Resources Board, has full voting rights in the preparation of the various annual and 3-year Generation, Distribution and Nuclear Portfolios, and participates with a director as METT (*Manager EPRI Technology Transfer) at the meetings held by the Technology Council* (TCM), the international METTs and the *International Advisory Council* (IAC).

The innovation activities in the **renewable energy area** focus on solar technology-based projects (basically photovoltaics and concentrated power).

The following activities are also worth noting:

Cybersecurity as support for AMI implementation

Following EPRI's cybersecurity assessment conducted as part of Iberdrola's AMI programme (*Advanced Meter Infrastructure*), EPRI recommended the inclusion of specific security controls in the specifications to equipment suppliers. Based on a mutual collaboration that both organisations have developed, Iberdrola asked EPRI to form part of the second stage of the project, which will seek to develop AMI architecture, protocols and encryption alternatives. Having reviewed these design aspects, EPRI provided Iberdrola with some recommendations for increasing the cybersecurity of its AMI system through standardised security solutions.

Fuel channel deformation

Iberdrola joined EPRI's channel deformation programme when it was launched in 2009. As a result, Cofrentes became one of the main plants for inspecting channels and measurements. By using EPRI research results and internal resources, Iberdrola has been capable of ascertaining the deformation of channels for future fuel cycle designs, and thus be able to optimise the localisation of elements to reuse in the following cycle so as to minimise the need for spare parts.

Reducing the number of fuel channels has significant operational and financial impacts:

1. Savings in the provision of channels.
2. Reduction in time and risk during the re-channelling operations during refuelling.
3. Reduction in waste and radioactivity.
4. Prevention during the insertion of control bars.

The information from the channel deformation programme also includes the design of new materials for channels that reduce bending and deformation. EPRI and Iberdrola intend to test some of the new channels to verify their technical properties and futures uses in real conditions.

Distributed Energy Resources and Energy Storage

Iberdrola's venture capital programme PERSEO has examined the possibility of investing in specific Distributed Energy technology areas. Thanks to the development of these technologies in the USA, with the development of multiple *startups*, Iberdrola requested assistance from EPRI to evaluate relevant strategies concerning distributed energy resources and worldwide energy storage.

Exclusion of foreign materials

The Cofrentes Nuclear Power Plant has had two faults in the most recent fuel cycle after various years without any. These faults are normally related to debris friction.

To improve Foreign Material Exclusion (FME) and waste recovery processes, Iberdrola hosted a European workshop in May 2015. This workshop in Madrid gave Iberdrola the opportunity to review this type of materials and learn from the experiences of other European and American *Utilities* in resolving similar issues. Iberdrola has reinforced EPRI guidelines and gathered the *feedback* from surveys to inform about the revisions of the foreign material exclusion process strategy during refuelling shutdowns.

Iberdrola applies the EPRI guidelines for combined cycle hibernation in Spain

Due to the decreasing electricity demand in Spain, partially due to the elevated penetration of renewable energies, Iberdrola's fleet of combined cycle gas turbines has had no other option but to reduce operations and/or possibly go offline for days or weeks. Iberdrola has been supervising and monitoring the developments in EPRI chemical guidelines for closing plants.

Iberdrola's updated operation and maintenance procedures have incorporated EPRI guidelines such as "Fossil Power Plants Layup Resource Tool". The value for Iberdrola lies in the standardisation of the different types of plants and duration of the closings; including the time and cost of these processes, and anticipating the times required to put the units back into production while keeping the equipment in satisfactory conditions for this operation. This proper understanding of the costs and implications of temporarily shutting down its units is rendering Iberdrola more competitive in the energy market.

Application of Advanced Knowledge Materials at Iberdrola fossil fuel plants

The Iberdrola technical support department has been monitoring the new developments on a new type of steel during the EPRI's Fossil Material and Repair Programme. This material was a source of problems at various coal-burning and combined cycle plants. The progress made in EPRI's research was applied to improve knowledge and prepare for the repair of components using this family of materials.

The knowledge acquired by Iberdrola in this EPRI project was used to establish the specifications for new components at the *Shoreham Power Station* in the United Kingdom and other new combined cycle groups. The discussions with suppliers are centred around obtaining better components with reheaters. This has yielded savings in the acquisition and is expected to result in future improvements in the operation and maintenance of the Iberdrola fleet.

Iberdrola and CIGRÉ

CIGRÉ (International Council on Large Electric Systems) is a global non-governmental, non-profit organisation founded in France in 1921 to promote and foster the exchange of technical knowledge amongst countries within the scope of high-voltage electricity production and transmission. This organisation groups power utilities, manufacturers of electrical equipment assets, engineering firms, universities and research centres across the world, and most likely constitutes the most important technical forum for addressing and researching these quintessential worldwide issues.

Iberdrola is the secretary of the committee known as "Rotating Electrical Machines" and member representing Spain in the work groups for transformers, protection and automation, rotating electrical machines, substations, electricity markets

and regulation, distribution systems and distributed generation.

IBERDROLA CHAIRS

The Iberdrola chairs are a means for realising the Company's commitment to R&D&i, and particularly its involvement in promoting research, training and collaboration with the world of science and universities, particularly in the regions where it operates.

The objectives sought with the creation of the various chairs include:

- Promoting University-Business technology transfer.
- Establishing a framework for collaboration in the launch of R&D projects and training initiatives in common areas of interest.
- Promoting specialised training in fields of greater interest to Iberdrola.
- Social commitment.

The existing agreements and the main actions carried out are described below.

Iberdrola Chair at the University of Salamanca

This Chair emerged in 2008 as an action framework that formalises the collaboration between both organisations and promotes education, research and innovation in fields of knowledge of special interest to both parties.

The main purpose of this Chair is to promote University-Business technology transfer and become a framework for collaboration in the launch of R&D&i projects and training initiatives in common areas of interest. The Chair also seeks to promote specialised training in fields of knowledge which are of greater interest to Iberdrola, and to carry out other social and cultural activities.

In 2014-2015, the research activities focused on three main areas:

Projects in the **Environment and Renewable Energy area**:

- **MiniREIS**: project for developing a new methodology to assess ecosystem services generated by the construction of infrastructures.
- **VELILLA**: project for studying and characterising the environmental biodiversity of the facilities at the Velilla del Río Carrión Thermal Power Plant (Palencia).
- **HIDROIL**: research project for characterising the condition of rotating equipment in generation stations employing lubricating oil and hydraulic fluids through infrared spectrophotometric analysis.
- **ARCOS**: project for studying and characterising the environmental biodiversity of the facilities at the Arcos de la Frontera Thermal Power Plant (Huelva).
- **LESSER KESTREL**: project for securing population estimates/censuses of the Lesser Kestrel (*Falco Naumanni*) in the area of influence of Iberdrola's Cuesta Colorada, Cerro Palo, Calderón and Muela I (Cuenca) Wind Farms with a view to defining mitigating measures to reduce the wind farms' influence on this species.
- **OWL**: project conceived to examine and mitigate factors causing the electrocution of this species of owls on power lines.
- **MITIGATION**: Following the Lesser Kestrel Project and after implementing measures in the wind farms to reduce their influences on these birds, a new project was launched to track and compare the effectiveness of the installed mitigation measures.
- **SOBRÓN**: technical assistance project for the nymph rescue process carried out after commencing Sobrón reservoir drainage (Ebro river in Burgos and Álava).

Projects in the **Grid Engineering area**:

- **COFACO**: project for examining and characterising cuts in one of the phases in the lines reaching a generation plant to be subsequently particularised at the Cofrentes Nuclear Power Plant (Valencia).
- **TABÓN**: project to develop a technology for verifying, inspecting and predicting power lines by measuring the earthing resistance to increase the efficiency in managing these assets.

Projects in **other activities**:

- **COMPLIANCE**: project for creating an ethics compliance observatory. The purpose of the project is to establish the terms and conditions so that the USAL can make the technical documents for creating an observatory on legal compliance.

The following **training and sponsorship activities** have also been carried out:

- **Conference on electricity sector regulation and sustainability**: Energy sector administrative law.
- **First Science-Technology Outreach Workshop**: CO_2 handling methods and lines of research in this field.

Training and Research Scholarships:

- **Training**: USAL students as Iberdrola trainees.
- **Research**: USAL researchers (University of Salamanca) in areas of interest to Iberdrola.
- **Energy saving and efficiency**: implementation of a cogeneration system for research and educational activities at the University.
- **Environmental education**. Sponsor for several environment-related courses organised by the Green Office (administrative unit reporting to the Vice-Rectorate for Economics, in charge of developing the institutional environmental policy).

Orkestra Energía Chair (Basque Institute of Competitiveness) – Deusto Foundation

ORKESTRA is an initiative launched by the Basque Institute of Competitiveness, which belongs to the Deusto Foundation, an organisation devoted to transferring scientific knowledge to society. Through this organisation, Iberdrola participates as a trustee in the Energy Chair, which works around four areas:

- **Energy and market economy**: analysing the context of the most relevant aspects of international and national energy markets as well as examining energy generation technologies and the incorporation of environmental and/or energy policy requirements.
- **Transport and energy:** working within four aspects: the current situation from a national and regional standpoint, energy consumption for overland transport and future technologies for transport.
- **Energy, technology and industry**: competitiveness and industrial development, for studying the energy supply from an industrial standpoint as an *input*, analysing the role of energy within business competitiveness, following the "diamond model for competitiveness" and "clustering" as well as the potential effects in connection with the incorporation of new energy technologies and the creation of new companies or businesses.
- **Energy geopolitics**: analysing the context of energy from a geopolitical standpoint. Examining the current level of dependency on hydrocarbons and their consequences on the energy model, and possible ways to address the challenges of energy dependency.

It thus seeks to provide elements for debate in order to propose solutions for achieving cost-effective and environmentally sustainable energy, thus contributing to competitive and industrial development.

The activities carried out over the last two years include:

In 2014,

- Study on "The impact of the electricity reform. Industrial competitiveness of the CAPV (Basque Country Autonomous Region) and other implications".
- Study entitled "An overview of energy and environmental taxes".
- Study on "Distributed generation and self-consumption: strategic and business implications. Analysis and tracking".
- Study on "Smart energy, new applications and models that are transforming the electricity sector" in collaboration with the BCG.
- Work on "Distributed energy resources. A proposal for tracking them" and "Distributed generation in the United Kingdom and USA of America. Photovoltaic penetration level in Spain, Germany, USA, United Kingdom, New York, Maine, Scotland and Wales".
- Report: "The challenge of Energy Regional cooperation within Europe: Spain, Portugal and France. A summary of the points raised during the debates".
- Publication of "Energy: current situation and trends. From Global to local".
- Publication of "The reliability of the electricity system".
- Presentation of the results of the most recent World Energy Council Conference [in collaboration with the Spanish Committee of the World Energy Council (CECME, acronym in Spanish)].
- Workshop: "Energy, Engineering and Industry" in collaboration with the Royal Academy of Engineering.
- 3rd "Energy Course: Gas, Grids and Renewable Energy".

In 2015,

- Study on Energy Prices and Industrial Competitiveness.
- Challenges of the energy sector and implications of energy and industrial policies.
- Revision and redaction of a final version of the studies regarding "Distributed Generation in the United Kingdom and United States of America. Photovoltaic penetration level in Spain, Germany, USA, United Kingdom, New York, Maine, Scotland and Wales" and "Classification of technologies by distributor companies and voltage sections in 2010-2013".
- Workshop on the "The Energy Reform in Mexico" in collaboration with Enerclub.
- Internal seminar on "Challenges and opportunities for energy and industrial development (*Oil&Gas*)".
- Presentation of the book entitled "The Future of Energy in the Atlantic Basin" in Madrid.
- Presentation of the work entitled "Smart energy, new applications and business models".
- Round Table on "Spanish Innovations in Renewable Energies: The Future of Renewable Energies as a Solution for Sustainability" in partnership with the DBS, *Centre for Sustainable Business*.
- Co-publication of the book entitled "The Future of Energy in the Atlantic Basin" together with *John Hopkins University*.

Iberdrola Chair in Energy and Innovation at the University of Comillas-ICAI

The Iberdrola Chair in Energy and Innovation at the University of Comillas-ICAI was created in October 2012 with the following goals:

- To be an instrument for formalising a stable partnership agreement between the University and Iberdrola to carry out research, innovation and training activities in fields of knowledge of strategic interest to Iberdrola.
- The creation of a University-Iberdrola link to render a strategic nature to this alliance within the field of innovative knowledge creation and

transfer that goes beyond the strictly economic area.
- To be a University tool for boosting research, development, innovation and teaching, as well as to strive for various social and cultural causes without calling on the University to provide full-time personnel.

The following activities seek to attain the above goals:

- Organising meetings amongst University professors and researchers with counterparts from other universities as well as companies and institutions that carry out training, research and publication activities in the energy sector.
- Developing specific research projects, both nationally and internationally.
- Managing the endowment of collaboration grants and scholarships for research and final-year projects related to the energy sector.
- Maintaining fluid institutional relations with other work and research groups both nationally and internationally.
- Compiling a specialised document base within the University's library.
- Organising scientific meetings, workshops and themed seminars in partnership with other institutions.
- Developing an annual workshop for debating and reflection with experts on various matters as jointly agreed by the parties.
- Publishing and disseminating the results of national and international forums through talks, presentations, communications and publications in specialised media.

a) ODICEO

The agreement with ODICEO within the framework of the Chair is particularly prominent in that it seeks to improve support for entrepreneurship by establishing a structure for simplifying access to funding for innovative companies. ODICEO is an entity backed by the ICAI's National College of Engineers and the ICAI chapter of the National Association of Engineers which provides comprehensive advisory services to individuals and entities in order to promote entrepreneurship in their own fields. Through this initiative, Iberdrola extends its activities further in support of the development of technology-based and innovative companies with high potential for economic growth. Along these lines, investments may be made in projects deemed to have potential in the energy field that expedite the change in the productive model towards a more sustainable society.

b) "MODEL FOR FORECASTING THE RESERVE NEEDS IN AN ELECTRICITY SYSTEM WITH HIGH RENEWABLE ENERGY PENETRATION".

The objective of the "Model for forecasting the reserve needs in an electricity system with high renewable energy penetration" project is to propose a methodology for ascertaining the operating reserve needs in an electricity system to address the uncertainties inherent in such a system (demand, generation) within a context of high wind power penetration. This project concluded successfully at the start of 2016.

The proposed approach was based on developing a computer tool to simulate the short-term operation of the electricity system with a view to assessing the consequences of having various reserve levels in the system. The model comprises a "unit commitment" subject to stochastic variations of both demand and generation from an uncontrollable renewable energy source. The model harnesses available resources to address these variations. The "unit commitment" algorithm requires particular attention in terms of its computational efficiency, so that it can run sufficient stochastic simulations to ensure the validity and soundness of the results.

Based on the results, we can draw the following conclusions:

- The wind power restrictions diminish when reducing the period of time of each unit.

- The reduction of the time unit in a "Unit Commitment" also diminishes the average value of the system's production costs.
- The elevated volatility of operating costs are caused by errors in the wind power forecast.
- Throughout the marketplace, reducing the market unit test period will reduce the operating reserve requirements.

This project is part of the activities promoted by Iberdrola through the Chair in Energy and Innovation at the Comillas Pontificial University

Technology Innovation Centre – TIC

Renowned as amongst the UK's leading international technology universities, the University of Strathclyde has developed the Technology Innovation Centre, which is transforming the way in which academics, businesses, industry and the public sector work together to provide Scotland with a global competitive edge. The TIC offers an extensive breadth of research and innovation areas, in which energy is one of the main activity areas.

The Renewable Energies business at *ScottishPower* has been working alongside the TIC since its inception. We are benefiting from the collaborative approach of the TIC to offer multiple projects and thus improve our renewable assets.

The main activity areas during recent years centred around:

- Asset management
- Data Analysis
- Life Cycles quitar los dos puntos
- Technical skills

Power Networks Demonstration Centre – *PNDC*

The Power Networks Demonstration Centre was jointly created by the University of Strathclyde, *Scottish Enterprise*, the Scottish Finance Council, *Scottish Power and Scottish & Southern Energy* with a view to streamlining the integration of new smart technologies in the electricity sector.

The PNDC provides a low- and medium-voltage distribution system (up to 11 kV) that can be operated without a grid connection and therefore enables rapid and secure integration and validation of new technologies under real-life functional operating conditions. Its main research areas include asset management, communications, integration systems, grids, active supply and demand management, power electronics, distributed energy, protection, control, sensors and metering.

ScottishPower is actively partnering with the PNDC to develop several R&D projects in these areas. 11 projects were launched during 2014 and 2015, some of them still active at the close of 2015.

ScottishPower Chair in Smart Grid Technology

In 2012, ScottishPower established the ScottishPower Chair in Smart Grid Technology with the University of Strathclyde.

The University of Strathclyde has a solid track record of getting good results in its work with industry partners and ScottishPower has worked closely with the University for many years.

The Chair conducts research that help tackle the challenges of the 21st century. The academic staff assists in furthering this work and supports the

development of highly qualified graduates needed by the energy sector.

Moreover, this partnership will serve as a basis for strengthening the international impact and industrial consortiums while promoting greater interest in this field of engineering.

There is increasing recognition that electric grids will have a vital role to play in the move to low carbon emission technologies in the United Kingdom by helping to reduce energy waste, making it easier for homes and businesses to generate their own renewable energy, and supporting smart meters and smart appliances for the home.

The Chair also integrates the *ScottishPower Advanced Research Centre*, which was created in 2007 and provides access to top class research resources and prominent researchers in power electronics.

Master's Scholarships and Grants for Research in Energy and the Environment Programme

Within the framework of its commitment to the regions where it has activities, Iberdrola supports the creation and transmission of knowledge that contributes in fostering a generation of professionals who are fully capable of rising up to the challenges of the future, which includes developing a sustainable energy model.

Since its commencement in 2010, the Scholarship Programme has had 430 beneficiaries in Spain, the United Kingdom, the United States of America, Mexico and Brazil, thus multiplying the number of scholarships offered since the outset by three. Every year, Iberdrola announces its Scholarships and Research Grants Programme in energy and the environment through its international foundations with a view to contributing to excellence in education and research in the field of energy, with a special emphasis on renewable energy, improving biodiversity and the efficiency of the energy system. The goal is to train high-calibre young professionals capable of contributing to changing the energy model.

- Postgraduate Scholarships

  This programme was conceived to train top-calibre professionals in the energy sector who have proven themselves to be capable of contributing to the development of a sustainable energy model that meets the energy needs of society and promotes environmental protection in the countries where Iberdrola is present. The scholarships are intended for Spanish, British, American, Mexican and Brazilian graduates, undergraduates and final-year students so they can further their master's studies in Spain, the United Kingdom and the United States. Doing so thus addresses the multinational reality of the Group, whose main activities are carried out in those countries.

  The aim is to attract the best candidates from Iberdrola regions and countries where the Group operates, while contributing to strengthening the relationship between Iberdrola and national and international universities and institutes of technology, particularly ones linked to education in areas related to energy sustainability.

- Aid for Research in Energy and the Environment

  The main instrument of this programme is the announcement of aid packages intended for training and development of young researchers in the area of sustainability. The purpose is to promote research in subjects aimed at developing a sustainable energy model, R&D&i projects and programmes that encourage progress in the area of sustainability.

Through close collaboration with Iberdrola Group teams in charge of innovation, research projects aligned with the Group's R&D&i strategy will be selected, supervised and supported.

King Felipe VI Endowed Chair in Information Science and Related Technologies at the University of New Mexico, United States

Iberdrola created the King Felipe VI Endowed Chair in Information Science and Related Technologies (erstwhile known as the Prince of Asturias Chair) in 2000 at the University of New Mexico, Albuquerque, with the backing of the Spanish Ministry of Science and Technology.

The chair was created primarily with a view to furthering research and advancing knowledge in specific areas within the fields of science, information technology and energy, preferably concerning smart grids and alternative and renewable energies. Likewise, the Chair aims to encourage collaboration within these areas between the institutions and communities involved, and act as a catalyst for significant collaboration amongst Spain, Latin America and the University of New Mexico.

4.

Perseo and entrepreneurship

Iberdrola VENTURES - PERSEO

PERSEO is Iberdrola's corporate venture capital programme, endowed with €70 million for investing in disruptive technologies and new businesses that ensure the sustainability of the energy model. Since its creation in 2008, over €50 million have been invested in technology-developing *startups* and new businesses in the energy sector worldwide.

The main aims of this initiative are:

- To encourage the creation of new business opportunities for Iberdrola.
- Securing Iberdrola's access to future energy technologies.
- To promote entrepreneurship and the development of an innovative corporate fabric in the energy sector.

4.1. Technologies of interest.

The main technologies that define the PERSEO investment portfolio are:

- Customer-oriented Solutions: energy efficiency, demand management, digital solutions, etc.
- Distributed Energy Resources: innovative generation and distributed storage solutions.
- New technologies applied to the Operation and Maintenance of energy infrastructures: robotics, sensors, software, etc
- Renewable Energies: technologies related to renewable energy generation (solar, wind power, offshore), particularly focusing on reducing BoS costs.

Through PERSEO, Iberdrola currently seeks projects that fit into the aforementioned areas and represent disruptive technology developments or new innovative business models. These projects can be e-mailed to perseo@iberdrola.es. Iberdrola will contact the people responsible for all the proposals received and analyse the feasibility of each project.

4.2. Investment portfolio

4.2.1. OCEANTEC (wave energy)

Oceantec was set up to develop a high-performance and cost-competitive wave energy capture device that harnesses the huge energy resource in sea waves.

Oceantec, in which Tecnalia is also a partner, also develops solutions for the assessment, implementation and operation of any type of device related to marine energy capture.

4.2.2. ANDRITZ HYDRO HAMMERFEST (tidal power)

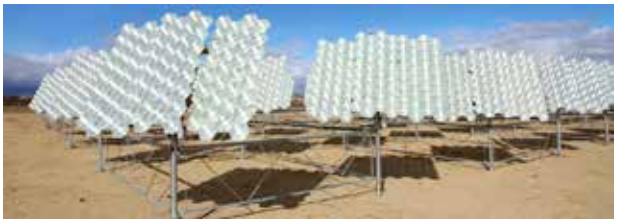
ANDRITZ HYDRO Hammerfest develops proprietary technology for capturing energy from currents and is considered a world leader in its field. The technology developed by the company has been tested thoroughly in the marine environment over extended periods of time and is now in the process of scaling for its marketing.

The company's majority shareholder, the Austrian group Andritz Hydro, is joined by other shareholders, including Iberdrola (through PERSEO) and Hammerfest Energi. The company has offices in Hammerfest (Norway) and Glasgow (Scotland).

4.2.3. MORGAN SOLAR (concentrated photovoltaics)

Morgan Solar Inc., headquartered in Toronto (Canada), was set up with the aim of making solar power a cost-effective alternative with no need for subsidising. Morgan Solar has developed the Sun Simba HCPV (*High-Concentration PhotoVoltaics*), a highly efficient and low-cost module.

Additionally, Morgan Solar, Inc. has developed the Savanna™ solar tracker for photovoltaic applications. This system increases performance between 25 and 40%, yet is easily installed and requires neither foundations nor heavy equipment.



The company has begun building the Sun Simba system and Savanna™ solar tracker for testing, demonstration and certification purposes in Ontario and California.

4.2.4. ARBÓREA INTELLBIRD - Arachnocopter

The Arachnocopter is a vertical take-off UAV (Unmanned Aerial Vehicle) capable of carrying a great number of electronic measuring devices, ranging from high-definition cameras to sensors for a broad range of civil and military applications.

One of the company's main products, the EoI6, is a foldable helicopter designed for inspecting wind turbine blades. The Arachnocopter EoI6 enables streamlined inspections with minimum offline time and huge savings in resources and logistics for these inspections.

Iberdrola (through PERSEO) holds a stake in the Salamanca-based Arbórea Intellbird through a co-investment with the Centre for Industrial Technological Development within the INNVIERTE programme. A group of investors associated with Alentia Capital Alternativo also holds stake in this company.

4.2.5. ATTEN2

The main activities of the Basque company Atten2, a *spinoff* of IK4-TEKNIKER and based at the Parque Tecnológico de Guipúzcoa complex in Eibar, are centred around designing, manufacturing and retailing sensors for monitoring the status of fluids, particularly oils, in industrial applications. The company's first products, namely *OilHealth* and *OilWear*, are sensors conceived for monitoring oil in wind turbines.

The first developed product can measure the degradation of the oil in wind turbine gearboxes to enable real-time monitoring and propitiating a greater use of oils.

Iberdrola (through PERSEO) holds a stake in Atten2 through a co-investment with the Centre for Industrial Technological Development within the INNVIERTE programme.

4.2.6. STEM

Stem markets energy storage solutions that combine predictive analysis, *cloud computing* and *big data* together with batteries with a view to improving the energy efficiency of the facilities of commercial and industrial customers.

Stem has recently secured the world's largest distributed storage contract (85 MW), which the Californian utility Southern California Edison is developing.

In addition to Iberdrola (through PERSEO), further large corporations have also incorporated as shareholders, including *General Electric, Total* and *Constellation Energy*.

4.3. Electricity for all

With a view to unifying and shoring up its efforts for promoting access to electricity in emerging countries, Iberdrola launched the "Electricity for All" programme at the start of 2014.

The programme aims to execute economically sustainable electrification projects by harnessing the Iberdrola Group's technical, logistics, organisational and financial capabilities.

As part of the programme, Iberdrola Ventures – PERSEO invests in innovative *startups* that provide access to electricity in emerging countries.

4.3.1. SUNFUNDER

SunFunder created a financing platform so that financial and corporate investors can have a stake in a diversified portfolio of *off-grid* solar projects in emerging countries throughout Africa, Latin America and Asia.

4.4. Open innovation ventures

"Open Innovation Ventures" supplements Iberdrola's innovation and venture capital activities by fostering collaborations with technology partners for the purpose of streamlining the development of new products of interest to Iberdrola.

The results of these projects are transformed into new businesses so that these developments can be retailed both inside as well as outside the Iberdrola Group.

4.4.1. GDES Energy Services

Company constituted in partnership with the Dominguis Group for streamlining the development of new technological products within the scope of energy infrastructure operation and maintenance. Nuclear and Renewable Energies will be the priority intervention areas for *GDES Technology for Services* (GDES T4S).

The purpose of the company is to create synergies within the technology field for operation and maintenance in the electricity sector. The business model of the jointly held company develops new products funded with capital from both partners, in which Iberdrola participates though its Perseo investment fund.

4.5. Innvierte Programme

With a view to maintaining and reinforcing the activities of the PERSEO programme, an agreement was signed in July 2012 with the Centre for Industrial Technological Development (CDTI) within the framework of the Spanish government's INNVIERTE programme to invest in new technologies for the energy sector.

The INNVIERTE programme aims to channel public-private venture capital to help start up and consolidate innovative and technology-based companies that are very likely to grow.

This initiative, in keeping with the efforts of Iberdrola to serve as a driving force behind the economy and society in Spain, will enable the Company to invest together with other private companies and public funding in business projects to propitiate a change in the production model and attain a more sustainable society.

Iberdrola has been selected for the INNVIERTE programme on the merits of its experience in venture capital initiatives, obtained precisely through the PERSEO programme.

4.6. Further Iberdrola initiatives for investing in startups and promoting innovation and entrepreneurship

4.6.1 NEOTEC

NEOTEC is the Spanish venture capital investment programme for encouraging the creation and development of innovative companies, particularly in three fundamental areas: information technologies, life sciences and "general" funds.

To do so, NEOTEC has been set up as an initiative managed by the European Investment Fund (EIF), which holds partial stakes in various venture capital funds managed by independent entities with an overall investment figure of €183 million.

As one of the main institutional investors, with a pledged investment of €10 million, Iberdrola is a permanent member of the Fund's Advisory Committee and an observer member of the Investment Committee on a rotating basis.

4.6.2 Stakes in other funds

In addition to the foregoing, Iberdrola participates in the following regional funds:

- Seed Capital Bizkaia in the Basque Country, whose mission is to promote and develop new or existing companies that intend to develop innovative projects, new products, markets or production processes, improvements in management, stability or continuity, future projection, stable job creation and wealth generation.
- ADE Sodical in Castile and Leon strives to develop businesses in Castile and Leon by providing financial resources to companies, seeking the most appropriate formulas for each project and, especially, participating in the share capital, granting of equity loans and other alternative funding instruments.
- RICARI in La Rioja aims to collaborate in developing and strengthening economic and industrial activity in La Rioja while providing support for new business initiatives. Its goal is to work closely with the company as a partner and not merely a funder by providing strategic and management assistance without interfering with the company's day-to-day activities. Ricari seeks to maintain a close, constructive and continual dialogue with shareholders and the management team as a temporary partner, remaining amongst the shareholders for approximately 3 to 6 years.
- Avante in Extremadura furnishes services to companies and economic agents with a view to helping them contribute to the economic and social development of Extremadura in partnership with the regional government of Extremadura for executing its corporate policies.
- Corporación Empresarial de Extremadura: this entity provides backing for feasible and profitable initiatives that contribute to strengthening the business fabric in Extremadura.

4.6.3 Further Initiatives

Iberdrola also collaborates with other forums, associations and meetings for encouraging entrepreneurial activity, namely:

- As partner of the Spanish Association of Venture Capital Entities (ASCRI), Iberdrola is actively involved in its *venture capital* committee, which seeks to promote investment at the earliest stages (entrepreneurship).
- As partner of Innobasque, Iberdrola is a key member in the Cleantech INNvest investor network, promoted by Innobasque in the Basque Country.
- Additionally, Iberdrola sponsors various conferences and events related to entrepreneurial activities, including the *Spain Startup & Investor Summit*.

5.

Projects

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5.1. R&D&i in the Generation Area

Introduction

The R&D&i efforts in the Generation area seek to secure new developments that can drive the efficient running of our assets in operation, new technologies for improving safety, and the reduction of the environmental impact from this operation.

The projects undertaken in the **Operational Excellence** area are oriented towards a constant optimisation of operations, management of the useful service life of facilities and equipment, reduction in operation and maintenance costs, and minimize environmental impact with a with the aim of adapting to an increasingly demanding energy scene that motivates us to improve constantly in terms of not only technology but also processes and operations.

Various activities are also being carried out in **Energy Management and Energy Markets,** since it is essential to have an understanding of energy markets, scheduling, contracts and risk management for efficiently running generation resources. This is why most resources are employed in the new market analysis developments that are currently and will be shortly in operation with a view to improving the forecasting of fundamental variables and optimising contract models and risk control and management models so as to maximise the profitability-risk ratio. This area covers all activities related to new requirements concerning market transparency and integrity.

Iberdrola reinforces its firm commitment towards reducing the environmental impact of its generation plants through the execution of various projects in the field of **Environmental Technologies and Emissions Reduction,** to provide environmentally sustainable solutions to issues such as *macrofouling* in the cooling systems at generation facilities or the adaptation of power plants to the increasingly stringent environmental requirements, providing an alternative to high-cost commercially available solutions.

Operating Excellence

HIDROPOLO

Research into the fatigue of hydroelectric power generator poles

The project comprises research and studies on the different causes behind the appearance of certain surface crazing and defects affecting poles at hydroelectric power stations for subsequent research and development regarding a new design for rotor poles to lengthen the useful service life of generators, thus increasing the safety and security of the facilities and their workers.

This overall objective can be broken down into the following specific objectives:

- Increase knowledge in the operating condition of the power plant at all times through the study of phenomena that could provoke the loss of rotor poles, and thus increase the reliability and availability of hydroelectric power stations.
- Secure technologically innovative solutions that are technically and economically competitive in comparison with solutions provided by suppliers.
- Analyse, understand and increase the remaining useful service life of hydroelectric power generators.
- Increase the safety of the hydroelectric power generation facilities and their workers.

To achieve the proposed objectives, the project dedicated efforts in the following activities:

- Research in the remaining service life of the generators at hydroelectric power plants through a stress study on fatigue and cracks affecting the poles via different techniques.
- Development of new poles for extending the useful service life of hydroelectric power generators and thus increase the safety and security of people and facilities.
- Application of the method in real environments to check functionality and performance.

Pole 6 Work with *Hand Yoke*

HIDROFLEX

New hydraulic and mechanical design of the Francis turbine runner for flexible operation across a broad load range.

The main objective of this project entails the research and development of a new and robust design for the Francis turbine runner with excellent hydraulic and mechanical performance properties at partial load, increasing its flexibility and contributing to the integration of renewable energies in the energy mix.

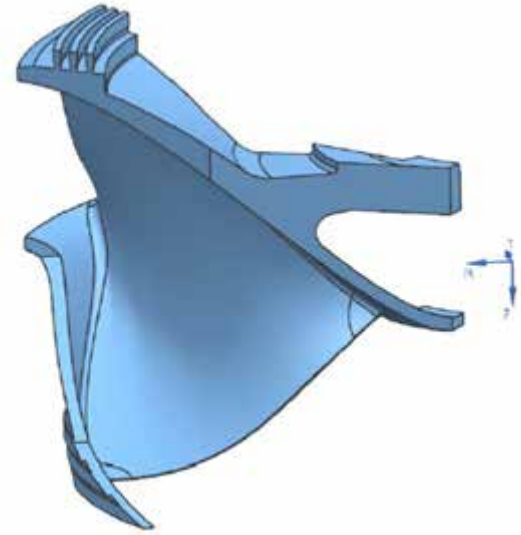
The specific objectives of this project are:

- Develop an experimental Francis turbine runner that can guarantee efficiency during operation between 20% and 100% of the maximum load to satisfy the flexibility requirements for hydroelectric power stations.
- Ensure that the parameters measuring mechanical and hydraulic performance (cavitation and vibration phenomena) are within the limits established for the operating range and expected service life.
- Reduce the effects occurring on the blades of the runner because of fatigue, erosion and corrosion phenomena that reduce the flexibility and safety of the system.
- Provide a new and innovative technological solution that efficiently increases the use of water at hydroelectric power plants and their flexibility.

To guarantee project success, the following development stages were executed:

- Analysis of current operations at the power plant.
- Technical and hydraulic design of the model.

- Development of the model and experimental tests.
- Model validation tests.
- Detail engineering design and development.



Selected runner

HIDRASENSE

New advanced air and steam detection technology in fluids at electricity generation power stations for efficiently managing energy resources

The HIDRASENSE project was conceived to develop an experimental system for detecting air bubbles (emulsification) and steam (cavitation) in fluids present at electricity generation stations, primarily thermal and hydroelectric power plants, through a photonic technique based on high-power lasers and wide-band photodetectors together with the required digital process. The project represents a very substantial step in the sector.

Example of optical air bubble sensor application in a dam

The specific objectives of the project are established as:

- Detecting real-time cavitation issues affecting the conduits in the hydraulic facilities at electricity generation stations, thus precluding problems derived from such issues.
- Detecting cavitation in dam drainage elements for spillway rapids and bottom drains alike to prevent undesirable effects: structural damage in the spillway rapid concrete, wear and even partial or total destruction of the elements such as the bottom drain valve.
- Developing an innovative management solution for reducing financial losses caused by unscheduled non-availabilities of thermal and hydroelectric power plants, and reducing the associated maintenance costs.
- Increasing the efficiency of the use of water resources as the raw material for generating hydroelectric power.

The project will remain active until the end of 2017 and is being deployed in the following stages:

- Theoretical study, requirements and specification of the system.
- Photonic sensor development.
- Design of the structure and installation in the plant.
- Characterisation in laboratory, calibration, validation and operating plan.

HORMIFLEX

Development of high-performance concrete

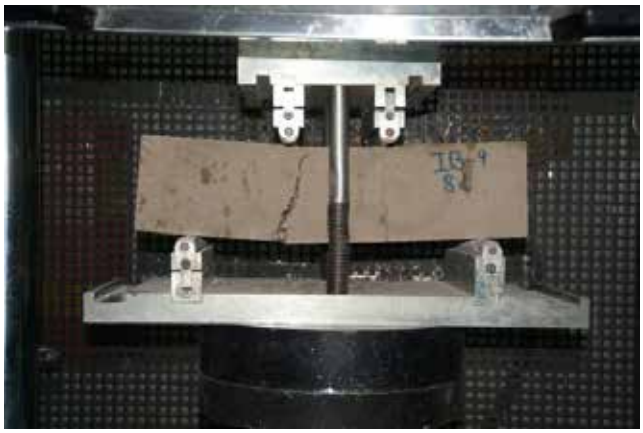
The overall objective of the project entails the research and development of a new sort of high-performance concrete to fill in the excavation between the ground and the high-pressure metal distributor at the Muela II hydroelectric power plant, hence reducing the generated stress states and providing a high-pressure piping in case of main conduit failure so as to guarantee the quality of the facilities, safety of the supply and environmental respect.

Some of the more prominent specific objectives proposed include:

- Determining the dosage of a concrete to meet elevated mechanical requirements: high tensile strength, elevated tenacity, compensated retraction (slightly expansive), low hydration temperature and employment: self-compacting and pumpable.
- Search for a material capable of high-pressure hydraulic containment.
- Attainment of a high-quality concrete of elevated impermeability that increases its durability against environmental aggression.
- Design of a concrete whose switch to production will pose no difficulties in either manufacturing or site application.
- Reduction in financial losses in case of breakage or failure in the main pipes at the hydroelectric power plant.

The following activities were carried out to achieve the expected objectives:

- Search for materials suitable for the composition of the concrete.
- Dosage study through experimental tests to determine the properties of the concrete.
- Continuous analysis of results to determine the optimum dosage.
- Definition of the main parameters for conducting the experimental high-performance concrete pumping tests, assimilable to the most unfavourable supply conditions at the site.
- Analysis of the results from different experiments and real environment tests.
- Development of a contrasting testing plan to validate the results.



Hormiflex

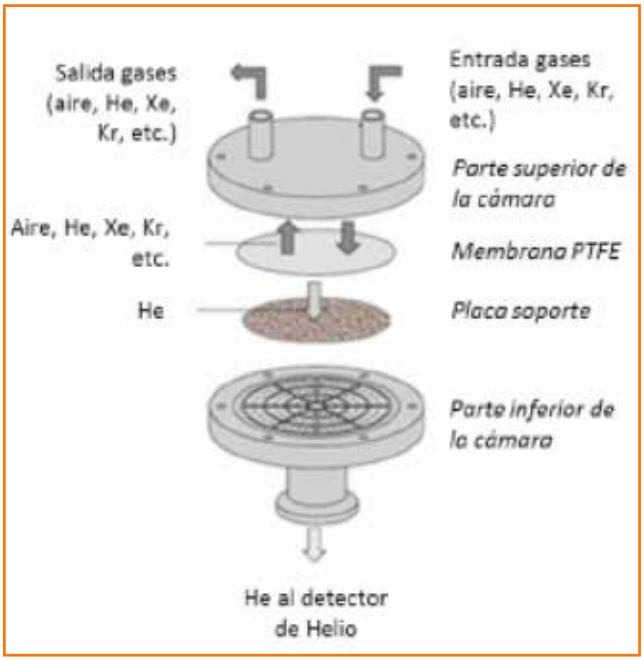
OFF-GAS

Continuous OFF-GAS monitoring

The overall purpose of this project entails the research and development of a new *Off-Gas* monitoring system for BWR (*Boiling Water Reactor*) nuclear power plants to assure the integrity of the reactor fuel and control rods by continuously measuring gases, retrieving data in real time to increase the response capacity in case of detecting a fault caused by a broken control rod or fuel failure.

Some of the most prominent objectives of the project include:

- Continuous monitoring of the concentration of helium in the gas flow circulating the *Off-Gas* line with a view to assessing the integrity of the control rods from the gleaned data.
- Ascertaining the integrity status of the reactor fuel and control rods at all times, and thus improving their operation management process so as to ultimately minimise the degradation of the cladding.
- Constant gleaning of gamma spectra in the *Off-Gas* line with a monitoring time that could be modified according to the specific activity of the sample, including spectrum processing and calculation routines necessary for securing the specific activity of relevant noble gases present in the line.
- Increasing the knowledge of the operating status of the plant at all times through the incorporation of variables from the new *Off-Gas* monitoring system in the plant process computer.
- Reducing the time necessary for conducting the power suppression (*Flux Tilt*) tests, reducing plant unavailability, dedication of laboratory personnel and their dose.
- Increasing the feasibility and availability of the Cofrentes Nuclear Power Plant by ascertaining the operating status of the plant at all times, which will enable the immediate engagement of protective measures upon detection of anomalies.



Gas separation chamber diagram

Life management

Ageing management of the reactor vessel interiors- isiONE Project

isiONE is an inspection management tool for vessels and interiors developed to fulfil the guidelines of an ageing and material degradation management programme in accordance with revision 2 of Guide NEI 03-08, "Guideline for the Management of Materials Issues", published by the *Nuclear Energy Institute* (NEI) in January 2010. For Boiling Water Reactor technologies , isiONE permits compliance with the requirements set out in the guide for implementing the programme effectively and demonstrably to third parties, which constitutes one of the pillars of the Life Management programme for the reactor vessel and interiors.

The implementation of isiONE includes the full assessment of the design bases; as-built configuration, record of assessments, inspections and repairs of all internal reactor elements; and the existing operating experience and requirements contained in the programme guides applicable to the specific configuration of the analysed plant interiors. This assessment is conducted by experts in BWR technology and degradation phenomena affecting the interiors of reactors of this sort, which thus ensures the comprehensive update

of all legislation, operating experience and recommendations applicable to the plant. Doing so secures an initial input for assuring full compliance with the requirements.

Feedwater

Development of a feedwater control system

The overall objective of the project is to develop a new single-fault tolerant feedwater control system with triple redundancy at the Cofrentes Power Plant that is integrated into a digital control platform to increase plant availability and guarantee operational safety, further honouring Iberdrola's commitment to more efficient electricity sources and supply guarantee.

Project development is supported by the following specific objectives:

- Optimising alarm diagnostics, thus increasing feedwater control system reliability.
- Improving management of the control system architecture, additionally equipping it with the acquisition of signals of a new nature.
- Bolstering the safety of the facility by reducing the frequency of trips, load drops and plant stops.
- Increasing the availability of the plant, resulting in enhanced performance of the energy generation process.
- Enhancing feedwater control system performance, reducing the trip average to below the average for boiling water reactors.
- Reducing faults and breakdowns in the feedwater control system components, costs associated with the maintenance tasks on it, and the loss of profits per trip, load drop or plant stop.

The project successfully achieved all the initially specified objectives. After designing and developing the new system, the in-plant validation tests were satisfactorily executed with a view to demonstrating system performance in supervising and controlling the thermal and electrical systems at the plant, and their success was likewise confirmed.

FUELTUBE

Transfer tube control system modernisation

The overall objective of the project entails the research and development of a new control process for the inclined fuel transfer tube to guarantee its operation during restocking spent fuel at a nuclear power plant with a boiling water reactor.

The following activities have been developed to achieve this objective:

- Design of the new algorithm for the inclined tube position decoder.
- Design all elements and components constituting the inclined fuel transfer tube system (IFTS).
- Development of the new IFTS control process from physical, mechanical, electrical and communications points of view.
- Experimental operating and validation testing of the new control system.

GT-CONTROLFLEX

Flexible gas turbine fuel control technology

The overall objective of this project has been to research and develop a new dynamic combustion model for the fuel chambers and a new thermal process study on the Gas Turbine (GT) at a Combined Cycle Thermal Power Plant to enable the simulation of new strategies in the flow-air ratio of combustion to reduce the technical minimum and favour the integration in the energy system of intermittent renewable energies.

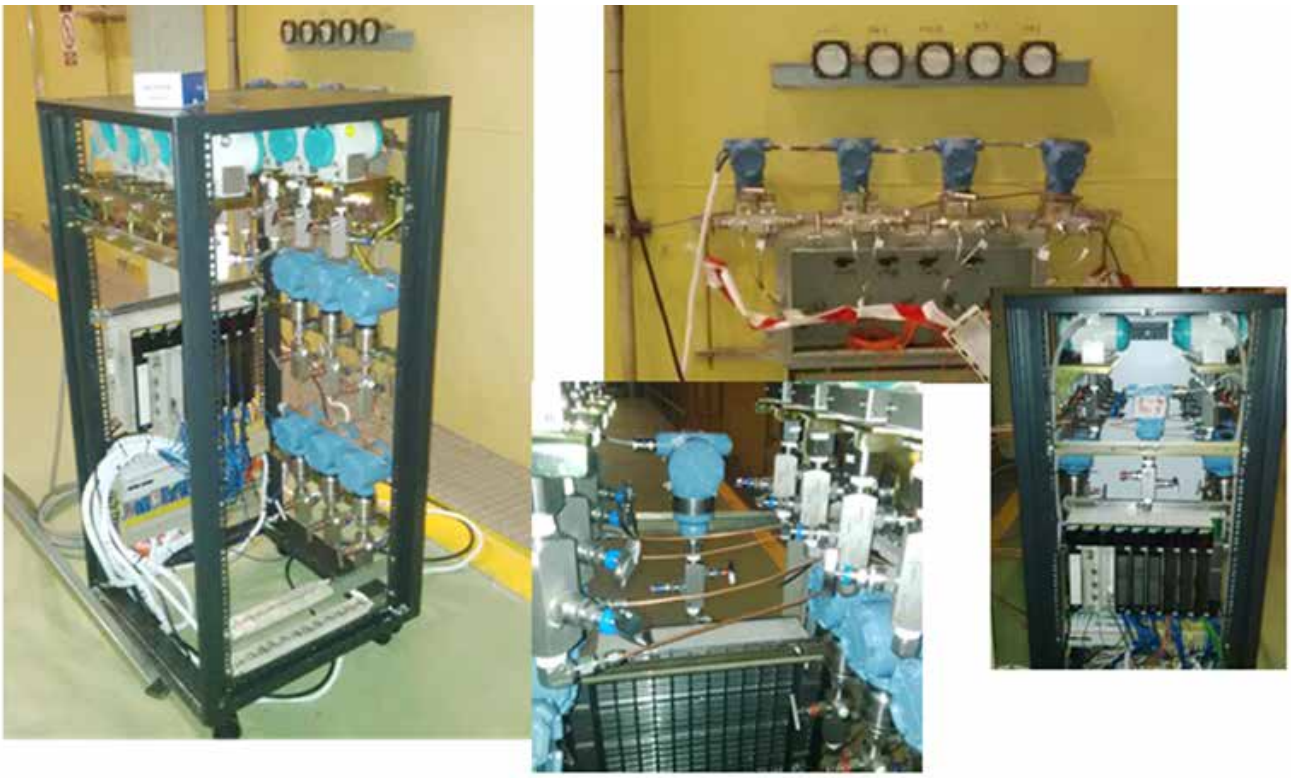
It should be noted that there is a socio-economic goal arising from the project regarding the reduction of the emissions of contaminating gases into the atmosphere, with particular attention given to nitrogen oxides (NO_x), given their contaminating effects and direct or indirect influence on global warming.

The specific objectives of this project are:

- Reducing the load technical minimum by up to 40% for a GT installation, maintaining the flame stability at low emissions and efficiency improvement in all load condition ranging within the minimum and base loads.
- Ascertaining the gas turbine's combustion dynamics through new theoretical combustion chamber models.
- Securing technologically innovative solutions that are technically and economically competitive in comparison with the products presented by gas turbine manufacturers and technologists.
- Reducing the startup and shutdown times to gain better service in operating the Spanish electricity system.

Culminating in 2015, the project successfully achieved all the initially proposed objectives, since it was able to reduce the technical minimum of the GT at the Aceca plant, enabling the reduction of polluting gases while reducing the startup costs on gas consumption.

Moreover, this ground-breaking technology was able to be extrapolated in three other plants: Arcos III, Castellón IV and Tarragona Power, which also secured success, thus ratifying its competitive character in responding to the needs of the Spanish electricity market.



New components

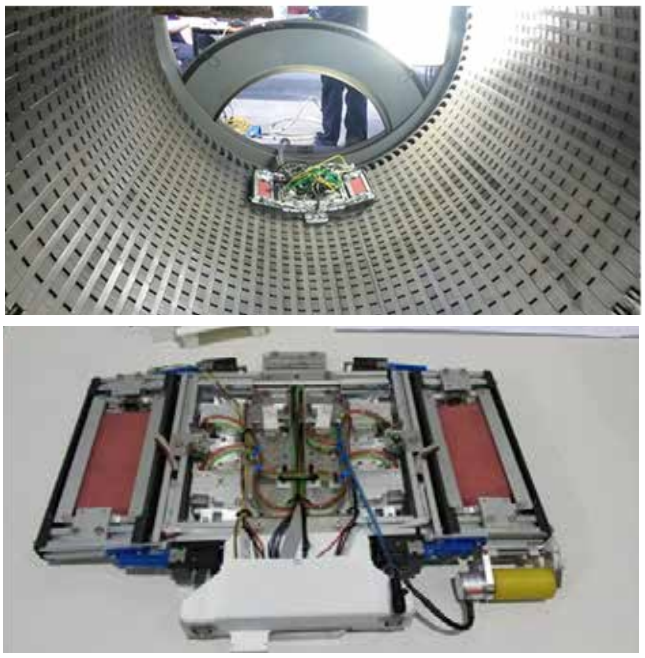
SIRO

Electricity Generator Robotic Inspection Probe

This project aims to research and develop a new system for inspecting the gap between the generators and the rotor so as to conduct visual inspections and testing for an efficient and reliable assessment that guarantees the interoperability of all alternators (generators) in the IBERDROLA fleet.

The specific objectives of the project include:

- Developing innovative assessment technology to reduce scheduled generator downtime.
- A new inspection probe applicable for all turbogenerators and hydropower alternators with a capacity greater than 10 MW in the fleet.
- Reducing the risks arising from mounting and dismounting tasks in alternator testing in limited accessibility conditions and minimum degrees of dismounting.
- Researching a solution that could reduce losses of profit resulting from system shutdowns.
- Equipping IBERDROLA with proprietary innovative and cutting-edge technology, hence the strategic nature of this project of global application that guarantees the independence of technology suppliers, and achieving a faster response to their specific requirements.



Current probe situation

Completed in 2014, the project satisfactorily developed innovative technology for evaluating generators that can be applied to turbogenerators and hydropower alternators with a capacity greater than 10 MW, thus complying with its initial objectives and enabling less financial losses caused by system stoppages.

INSROCA

Robot for inspecting the pressurised recovery boiler elements

The main objective of this project entails the research and development of autonomous inspection technology for detecting steam leaks situations in recovery boilers at combined cycle plants to thus speed up repair times and enable effective preventive maintenance.

This project is centred around the following specific objectives:

- Developing a technology for accessing the recovery boilers at combined cycle power plants and detecting potential faults, thus enabling a virtually immediate repair while precluding wait times and optimising their operation.
- Developing positioning and sensor subsystems whose integration as a unit is capable of detecting leaks before plant personnel can physically access the boiler.
- Providing combined cycle thermal power plants with the flexibility required by the Spanish energy system, minimising the inefficiencies causing downtimes.
- Equipping recovery boilers with ground-breaking technology to increase their accessibility and simplify control regardless of their extreme operating conditions (elevated pressures and temperatures).
- Research into a solution for reducing losses caused by system downtimes, which are calculated at approximately 20,000 €/h in electricity generation for a 400 MW cycle.
- Developing a proprietary tool for conducting preventive maintenance on boiler collectors that are currently inaccessible. This tool will

enable the detection of cracks before they cause a forced non-availability in the boiler.

Following the stages for initially studying, designing and developing the technology, and through the positive results secured in the testing stages in the laboratory (cold and hot) and on-site (cold), the project concluded satisfactorily as it achieved the expected goals.

We are currently awaiting to establish an appropriate maintenance window at one of the combined cycle power plants in Spain to validate use in actual situations with the boiler cold and hot.

INSROCA Prototype

ECRIGEN

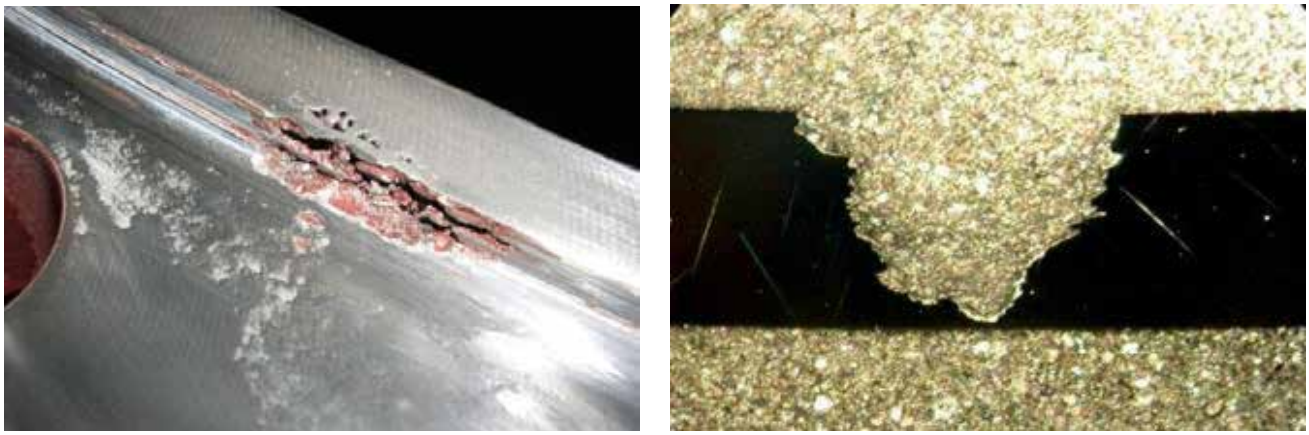
Enhanced reliability of critical systems and equipment at generation stations

The project seeks to expand understanding while improving the reliability of critical systems in IBERDROLA generation plants to optimise their operation and thus guarantee electricity generation. The project comprises three lines of research:

- Development of a dielectric oil analysis method to ascertain the degree of ageing of a power transformer's solid insulation.
- Development of an early fault diagnostics system for rotating machines through lubricating oil analysis.
- Performance evaluation of components subject to highly aggressive operating conditions (elevated temperatures and/or high corrosivity) such as boilers, seawater cooling circuits and effluent systems.

Concluded in 2014, the project achieved all its specified objectives:

- Development of a proprietary method for ascertaining the content of furans present in dielectric oil, especially 2-FAL (2-furaldehyde, furanic compound formed by overheating as a result of a fault in the transformer). This method was patented and implemented in the predictive maintenance of the entire fleet of transformers at the generation facilities. A model has also been developed and validated for assessing the ageing of the cellulose insulation in power transformers.
- The research and analysis of the variables influencing the in-laboratory diagnosis quality of the analysis on industrial oils enabled us to develop an expert diagnostics system



Corrosion in duplex stainless steel type 2205 (left) and austenitic stainless steel type AISI 316L (right)

equipped with criteria for assessing lubricants optimised specifically for the IBERDROLA fleet.
- Establishment of a corrosion resistance ranking for different materials in the specific environments at IBERDROLA power plants.
- Characterisation of the properties of welds and repairs on high-temperature materials used in boilers at thermal power plants.

Flexibility and Efficiency Measures

A project was launched in August 2014 to improve the design of the degasser at the EW Aranda cogeneration plant, ultimately with the objective of optimising its performance at low flow levels of steam and, in doing so securing an estimated savings of 0.3t/h in terms of steam.

The savings in primary energy generated in 2014 alone from the implementation and development of the project amounted to 1.8 GWh.

The EW Cartagena cogeneration plant is hosting a project to replace the third stage of guide vanes in the Gas Turbine (GT), through the new model with an optimised profile to improve the GT Heat Ratio by 0.8%.

A potential primary energy savings of 6.4 GWh was verified since the project began in 2014.

ITSASERAUPEN

Offshore structure corrosion and macrofouling prevention

The 'ITSASERAUPEN' is an R&D initiative aimed at reducing wear caused by seawater corrosion at generation facilities. This initiative arose from the need to alleviate the technical and economic issues that certain electrical facilities are facing because of seawater, namely offshore wind farms and generation plants that utilise seawater in their cooling systems.

The final goal established for the project is to create a series of high-performance and environmentally sound products that can meet the working conditions of marine environments, where wear from highly aggressive corrosion occurs the most.

To do so, some of the generation plant elements exposed to these phenomena will be manufactured with a new design, thus affecting components such as conduits, valves or heat exchangers, and materials, and coated with corrosion protection materials of various natures (ceramic, polymeric or hybrids).

These elements will then be installed in a seawater cooling system and their progress will be thoroughly analysed and compared with conventional materials.

Additionally, the equipment, systems and components in generation plants currently facing corrosion issues will be identified and the best solutions applicable for each case will be examined.

Grille, water treatment plant, Mesaieed

Box supports in the electrochlorination building, Koudiet CC

All developments encompassed in the ITSASERAUPEN project will be made in terms of a full Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) conducted on the solutions to generate, including base materials, manufacturing processes, application and even integration at the offshore plants.

Generalised corrosion on bolts and flange, Mesaieed CC

NDT

Guided Wave Non-Destructive Testing

A key factor in determining the condition of pipework that is exposed to high temperature and pressure stresses is the routine evaluation of such pipework using Non-Destructive Testing (NDT) techniques. Conventional Ultrasonic Testing (UT) of service material relies upon local access and therefore incurs significant access and insulation costs. This project brought together the engineering teams of Iberdrola and ScottishPower to conduct a trial using a Long Range Ultrasonic Testing technique (Guided Wave Testing) to inspect long runs of steam pipework at Longannet.

Due to the wall thickness and welding arrangement of main steam pipework at Longannet, it was necessary to construct a test piece in order to fine tune the Guided Wave Testing technique specifically for use with this material and to ensure that it would be able to identify defects.

FGC

Shoreham Fuel Gas Compressor Coalescing Filter

The Shoreham fuel gas compressor (FGC) is an oil lubricated reciprocating piston type compressor which supplies gas to a gas turbine. The FGC uses a wet lubrication system to lubricate the pistons. During 2014, an inspection of the Gas Turbine revealed that, as a consequence of this system, oil had been entrained into the gas stream. This oil has to be removed to prevent the gas turbine burner system becoming blocked by carburised oil having the potential to adversely impact the emissions performance, efficiency and availability of Shoreham.

Although the original design and installation of the compressor included an oil scrubbing system to remove the oil, this proved to be ineffective in removing smaller particles of oil below 5 micron. As a result, a study of alternative systems was reviewed and a new oil filtration system using coalescing technology was developed to remove the smaller particles of oil. The filtration system was arranged in a duty/standby arrangement with an innovative cross over pipe to allow the dual filters to be operated in series if required. The whole system was skid mounted and arranged to eliminate modifications to the existing pipework. An automatic condensate blow down and recovery tank was included in the system design.

Coalescing Filter

RYE HOUSE PRESERVATION

Development of Preservation of UK CCGT

Rye House CCGT obtained a contract for limited operation throughout 2015. One aspect of this arrangement required Rye House to be put in preservation for an extended period throughout 2015. The degree of preservation had never been experienced by ScottishPower previously. The project required a detailed investigation into the plant layout, areas that would require to be preserved as

well as possible access points to install a series of dehumidifiers. The project was undertaken in close collaboration with Spanish colleagues to develop an understanding of the measures that the Spanish CCGT fleet had adopted. During this collaboration, it was established that there were a number of significant differences between Rye House and the Spanish CCGT fleet in terms of the layout of the plant, particularly the air cooled condenser, requiring a significantly more detailed assessment of the preservation requirements for Rye House

Compensation Turbines

Hydro Group Compensation Turbines

In 2015, a potential development of compensation turbines was investigated within the ScottishPower hydro group in conjunction with Iberdrola's colleagues from the hydro department in Spain. The project required the development of new knowledge associated with the possible pressure heads and water flows in the areas around some of the Hydro sites. Modelling of the pressure gradients and flows was carried out for the varying river conditions that were likely to be experienced.

Predictive Monitoring

Predictive monitoring systems for generators in hydroelectric power stations

The project aims to developing an industrial piece of equipment for monitoring the condition of generation units to render an early diagnosis of faults through voltage and current waveform analysis.

To date 11 monitoring system units have been installed in the generation units of the NEOENERGIA Group and are being studied and tested to assess their practicality and effectiveness.

Predictive monitoring

Auxiliary Motor Systems

Development of the first Auxiliary Motor System Condition Controller assembly

Through this project, the NEOENERGIA Group seeks to develop, build and install the first parameter controller assembly for analysing and diagnosing breakdowns occurring in systems with a view to enabling predictive maintenance for anticipating possible faults. The project also aims to improve the specifications of the prototype at all levels to either prevent or rectify any faults occurring previously.

Six controller units have already been built and are installed at the Termopernambuco Power Station.

Auxiliary motor monitoring systems

Energy Management and Energy Markets

REMIT

Operational transparency in markets

Facing a market growing ever more global and competitive where there is a need for optimising margins, controlling risks and improving asset management, there is also an arising need for guaranteeing operational transparency in the markets where IBERDROLA participates. With these factors in mind, work began on the REMIT project. This project seeks to develop advanced tools for guaranteeing transparency in trading operations via three basic components:

- Developing the framework for precluding the use of insider information (non-public information)
- Surveillance to forestall market manipulation
- Reporting on operations for supervision

PREVER

New Energy price and demand forecast risk mitigation method.

The overall aim is to develop a European-level integrated energy trading management and energy market transaction decision-making methodology for efficiently operating generation assets, actively managing the risks of open positions, and securing new ways of forecasting energy prices.

Successfully concluded in 2014, the project achieved all the specific objectives proposed, namely:

- Research and development of a European-wide energy trading operation risk management methodology and ascertain the risk level to which the company's financial activities were exposed.
- Develop a new price forecasting methodology enabling the definition of a global trading activity management strategy.
- Design and develop a new medium-term simulation tool regarding Iberdrola basins for a given management decision.

BID Monitor

The intelligence of a machine harnessed to support decision-making regarding electricity sales

This Elektro project seeks to develop a system capable of compiling and analysing data from different sources to build a database with the greatest amount of information possible on the Brazilian energy sector and other public sources (such as climatology and macroeconomics). This system enables behavioural tracking on data generated by small generators and electricity sales distributors alike, alerting and providing early support to technicians who must make decisions so they can accurately ascertain when and how much electricity should be sold or bought at a given moment by either entering into long-term contracts or trading on the retail market.

This project seeks to establish a methodology and some tools for supporting decision-making processes related to electricity sales that will reduce uncertainty, mitigate potential errors in contracts, and maximise the benefits of the process.

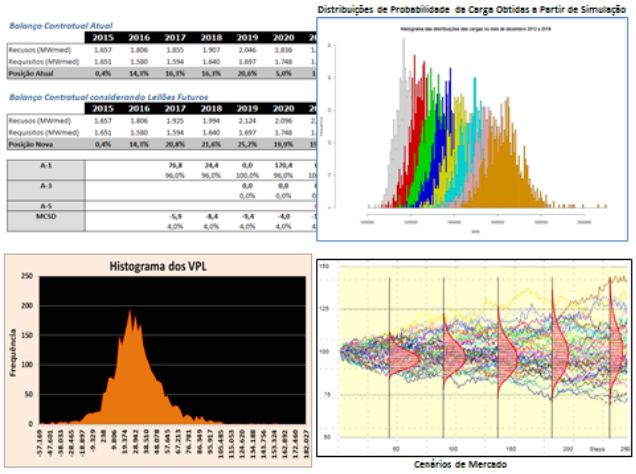
Mathematical Optimisation

Mathematical support model for energy sales decisions.

One goal of a distributor is to contract all the energy corresponding to its market on the Sales Market within a 5-year horizon to avoid penalties in case of energy deficit or surplus. The calculation of this tariff is very complex given the uncertainty of the market growth rate and the existence of multiple types of contracts and energy retailing mechanisms.

In this regard, Elektro seeks to develop a decision-making support system using Mathematical Optimisation, which considers the regulatory specifications for retailing and market behaviour/conduct, to ascertain the best contract strategy for each future scenario. The target is to reduce deviations to no higher than 5%, which would thus

lower the costs for Elektro should it need to revert to subcontracting energy.



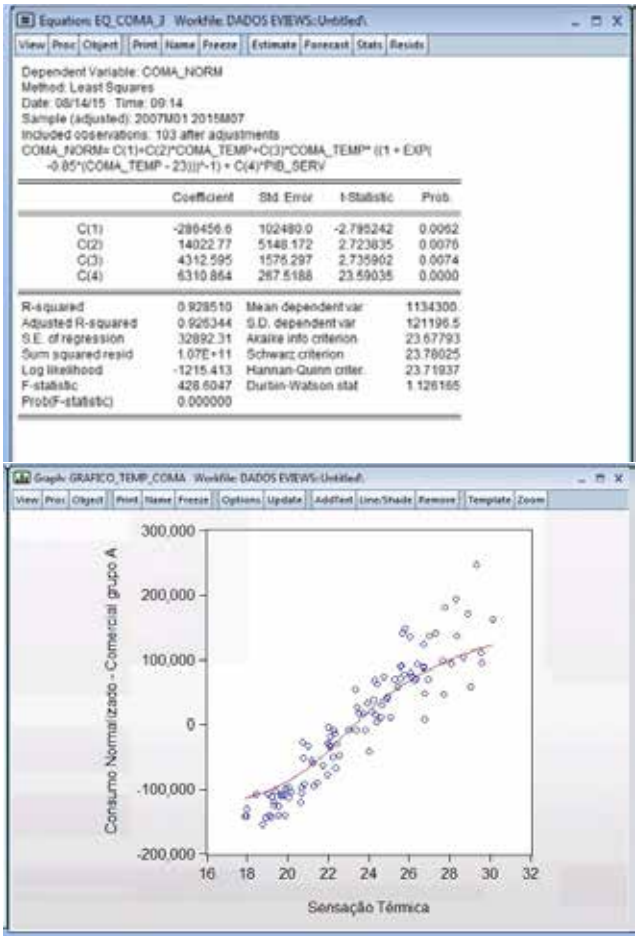
Mathematical support model for energy sales decisions

Temperature

Non-linear estimate between consumption and temperature

Elektro and other Brazilian electricity distributors have been deeply affected in recent years by adverse weather conditions in terms of both operation as well as energy consumption. Many studies point to an overall increase in consumption patterns caused by the steep increase in purchases of domestic cooling and ventilation devices. In this context, it would seem essential for a distributor to have a decision-making support system that could incorporate weather indicators into demand forecast models.

The project was therefore conceived to create a forecasting model that could accurately capture the effect that temperature has on energy consumption. To achieve this objective, Elektro will employ an original system known as *Smooth Transition Regression*.



Temperature estimator programme

Reserves

Statistical model for forecasting affluence levels and water reserves.

The water reserves in Southeast/Central-east Brazil combine to make up nearly 70% of Brazil's hydroelectric power generation capacity, though in recent years they have been lower than their historic average.

In this context, between 2014 and 2015, Elektro developed a statistical model for estimating both the inflow as well as the level of reserves at these locations in the upcoming years. This model enables simulation of diverse scenarios and is useful for calculating the probabilities needed to make decisions regarding the energy rationing that may become necessary in the coming years. The model retrieves data from the NOAA (*National Oceanic and Atmospheric Administration*) such as water

temperature or rainfall levels and then employs the Monte Carlo method of multivariate computation.

Water resources map

ESC

Energy Smart Community

The New York Public Service Commission has introduced the concept of the utility as a Distribution System Platform (DSP) that would act as a system and market enabler of distributed energy resources. The DSP would utilize Distributed Energy Resources (DERs) to make the electric utility system more efficient and increase societal benefits such as reduction of emissions.

The DSP functions would include:

- Integration of DER in utility planning and operations
- Operation of a distributed energy management system to act as a platform for DER products and services
- Creation of transparent pricing mechanisms to enable a distributed market
- Engaging customers to be active participants in the market

The Companies filed a proposal to implement an *Energy Smart Community* wproject with the New York State Public Service Commission in May 2015. The Energy Smart Community will serve as a platform for initiatives and technologies that will advance the Company's ability to service as DSP. The project will enable identification of methods that successfully engage customers, the community, and the market. The project will allow the Company to deploy certain foundational investments in a concentrated geographic area and lessons learned will help shape strategies for more effective and efficient deployment throughout the Company's service territories.

Environmental Technologies and Emissions Reduction

MIGRES

Development of a comprehensive method for managing control bars and channels as radioactive wastes.

This project addresses the development of a new comprehensive for used control rods and fuel channels of a nuclear power plant using *Boiling Water Reactor* (BWR) technology, and radioactive waste that will enable a sustainable management thereof, whereby reducing the volume of the stored waste to more effectively occupy the space designated for storing waste of elevated activity and minimising management costs.

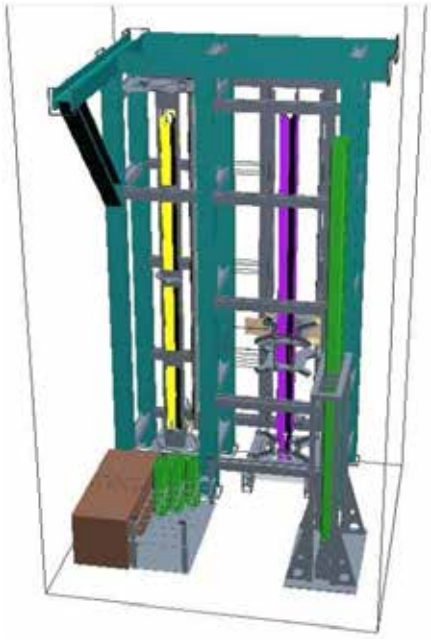
The following specific objectives have been established:

- Adaptation of the nuclear core design and management codes of the Cofrentes Nuclear Power Plant to directly secure the neutron flux data necessary for estimating the isotopic inventory of the rods depending on their operation history.
- Reduction in the occupation level of control rod hooks in Fuel Storage Pools to enable refuelling in 2021 with no operating restrictions on the Cofrentes Nuclear Power Plant.
- Design of an integrated process that, by reducing waste volume, enables a subsequently efficient and rapid management when permitted to be shipped to centralised storage.

- Schedule of cutting and conditioning operations to minimise the possibility of contaminating fuel pools with effluents from rods or cutting particles and waste.
- Reduction in opening and closing of gates between the different pool areas to minimise the possibility of faults or losses in the seals of these gates.

To achieve the proposed objectives, the project was divided into three stages:

- Initial research on the installation and establishment of prerequisites: analysis of previous information and assessment of nuclear waste characterisation techniques.
- Design and development of new technology for managing control bars and channels at BWR power plants: this activity comprises the development of methods for radiologically characterising control rods and channels, and the cutting and conditioning of waste, in addition to the design and development of an experimental prototype.
- Development of technology tests and validation.



Migres structural design

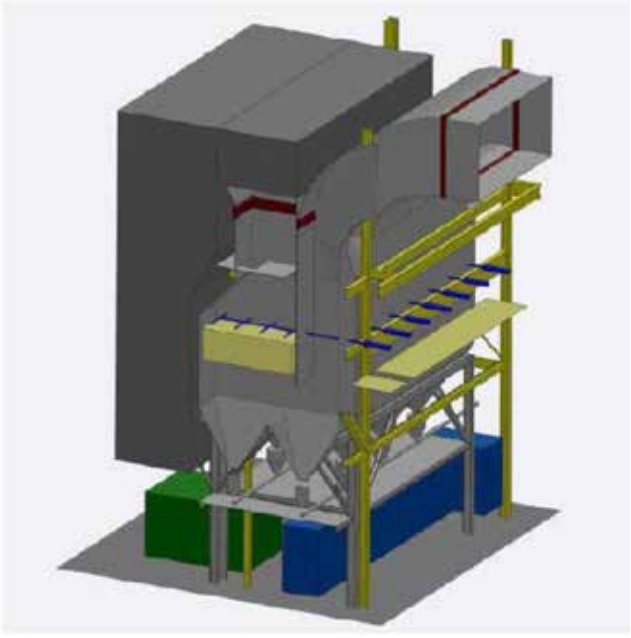
COEBEN II

Clean coal combustion technologies

This project addresses the development of unconventional technology for the abatement of catalytic NO_x at the Velilla del Rio Carrión thermal power plant that has a potential for integration with other primary and secondary mitigation measures. Capable of providing massive reductions in NO_x, this technology was developed to adapt current facilities with no need to make substantial construction modifications.

The execution of the project, which concluded in 2014, can be considered as a huge success viewed in technical and economic terms. The achieved objectives include:

- Development of an advanced technology for reducing NO_x that has the potential to transform the Velilla conventional thermal power plant to ensure the technical-economic feasibility of the use of Spain's anthracite coal supply.
- Development of the pilot plant, definition of its operating protocol and base functional validation for each of the developed critical elements.



Conceptual diagram of SCR U-TYPE technology with a catalyst layer

- Design and execution of a set of experimental tests within a normal operating mode of the experimental reactor (long and short duration), which, working together with other reduction technologies, enabled us to satisfactorily attain the sought-after NO_x levels.
- Total NO_x (catalytic and non-catalytic) reduction of up to 88.4% at intermediate load, 80.4% at full load and 76% with the technical minimum.

ALGAEFIX

Capture and bio-fixation of CO_2 through microalgae

The purpose of the project is to study the technical-economic feasibility of a CO_2 capture and bio-fixation process using microalgae at an industrial electricity generation plant with a view to yielding products of added value by transforming pollution into products that are useful to humans. To do so, a new design for flat vertical reactors will be used. The efficiency, production potential and CO_2 fixation capacity of this design are greater than conventional open reactors.

The key points developed for creating the CO2ALGAEFIX prototype are:

- Research and implementation of a method for capturing and temporarily storing CO_2 such as a combustion gas treatment system.
- The use of real combustion fumes from an industrial plant is a European-level innovation.
- System for cultivating and producing migroalgae using flat vertical reactors. No (pilot or pre-industrial) plants currently use this type of cultivation system, which represents a universal innovation.

DESOx

Advanced desulphurisation process control system

Implemented at the Lada Coal-fired power plant in Asturias (Spain), the project focuses on developing an integrated and technologically advanced system for reducing SO_x emissions and other effluents from desulphurisation to considerably reduce the environmental impact generated, while increasing the overall generation process and determining the optimal conditions for plant operation.

Final DESOx installation

The project entails the development of a new advanced desulphurisation control and management system that incorporates operating and environmental variables to attain greater flexibility in fuel purchase management while increasing the thermal power plant's competitiveness.

Successfully concluded in 2014, the project secured a wealth of knowledge on the desulphurisation process at the Lada thermal power plant. The project therefore achieved all its initially stipulated goals:

- Increasing the plant's overall efficiency.
- Preventing erosion-based material resistance issues in the desulphurisation facility caused by the lime current recirculating in absorber pipes.
- Improving the recovery of gypsum generated as a subproduct of desulphurisation.

SMARTCOx

Advanced CO_2 capture technology

The SMART CO_x project was conceived to develop an advanced, modular and scalable CO_2 capture technology for small industries, institutional buildings, residential areas and factories that is simple, easy to implement and low cost.

The following design activities were executed to build the first prototype with this technology:

- Design and integrated development of an innovative modular CO_2 capture prototype that is reconfigurable and scalable.
- Development of an innovative system of heavy duty smart diffusers that can adapt to the varying characteristics of the fumes to process.
- Innovation in a flow and smart valve control system for configuring operation according to the physical characteristics of the incoming airflow (pressure, gas concentration, etc.).
- Design of a gas conditioning system for emissions treatment and its rapid adaptation to the conditions required for adsorption based on the material.
- Design and development of highly efficient and modular treatment chambers enabling the optimisation of adsorption and desorption, and capture unit flexibility and scalability.
- Design of an innovative absorbent material regeneration system to extend the useful service life and efficiency of the system.

To validate the results insofar as capture volume and efficiency, an initial prototype was developed with the following components:

- Construction of a prototype for a new diffusion system.
- Construction of a prototype gas adaptation system for different emission sources.
- Construction of a prototype for an integrated CO_2 capture system.

Longannet Combustion Optimisation

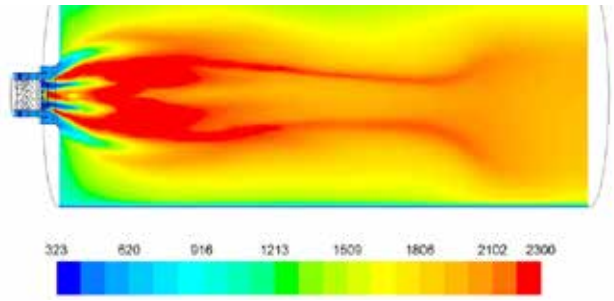
Emissions monitoring and sprayed fuel distribution systems at Longannet

With this project, ScottishPower intends to implement a series of measures at the Longannet Thermal Power Plant to ensure compliance with NO_x emission limits according to the Industrial Emissions Directive (IED).

New Flexicom system installed

The solution entailed installing an emissions monitoring system (ABACO Opticom) and a pulverised fuel distribution system (Flexicom). NO_x is produced as a result of the chemical reactions between the fuel and combustion air at the elevated temperatures of the furnace.

Essentially, the Flexicom system concentrates the fuel to the lower portion of the furnace. This reduces



Temperature profile of a burner at Longannet

the overall temperature that the furnace will operate to and also increases the residence time of the fuel in the furnace, which further reduces NO_x. The ABACO monitoring system optimises the combustion process through an expert control system. Flexicom is an innovative emissions reduction system, with Longannet being the first of this type of application on a front-wall fired furnace

The system was commissioned, optimised and performance tested during 2015 to fully evaluate its overall performance. This technology was previously validated at the Velilla thermal power plant in Spain.

In parallel with this new technology and in partnership with the University of Glasgow, we developed a modelling study on the NO_x burners existing at Longannet, employing Computational Fluid Dynamics (CFD) models to enhance the original design and configuration with a view to being able to reduce NO_x emissions.

5.2. R&D&i in the Networks Area

Introduction

Unmanageable renewable energy generation sources have been steadily increasing their participation in the generation mix of developed countries. This is a reality that also entails new challenges for the electricity distribution grid, which was designed for another context of energy flows. It is thus essential to overcome the challenges facing grid operation and management to efficiently harness this new production of distributed electricity production and facilitate their integration, supporting efforts to reduce carbon emissions into the atmosphere while safeguarding the quality and safety of their supply at all times.

The current concept of grid management must now mature into a concept of system management with a grid incorporating new functionalities (Smart Grid) based on new communications technologies and IT, thus affording greater visibility to the events at each grid coupling point (remote management, remote metering), greater automation levels (real-time operating assistance systems), cutting edge generation plant protection systems, and a broader capacity for demand and supply production management.

Smart Grid is a technological evolution of the energy distribution system that combines traditional facilities with modern monitoring technologies, and information and telecommunications systems. Iberdrola hones its efforts in innovation on the grids area to offer a broader range of services to customers, improve supply quality, respond to society's future demand for electricity and achieve optimal power distribution management.

Smart Grids

UPGRID

Real and tested solutions to enable the flexible integration of active demand management and distributed generation

Low-voltage (LV) and medium-voltage (MV) grids are currently afflicted from local accumulations of distributed generation, resulting in increased risks and difficulties in managing the distribution network. Similarly, the lack of observability and control means that the LV grid cannot be operated and maintained under optimum conditions.

This project therefore proposes a standardised, open and integrated improvement to LV grids by developing four demo facilities running in a real smart distribution grid environment. They are currently being deployed at the following sites in Europe: Bilbao area (Spain, using the Bidelek Sareak demo project), Parque das Nações in Lisbon (Portugal), the municipality of Åmål (southern Sweden) and the municipality of Gdynia (northern Poland).

The project is pursuing the following objectives:

- Developing and validating solutions to allow advanced functionalities to be added to existing technologies, thus setting up a truly integrated smart system.

LV Grid Management System Basics

- Improving observability and control capacity of LV and MV grids so as to better anticipate technical problems associated with the large-scale integration of distributed generation, while also bringing end consumption (LV and MV) closer to operating and planning systems.

This three-year project got under way in January 2015 under the European Horizon 2020 (H2020) programme developed by an Iberdrola-led consortium comprising nineteen partners from seven different European countries: Spain, Portugal, Sweden, Poland, the United Kingdom, France and Norway.

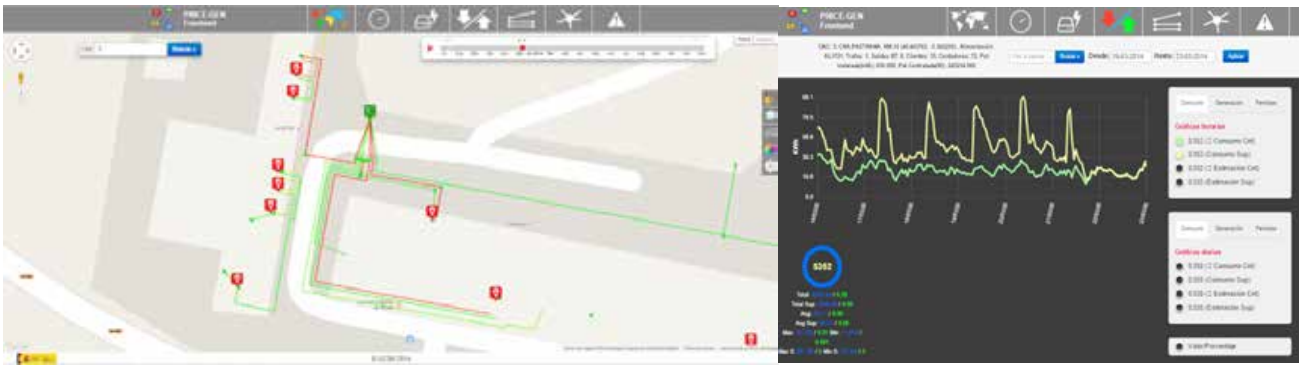
Spanish demo location

PRICE

Henares Corridor Smart Grids Project

The PRICE project (Henares Corridor Smart Grids Project) encompasses various areas to cover the needs identified for developing a smart grid within a framework of efficiency, safety and sustainability. The overall objectives were:

- Monitoring and automating the low-voltage and medium-voltage (LV/MV) power grid, improving operation and maintenance.
- New energy management system.
- Improving the integration of the already existing distributed generation.



Energy Balance Tool (UC3M)

- New options and services for integrating the demand.
- Contribution to interoperability and common open standards.

Successfully concluded in 2015, the project achieved all the targeted global objectives, distributed in four essential blocks/sub-projects to advance in the concept of *Smart Grids*. The examined areas and particular advances secured by each subproject were:

- **PRICE- RED: Monitoring and Automation**
  Through this project, we were able to develop a new smart and interoperable grid platform by integrating systems and equipment into transformer stations, thereby allowing us to monitor and automate the entire MV distribution grid.

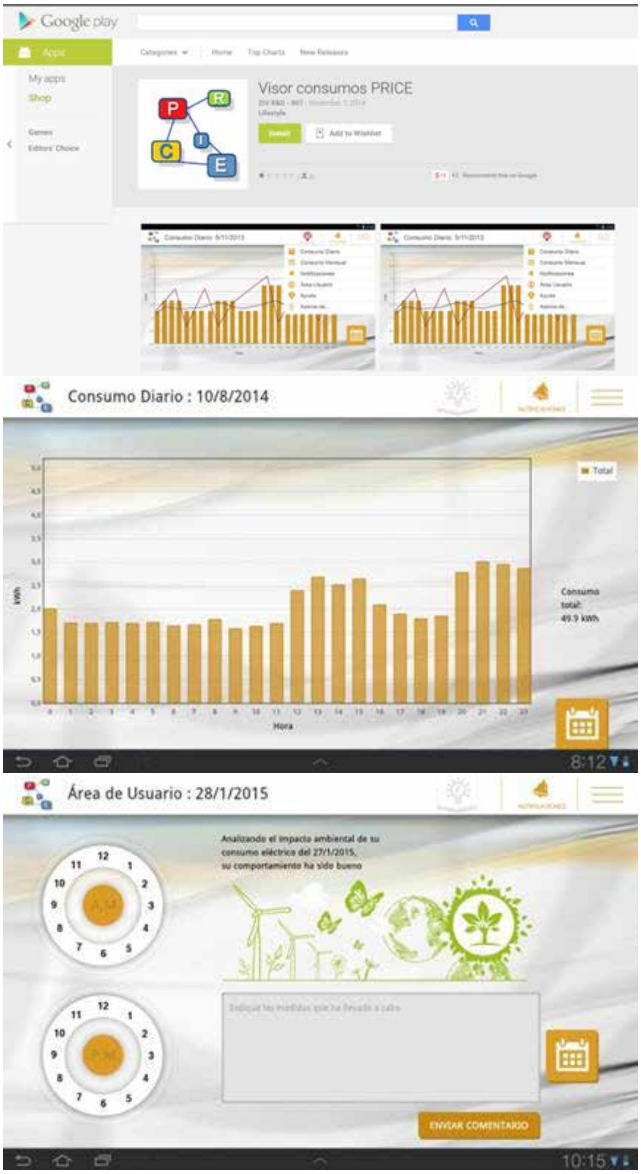
- **PRICE- GEN: Energy Management**
  The PRICE-GEN project culminated with the development and implementation of an optimum and interoperable grid architecture that satisfies the new needs of the smart grid. Doing so required the development of new smart metering devices (concentrators) to secure punctual consumption and generation data of not only customers but also the power grid (LV supervision). The Energy Balance tool produced during the project proved to be a salient tool, as it enabled the detection of non-technical downstream losses (LV grid) at the MV/LV transformer level.

- **PRICE- GDI: Distributed Generation**
  This project enabled the development of a new distributed generation management system with a view to guaranteeing the quality of the electricity supply for future electricity-related scenarios characterised by an elevated penetration of energy resources distributed through the grid. To that end, a new system for monitoring generation at the distribution level was created along with new power electronics solutions

MV STATCOM (PV solar farm, La Herrera, Albacete)

that enabled not only stabilisation of MV and LV grid voltage but also, in connection with distributed generation units, grid operation support. Doing so facilitates the integration of distributed generation in the electricity distribution grid.

- **PRICE- GDE: Demand Management**
  The PRICE-GDE project successfully developed a platform (DSO / TSO Demand Management Office) for communicating and coordinating with grid operators, i.e., distributors (DSO) and carriers (TSO) alike, in terms of managing the electricity demand of homes and electric vehicles. This platform is capable of modifying the demand curve by sending technical and non-technical setpoints. This system enables multi-directional communication for all involved agents, including the final user through the home viewer tool that can send comments and receive consumption data and setpoints, thus simplifying Efficient Demand Management.



Herramienta/App Visor Consumos PRICE

GRID4EU

Large-scale demonstration of advanced smart grid solutions

The aim of the project is to test innovative conceptual systems and technologies under real conditions in order to highlight and attempt to remove some of the barriers (technical, economic, social, environmental and regulatory) to the use of smart grids, and to achieve Europe's objectives for 2020. Smart grid potential has been tested through the integration of renewable energies, the development of electric vehicles, grid automation, energy storage, energy efficiency and shorter recharging times.

The project studies how distribution system operators can dynamically manage and match supply and demand, which is crucial when it comes to integrating large volumes of energy from renewable sources and allows consumers to become actively involved in choosing their energy. Lastly, these innovative concepts and technologies must offer a suitable cost/performance ratio, thus increasing grid reliability, flexibility and resilience.

The project is being carried out at six pilot areas to provide a more transversal investigation process while allowing the results to be shared amongst the different power distributors involved in the project.

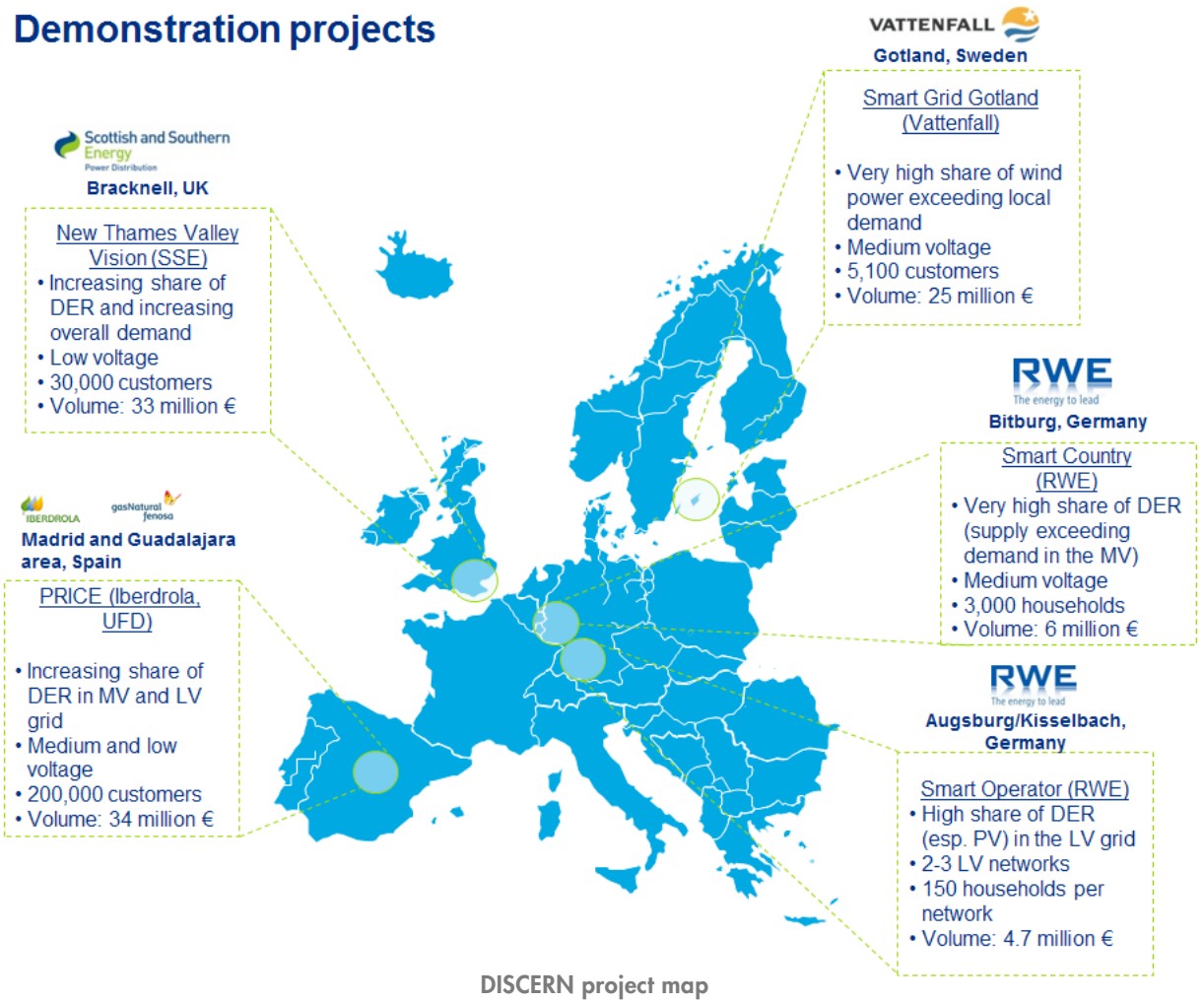
The project will run for four and a half years, ending in 2016. The main challenges are:

- Optimised and ongoing integration of a number of small and large-scale energy resources.
- Balancing of intermittent energy resources (including more accurate predictions) with demand response and storage.

DISCERN

Improving the operation of distribution networks through optimal use of distributed intelligence.

The DISCERN project (*Distributed Intelligence for Cost-Effective and Reliable Distribution Network Operation*) aims to assess the optimum level of intelligence to be installed on distribution grids so as to determine replicable technological solutions that will enable development without comprising grid reliability, profitability and controllability. This will ultimately allow for more rational grid management and better planning of grid scale and extension, thus facilitating the large-scale introduction of renewable distributed generation.

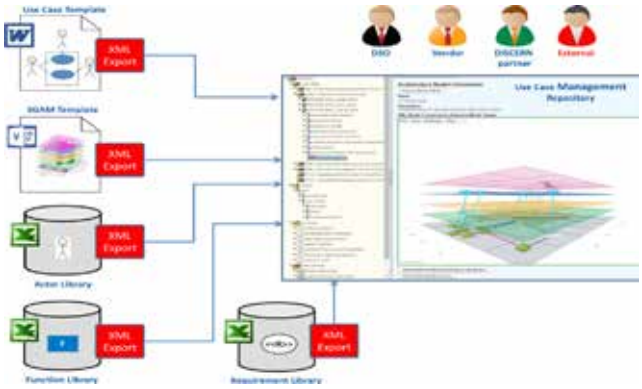


DISCERN project map

The project provides recommendations for optimum levels of intelligence distributed across medium- and low-voltage grids. These recommendations have arisen from an analysis of five previous projects operated by five major European distributors, and also of field tests conducted during the project on a number of the recommended technologies implemented at three distribution networks.

The project is therefore divided into three areas:

- Validating the demonstration projects and creating use cases: analysis and comparison of solutions by defining common use cases for all projects.
- Simulation and testing: simulations and roll-outs of the demonstration projects to validate the solutions and measure their performance through the use of key performance indicators (KPIs).



Access to the management repository/ Model architecture information

ADVANCED

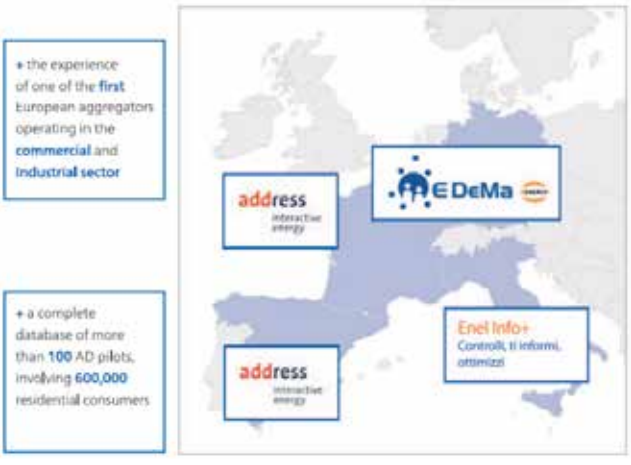
Empowering smart customers to participate in active demand management and thus bolster electricity supply efficiency

The ADVANCED project (*Active Demand Value And Consumers Experience Discovery*) has concentrated its efforts on developing an action plan for implementing Active Demand Management (ADM) / Active Demand (AD) for residential, retail and industrial customers across Europe. This plan was developed based on indicators of social-economics, customer behaviours and experience acquired in other European initiatives already developed in earlier projects.

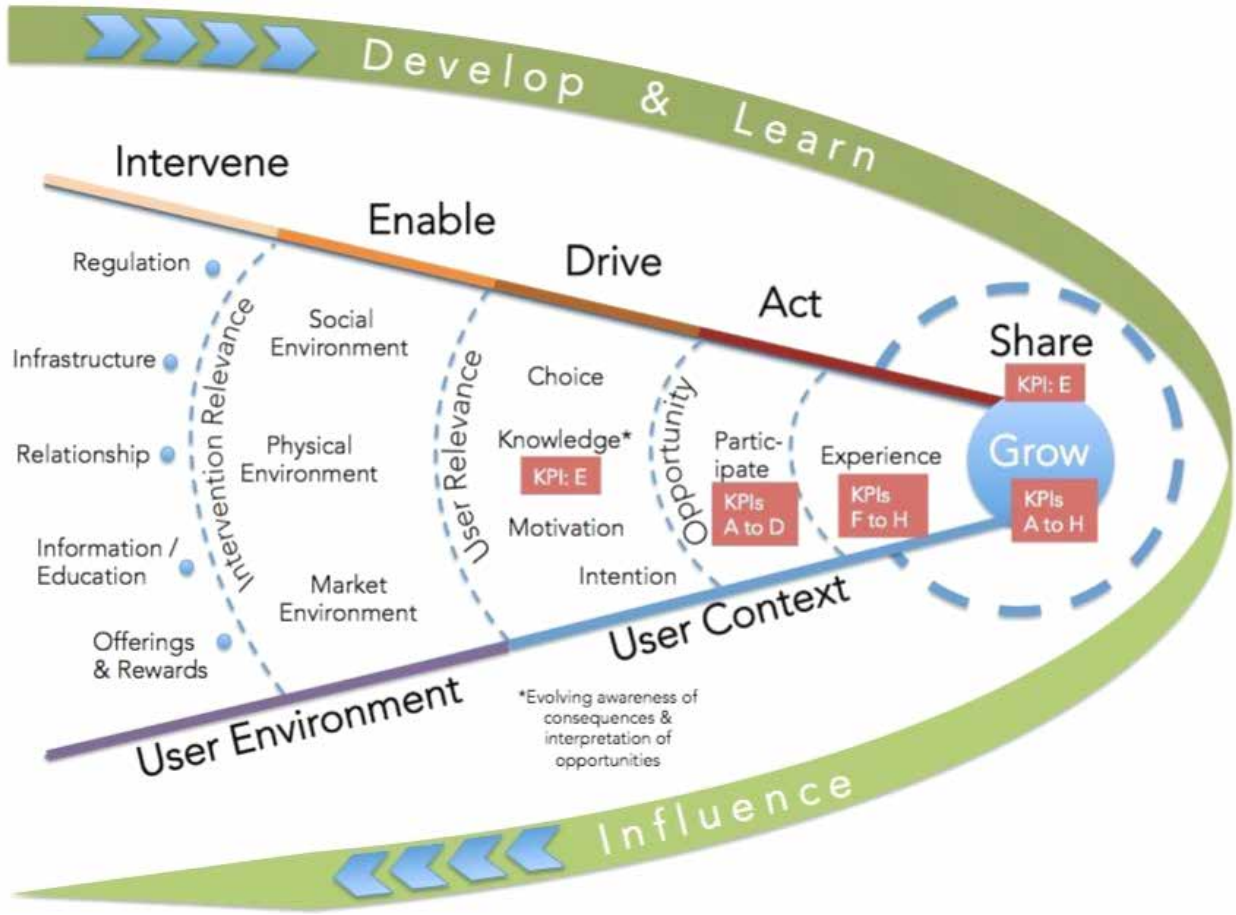
The work undertaken throughout the project ultimately produced a conceptual model for characterising the active participation of customers in ADM. This model incorporates all the relevant variables identified during the project and their interrelationships. The model is now the basis structure of the knowledge gleaned during ADVANCED and has been validated throughout the project based on the analysed experiences. Roadmaps were also drawn up to simplify ADM implementation to encompass within the residential (including small retail) and industrial scopes.

The specific objectives of this project were:

- Assessment and comparison of case studies to understand the breadth required for actually implementing the pilots.
- Substantiation of the benefits yielded by the participation of customers as key roles in the AD.
- Analysis of the inherent impacts of the electricity system in light of its potential contribution to the stability and efficiency of the system.
- Development of benchmark frameworks (with validated recommendations through an efficient AD programme) with a view to enabling residential, retail and industrial consumers to actively participate in the demand, thus simplifying AD expansion throughout Europe.



Demo projects that provided field data to the project



Conceptual model developed in ADVANCED regarding the participation of customers in Active Demand Management

On its conclusion in December 2014, and following the analysis of four prior demonstration projects in Italy (Info+), Spain (ADDRESS, Spanish demo), France (ADDRESS, French demo) and Germany (EDeMa); and a database of ADM projects conducted around the world, the ADVANCED project confirmed the importance of active demand participation. The flexibilities that AD can afford the system were calculated based on an optimistic technical scenario. Bearing in mind that the overall potential of AD across the residential, retail and industrial sectors, the potential for the available AD is immense and should be explored further in the four countries.

GRID+

A network of projects that are developing Europe's future electricity grids

The overall goal of this project was to implement and support the framing of the EEGI (European Electricity Grid Initiative) between 2012 and 2014 both inside and outside Europe's borders. Through the research and study of new banks of knowledge necessary for implementing smart grid solutions as effectively as possible, distribution through European grid operators can be improved.

The work plan was organised based on the following activities:

- Research mapping, development, demonstration and implementation of solutions for the network of smart grids inside and outside Europe.
- Commitment with smart grid initiatives having a global perspective.
- Definition, update and use of key performance indicators, and the revision of financing mechanisms.
- Support to extending replication activities and results of R&D&i projects in EEGI from technical, economic and environmental aspects.

- Provision of regular revisions of the EEGI implementation plan insofar as progress concerning TSO (Transmission System Operator) and DSO (Distribution System Operator).
- Project management and interaction with customers and partners.

	-1	Not relevant
	0	Ready to deploy at large scale
	1	Need more demonstration or pilot projects to validate the maturity
	2	Need moderate development (work with manufacturers)
	3	Require more research (work with research institutes)

GRID+

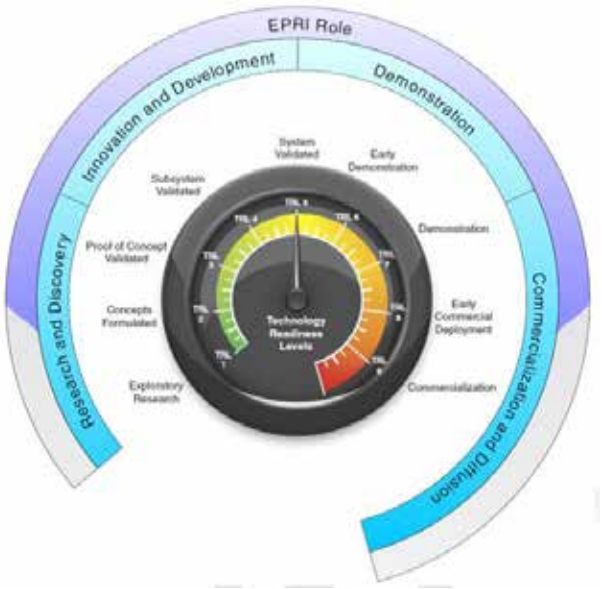
METER ON

Establishment of a network of national R&D demo projects regarding smart grids and processing data and the metering infrastructure

This project seeks to guide the implementation of smart metering infrastructures throughout Europe by compiling the most successful experiences and showcasing conditions to enable their development. On the basis of lessons learnt, the purpose of the project was to provide any interested party with an open information platform having clear recommendations insofar as how to address the technical barriers and legislative barriers that might hamper the adoption of smart metering technologies and solutions in Europe.

The project was carried out through the following activities:

- Compiling smart metering projects.
- Analysis of each project in accordance with the set of identified information domains.
- Recommendations insofar as the path to follow based on lessons learnt from more successful past smart metering experiences.
- Dissemination of smart metering knowledge gleaned and generated to stakeholders through a variety of tools and channels.
- Appropriate project and activity management and coordination, thus enabling communications amongst all project partners and final users.



Smart Transformer

Development of a smart distribution transformer

The purpose of the project is to develop a distribution transformer prototype that includes *Smart Grid* technology for the real-time monitoring of elevated electricity volumes. Equipped with an internal overvoltage safeguard and automatic pick-up system. Through wireless communication, the equipment provides the Operations Centre with information on the status of the grid.

The project is implemented as a pilot through the companies in the Neoenergía Group. There are currently four systems installed in Salvador and three in Feira de Santan. The system has been patented at the Brazil Patent and Trademark Office.

Smart Transformer

Smart Sensors

Development of a series of wireless communication sensors

The goal of this Neoenergía project is to develop a series of wireless communication sensors that enable remote monitoring of the electricity grid from the control centres. These sensors will thus enable the detection of faults in distribution lines and improvement of the supply quality. They have been approved and installation has begun: 237 units in 2015 and 155 more expected during 2016.

Wireless smart sensor

The sensors pertain to a new innovation project, whose purpose is to develop all the technology necessary to enable the future implementation of *Smart Grids*.

Optimised Load Management

Real-time management of the electrical systems

Neoenergía seeks to create a robust system comprising metering equipment installed in distribution circuits and a telecommunications system that includes heavy duty processing hardware and software designed for the real-time management of electrical systems.

The software is already installed and actively used in the operations area. There is a possibility of integrating this solution as a smart grid system module currently under development. The patent is already registered at the National Patent and Trademark Office.

Smart Grids

Implementation of the concept of Smart Grids in pilot towns with strict environmental restrictions

The project seeks to implement a smart grid model on the island of Fernando de Noronha, using the Neoenergía distribution grid as the test and experiment bench for applying this new technology.

A significant part of the telecommunications, micro-metering, automating and micro-distributed generation structures are already installed on the island of Fernando de Noronha and commissioning of the structure is expected for April 2017.

Grid Management

Definition and development of a Smart System for handling the Efficient Technical Distribution Grid Management

The project seeks to create a technical management system comprising smart meters, data concentrators, data transmission applications and control and simulation software. The system is oriented for

operational analysis, protection, supply quality, non-technical losses and scheduling.

The *Smart System* is currently installed in the pilot stage at Neoenergía and its corporate use expected.

Smart Communication

Smart Communication System amongst Operating Centres

The project aims to create an assembly of electronic circuits and a series of transmission antennas as a reliable communications system between Operating Centres based on distribution codes, and between metering centres and the meters themselves installed at customers's facilities.

The system was installed in the town of Gravatá and is undergoing a prior testing stage before possible corporate use at Neoenergía.

Smart Communication project testing

Microgrids

Distributed generation with alternative and renewable energy sources

The goal is to install and implement a pilot system of micro-distributed generation grids to work with alternative and renewable energy sources (solar power, fuel batteries and micro-wind turbines). They should include energy metering platforms, which are of particular interest to Elektro, and consider bi-directional information flows and supply quality.

The research currently in progress will increase the knowledge and expertise on the new methods of metering electricity centred on reactive power. This will provide greater accuracy in estimating the impact that distributed generation microgrids, included in the plans to upgrade and modernise the electricity metering farms, have when coupled to the low-voltage grid. The goal is to afford greater visibility regarding technical losses, marginal costs and prices establishment to be able to integrate Distributed Generation to the grid.

Smart City

City-wide implementation of a benchmark model based on *Smart Grids*

The project began in August 2014 for the purpose of creating a large test bench to become a benchmark *Smart Grid* model for the future implementation of *Smart Cities*, contemplating the different innovative solutions for the automation and operation of energy grids, distributed generation, remote metering, electric vehicle integration and new services for customers. The city of Sao Luiz do Paraitinga was selected to implement and test this project.

This Elektro project will enable us to ascertain the main technical impacts of modifying customer energy consumption habits. Through community participation and awareness-raising efforts, we expect to achieve greater levels of efficiency based on the rational use of energy and thus establish the concept of a *Smart City*.

Sao Luiz de Paraitinga

Smart Grids are currently considered to be the main technological breakthrough in energy distribution systems that the international scientific-technical community is targeting in its research. Smart grids are capable of bearing a massive amount of billing, regulation, device status and security data. This is therefore an electricity supply system that responds to and communicates directly with customers. Now there are many facets in this technology, as *Smart Grids* are based on efficient energy management, rapid system recovery following an interruption, and greater interaction between distributors and customers. Smart Meters, which are equipped with communicators and computing systems, are nevertheless the starting point to implement any *Smart Grid*. The foregoing broadens our views on these new technologies, enabling us to build a new concept in terms of communication, control and metering that we can refer to as a *Smart City*.

The major outcomes include:

- Developing a distributed generation system, installing 270 solar panels in 7 residential areas, 3 public buildings, a shopping centre and an Elektro centre. The total installed power capacity reached 63.25 kW and a 2.4 kW wind turbine was also installed.
- Installing new public lighting, comprising 120 LED streetlamps. Additionally, an energy and lighting profile was drawn up for the entire city to optimise their use.
- Commissioning of an advanced metering infrastructure employing radio-frequency meters.

Ciudad Inteligente

ARC

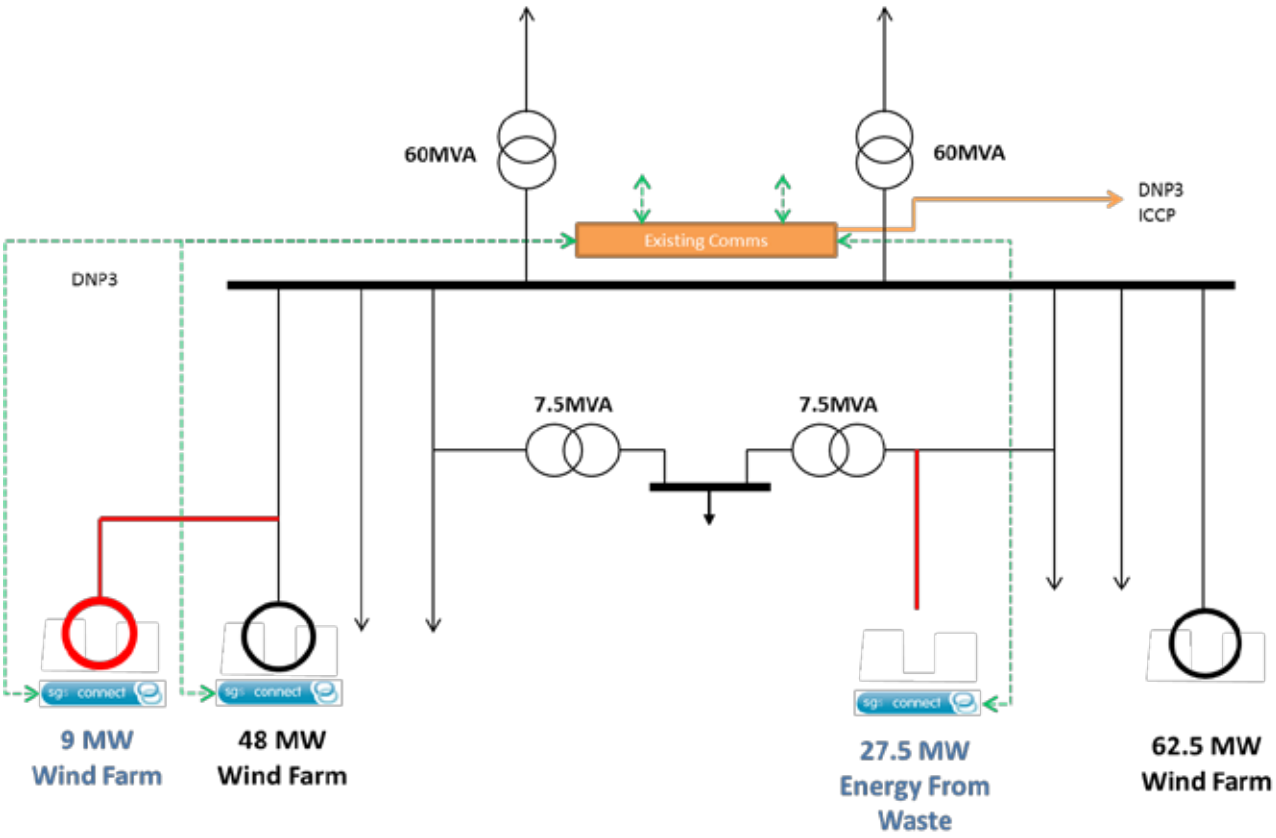
Accelerating Renewable Connections

ARC was conceived to accelerate the process and reduce the time necessary to connect renewable generation to the electricity grid. ScottishPower is developing this project in collaboration with Community Energy Scotland, Smarter Grid Solutions and the University of Strathclyde. ARC will help communities consume locally produced energy, thus allowing generators to produce more while benefiting from the consequent reduction in costs.

An Active Network Management (*ANM*) system is being tested. This system enables new generators to connect to the network more quickly and cheaply in areas where the network was previously thought to be at full capacity. The project has been launched in the regions of East Lothian and Borders, an area covering some 2,700 square kilometres from North Berwick to Holy Island, and from Hawick and Galashiels (Scotland).

Thanks to this development, renewable energy generation projects will have the opportunity to be connected to the distribution network sooner if they accept that their energy export will be matched to meet network constraints on a minute by minute basis. which is defined as a Actively Managed generation connection since generators can be asked to reduce or increase their generation to meet local electricity demand and other network factors. This process is called Active Network Management (ANM). As more electricity is used in the area, more electricity can be generated. Work is underway with local organisations to develop new ways to tally locally produced energy with local demand, thus creating the opportunity to enable more network access for generators at times when generation export is high.

The ARC Project won the "Best Innovation" award at the *2015 Scottish Green Energy Awards*.



ARC Diagram

Flex Nets

Flexible Networks

This ScottishPower project is part of OFGEM's "Low Carbon Network Fund" programme. The aim is to provide solutions and alternatives, spearheaded by distribution network operators, to increase and enhance the capability of the networks resulting in an additional 20% headroom capacity. The project was undertaken between 2012 and 2015.

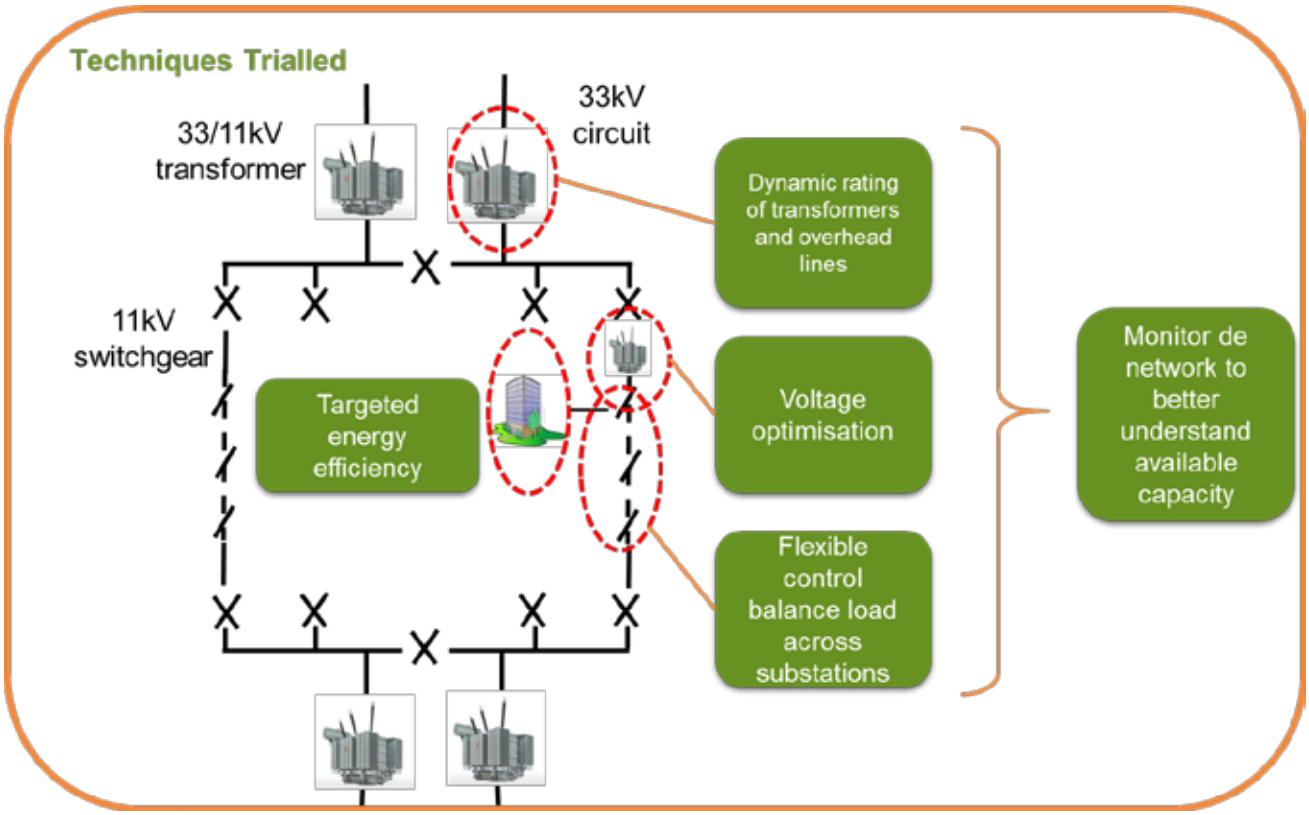
The main reason behind the project was to allow more low carbon technologies to be integrated without adversely affecting the quality of supply while also postponing network reinforcements until there is greater certainty on the nature of future loads thereby avoiding inefficient network investments.

A series of innovative solutions already exists to increase network capacity margin, but they are not yet sufficiently developed technically and/or economically. The aim of the project is to increase network capacity by 20% through a series of innovative measures. This will allow more customers to make the transition to new low carbon technologies.

Certain conflicts exist between ideal network design, operation and management of the distribution network, whereby a more comprehensive focus such as the one undertaken at FlexNets will simplify interaction between the functions of business, planning, operations and asset management to optimise developed tools and techniques.

The aims of the different activities are as follows:

- Developing an improved network monitoring methodology, developing tools that optimise the integration of low carbon technologies and using innovative techniques that are being trialled.
- Trying out novel measures to enhance grid performance such as dynamic characterisation of the thermal response of assets, voltage optimisation and flexible network control.
- Identifying solutions with which to demonstrate as effectively as possible the key improvements in the cost of adapting to future energy needs.



Flex Nets Diagram

- Developing investment plans and future deployments for the most cost-effective technologies
- Disseminating learning amongst key stakeholders such as customers and other network operators to ensure sustainable implementation through future shifts in technical and regulatory policies.

VISOR

Visualisation of Real Time System Dynamics using Enhanced Monitoring

VISOR is a ScottishPower project funded by the regulator OFGEM through its NIC (*Network Innovation Competition*) programme.

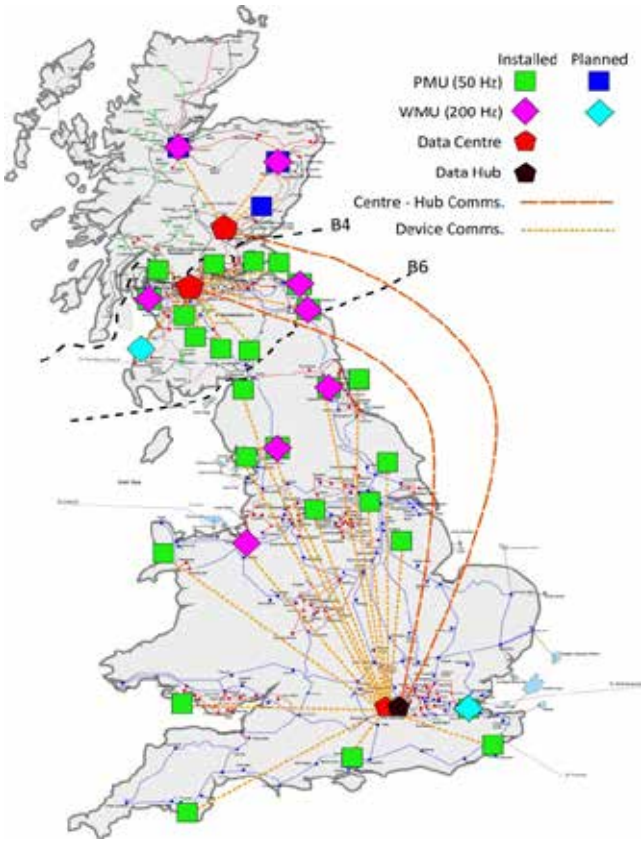
The goal of this project is to develop a Wide Area Monitoring System (WAMS) for the UK's transmission grid, which encompasses 3 separate Transmission Owners (TO). Combining synchronised measurements from all three TOs to improve visibility of dynamic system behaviour and enhance network resilience, increase network capacity and deliver savings to customers.

The project is underpinned by a groundbreaking data acquisition infrastructure consisting of new monitoring units, data centres and dedicated servers, communicating via a new high-performance communication link between the three TOs in Scotland and England.

It provides a potentially avoided investment benefit of £45m for every 100 MW capacity realised. It will also provide the system operator with the ability and confidence to harness the full capacity of the grid where increasing volumes of wind generation lead to more volatile system flows, resulting in greater operating margins to maintain and manage grid security. A conservative estimate of operational savings is £4m per annum.

The WAM system will also provide transmission owners with a risk-mitigating measure in a period of uncertainty to help safeguard the grid against low-probability high-impact events that may result in partial or widespread system failure.

VISOR seeks to improve understanding in two essential areas of the transmission network: Real-Time System Dynamics and Sub-Synchronous Oscillation Monitoring made possible by the aforementioned synchronised integration of the measurements from the three grids. Improving our understanding of such phenomena will allow us to get more from existing assets, and ensure the system remains reliable as the grid becomes more diverse.



VISOR System

There are a couple of 'pinch-points' in the GB transmission network, where constraints (forced reduction in generation) are frequent. The England-Scotland boundary is one such pinch-point, where wind generation in Scotland is often constrained off and replaced by generation elsewhere. This comes at a cost to the customer and restricts the installation of new wind farms in Scotland.

Furthermore, due to the increasing diversity of generation, HVDC links, and other power electronic devices, the dynamic behaviour of the GB system is becoming increasingly complex. This is reflected in the appearance of new and dynamic modes of power oscillations, which are referred to as Sub-Synchronous Oscillations (SSO).

The greater understanding of SSO enabled by VISOR will enhance grid resilience and optimise system stability limits, thereby effectively increasing grid capacity using existing assets. This translates into an increase in generation capacity and alleviating generation constraints for generators.

HVDC

High-Voltage Direct Current Western Link

The amount of renewable energy generated in Scotland is rising fast, but it cannot be transmitted to the south of the country as the existing electrical connections are at full capacity.

HVDC Western Link will be the UK's first subsea direct current transmission interconnector using paper polypropylene laminate (PPL) technology to link West Scotland's transmission network to that of North Wales; along the Irish Sea by way of a 380 km-long high-voltage underwater cable. This project, partnered by ScottishPower, aims to develop the world's longest 2.4 GW-capacity DC cable and work at 600 kV. The national transmission grid uses alternating current, but the conversion to direct current was essential to prevent the effects caused by energy losses in long high-voltage cables.

To that end, the following activities have been proposed:

- Making technical advances in high-voltage cable insulation for use with high-capacity, high-voltage direct current.
- Developing advanced filters that prevent the appearance of harmonics and their potentially damaging effects on other electrical equipment connected to the network.
- Acquiring the technical knowledge to analyse the lack of compactness anomalies in cable insulation.
- Improving cable manufacturing processes.

HVDC Western Link

ANGLE-DC

Medium-voltage direct current cable

The 33 kV distribution network on the Island of Anglesey is increasingly congested due to increased demand and the number of distributed generation connections. ANGLE-DC is an innovative project partnered by ScottishPower that seeks to demonstrate a practical, flexible method for reinforcing distribution networks by adapting AC assets to DC operation. ANGLE-DC will adapt existing power electronics technology to construct a medium-voltage direct current (MVDC) cable for simplifying the integration of renewable resources and accommodate future growth in demand. The activities will be as follows:

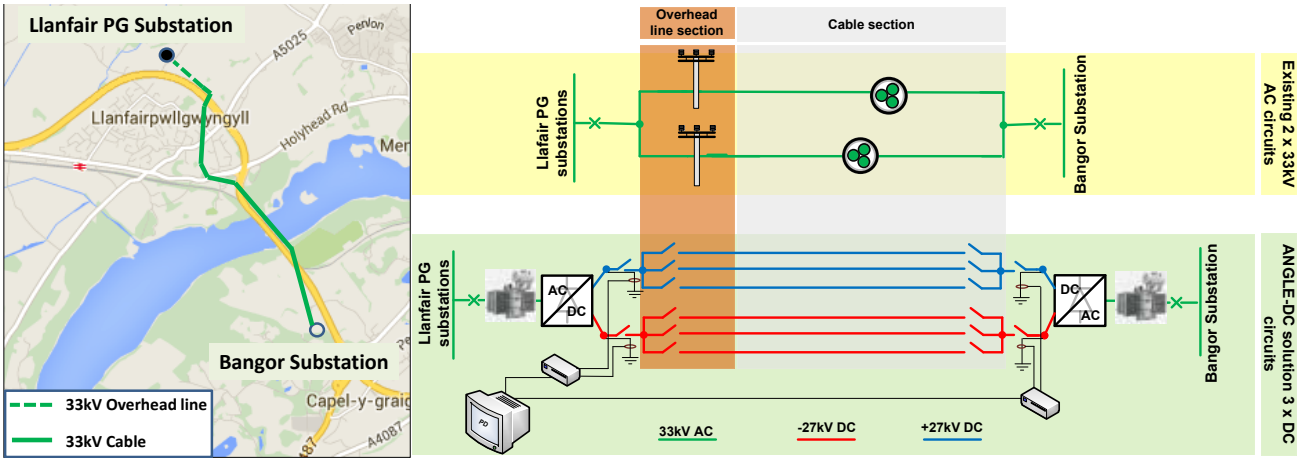
- Integration of an MVDC line into the UK distribution grid
- Conversion of AC circuits to DC operation
- Full monitoring of all converted DC circuits

FITNESS

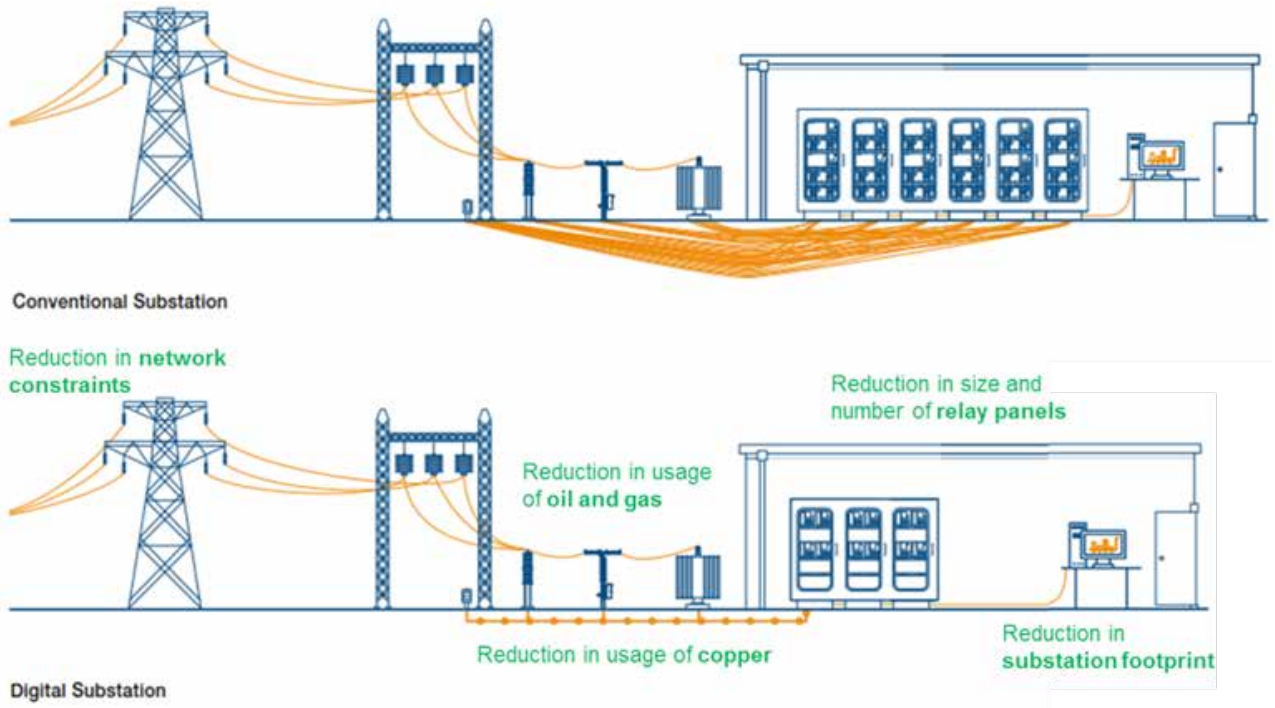
Future Intelligent Transmission Network Substation

ScottishPower's FITNESS project, which draws from the 2015 NIC (*Network Innovation Competition*) programme, aims to test and demonstrate a new concept in digital substations based on the IEC61850 standard. FITNESS proposes a low outage and low risk approach to substation non-load and load related investment for TOs as well as DNOs by replacing hardwired signalling with digital communication and through provision of an open platform upon which novel and enhanced monitoring, protection and control functions can be built.

This allows faster deployment, greater availability and increased security and control, with less environmental impact and at a lower cost compared to conventional designs. It will also allow any new substation construction and expansion to be deferred.



ANGLE-DC Structure and location



FITNESS project benefits

This project is highly innovative at a global level and will offer a demonstration of the first fully-digital substation in the UK. It will test interoperability and incorporate the functions of monitoring, protection and control that are to cover both present and future network needs. FITNESS was conceived to overcome barriers that existed between the trials conducted to date and the implementation of a philosophy that could be applied to a real substation.

The ultimate goal of FITNESS is to allow transmission and distribution network operators to design future constructions focused on a digital substation. The cost reduction for each situation, once FITNESS has been successfully demonstrated, is estimated at around 10%. Profits include a reduction in planned outage duration and network constraints.

FICS

Flexible Interconnect Capacity Solution

FICS tests a new model for interconnecting large-scale controllable Distributed Generation (DG) to the grid, where "controllable" encompasses the ability of the utility to potentially curtail or manage the delivery of electricity generated by a DG to the distribution network. The traditional interconnection process assumes that a utility must invest in network facilities (network reinforcements) necessary to accommodate the maximum rated capacity of proposed DG under boundary cases of minimum and maximum load. The DG developer is required to finance the incremental costs of network reinforcement attributable to their interconnection, and as a result the DG opportunity may not be economical.

Under a flexible interconnection, during constrained periods due to thermal or voltage issues caused by DG the developer will agree to have the utility curtail or manage generation export below maximum capacity in return for reducing or avoiding incremental network reinforcement costs. FICS aims to establish a flexible interconnection solution for DG developers and the utility to come to an agreement that maintains the viability and benefits of large-scale DG development, providing AVANGRID the opportunity to solicit a management fee from participating developers that helps offset the upfront and ongoing cost of providing the service.

Scottish Power has already realised flexible interconnection demonstrators in the UK (*FlexNets*) and it will now be implemented in the US. FICS uses *Active Network Management* (ANM) technology

that leverages automation control to provide greater visibility into the operation and performance of the grid as more distributed energy resources capacity is interconnected. ANM can work in isolation or as part of an integrated approach, providing unified smart grid system architecture that is a secure, safe, and reliable alternative to traditional network reinforcement.

AMI

Installation of a smart meter infrastructure in Maine

Through this project, Avangrid aims to replace traditional meters in the state of Maine with smart meters. Once applied, these changes are expected to save 2.5 million kilometres in travelling to read meters throughout the region. Translated into emissions, it will represent a reduction of 1,050 t of CO2 per year.

This project will also result in a significant increase in efficiency as well as reduced energy needs and use of fossil fuels for generation, thereby saving annual emissions amounting to 42,000 tonnes of CO2, 46 tonnes of NOx and 107 tonnes of SO2.

The expected operational benefits from this project are:

- Elimination of energy estimates in bills.
- Direct customer access to a detailed study of their energy usage.
- Possibility of benefitting from occasional personalised discounts.
- Faster detection of power cuts and resulting responsibilities.
- Remote control enabling connection or disconnection to/from the electricity grid.
- Increased quality and reliability of the energy service.
- Reduced losses and theft of electricity.
- Reduced metering costs.

Asset management

TABON

Highly efficient smart system for inspecting earthing mechanisms at transmission towers

Electrical systems, specifically the grounding systems, are characterized by highly dynamic operations in measurement and analysis tasks, and, furthermore are in constant evolution. This enormous complexity requires innovative new models to provide added flexibility and evolvability. For this reason, the analysis , diagnosis and prediction in such environments are generally complicated. This complexity makes it necessary to build new models that facilitate analytical work by creating adaptive systems which provide flexible and scalable capacities to the distribution companies.

The TABON project now offers a brand new technology for verification, inspection and prediction of power lines specifically in relation to grounding systems, so as to improve the process of measuring ground resistance while enhancing management efficiency.

To accomplish this wider goal, the following specific objectives have been successfully completed in relation to the main activities envisaged under the project:

- The correlation between the values of forward and contact voltage and ground resistance has been confirmed.
- Development of a smart, distributed, dynamic and self-adaptive platform that will enable the The result is a new technology enabling the integration of integration of distributed energy resources A system has been developed for managing power lines (installing new lines and decommissioning and modifying existing lines), managing towers (installing new structures and decommissioning and modifying existing structures), filtering towers and lines, showing information on both lines and towers,

and generating samples for a line selected within the system.

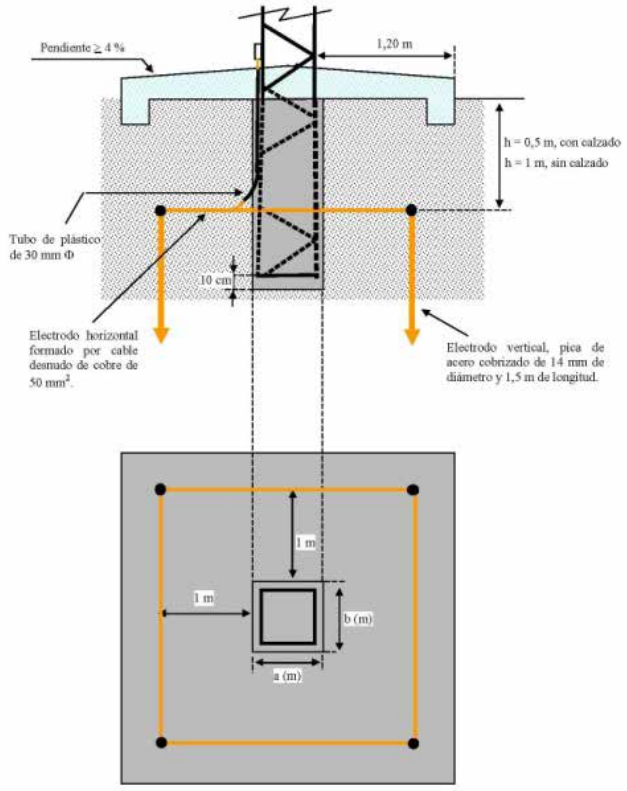


Figura 1.- Geometría de electrodos utilizados en apoyos frecuentados de líneas aéreas de media tensión.

TABON system diagram

MATUSALEN

Tool for determining the ageing of medium-voltage cables in underground power distribution lines

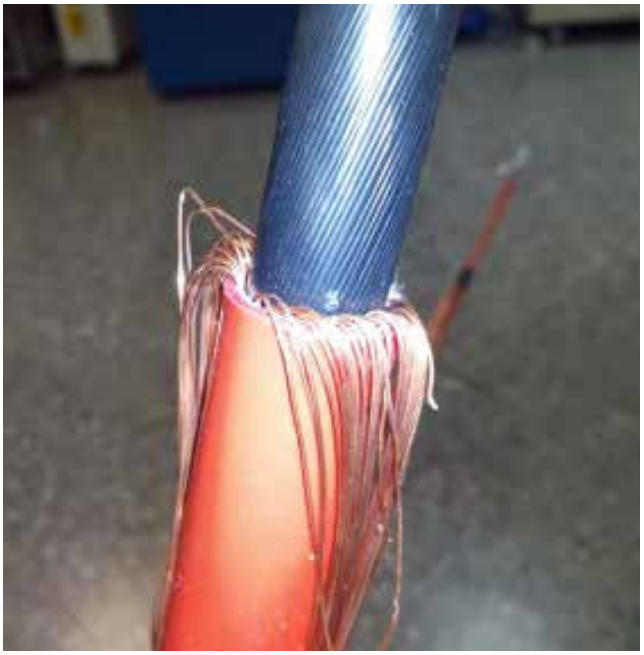
The overriding objective of the MATUSALEN project is to develop an advanced interoperable technological solution featuring cutting-edge hardware and an innovative system for estimating the wear of medium-voltage cables found in underground power grids, thus improving the way the assets are managed and enabling an optimum roll-out of future smart grids.

Cable cross-cut with two different degrees in ageing

The project focuses on the ageing and wear of both cables and instrumentation (sensors used to run system self-diagnostics and provide historical data) within the smart grid and will ultimately offer an innovative one-stop solution for managing medium-voltage electrical assets. The technology can easily be exported and adapted to international power grids.

The project includes the following specific objectives:

- Acquire further insight into the state of cable and their additional electric equipement insulation as well as factors that influence their useful life.
- Investigate and develop new interoperable systems for monitoring and diagnosing the age of the power grid.
- Design an advanced methodology and an innovative expert system for measuring the useful life of cables compatible with the architecture and roll-out of existing and future *Smart Grids*.
- Improve the asset management strategies of power distribution companies, enabling them to lower their operating and maintenance costs while establishing suitable technical patterns and standards for operating their assets.
- Ensure greater observability and control capacity over the power distribution network as a whole, through new technological solutions and tools that can efficiently process information on the state of the grid and make it available to the centre of the distribution system operator.



Ageing test bench in ITE and sample for testing

The project is expected to be completed in 2017 and is currently under development through the following activities:

- Analysing the degradation of both cables and ancillary installations on medium-voltage power lines.
- Improving the monitoring, oversight and diagnosis of medium-voltage components of *Smart Grids*.
- Specifications for designing the expert system to enhance asset management and develop a demo version.

SILECTRIC

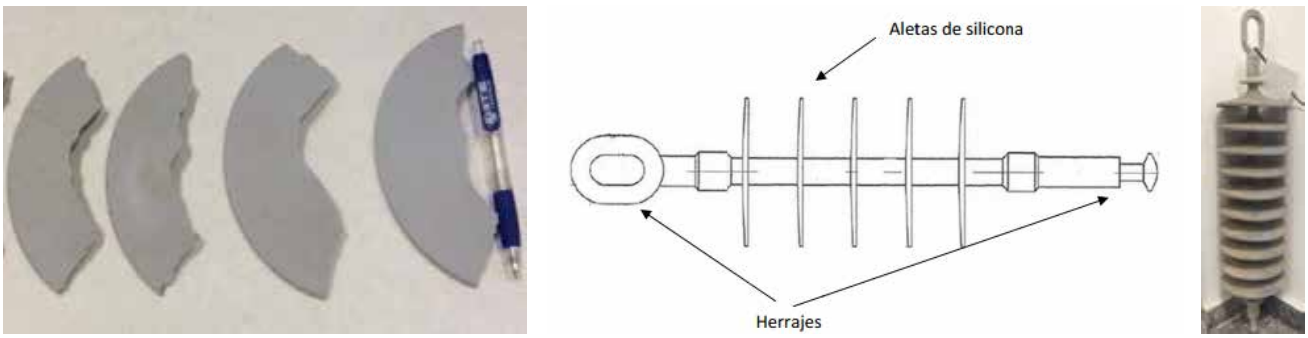
Development of materials for power line insulators and electrical switchgear for extreme conditions and to ensure a long useful life in medium-voltage systems

The general objective of the project is to obtain new insulators for high-voltage lines and switchgear with improved properties, making them fit for extreme operating conditions and environments in which components age and degrade more rapidly. This will also help improve the quality of supply and the efficiency of power distribution networks by reducing the number of outages affecting polymer line insulators.

To accomplish this goal, the following activities are under way:

- Establishing accurate assumptions for ageing mechanisms so as to acquire an in-depth understanding of the degradation phenomena that occur over the life of an insulator.
- Investigating and obtaining new insulating materials with improved properties (silicons for insulator fins).
- Developing and validating prototypes with improved properties through an experimental characterisation procedure that tests the materials under severe operating conditions to provide an accurate picture of their real and effective durability.

The project is expected to be completed in 2017 and will lead to substantial improvements in the quality of the components installed throughout the grid. Measurable short-term benefits include improved materials that can outperform traditional silicon components under trial conditions, while the medium-term benefits will include a reduction in



Structure of an insulator comprising silicone flanges

line insulator power cuts as part of the strategy of continuously improving quality of service.

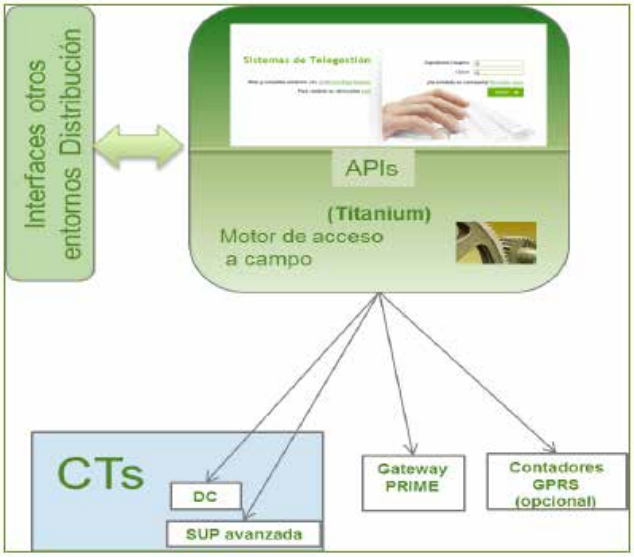
Operating Systems

STG

New Remote Management System

Work has begun on developing and validating the new Remote Management System (RMS) that will provide instant and reliable access to the required information, integrating various modules for efficiently managing the electricity grid and meters. The system boasts new functionalities for ensuring support that is sustainable over time as well as continuous evaluation thereof, thereby creating a stand-alone platform and leveraging the current advantages afforded by *Smart Grids*.

Apart from its greater capacity and tailoring to the needs of the business, another major advantage is the integration of Titanium (field access interface) and STGWeb, whereby users can do everything via STGWeb with direct field access (always with the appropriate security). This, combined with greater real-time integration, will allow further development in line with IBERDROLA's vision of smart grids.



STG system diagram

Remote control data monitoring with TABON

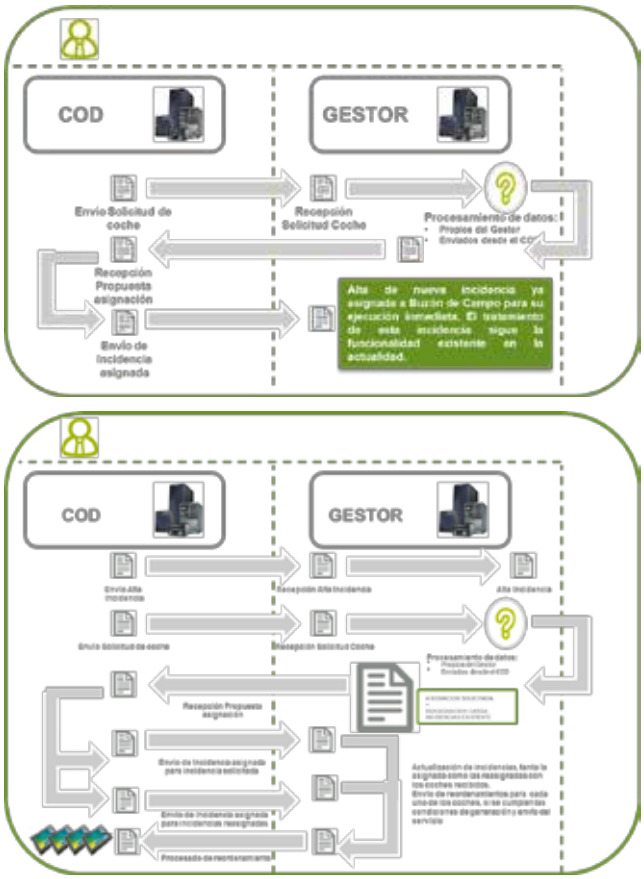
GISNET

New GIS Distribution system

The aim of the project is to implement a new graphic system that supports the Technical Inventory of the IBERDROLA network, and its integration with the rest of the systems supporting key business processes (Operation, Planning, Construction, Maintenance and Supply Point Management).

The future system will:

- Enable the fulfilment of new requirements arising from the current regulatory framework and help improve the efficiency of the business, based on the technological upgrades of the new platform.
- Improve the integration of the new system within the organisation's systems map, thereby reducing support and maintenance operating costs.



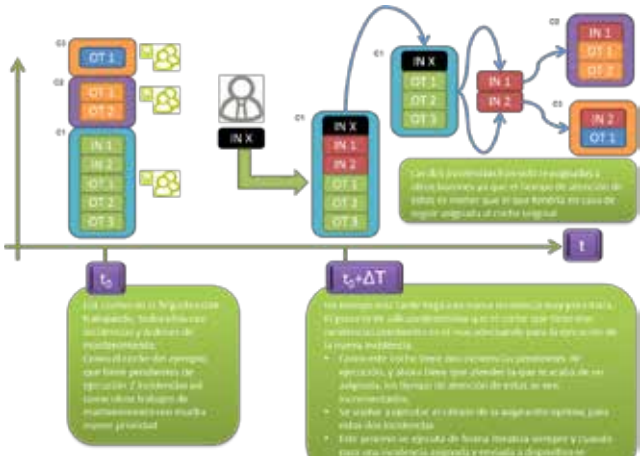
AGAVE

Optimisation of Fault Assignment

An algorithm has been developed to optimise the assigning of incidents generated by Control Centres that affect medium- and low-voltage (MV/LV) grids.

Before this algorithm was developed, the Control Centre forwarded any incidents to the person in charge at the maintenance group to manually assign them to the appropriate field team to handle the fault. In most cases, there was a single field team tasked with resolving faults on the grid. Therefore, that team did not carry out maintenance work throughout the working day and was instead assigned as the standby fault team.

Implementation of the optimising algorithm, integrated into the functionality of the Work Order Manager (WOM), a tool developed by IBERDROLA in which the delegated person prepares and assigns each job associated with his or her area of responsibility, has eliminated manual management of faults, limited manual action at the Control Centre as regards the forwarding of low-voltage faults, and



AGAVE optimiser diagram

enabled all field teams to carry out maintenance work while there are no faults that need resolving.

Thanks to mobility devices, WOM knows the GPS location of each team operating in the field at all times, what work it is performing and the estimated time required to complete the intervention. By leveraging the availability of this information, an algorithm was developed that receives the incident through the Control Centre and calculates which

field team will take less time to resolve the incident, without manual intervention for LV incidents. The complexity of MV incidents, which require grid elements to be switched at different points and in differing order, does not allow full automation of the assignment of such switching work, which the Optimiser assigns to the field teams that can deal with them soonest.

The Optimiser considers the gains from reassigning incidents not yet activated, so that a new incident arising or another team available in the field would re-launch the Optimiser's calculations in the new scenario for all incidents assigned yet not started. The desired result is to keep the overall time required to resolve all incidents active at the moment of calculation as short as possible.

The Optimiser also ensures that fault resolution time is as short as possible by considering the location of all maintenance group field teams, thus avoiding situations such as identifying the ideal vehicle for workers who would require far more time to assess the overall situation and ascertaining the optimum job assignment.

MEDISWeb

Mobility solution for maintenance contractors

In mid-2015, the Mobility solution used by maintenance groups on their field Tablet-PC, MEDIS, was migrated to an HTML5 environment that would enable publication on any type of platform (Windows, Android, iOS, etc.), giving rise to the current MEDISWeb.

This tool was migrated to align the mobility solution used by internal personnel with the contractors collaborating with the Territorial Distribution Units (TDU) in their day-to-day operations, thereby reducing the administrative work of many people who need to access corporate systems to submit all information provided by the contractors regarding jobs performed for the maintenance groups.

FAMI

New Functionalities Associated with Smart Metering

IBERDROLA has been working to endow the process chain with new intelligent functionalities ranging from consumption readings to operation and maintenance tasks, which are all necessary for providing consumers with duly processed information. The aim is thus to provide new processes for controlling and communicating readings from all installed smart meters so that the analytical information that is generated (especially load curves) can be quitar gathered, categorised and stored efficiently, in field operational processes and inspections are automated using mobile terminals, and users can be offered new web services.

IBERDROLA has developed new metering functionalities associated with smart meters, providing efficient tools that afford new functionalities in relation to readings, remote management and analytical data storage, and automation in mobile terminal readings and inspection record processing, as well as providing new functionalities and services associated with process re-engineering undertaken on IBERDROLA organisational systems that will allow information to be presented more clearly on user support channels such as the consumer support website. In addition, all of the above is achieved from a simple, intuitive, cost-competitive perspective that maximises the efficiency of information processes and information management through *Big Data* and that, above all, brings added value for the end consumer.

Spectrum Control Centre

Creating a Control Centre that integrates SCADA/EMS/OMS/DMS

This projects aims to be the first to integrate *Supervisory Control And Data Acquisition (SCADA) and Outage Management System (OMS)* in the US. While similar systems already exist in Europe, this will be the first system to use *Transmission Network Applications*, a far more complex network that is only in place in the US. Another key innovation is

the fact that the system control database will be stored in a *Geographic Information System (GIS)*. Sharing operational data in GIS will allow both technicians and asset managers to access said data. This in turn will allow huge improvements to the quality of databases, directly affecting the security of field workers and the reliability of the system for customers.

The specific objectives of this project are:

- Installing Spectrum *Energy Management System (EMS)* and withdrawing the previous systems
- Combining the two Avangrid control centres and the two alternative control centres into a single system, thereby saving on maintenance costs and allowing procedures to be unified.
- Plotting the HV transmission layout in GIS and building an interface that provides daily updates to the EMS database of both the transmission network and the distribution network.
- Connecting EMS to the incident management system so that the *Outage Management System (OMS)* can predict and manage power cuts (outage) in the system at any grid voltage level.
- Providing field workers with real-time access to the data required to assess and restore the electricity grid supply.

System Automation

Modernisation and upgrading of electrical substations in Maine and New York

The aim of this project is to completely overhaul both the structure and operation of electrical substations as well as their functions. We intend to introduce digital switches and meters along with numerous automated elements, which will allow service to be restored automatically.

We will also be upgrading the communication systems by means of *Supervisory Control And Data Acquisition (SCADA),* that will allow us to connect the transmission and distribution systems to the control centres. The upgrades enable the whole of the installed electricity grid to be assessed and displayed more accurately, affording greater control of the installed equipment. By possessing more information and safer methods of response, which do not require teams to be sent to the point where incidents occur, the SCADA system will allow us to identify and deal with any power cuts more quickly and safely.

In addition to the substation upgrades, AVANGRID will install hundreds of reclosers throughout the distribution network. These reclosers quickly and automatically restore power lines following minor disruptions such as those that occur when a branch falls onto an HV cable.

Service Quality

DVR

Dynamic Voltage Restorer

Neoenergía intends to build a prototype low-cost 380V/200kVA Dynamic Voltage Restorer (DVR) able to efficiently identify power drops and surges

DVR Prototype

on the grid and to connect a voltage regulator in series with the grid, whereby the grid will not be affected by a voltage fluctuation.

The main challenge is to achieve a technical solution that is able to prevent service disruptions through a cost-effective solution that meets supply standards.

The prototype is nearing completion and its installation on the electricity grid is already scheduled, following which the trial phase will be undertaken.

Pruning

Mechanical pruning and robotic pruning

Neoenergía is carrying out various activities, applying environmental, technical, economical and safety improvements, aimed at increasing service productivity by developing new pruning systems to replace the current manual system.

Pruning arm installation and prototype

First trials with the pruning arm

They are developing an extendible, stand-alone arm that can be fitted to vehicles and controlled remotely. It has a pruning tool on the end designed for use in urban areas. The arm is divided into two sections, each operated individually by joystick. One section is for positioning and the other for cutting. This system aims to reduce the risk of accidents and faults on the electricity grid.

The project also includes construction of a pruning waste treatment plant. Talks are underway with public administration to identify potential locations.

Concurrently, development is also underway for a modular mechanised pruning solution comprising various mechanical subsystems. The prototypes are now available to field teams and the patent has been registered at the INPI.

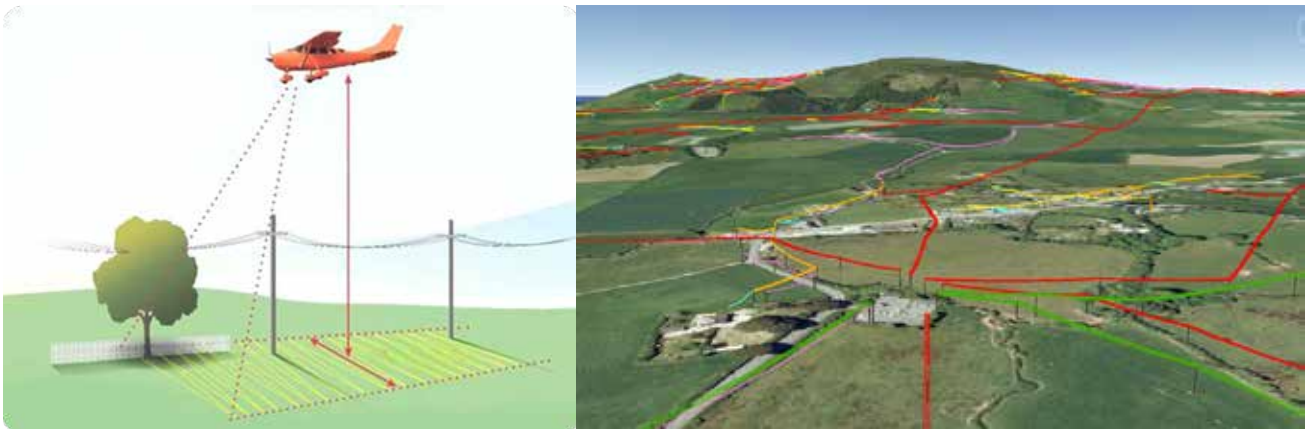
Rigid photoluminescent coverings

Development of rigid photoluminescent and/or fluorescent coverings

The aim of this Neoenergía project is to allow nighttime maintenance work to be carried out on the energized grid by replacing the usual rigid coverings with ones that are visible in low light. The coverings are designed to be installed on pylons and cross arms.

The coverings are now available for installation on equipment and undergo the pertinent controls. The invention patent for the chemical formula has been registered.

Rigid photoluminescent coverings



Virtual World Asset Management Project (VWAM)

VWAM

Virtual World Asset Management

ScottishPower's *Virtual World Asset Management* (VWAM) project uses cutting edge aerial inspection technology at distribution level to assist vegetation and asset management.

This project aims to deliver a precise Virtual World representation of a Distribution Network Operator (DNO) overhead lines (OHL) network through the use of remote sensing technologies such as Light Detecting and Ranging (LiDAR) that can be affordably refreshed and utilised in a VWAM system. In doing so, it will reduce the DNO's requirements to complete cyclic manual inspections while providing more information on assets and addressing any immediate risks that arise.

The methodology being applied is as follows:

1. The creation and updating of the network's Virtual World using LiDAR.
2. Collection and analysis of basic data that will allow comparisons to be made between traditional Vegetation Management (ESQCR) and VWAM.
3. Assessment and validation of the obtained data.
4. Financial evaluation of the benefits afforded by VWAM when introduced into various distributor programmes.
5. The identification and delivery of the optimum integration of VWAM into DNO corporate systems, e.g. Geographic Information Systems (GIS).
6. Identifying the maximum benefits from implementing a VWAM system.

The project will encompass around 30% of ScottishPower's overhead lines specifically the areas of North Wales and Dumfries & Galloway.

The algorithms used in the project significantly shorten the turnaround of the data generated from the flyby from weeks to just 24 hours. This will allow a more specific vegetation management as well cost savings against the tree cutting budget.

Protection

Nanometric coatings

Anti-adherent nanometric coatings for ceramic insulators

The project being undertaken at Neoenergía aims to develop an anti-adherent film that can be installed on ceramic insulators used in electricity transmission and distribution networks, primarily in regions where the network is exposed to aggressive and invasive environments.

Two different types of nanometric film have been developed, both of which are insulating, hydrophobic, anti-adherent, non-magnetic and self-cleaning. There are currently three nanometric films installed on insulation coatings at the Pituba Substation and four at the Sauipe Substation, which are undergoing the

tests scheduled for the project. There is a new innovation proposal in which a manufacturer interested in marketing the product will take part. The patents have been registered at the INPI.

Nanometric coatings

APM

Modular polymeric insulator

The primary application for the modular polymeric insulator is coating (exterior insulation) for the electricity grid in regions with low or high environmental aggressiveness. The prototypes are installed on 34.5KV and 13.8 KV lines of the Pituba Substation, the Sauipe Complex and Puerto de Sauipe, owned by Neoenergía. A new innovation proposal in being developed which allows the product to be marketed through a partner manufacturer. The patent has been registered at the INPI.

APM Prototypes

ARMTRS

Magnetic Voltage Self-Regulator with Saturated Reactance

The aim of this Elektro project is to develop an industrial prototype 13.8kV Magnetic Voltage Self-Regulator with Saturated Reactance (ARMTRS - Auto Regulador Magnético de Tensión con Reactancia Saturada) with a serial connection between a capacitor bank, a linear reactance, and a parallel connection with a saturated reactance. The prototype acts as a voltage regulator in steady-state and as a brownout limiter in single-phase. The prototype is being tested on the grid and the patent has been registered at the INPI.

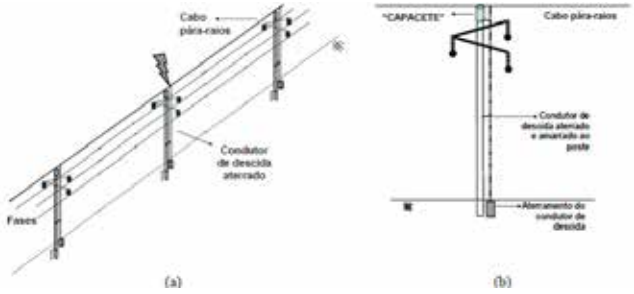
ARMTRS Prototype

Protection

Lightning protection

Neoenergía is carrying out various activities aimed at safeguarding power lines and subtransmission systems against lightning strikes, thus reducing the number of power cuts that they cause on the group's transmission network.

In the preliminary design, the independent structures were fitted so as not to touch the metal parts of the line and positioned to preclude electric bridges in the gap between the guard and the line, yet reducing the distance thereto in order to minimise costs.



Grid guard installation diagram

This design is being tested on the grid along 14.8 km of 69 kV line, encompassing a total of

81 structures. The final phase of testing will be undertaken during a period of major storm activity and, consequently, lightning strikes.

They are also developing and validating earthing systems and protection systems for distribution and subtransmission lines to safeguard against lightning strikes. These systems identify the current intensity of lightning strikes as well as the number of incidents that occur on the lines.

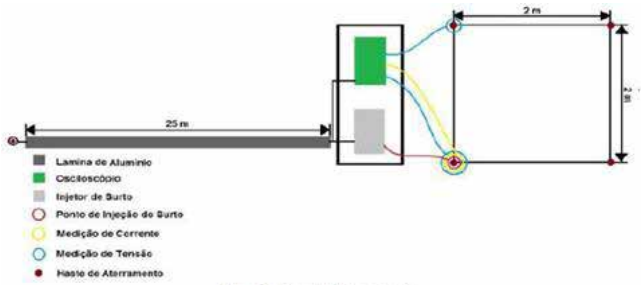


Figura 2. Croqui do Experimento.

Safeguard diagram

New Equipment and Materials

Night Maintenance

Tools and methodology for line maintenance at night

The goal of this project, which is being undertaken at Neonergía, is to develop a lighting system and low-noise hydraulic tools to enable night maintenance operations on energised lines.

Night maintenance equipment

The developed equipment has been patented and registered and is now being evaluated and tested for subsequent implementation at the company.

They are studying the possibility of marketing the equipment developed in this project by collaborating with suppliers who will add value throughout this process.

Measurement and protection transformers

System for inspecting measurement and protection transformers

This Neoenergía project seeks to develop optical current and voltage transformers for use on measurement and protection transformers, thereby reducing the billing errors that occur when large volumes of energy are handled.

Transformer measurement and protection equipment

The equipment is in the process of being certified by the National Metrology Institute (Inmetro), which is an essential accreditation as well as a mandatory requirement imposed by the Electricity System National Operator (ONS) and the regulator (ANEEL). The patent is registered at the INPI.

Metering Boxes

New power distribution instrument boxes

The project aims to create an initial series of prototype metering boxes made from composite materials consisting of propylene and sisal and coconut fibres. The project has installed 292 instrument box assemblies, and 66 alternative instrument box covers made from glass instead of the traditional polycarbonate have also been developed. The boxes are currently in a pilot stage and undergoing an evaluation process at Neoenergía.

Metering box prototype

Hydraulic tool

Prototype hydraulic tool that improves connections between cables

One of the main problems in network maintenance involves electrical connections between cables, made using wedge connectors. Neoenergía seeks to develop a prototype hydraulic tool that allows both cutting and clamping when making connections, powered by batteries and operated hydraulically.

The product is at the type-approval stage and prototypes are now available to Neoenergía group field teams. The patent has been registered.

Hydraulic tool prototype

Overhead lines

Replacement of energized overhead lines

The aim of this project is to create a method that allows MV overhead lines and LV conductors to be replaced by protected and multiplexed cables respectively, without having to interrupt the power supply.

6 LV kits and 6 MV kits have been developed, all of which are available to conduct field tests with the equipment at Neoenergía. A patent has been registered.

Kit already installed

RFID

Radio-frequency label

The aim of this Neoenergía project is to create a radio-frequency label for distribution network equipment that is able to retain data and maintain full encapsulation for more than 25 years, while being exposed to ambient temperatures and prolonged solar radiation.

100 units have so far been developed and installed on the equipment. A new innovation project is envisaged, partnered by suppliers for future marketing of the product. A patent has been registered.

RFID radio-frequency label

Manometer

Electricity metering equipment without interruptions to supply

This project seeks to develop a device that enables meter readings without the customer being disconnected during the process. Being self-adjusting, the device will control the current entering the meter in accordance with the customer's energy usage during the metering process by automatically adjusting the input current according to the load variations of the internal installation.

Pressure gauge prototype

The project is in the initial development stage and is still being adjusted to adapt to the different meter models with which the Neoenergía group works. New supports and a mobile chassis are being developed that will make it easier to carry the device over uneven terrain. They are also studying the possibility of upgrading the device's firmware and hardware to optimise the equipment's performance.

Piezoelectric Sensors

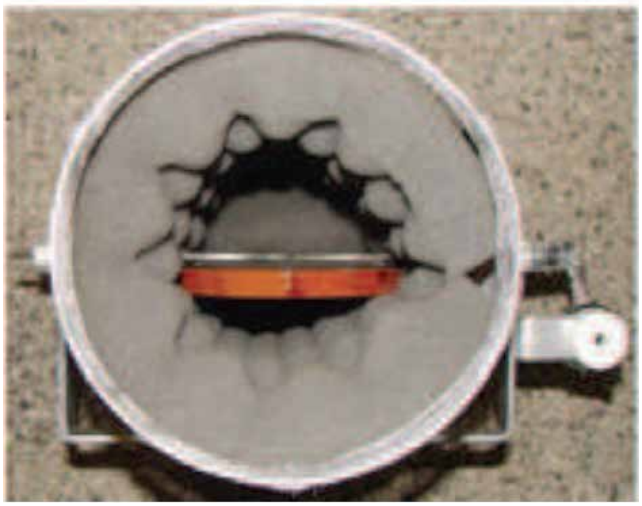
Development of sensors for acoustic detection of electrical discharges inside distribution transformers

This Elektro project aims to demonstrate the viability and develop a prototype polymeric piezoelectric acoustic sensor for acoustic monitoring of electrical discharges that occur inside power transformers.

Detection of partial discharges is a key resource for enabling preventive and predictive maintenance. In this particular case the sensor will detect ultrasonic sound waves at 180kHz. The main element of the sensors are piezoelectric membranes which, in this case, are going to have a piezoelectric coefficient of approximately 300pC/N, far higher than conventional ceramic membranes, and which is perfectly suited to acoustic vibrations. The main features that they are seeking for the prototype are

malleability, low cost and compatibility with *Smart Grids* technology.

Given that piezoelectric technology has been fully understood and demonstrated for some years now by universities and technology centres in Brazil, the sensors could be manufactured entirely in Brazil, thereby reducing the need to import such equipment. Online monitoring of transformers will be the next step in transformer maintenance.



Noise detection sensor

D-TCSC Compensator

Development of an electronic compensator for distribution systems

The goal is to build an electronic compensator capable of addressing the dynamics of a distribution system's high loads by increasing reliability, reducing losses and improving the quality of the power supply. Using the *Smart Grid* philosophy, the compensator must be able to establish direct, stable contact with the Elektro operations centre.

A prototype is being developed with two D-TCSC control modules and their respective electronic support boards, which is now undergoing field tests. They hope to present the final prototype in 2016.

Compensador D-TCSC

Low-voltage regulator

Development of an automatic low-voltage regulator for Elektro networks

This project aims to establish the exact specifications for transformers, as well as designing, implementing and integrating a series of smart tools to regulate and control the low voltage of the Elektro distribution network.

By implementing this low-voltage regulating system, the company hopes to create a technically and economically viable alternative that will resolve situations in which consumers receive a voltage outside the limits set by current legislation. Operation will be carried out by means of an innovative smart voltage-regulator module and switching will be carried out by power electronics. Controls performed using power electronics devices do not entail mechanical wear like traditional voltage regulators, which will increase the equipment's service life. Therefore, implementing this system is expected to improve the quality of the power supply by adapting to the different load profiles. This improvement will, in turn, help reduce costs and adapt the current electricity billing model.

The main functions of this system are:

- Remote monitoring of low voltage surges.

- Automatic warnings of electrical anomalies.
- Enabling decision-making and remote actions such as by-pass switching or inserting reactive energy compensators.

Automatic controller already installed

IANT

Intelligent analysis of network images taken by an unmanned aircraft

The purpose of this Elektro project is to develop the tools, computational resources and necessary methodology for intelligently analysing photos and videos of distribution lines using an unmanned aerial vehicle (UAV).

Although image analysis software and algorithms are available, none is specifically designed for the images under study, in which any anomaly or deficiency in the electrical materials used on lines and networks must be precisely identified. The studies undertaken will expand the knowledge base and help to carry out other related studies. This method will undoubtedly increase efficiency and safety in grid maintenance and inspection procedures, thus making Brazil a leader in the use of this technology.

IANT aircraft

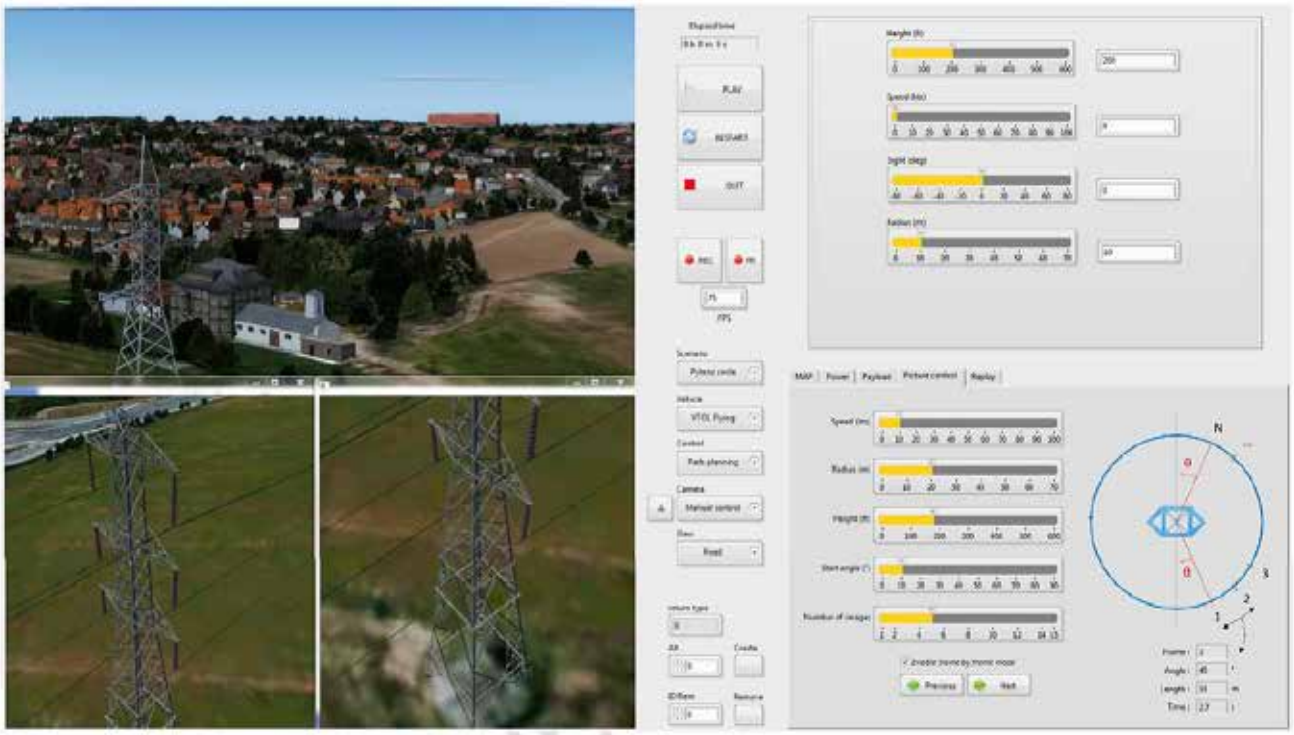
BVLOS

Beyond Visual Line of Sight

Beyond Visual Line of Sight (BVLOS) is the largest collaborative project launched by the UK electrical and gas distribution network operators to date. The project seeks to speed up the integration of Unmanned Aerial Vehicles (UAVs) and reap the benefits they will bring to consumers. The project is attempting to accomplish its objective by removing the main barrier that prohibits the use of UAVs beyond the pilot's visual line of sight, this in turn prevents the UAVs from being feasible for inspecting long stretches of network when compared to traditional manned flights.

The project specifically aims to:

- Meet the UK's need to undertake network inspections using UAVs.
- Simulate the flight requirements for conducting inspections.
- Identify the optimum solution, including collision avoidance and communications.
- Create precise specifications for BVLOS UAVs.



Images and data sent from the UAV

The UK Civil Aviation Authority (CAA) has subsequently come on board and is adding significant gravitas by reviewing and validating the projects deliverables.in the project and providing the necessary safety, by way of revisions and validations, on all prototypes.

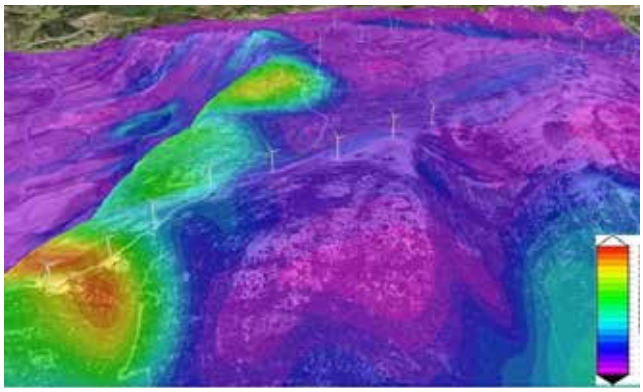
5.3. R&D&i in the Renewables Area

Introduction

Renewable Energies

Innovation activities in the area of renewables have mostly focused on improving the efficiency of operational assets, the integration of renewable energies and the development of new designs or processes for projects in the pipeline or future projects mainly associated with offshore wind power and other renewable technologies.

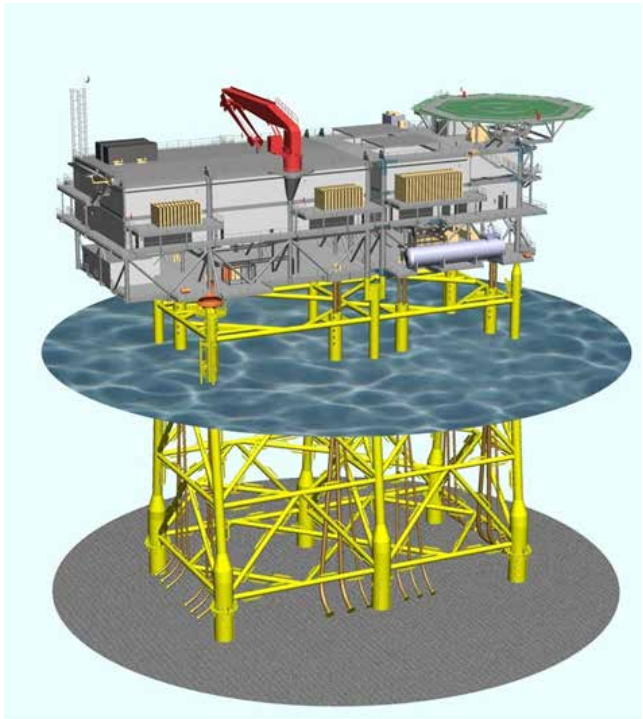
Improving the efficiency at Wind Farms is aimed at reducing operating and maintenance costs, most notably activities focused on enhancing production through improved wind resource forecasting, activities to analyse the oils used in wind turbine gearboxes to lengthen their service life, and tools for managing wind farm operations



Wind farm modelling with supercomputer

Within the projects aimed at **improving the integration of renewable energies** special mention should be given to project Smartwind, which involves creating models and simulations for using wind farm storage sites to provide ancillary services such as reducing deviations in the production offered compared to actual production. The Newplavol project focuses on photovoltaic power storage.

Innovation in offshore wind power projects is fundamental for reducing costs and limiting the risks in projects in the pipeline and future projects. For instance, at Wikinger wind farm an on-site campaign has been run to validate the design of the jacket foundation piling (tasked with securing the foundations to the ground) due to the special characteristics of the seabed, with major improvements being achieved.



3D design of the Wikinger substation

Special wind power initiatives

In order to gain a more in-depth understanding and assessment of the problems that the offshore environment adds to the promotion, construction and operation of wind farms, IBERDROLA takes part in major research initiatives. The most notable examples are:

Offshore Wind Accelerator (OWA)

OWA is an initiative spearheaded by UK organisation "The Carbon Trust" and partnered by the leading promoters of offshore wind farms. The primary goal is to reduce the cost of offshore wind power technology.

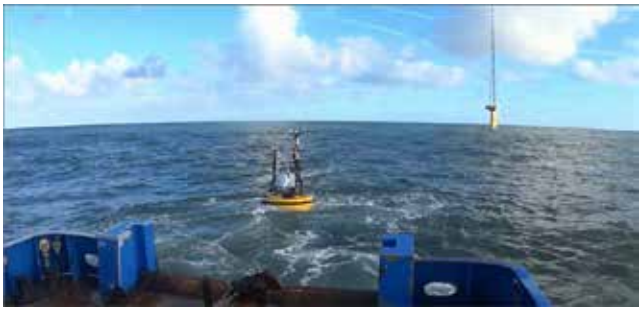
To ensure that the activities are conducted properly, the initiative builds upon projects of common interest to all the promoters, in which general issues are addressed, as well as discretionary projects aimed at fostering the development of new designs, procedures or standards. In all cases, the proposals are prioritised, identifying those with the greatest potential for cost savings. In addition, they try to involve the entire supply chain, with special support for possible innovations of interest so they can achieve a market position.

The initiative is based on four main thematic activities as described below:

- Wakes: This area includes all initiatives aimed at improving production estimates and optimising the design of wind farms through a better understanding of the energy resource, thereby reducing the cost of such facilities. Great effort is being made to model the wake effect on wind farms caused by interaction between the wind and the turbines. The activities undertaken include: optimising the resources used by wind and wake simulation models; improving wake models as well as lessening the associated uncertainty; developing tools to optimise the arrangement of wind turbines at an offshore wind farm; and studying and modelling turbulence to optimise the design of support structures and wind turbines.

  As regards measuring real atmospheric conditions at wind farms, special mention should be given to the project called *Floating Lidar*, in which different floating LIDAR (measuring the wind by emitting laser beams, *Light Detection and Ranging*, mounted on buoys) that will lower the cost of measuring campaigns at sea compared to the traditional use of weather towers. Furthermore, the models currently in use will benefit from the measurements obtained through this technology, allowing improved production calculations. The main goal is to validate this sort of technology at different sites to replace the current technology.

  Studies have also been conducted into the measuring of offshore wind power curves using LIDAR technology (Nacelle, *Scanning Lidar* in the transition piece or *floating LIDAR*).



Floating LIDAR (Source: ScottishPower website)

- Accessibility: Generally, within this working group, they closely monitor all new developments regarding access systems and vessels, planning models for operation and maintenance strategy, reviewing of related regulations and everything related to offshore wind farm accessibility. In particular, they are working on marketing innovative access systems and vessels for performing offshore wind farm operation and maintenance work to reduce the risk associated

Offshore wind farm access ships (Source: The Carbon Trust)

with these new inventions. To that end, funding has been made available to companies with new designs to demonstrate their concepts by means of numerical models, tank testing and prototype construction. Moreover, support continues for new transfer system and vessel ideas such as the *Tube Docking Device* transfer system.

Further projects have been undertaken within the framework of OWA Access such as:

- The development of *Performance Metrics* for transfer systems and vessels that allow the costs to be assessed for each vessel and site.
- Development of the tool known as "SafeTi" to predict the movement of vessels and thus boost technicians' confidence to access a turbine, and to increase overall accessibility to the wind farm as well as availability.
- Development of a model for crew transfer vessel (CTV) accessibility to offshore wind farms to compare different transfer systems for a given scenario and define an optimum strategy for wind farm access.

- Electrical systems and cables:
  The studies carried out mainly focus on improving the efficiency and reliability of offshore wind power electrical systems, with projects aimed primarily at raising generation voltage to 66kV, thus aiding commercial development throughout the supply chain, including the testing and certification of four XLPE interarray cables at that voltage, which is currently one of the elements that most restrict the implementation of 66kV.

  Various studies have also been conducted to optimise transmission systems, including studies to optimise direct current substations (HVDC) by combining AC and DC substations; analysis of a new proposal for an HVDC system encapsulating diode rectifier technology (a solution put forward by Siemens); and analysis of low-frequency AC links as an alternative to DC power transmission.

  In addition, various studies have been undertaken associated with the laying of undersea cables aimed at reducing their installation costs and failure rates. In this regard, a methodology has been developed for burying the cables, thus reducing the associated costs, various alternatives have been analysed associated with cable performance in dynamic environments that would lead to cost savings, as well as improvements to the installation process, and reduced operation and maintenance requirements.

- Foundations: The main objective of this activity is to reduce the costs associated with foundations, in terms of both initial investment as well as their maintenance and service life. To that end, various studies have been conducted into maximising the service life of foundations, establishing different monitoring strategies, protection against corrosion, and fatigue analysis . Likewise, work continues on optimising the designs currently in use through such projects as PISA, whose aim is to increase the application range of single-pile foundations and reduce the conservatism associated with their design, or GOAL, which seeks to develop guidelines for applying ordinary Portland cement on cemented joints thereby reducing both the costs and risks of the technology. In addition, the main characteristics of various types of gravity foundations have been analysed, including their viability for sites of different types.

Also, as a key aspect in such activities, the development of innovative foundation solutions continues to be supported. To that end, various studies have been conducted to mitigate the associated risks by developing different design engineering tasks, as well as implementing integrated foundation-wind turbine design methodologies. Lastly, funding has been

Suction Bucket Jacket foundation
(Source: Dong Energy website)

provided for the installation of prototypes that allow the concepts to be validated and reach the market. They include the *Universal Foundation* prototype, on which a weather station has been installed, and the *Suction Bucket Jacket*, which includes the installation of a wind turbine.

Universal Foundation
(Source: Universal Foundation website)

SPARTA CATAPULT

IBERDROLA is partnering the collaborative project Sparta (*System Performance, Availability and Reliability Trend Analysis*), managed by the UK's *Offshore Renewables Energy Catapult*. This project is aimed at detecting opportunities to improve wind turbine operating efficiency, as well as analysing wind turbine availability and failure rates based on information provided by different wind farm promotors, which will allow operational cost savings and boost production.

Technology Innovation Centre

The LCPE (*Low Carbon Power & Energy programme*) run by the TIC (*Technology & Innovation Centre*) consists of industrial/academic collaboration over a 5-year period between ScottishPower, Scottish & Southern Energy and Strathclyde University. The partners are working together to identify and undertake research projects in the area of energy and low-carbon content, in any sector including renewables, energy and network management. Collaboration began in 2013 and has led to the development of a primary research plan based on 13 collaborative projects, mostly involving onshore and offshore wind power.

The main objectives associated with wind power have been to reduce investment and operating costs as well as maximise profits through complex simulation tools. The projects completed to date include such high impact areas as:

a) Tools for offshore logistics and installation planning
b) Monitoring and analysis of onshore wind turbine foundation fatigue.
c) Laying and installing of offshore electric cables.

The programme recently won the *Knowledge Transfer Partnership Award for "Multiparty Collaboration"*, with specific reference to the pioneering project focused on optimising the balance between production costs, investment costs and operating costs by analysing the strategy on the contracting, use and meteorological risks of offshore wind power O&M and installation vessels.

Energy Resource Prediction

OPENFOAM -SEDAR

Supercomputing applied to wind farm design

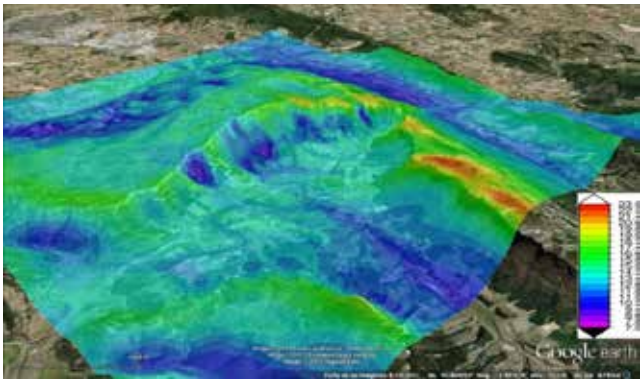
The key objective of this project is the use of fluid dynamics calculation models and their integration with supercomputing techniques so as to develop more reliable models for calculating how a wind farm will perform during the design stage, before being constructed.

Such techniques, where IBERDROLA is pioneering their practical application in wind farm design, affords two major benefits:

- Reducing the costs of a wind farm's measurement campaign, so that less measurement infrastructure is required at a given location when estimating the available resources.
- Greater and more accurate understanding of how the wind will behave at a site with complex orography.

This translates to a better estimate of potential wind farm production, better on-site positioning of wind turbines and, therefore, less risks in decision-making when investing in a wind farm.

It is worth noting the close collaboration in these activities between IBERDROLA and the National Supercomputing Centre (BSC – *Barcelona Supercomputing Center*), where best practices and knowledge are exchanged to achieve the best possible results.



Wind farm modelling with supercomputing

EERA-DTOC

Tools for designing large-scale offshore wind farms

The rapid expansion of offshore wind farms has highlighted the need to develop IT tools for efficient wind farm designs and greater accuracy in energy production forecasts.

The main objective of the project has been the development of new IT tools for optimising the implementation, design and operating of wind farms. It involves integrating data into a virtual simulation system to estimate the wind resource and expected production, the electricity design parameters of wind farms along with other parameters for carrying out operation and maintenance tasks on offshore assets.

In particular, this project has analysed how wind farms interact with nearby wind farms, so that such effects can be taken into account during the design stage with a view to designing them more efficiently.

LIDAR

Light Detection And Ranging applied to wind turbine control

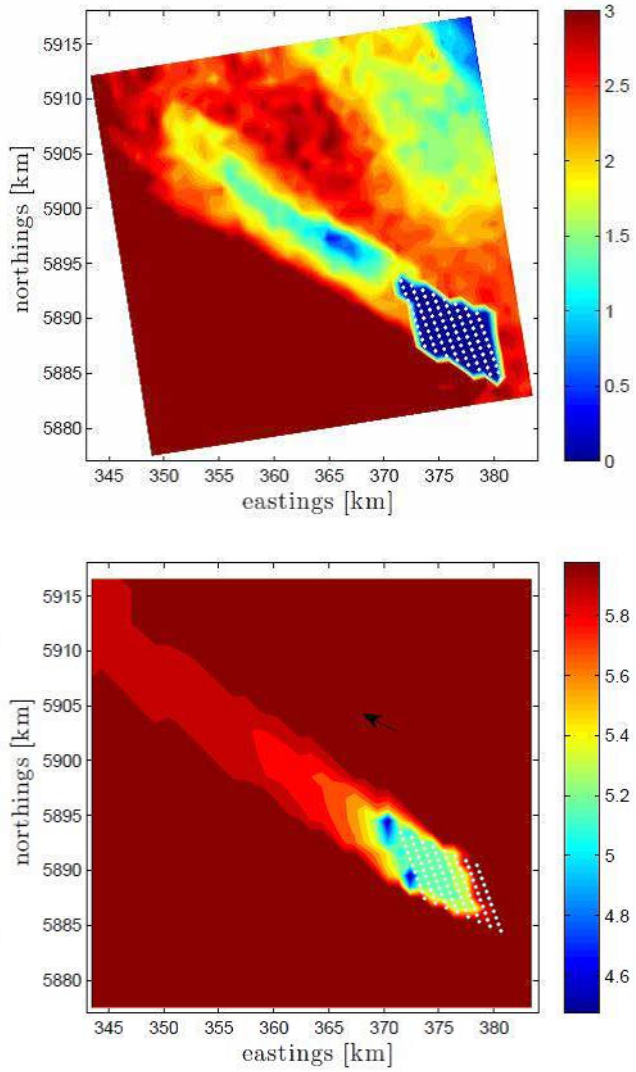
A study into the use of Horizontal LIDAR technology for detecting systematic errors in wind turbine alignment in relation to prevailing wind direction and adjusting wind sensor calibration parameters to ultimately increase wind farm production and extend their service life. The project encompasses the following activities.

Analysing and defining the technical requirements of horizontal LIDAR technology to obtain representative results that enable future expansion of the technology.

Evaluating the accuracy and reliability of the horizontal LIDAR device that is going to be used by comparing its measurements with those of a weather station that meets all the requirements specified by international standard IEC61400-12-1.

Verifying wind turbine orientation and making possible adjustments to wind sensors that optimise the wind turbine's energy efficiency.

Analysing the impact of the adjustments made on the wind turbine's energy efficiency. The study will be undertaken following two different methodologies. The first is based on the tested wind turbine's power curve, and the second is based on the relationship between the tested wind turbine's active power and that of nearby wind turbines. In both cases, before and after the adjustments to the yaw system and wind sensor calibration parameters.



Wind farm wake simulation

Improved integration of renewable energies and energy storage

SMARTWIND

Smart Energy Storage for wind power integration and quality improvement

The project's goal is the use of energy storage by means of batteries in combination with a wind farm. This project has been co-funded by the CDTI (Centre for Industrial Technological Development, a public business entity which reports to the Spanish Ministry of the Economy and Competitiveness), through the specific EEA-GRANT programme.

The project has determined:

- Firstly, the possible applications for the use of storage associated with a wind farm and the necessary technical requirements.
- Secondly, a tool has been developed for dimensioning the necessary storage associated with a wind farm to reduce the cost of deviations that occur as a result of differences between forecasts and the wind farm's actual production.

Storage applied to wind farms (Source: A123 Systems)

BESTPATHS

Beyond state of the art technologies for power AC corridors

The Best Paths project will help to overcome the challenges of integrating renewables into the European Union's energy mix in the coming years. The ultimate goal is to develop new networks that improve Europe's high capacity transmission networks and increase the flexibility of electric systems.

The project brings together leading experts around five large-scale demonstrations that validate the technical viability, costs, impact and benefits of different cutting-edge power transmission technologies. The aim of the demonstrations is to achieve a solution for high-voltage direct current (HVDC) electricity transmission, and to increase and upgrade existing AC transmission lines, as well as an operational study of meshed DC grids and their interaction with AC grids.

It is in this last point where IBERDROLA is spearheading a group of industries and technology centres to create a scaled simulator that will be used to study the interaction between various DC converters on different types of meshed grids, thereby helping to better understand and design such grids and in assessing future electricity macro projects at offshore wind farms.

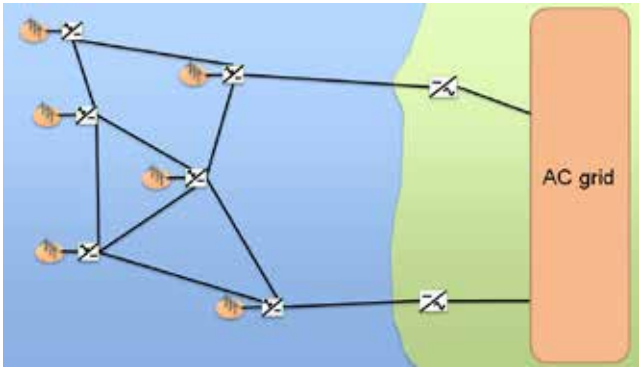


Diagram of meshed evacuation grids for an offshore wind farm (Source: A123 Systems)

NEWPLAVOL

Research into large photovoltaic plants connected at high voltage and subsequent modular storage

The NEWPLAVOL project will study the requirements for an energy storage system as a supplement to a renewable energy generation facility, such as a photovoltaic plant with high installed capacity.

Combining renewable energy generation facilities with an energy storage system offers major theoretical advantages such as managing the intermittency of renewable resources, energy quality management and compliance with network codes. However, such synergies cannot be leveraged unless some major technological challenges are overcome, including storage technology selection, optimum plant configuration and ideal power electronics, while also taking into account the economic viability of the solution. All such issues will be addressed in this project in collaboration with two of the most important European research centres, namely SINTEF in Norway and Tecnalia in Spain.

The overall aim of this project is to develop new designs for large photovoltaic plants (over 100MW) and to model the characteristics of the generated energy.

In addition, they will be studying a modular energy storage and stabilisation system associated with the plant that will entail developing a tool ultimately aimed at ensuring fulfilment of each scenario's technical requirements and providing economic data (payback period, internal rate of return, net present value) that enables an investment in energy storage to be evaluated.

The project's technical objectives are determined by the need to overcome the difficulties posed by such large plants. The key challenges addressed by this project are:

- To integrate plants into power grids regardless of the geographic area and the available electricity network.
- To study the implementation of large plants allowing for their unique characteristics.
- To minimise impact on the connection network.
- Regulation of the active and reactive power at the plants.

- To study the plant's response to demand in the face of dips and faults.
- To integrate a storage model that allows us to make energy generation more stable at said plants and, in turn, make the market more predictive.

Storage applied to wind farms.
(Source: A123 Systems)

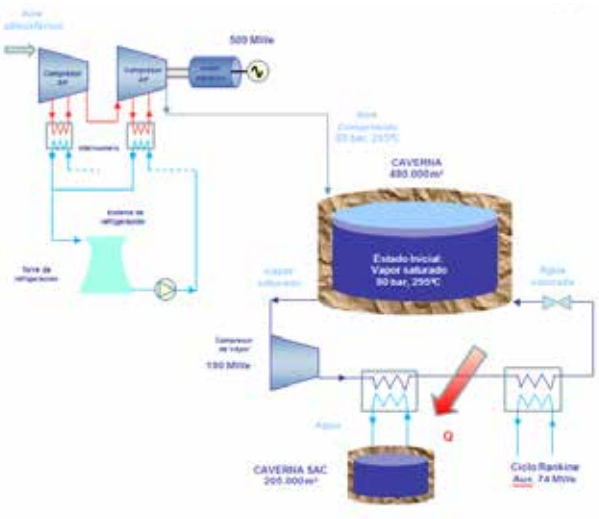
CCC WIND

Combined Cycle CAES technology for wind farm energy storage

As an alternative to the new methods for associating storage with renewable energy generation facilities, the CCC WIND project has analysed an innovative design for compressed air energy storage (CAES) plants which, due to their unique characteristics, could be appropriately dimensioned and managed so as to provide the stable and continuous services required at renewable energy plants.

The main goal of this project is, therefore, to research constant-pressure combined cycle CAES technology that allows us to store the energy generated at wind farms safely, reliably and efficiently, thus enabling better demand management and environmental improvement.

To achieve this goal, two activities are being carried out:



CCC WIND technology diagram

- Combined Cycle CAES technology. Implementation alternatives. Extensive research has been conducted into the various implementation alternatives such as constant-pressure CAES. To that end, they have been compared to more conventional, constant volume CAES plants similar to those built in the US (Alabama) and Germany (Huntford), along with others still being promoted in different countries.
- Conceptual system design. Application to wind farms. A small-scale comparison has been put forward that could be associated with a wind farm, storing the electricity that is produced. An optimisation process has been carried out, establishing the configuration and design parameters for multiple solutions until the two most interesting are selected, which are then analysed in great detail. The need to use a gas turbine as a way to heat the stored air has been considered. Dimensioning of the plant has been optimised according to the size of the examined gas turbine and the temperature of its exhaust gases.

Wind Farm efficiency improvement

Efficiency improvement is aimed at reducing operation and maintenance costs, and boosting production at our operational wind farms.

ENERGY THRUST

Turbine power curve optimisation

This project aims to boost the production of G8x and G5x turbines by optimising the power curve.

Such improvements are focused on four aspects of the wind turbine's operating mode:

- Optimisation of its alignment.
- Optimisation of low-wind blade angle control.
- Optimisation of moderate-wind power curve control.
- Extra power in high-wind range.

In 2015, the project was tested on a 600 MW sample and the envisaged production improvements were achieved.

DARWIND

Data Analysis of Reliability in WINDfarms

The application of statistical techniques for developing maintenance methodologies and protocols has been employed in the industry for decades. Such techniques allowed us to adjust the design and quality of components to ensure a long service life. They also allowed us to develop preventive and predictive maintenance programmes to reduce corrective actions and optimise maintenance periods so as to reduce costs without compromising component integrity.

As a wind power operator and developer, IBERDROLA has the necessary experience, size and operational equipment diversity so that the application of such techniques enables operational cost savings as well as the ability to increase asset availability. The company's close relationship with turbine manufacturers has afforded extensive access that complements the company's know-how as regards the development of such analysis techniques.

Against this background and with this positioning, the DARWIND project seeks to develop a tool that allows IBERDROLA to make decisions on asset management. On that basis, indicators have been defined for preventive maintenance and increased component reliability, as well as an operating cost model that is ultimately aimed at:

- Optimising preventive maintenance.
- Reducing corrective maintenance.
- Increasing revenue by reducing wind turbine downtime.

Oleo and Mineroil

Extending the service life of oils

The main objective of these projects was to gain knowledge and experience regarding the performance, properties and service life of oils, both mineral and synthetic, used for correct lubrication of wind turbine gearboxes.

Such knowledge allows better oil management by optimising the usage period with a view to extending its service life without reducing its performance or compromising the equipment's service life.

Both projects thus afford maintenance cost savings as well as reducing the amount of waste generated throughout the assets' lifespan.

Various studies were conducted on different gearbox and wind turbine models, under different climatic and operating conditions as well as using different brands of oils.

Vortex generators

Improved aerodynamics with vortex generators

The aim of the project is to improve blade aerodynamics by installing vortex generators along their length. This achieves greater control of air turbulence along the edge of the blade and, consequently, reduces stress as well as generating a small increase in production by improving laminar flow in the exit cone.

Wind turbine blade vortex generation

Autoluber

Automatic lubrication

Development of a new automatic lubrication system allowing regular, controlled dosage in the main bearing system of the wind turbine rotor.

Through this system we achieve better lubrication of critical wind turbine components, thereby extending their service life as well as reducing friction and vibration caused by a lack of lubricant on the main bearings, which could lead to high bearing temperatures and ultimately fires and catastrophic equipment damage.

Rotor bearing self-lubricating system

DOMINA

Tool for comprehensive management of renewable assets

DOMINA is IBERDROLA's corporate tool for comprehensive asset management. Its key objectives are to ensure the maximum useful life of facilities, optimise maintenance procedures and maximise understanding of the technology.

The DOMINA tool has been under internal development since 2004 and was first introduced in Spain, subsequently spreading to all remaining geographic areas. The DOMINA tool is thus used and applied for the nearly renewable 14,000 MW operated by the Company around the world and represents a major step forward in maximising operating efficiency by unifying and standardising work methods and asset management in the different geographic areas. Due to its success, the tool has been launched in the UK and US by way of a technology assignment contract.

Over the last two years, R&D&i breakthroughs in this project have been geared towards managing information related to work orders and other maintenance tasks far more efficiently, by both upgrading internal IBERDROLA systems and improving communication with external companies. This, combined with more efficient contract management, has led to reduced wind farm operating costs.

METEOFLOW

A comprehensive system for forecasting meteorological variables

Meteoflow is a comprehensive system for predicting medium and long-term meteorological variables at the different national and international sites.

The project came about in 2004 in response to a need for production forecasts in order to participate in the Spanish electricity spot market.

The system has since been under constant development, responding to the company's new requirements. The current objectives of the project

are to meet the requirements of the different energy retail markets in which IBERDROLA facilities participate and support the scheduling of their Operating and Maintenance tasks. The success of this system has also led to its being launched in the UK and US by way of a technology assignment contract.

The key work carried out over the last two years includes:

- Incorporation into the forecasting system for the entire fleet of wind power facilities around the world (14 GW).
- Development of an automatic alarm system that oversees the quality of forecasts generated by the system.
- Analysing and predicting possible unique phenomena by observing the effects of high wind on wind farm power curves.
- Calibrating *offline* methods incorporating a production-producible combination both in the records and in real time.
- Developing and assessing new prediction methods based on global and local models.

This includes development of a specific application for predicting offshore wind farm production, which is an essential pillar of the company's growth in the wind power business over the coming years.

Offshore wind power

Projects involving offshore wind farms

In 2015, there were in excess of 12,000 MW of installed offshore wind energy worldwide, over 90% of which is in Europe. However, while the figures reveal technology deployment, major technological challenges nevertheless remain and must be overcome to reduce its cost.

In recent years, the Company has become a global benchmark in the offshore sector, including the following projects.

- West of Duddon Sands, (North Sea, 389 MW): The project, which has been in commercial operation since October 2014, has been jointly undertaken by IBERDROLA (through ScottishPower) and the Danish company Dong Energy. It has 108, 3.6 MW turbines installed on single-pile foundations approximately 20 km from the coast at a depth of 20 m. This wind farm has been completed successfully, on budget and on schedule.
- Wikinger (Baltic Sea, 350 MW): Wikinger wind farm in Germany has 70, 5 MW turbines installed on jacket foundations and is located some 75 km offshore at a depth of 40 m. The wind farm is currently under construction with the first foundations scheduled to be installed in spring 2016 and connection to the grid in 2017.
- East Anglia 1 (North Sea, 714 MW): This wind farm in the UK has 102, 7 MW turbines installed on jacket foundations and is located some 45 km offshore at a depth of 40 m. The wind farm is scheduled for connection in 2018.
- St. Brieuc (Côtes-d'Armor - France): this is a 500 MW wind farm developed in consortium (70% IBERDROLA) and located some 35 km offshore at a depth of around 40 m. Connection to the grid is scheduled for 2022.

Innovation in offshore wind power projects is fundamental for reducing costs and limiting the risks in projects. With this general approach, we should highlight some of the activities carried out in the Wikinger project:

- Development of a numerical weather forecasting tool for planning installation work and operations.
- Implementation of an on-site pile test campaign at Wikinger wind farm aimed at validating (and optimising) the design of the jacket foundation piling (tasked with securing the foundations to the ground) due to the special characteristics of the seabed, with major improvements being achieved. In addition to validating the design, the project also seeks to develop new offshore testing procedures that can be applied to any terrain of uncertain characteristics by conducting a series of tests

on calcareous ground. The conclusions drawn from the tests will be carried across to the development of new, more reliable design procedures.

- Design of a 4-leg jacket foundation for the Wikinger project. The design of the foundation has been adapted to the site, and it has been optimised to simplify the fabrication process.
- Innovative design of the offshore substation for the Wikinger wind farm that involves building it in two parts due to weight and size restrictions for transportation, along with its foundations on a 6-leg jacket structure.

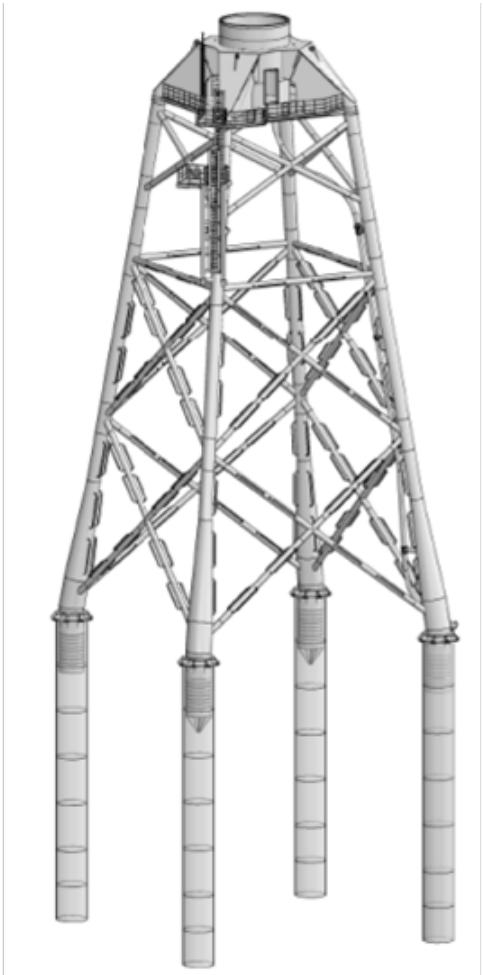
Wikinger wind farm pile test campaign

LOWIMPACT

Low environmental impact offshore wind farm foundations

The key objective of the LOWIMPACT project is to design low-cost, low-impact offshore wind farm foundations for shallow- and mid-water levels by developing technologies that increase the cost-effectiveness and sustainability of offshore wind farms. To achieve this goal, the following objectives have been defined for the project:

- To develop mid-water foundation strategies (including optimising construction, transportation, installation and maintenance processes) to increase competitiveness and reduce the current implementation costs of offshore wind power.
- To optimise the designing of foundations through the development of innovative foundation designs.
- To achieve an eventual saving on foundation costs, including the transportation and construction of foundation structures with the solutions developed in the project, thereby avoiding the use of heavy-lift launch vehicles.
- To develop strategies that enable high replicability of the foundation process based on an economy of scale factor.



Jacket foundation diagram

3D design of the Wikinger wind farm

The following operational objectives were also established:

- Designing and dimensioning various mid-water gravity foundation alternatives and selecting the most suitable.
- Analysing the construction, assembly, transportation, installation and maintenance processes for offshore gravity foundations and the necessary auxiliary machinery (cranes, port facilities, vessels, etc.).
- Developing an optimised gravity solution based on standard technology used in the construction industry for depths of 30-60m.
- Tank testing and hydrodynamic simulations to validate the developed solution.
- Cost-benefit analysis and life cycle study for the developed solution.

The project was concluded successfully with the development of two gravity foundation solutions for depths of 30-60m, based on the use of standard construction industry technology, and avoiding the use of heavy-lift launch vehicles commonly employed in the offshore wind power sector, which have limitations due to the small number of available units and their high cost.

3D design of gravity foundation

ATEMPO

Assembly support vessel

This project seeks to address two key aspects of offshore wind power:

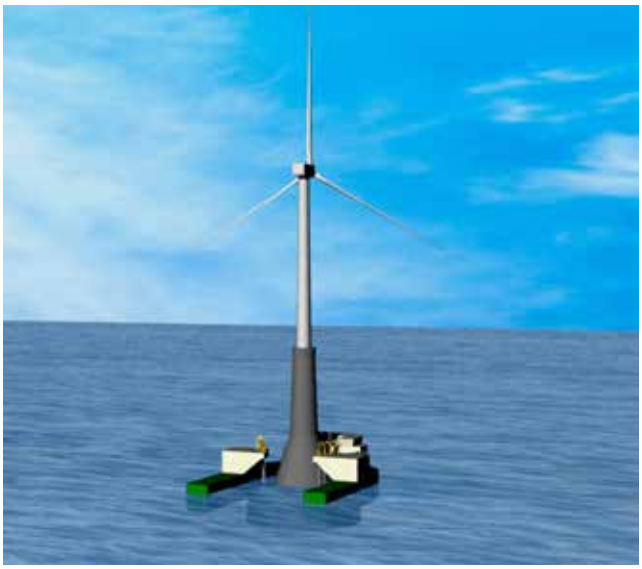
- The need to reduce technology costs (such as reducing foundation and installation costs) as well as reliance upon the costly and limited installation vessels currently in use (HLVs, Jack-ups).
- Reducing risks and increasing operational advantages of foundation and wind turbine installation processes.

To meet these needs, the project aims to develop a conceptual design for an assembly support vessel for a comprehensive offshore foundation-wind turbine solution. It will be possible to use the vessel to transport and install an 8MW gravity foundation-wind turbine assembly, thus avoiding use of the usual installation resources.

The following activities were established for correct completion of the project:

1. Realisation of the project's design bases.
2. Conceptual design of the vessel.
3. Validation tank tests and trials.
4. Preliminary study of downstream secondary uses.
5. Preliminary life cycle analysis.

The project concluded satisfactorily with the conceptual design for vessel that will enable installation of the foundation-wind turbine assembly for an 8MW turbine. Scale model tests (1:40) have also been carried out at CEHIPAR (El Pardo Hydrodynamic Experimentation Canal), producing satisfactory results that have enabled the numerical models used in the design to be validated. Within the scope of the project, other possible uses for the vessel have been studied (in addition to the primary objective of installing gravity foundations), such as: installing jackets, installing other offshore devices, or carrying out additional maintenance tasks. Lastly, the main costs of the vessel have been established, both investment and maintenance, along with preliminary amortisation criteria.



Offshore wind farm foundation assembly support vessel

LEANWIND

Logistic Efficiencies And Naval architecture for Wind Installations with Novel Developments

This 4-year project began in December 2013 and involves 31 companies and universities/research centres.

The key objective of LEANWIND is to reduce costs throughout an offshore wind farm's life cycle by applying LEAN principles and developing technologies and tools that help achieve this objective, including: foundations (fixed and floating), installation and maintenance vessels, optimising of O&M tasks, designing numerical planning, logistics and cost tools, etc.

Within the framework of this project, IBERDROLA's participation is mostly associated with developing a floating platform, including tank tests at University College Cork (UCC).

TLPWIND

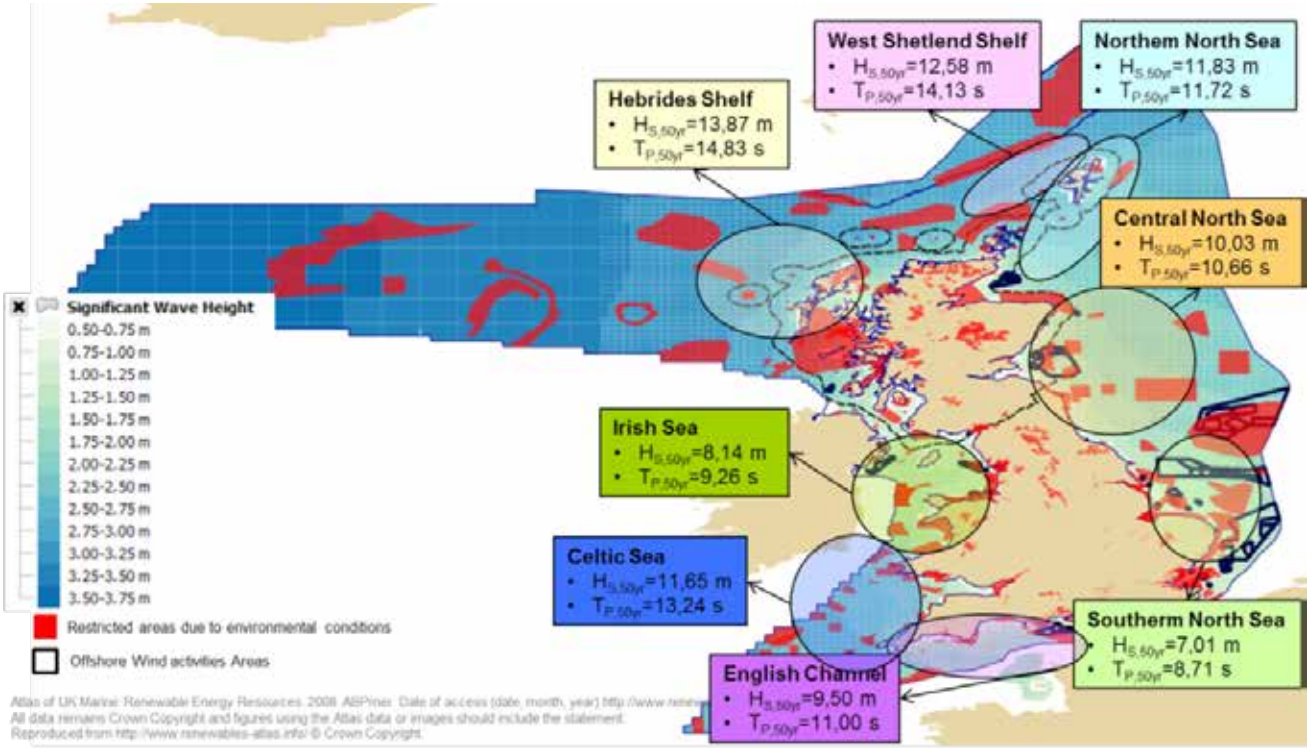
Tension Leg Platform

This project encompasses the researching and subsequent development of an anchoring system for TLP (*Tension Leg Platform*) type floating platforms applicable to the offshore wind power business, thereby increasing competitiveness and reducing the technological risks associated with the design, construction and installation of the aforementioned system.

The objectives to be achieved are:

- Conceptually defining and developing a TLPWIND®platform adapted to the chosen site, which will allow the functional requirements for the anchoring system to be identified and specified.
- Development of a solution (floating platform + tension anchoring system) that is competitive compared to existing developments in floating platforms designed for the same purpose.
- Validating tendon response and structural design of connectors for the developed anchoring system.
- Developing a new concept in platform installation methods based on tension anchoring systems applicable to the offshore renewable energy sector.
- Developing a new system for connecting anchoring lines to a floating platform, thereby reducing installation times and, therefore, the risks posed by working at sea.

To that end, five major activities are encompassed; firstly, a study and assessment of potential sites where TLP solutions can be developed. To do so, the sites are characterised according to their geophysical and meteoceanic conditions.



TLP map of the waters surrounding the United Kingdom

The second activity involves developing the conceptual design for a case study that will be used for the subsequent designing of an anchoring system, taking into account the conceptual design of the TLP for the chosen site as well as the dynamic behaviour of the TLP. The requirements for the developed platform's anchoring system were also evaluated.

Subsequently, a comprehensive design was drawn up for the anchoring system's own installation system to shorten the time for installation and the installation related offshore work by developing a fully optimised installation process. Lastly, possible reductions in the costs and risks associated with the anchoring system were assessed by developing a cost assessment model for the aforementioned technology along with a model for estimating the LCOE (*Levelized Costs Of Energy*), linked to an in-depth analysis of the associated risks of all developments achieved.

Anchoring system design

Anchoring system installation

Further renewable energy technologies

Ocean energy

DTOCEAN

Optimal Design Tools for Ocean Energy Arrays

The aim of this project is to expedite the industrial development of ocean energy and provide design tools for installing the first generation of wave and tidal current converters. The tool, which is the project's main development target, will have five modules:

- Electrical design module
- Hydrodynamic design module (*Array Layout*)
- Foundation and anchorage design module
- Design module for logistics throughout the project's life cycle
- Operation and Maintenance module

The project, launched in 2013 and scheduled to end in 2016, has 18 industrial partners and collaborating research centres.

The company's mission within the project is to offer a promotor's viewpoint during development of the tools so that they will be as useful as possible to end users, thereby avoiding their becoming a merely academic exercise.

ORCADIAN (PELAMIS)

Demonstration project of PELAMIS second-generation technology

The ORCADIAN project involved the construction and commissioning of two Pelamis wave energy devices near the Orkney Islands off the north coast of Scotland, at the European Marine Energy Centre (EMEC). They are second generation Pelamis devices (P2).

The IBERDROLA device was installed at the EMEC In May 2012. Throughout 2013 and 2014 a comprehensive testing programme was undertaken, gradually subjecting both machines to the most demanding sea conditions, as well as an analysis of the key results, thereby expanding our knowledge on wave energy generation devices.

Pelamis P2 Device
(Source: ScottishPower Renewables website)

HAMMERFEST

Validation of a tidal power device

An HS1000 tidal power device has been installed in waters pertaining to the European Marine Energy Centre (EMEC) on the Orkney Islands in Scotland, with a view to validating this technology. IBERDROLA has conducted a comprehensive analysis of production while attempting to follow, as far as possible, the standard procedures for assessing production to increase our understanding as regards the running and operation of marine power devices.

AHH Device (Source: AHH)

MARIN-EL

New large-scale, self-installing offshore substation

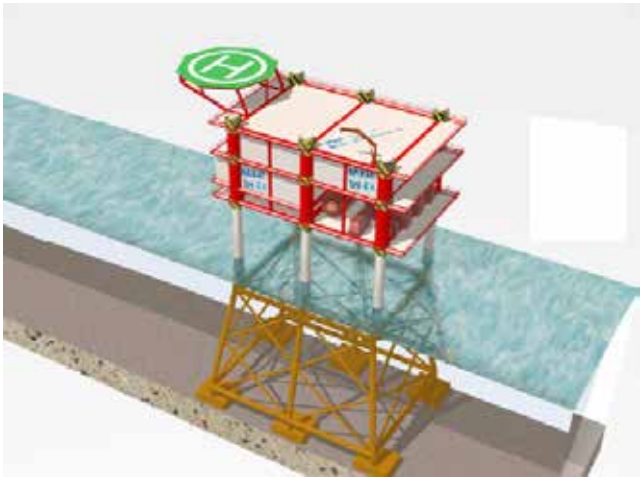
The MARIN-EL project is an R+D initiative that seeks to develop a faster and cheaper system for installing electrical substations at ocean energy plants.

The MARIN-EL initiative aims to offer an alternative for addressing one of the challenges that can hinder the deployment of marine energy, especially offshore wind power, e.g. the increased size and weight of a critical element in an offshore power plant such as a transmission substation.

These substations must meet increasingly demanding conditions derived from the higher rated capacity of such facilities, together with requirements concerning the quality of the generated energy, thus requiring larger and heavier substations.

Moreover, the fact that offshore wind farms are so far from the coast means that DC transmission has to be used as it minimises losses during energy transmission, though this also calls for larger and heavier electrical equipment.

Current methods for transporting and installing such substations are based on the use of special crane barges that lift the infrastructure onto a previously installed support. However, these barges have limitations in terms of the sizes and weights that they can handle, requiring solutions that are relatively inefficient in the case of large substations.



Design of the new self-installing substation

Within the MARIN-EL initiative, an alternative solution is being developed, called a 'self-installing substation', whereby the substation is lifted onto built-in supports. In addition, intensive studies will be conducted into all elements of the substations, as well as technological alternatives for optimising them.

For this project, special importance has been placed on the environment and, consequently, an installation impact assessment has been included based on a life cycle analysis.

UHINDAR

Offshore wave energy generation using offshore wave energy converter (OWC) with oscillating water column

This innovative project is developing a generation system for harvesting wave power using OWC along with the necessary electrical infrastructure to construct a wave farm with this technology.

The UHINDAR project will be undertaken in three stages:

1. The first focuses on modelling how the elements behave at an wind farm in isolation.
2. The second stage will focus on studying and analysing the interaction between different models developed by way of tests conducted at sea to adjust their correct definition.
3. The final stage involves analysing the results obtained in the earlier stages to define an optimal wind farm and resolve the details of the different components to obtain a reliable simulation as to the costs of the energy that will be obtained.

The specific technical objectives addressed by this project are:

- Developing the mathematical algorithms to model the elements contained in the farm's infrastructure during installation, maintenance and dismantling.
- Researching the interaction of all individual mathematical models as well as the different

development parameters for a single modular tool under different operating modes.

- Researching a new captor configuration and the electronic power and control architecture that will help increase the reliability of the technology at the wind farm in which it will be encompassed.
- Researching a new arrangement for the elements constituting the energy transmission system (captors, cabling and transformers) to obtain technical parameters that will afford greater energy efficiency.
- Researching an innovative model for calculating energy losses in conducting and transformation to locate such losses accurately and minimise them.
- Developing an array anchoring structure with a reliable dynamic behaviour, in the face of different acting loads, that maximises the life cycle and optimises the maintenance plan.
- Studying the critical parameters to be resolved with a view to fully integrating the captor into the wind farm with suitable electricity transmission and ideal anchoring

Biomass

LIGNOCROP

Research on Combustion Crops

The main objective of Lignocrop, a project funded by the Spanish Ministry of the Economy and Competitiveness, is to drive a sector of activity dedicated to energy crops in an environmentally and economically sustainable manner and whose ultimate aim is to supply fuel to electrical or thermal power plants.

The aim, therefore, is to demonstrate the technical and economic-financial viability of woody energy crops as an alternative that complements traditional crops, revive activity on marginal lands and look at the impact on employment and wealth creation produced in the rural setting where they are implemented.

It is the first pre-industrial scale project to carry out a study on the optimisation of the entire energy crop logistics chain: genetic selection of crops, production of the plant in the laboratory, growing plants in the most suitable locations, harvesting and preparation, processing of the biomass and delivery to the end user.

It has a total of 60 hectares of woody energy crops with a maximum useful life of 12 years at four geographically and meteorologically diverse locations: Peñafiel (Valladolid), Tahivilla (Cadiz), Molina de Aragón (Guadalajara) and the plain of Granada.

The project began in late 2010 and is set to run until early 2018. They are identifying the main parameters for not only ensuring control and improvement of cost and production efficiency, but also the efficient management of key environmental aspects.

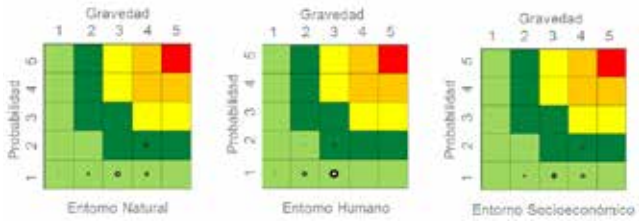
Biomass harvesting process

Environment and sustainability

ERA

Analysis of environmental risks at renewables facilities

A model and IT tool are being developed to identify and analyse the environmental risks associated with renewables facilities (wind farms and mini-hydro plants). The tool will provide support for controlling the facilities' environmental risks by analysing them within a natural, human and socioeconomic setting.



Environmental risk analysis tool diagram

BRIO

Wind turbine rotor blade recycling

BRIO is a research project aimed at recycling wind turbine blades. The objective is to create an innovative, sustainable system for managing and recycling blades from wind farms that have reached the end of their service life.

It arose from the need to address the issue of waste originating from wind turbine blades at wind farms. Such waste is generated when blades are no longer useful, for operational or maintenance reasons, or because a wind farm has come to the end of its service life and must be dismantled or reconditioned.

Currently, management of such waste is an emerging problem since, given the recent development of the wind power business, a significant amount of this waste has not yet been generated.

In this regard, the BRIO project seeks to advance viable solutions for optimising wind farm dismantling procedures, duly contemplating the management of this type of waste. The project also aims to make legislative recommendations, within the framework of the European Union, on how to regulate these issues.

Some of the activities to be undertaken include:

Developments in assessing the logistics involved in dismantling wind farms, an environmental assessment based on the life cycle analysis methodology, and proposals for environmental legal recommendations.

Mechanical recycling of end-of-life wind turbine blades to obtain organ fibre concentrates and other materials earmarked for new applications such as secondary raw material, as reinforcement in concrete prefabs or the core material in prototype multilayer panels.

Application of fibre concentrates originating from wind turbine blades in prefabricated concrete.

The project, which contemplates a demonstration of the developed recycling procedures, will have a budget of over one million euros as well as funding from the European Union, within the framework of the LIFE+ programme. IBERDROLA is spearheading the project, which will run for two and a half years and has two other technological partners. the IK4-GAIKER technology centre and TECNALIA

Wind turbine blade replacement process

Wind farm where the BRIO programme was implemented

Wind turbine blade transport and anchoring work

5.4. R&D&i in the Distributed Energy Resources Area

Introduction

The electricity sector is undergoing a transformation. New technologies such as smart meters, advanced network communications and massive data analysis are driving much of the change.

Various technologies are appearing that come together to create an emerging set of innovations, popularly known as distributed energy resources, which pose new challenges and provide new opportunities in the electricity sector.

New electricity storage technologies, for instance, and improved energy management tools give customers more options for controlling usage and reducing their energy bills. The growing number of electric vehicles that connect to recharging systems at home is a further example of such innovations. What is more, various distributed generation technologies exist that customers can consider for generating and managing their own electricity.

One of the main lines of innovation at Iberdrola is the development of groundbreaking business models and technologies that will enable us to deal with the energy challenges of the future and adapt to changes that arise in the electricity sector.

Storage

SAGER

Large-scale energy storage systems

The aim of the SAGER project is to install an energy storage system associated with an element of the distribution network to assess its potential for rendering services that support improvements to power supply quality. To that end, the following scopes are included:

- Development of an energy storage module based on advanced lead technology.
- Development of power electronics for connecting the system to the grid. It must be a highly efficient modular system.
- Development of an EMS (*Energy Management System*) which, based on the system variables, makes decisions on battery charging/discharging to optimise both economic performance and technical operation.
- Integration of systems in a prototype 500 kW SAGER with 900 kWh storage capacity to validate the technology in a field installation.
- Proposal for a family of SAGER solutions allowing for different Transformation Centre scenarios as well as other possible applications.

Advanced lead-acid batteries have been put forward as storage technology which, by maintaining the robustness and moderate cost of conventional lead, offer a longer service life in terms of cyclability.

The prototype SAGER is located at the Arquímedes electrical distribution centre in Júndiz (Álava, Spain). It has been designed around two buildings, one to house the power equipment and another for the batteries.

SAGER Transformation Station

ESSTOZEB

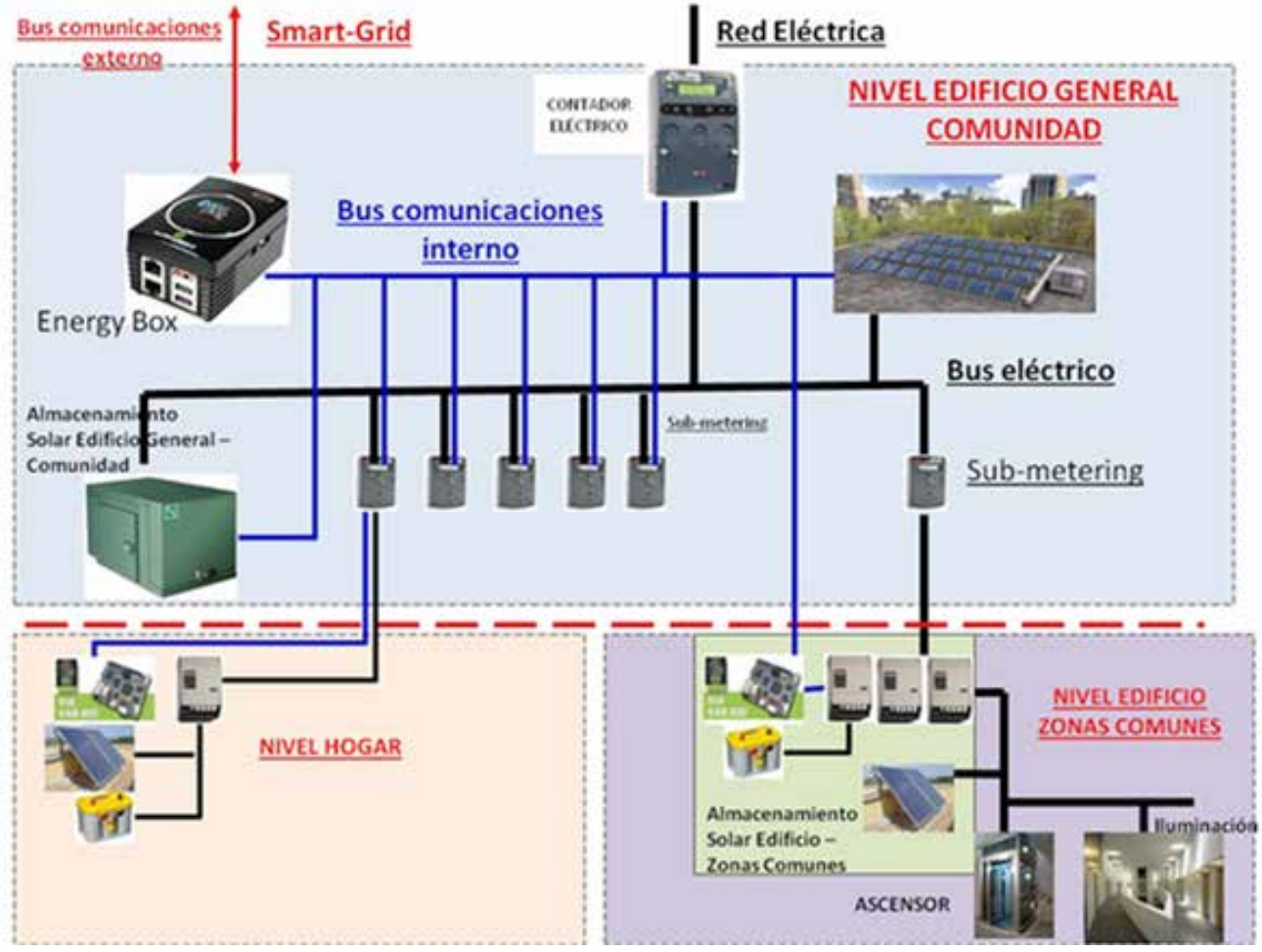
Energy Storage Systems to Zero Energy Buildings

The project is focused on integrating generation and storage systems and improving energy efficiency for optimal management of a building's elements and to move towards ZEBs (*Zero Energy Building*) from an energy efficiency perspective.

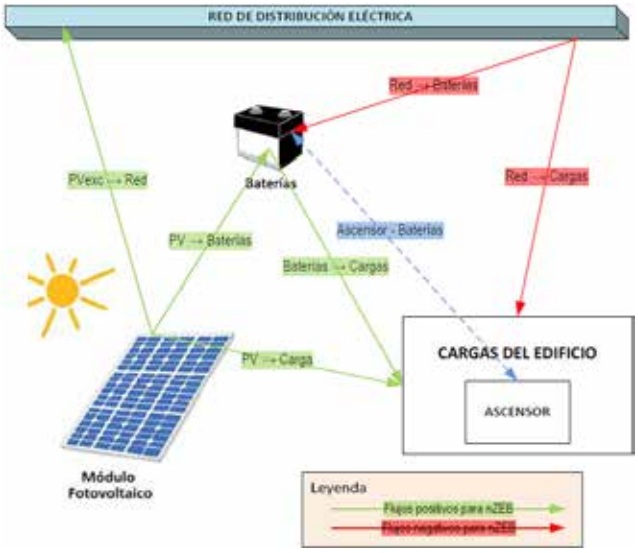
Storage systems lie at the core of the project since they enable the very concept of ZEBs, and their customisation and optimisation are key factors for making the system economically viable. They also pose the greatest challenge for the project, as functional and safety aspects must be made compatible with a controlled cost and a design that is specifically adapted to each application.

Defining scenarios and developing management algorithms taking into account the elements to be controlled (loads, generators, storage, etc.) along with functionalities and degrees of freedom (on-grid mode, autonomous mode, network charges, etc.) represent another major part of the project.

Improving the efficiency of the electrical loads that make up the building is also a priority for the project since, in some cases, there is potential for improvement that must continue to be explored. In addition to this improved efficiency, it is necessary to develop tools to gauge the optimal ZEB configuration and dimension renewable power systems and storage systems by considering the loads to be supplied, system functionalities and the issues of grid coupling and pricing.



ESSTOZEB Operating Chart



ZEB building load diagram

To address these needs, four areas of development are considered:

- Building energy management: where management algorithms and scenarios are defined based on the accumulation of energy in buildings. Also, on integration of said buildings into the *Smart Grid*.
- Advanced accumulation systems: where we analyse the design and industrialisation of Lithium-Ion batteries specifically designed and sized for these applications.
- Energy efficiency: where tools are developed for the correct dimensioning of ZEB systems, as well as improving the efficiency of their component subsystems.
- Application: where developments are integrated and the benefits obtained are shown within a controlled scenario.

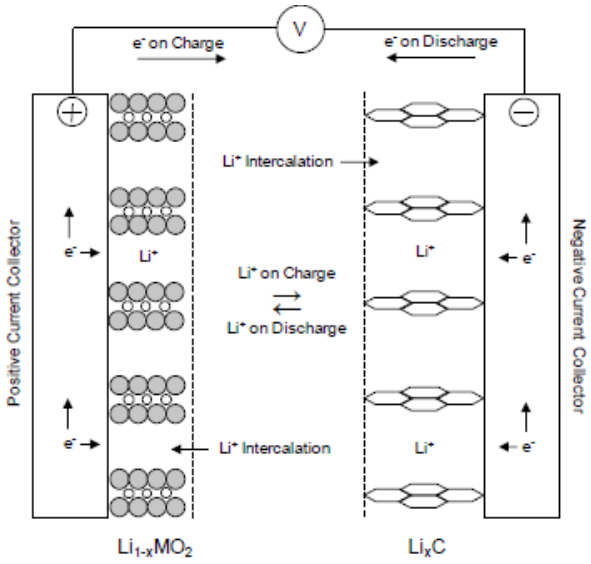
SIRBATT

Stable Interfaces for Rechargeable Batteries

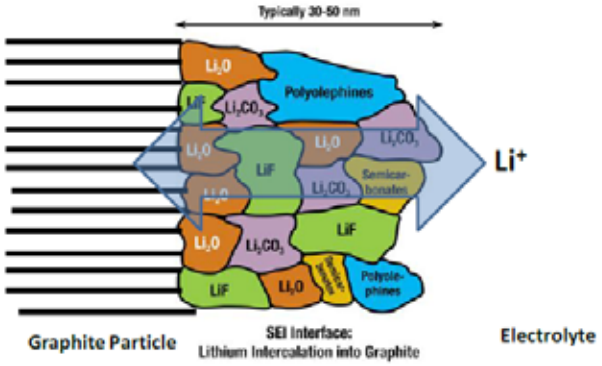
Li-ion batteries, as well as covering a wide range of applications, offer excellent properties. There are, however, certain barriers to overcome so that they can be adopted generically: power, life span, safety and cost. Lithium and lithium-ion chemistry affords major advantages over other technologies in all four aspects. Within the SIRBATT project, theoretical studies will be conducted to potentiate the four aspects:

- Power: The materiales for the electrode will be designed so as to allow rapid diffusion of ions within the structure as well as short charge/discharge times.
- Life span: through improvements to the interface between the electrode and the electrolyte, and by optimising the electrolyte's solid interphase, whose degradation shortens a battery's life span.
- Safety: the aim is to improve battery safety by designing microsensors that enable optimal monitoring thereof.
- Cost: for large-scale applications, it is taken into account at all times that cost will always be limiting, so the most cost-effective solutions will be sought.

In addition to the technological improvements to batteries pursued by the SIRBATT project, they wish to ensure their applicability in real execution



Lithium-Ion battery



Lithium Penetration in Graphite particles

environments. Therefore, they will be studying the usefulness of these developments in one of the possible applications, namely the backup systems at power stations such as nuclear power plants. To that end, battery performance simulations are to be carried out, adapted to the demanding operating requirements of such plants.

To undertake all of these activities, the SIRBATT project has 12 partners encompassing 6 universities, 1 research institute and 5 companies, led by the University of Liverpool, from seven European countries (UK, Germany, France, Poland, Italy, Portugal and Spain), which represent a balanced consortium for the project's academic objectives and the practical application of the results.

GRID+STORAGE

Integrating energy storage solutions with R&D activities in electrical grids

The GRID+STORAGE project is seeking to define and implement an integrated R&D roadmap for Europe; one that aligns the energy storage with grid research and innovation activities, in the realm of both power transmission and distribution.

The following project activities will continue until the end of 2016:

- Public consultations, targeting stakeholders across Europe in relation to the electricity value chain and other energy networks.
- Project monitoring through planned initiatives relating to *Smart Grids* and energy storage at national, regional and international levels.
- Regional *Workshops* aimed at sharing the knowledge generated and discussing the state of the art of each member state, thus allowing us to identify the project-related needs.
- Disseminating the knowledge obtained from carrying out the project and also the knowledge gathered from other completed projects through an open platform that is already up and running.

These activities will allow the consortium members to draw up an integrated R&D roadmap, thus allowing them to construct a more secure electricity market until the end of 2016 by implementing the short-term integration plans for the 2016-2018 and 2017-2019 horizons.

Distributed Generation

iGREENGrid

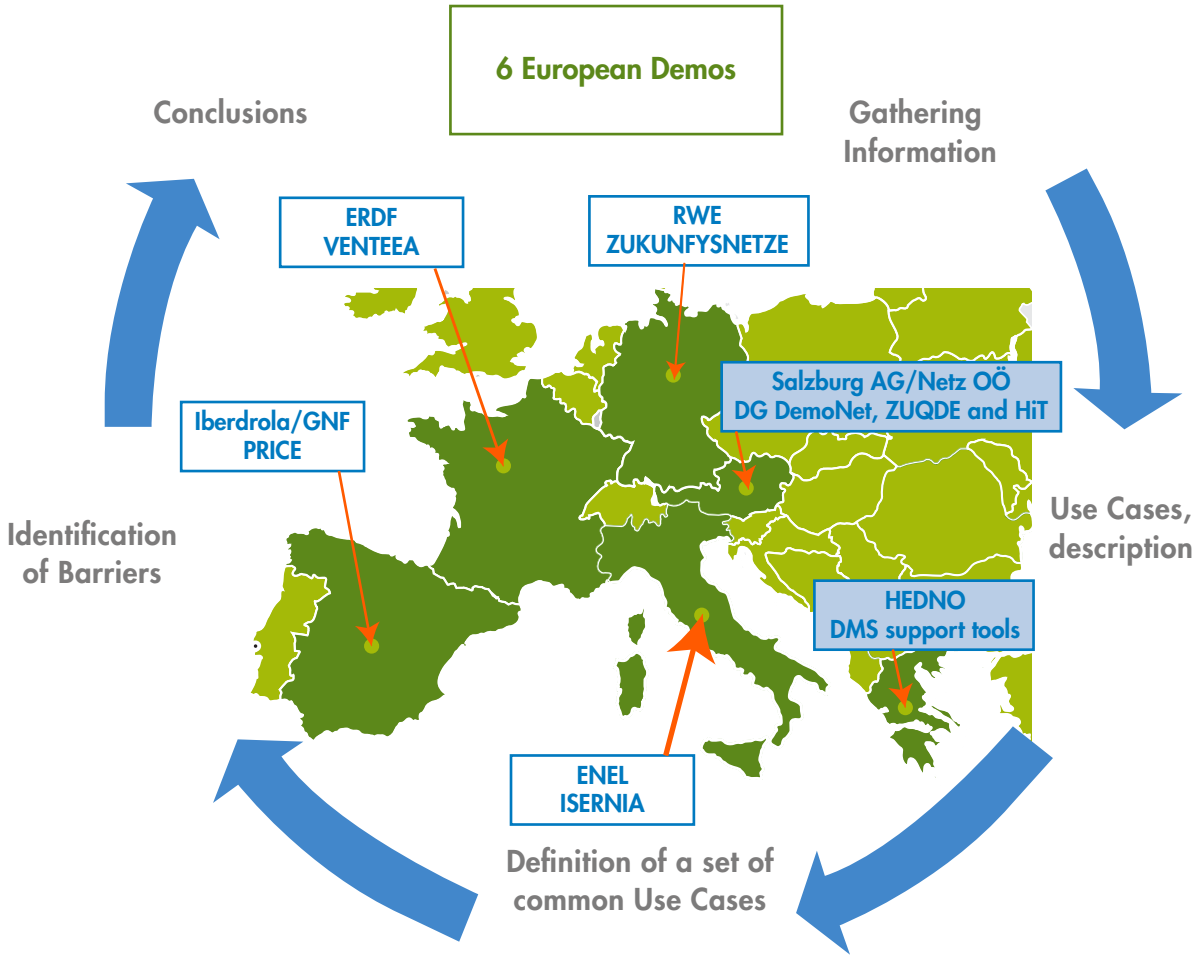
Integrating Renewables in the European Electricity Grid

The project focuses on increasing the hosting capacity of distributed renewable energy sources (DRES) in power distribution networks without comprising reliability or jeopardising quality of supply.

At its heart, the project seeks to share knowledge and promote best practices in finding potential solutions for the effective integration of DRES through six demo projects in LV and MV grids across six different countries. The results obtained have been compared and validated via simulations in other environments so as to assess project scalability and replicability at EU level.

The project pursues the following specific objectives:

- Identifying the most promising solutions and proposing guidelines on how to increase hosting capacity for distributed production energy across electrical distribution networks.
- Evaluating the extent to which hosting capacity can be expanded through the use of real-time monitoring and advanced control so as to help ensure that each point along the grid receives the maximum possible amount of renewable energy production.
- Optimising and balancing flows of energy across the grid.
- Providing information on the distribution network and its connection points.



Map of European projects constituting IGREENGrid

Photovoltaic Solar Power Generation

Improved integration of solar photovoltaic generation in Brazil

The project, undertaken by Neoenergía, seeks to implement and operate a 1MW solar photovoltaic plant connected to the grid. The plant will include a solar weather station to monitor and analyse data from the plant, along with a laboratory that will serve as a point of reference in the study of solar power. The lab will also serve as a certifier of components and systems. Another goal is to develop electronic power transformers that can be connected to photovoltaic solar power systems and to provide recommendations, technical advice and proposals to improve the integration of solar photovoltaic generation into Brazil's energy mix.

Land selected for building the photovoltaic plant

BIOGÁS

Biogas-fuelled electricity generation pilot

This project led by Neoenergía is based on the constructing of a pilot power plant using biogas from anaerobic reactors at waste water treatment plants.

The project aims to establish a series of recommendations for generating energy from an alternative source by way of techno-economic analysis and assessment of national equipment that could replace imported equipment. Another objective is to analyse the feasibility of future projects using the knowledge gained in this project.

Biogas electricity generation plant

Construction of the pilot biogas plant where the tests are to be performed is progressing satisfactorily. Work is currently underway to pressurise the system and locate gas leak points.

Biogas in scattered biodigesters

Distributed generation based on scattered biodigesters

This Neoenergía project entails the construction of a pilot plant to harness biogas from waste water treatment plants, with a minimum installed capacity of 200 kW.

The ultimate goal is to build technical and economic models to study the feasibility of integrating distributed generation based on scattered biodigesters into Brazil's electricity system.

The demonstrative part of the project has concluded and it is now in the generation monitoring phase. The future pilot project is at the tendering stage to acquire the necessary equipment for its implementation.

Wastewater biodigestor

Solar thermal

New hybrid solar microturbine system for cogeneration

The aim is to build two solar concentration plants for agro-industrial purposes and support a network of domestic suppliers that allows new plants to be built in Brazil. One of the plants will be located on the Pirassununga Campus at Sao Paulo University, an Elektro concession area.

It is vital to develop the necessary engineering to integrate a high temperature solar system within the agro-industrial sphere. The project entails creating the first tower-based Hybrid Solar Plant with heliostat field and storage system. It will also have the country's first heat-collecting receiver.

Solar trackers

Technology that improves the efficiency of Photovoltaic Systems

The development of technologies for concentrating solar radiation along with suitable cells for converting that radiation into electricity has a vital role to play in the growth of renewable energies and the government support they will receive in the

future. Concentration Photovoltaic Systems have a great future in a country like Brazil, where regions exist in which normal direct radiation can have higher values than those of global irradiation.

The aim of this Elektro project is to achieve greater kWh/kWp productivity by increasing the capacitive factor of photovoltaic units connected to the grid. This will be done by reassessing the multi-function cells of high concentration systems and developing a prototype solar tracker for distributed generation units, designed for application in flat photovoltaic systems connected to the grid. It is hoped that this technology will bring costs down and maximise the amount of solar radiation captured.

The following tasks will be carried out in the project:

- Diagnosis of the productivity and competitiveness of the different technological options used in electricity production through photovoltaic systems connected to the grid.
- Development of a prototype solar tracker for photovoltaic systems connected to the grid, as well as a process for calculating and simulating its operations, including backtracking effects.
- Development of an electronic mechanism for controlling the trackers.
- Engineering and construction project for a 1 MW plant based on this technology.

Solar tracker prototype

SOFC

Rebalancing of the SOFC (Solid Oxide Fuel Cell) Plant

Unlike other clean technologies, fuel cells have the advantage of being able to generate electricity regardless of the weather conditions. This, combined with their high efficiency and reliability, means niches can be found that will allow the cost of the cells to be brought down, if they are manufactured on a large scale. These cells will, for instance, enable us to satisfy the consumption peaks that occur in small communities without the need for large-scale facilities. Or land.

The main goal of this study, which is spearheaded by Elektro, is to establish a detailed and complete prototype 500MW Hybrid Solid Oxide Fuel Cell Plant powered by ethanol. Through system simulations, the aim is to show that ethanol can be used to produce energy efficiently (electricity and thermal energy) using SOFC.

It is vital to support the application of this technology in energy-efficient generators, designed for distributed generation, based on a renewable energy source that is abundant in Brazil, namely ethanol. This will allow us to ensure the viability and security of Brazil's future energy mix.

Solid Oxide Fuel Cell

Electric vehicles

GREEN eMOTION

Large-scale implementation of electric mobility in Europe

The main objective of the Green eMotion project is to create a single, easy-to-use framework to allow the large-scale introduction of electromobility in Europe. Based on existing regional demonstration projects, projections were made regarding the scalability and feasibility of developing an interoperable, standardised electric mobility system using *Clearing House* (settlement of recharging transactions, charged to the end user) aimed at demonstrating and establishing the best conditions so that companies and consumers will drive electric vehicles.

The regions were chosen based on such criteria as geographic dispersion within the EU, climatic diversity, the heterogeneity of the launching, and the number and type of existing vehicles and charging stations. This project entailed the installation of over 2,500 recharging points in the demo areas for powering the 2,000 electric vehicles existing in 2011 while increasing their triggering force, at a total cost of €380 million.

The project, which ended in 2015, achieved major advances in the following areas:

- Social acceptance: customers have been shown to be particularly sensitive to the electric vehicle's (EV) purchase price, whereby there is a preference for conventional vehicles. Through these actions, incentives and tax cuts were shown to be effective ways to stimulate EV sales. In addition, although EVs are a key instrument in reducing CO_2 emissions, exhaust emissions and noise, the development of more environmentally-friendly batteries is required for the use of EVs to become more widespread and achieve mass acceptance.
- Freedom of movement: the project has defined Europe's IT architecture to ensure an adequate connection for all customers, which will allow open, easy access for EV drivers to the recharging system, as well as adding value through charging point reservation services and simplified payment.
- Economic challenges: the cost of integrating the charging network and infrastructure can be significantly reduced through the use of intelligent recharge strategies to control recharging times and power supply. Charge management can also optimise the integration of variable renewable energy such as solar and wind power by controlling the power demand for the so-called charge zones.

The main strategic impact achieved through the project was the stimulus to EV market development to meet EU policy targets (economic and climatic). Within this context, Green Emotion is part of a bridging project whereby, on the one hand, it links up the different demonstration projects both nationally and regionally within the EU and, on the other, bridges the gap between national projects and allows large-scale rollout.

ICT4EVEU

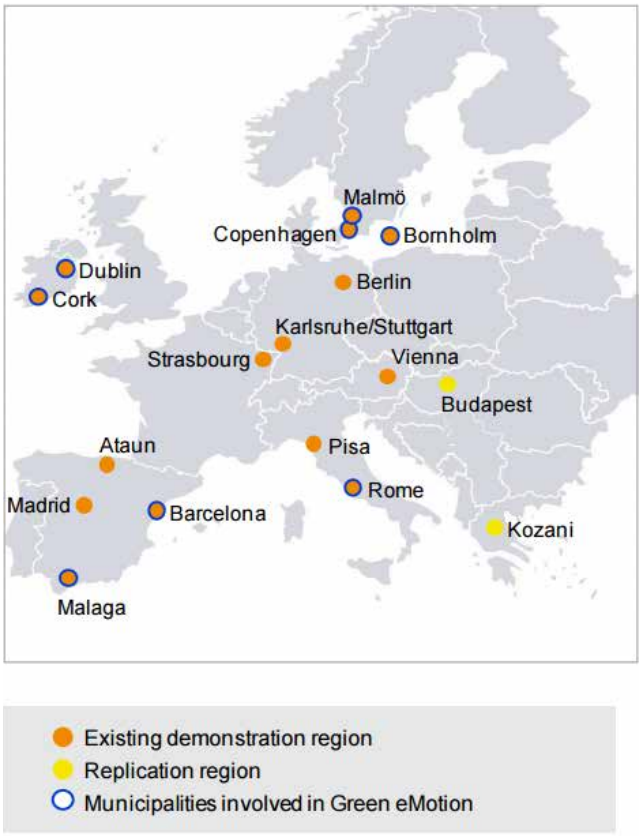
ICT Services to enhance electric vehicle user experience.

One of the main issues within the EV sector is the lack of a single standard for the technologies that surround such vehicles. From the different charge types through to the different communication protocols used by the existing devices, electromobility is now facing a new set of challenges, requiring unified management to render the use of EVs in cities viable.

Therefore, this project does not focus solely on developing a specific technology or device, or even researching new components or alternative technologies. Its main goal has been to implement a set of ICT-based EV services aimed at integrating existing technologies to enhance the user experience.

The specific objectives that have been proposed include:

- Developing a set of services that allow users from different cities and regions across Europe



European map of the regions participating in the ICT4EVEU project

to access the charging network regardless of the technology or types of charging points that exist.

- Recommending and guiding the driver to the most suitable recharging station, according to battery status and network availability.
- Allowing a charging point to be booked in advance and facilitating payment methods and notifications (by email, SMS, etc.) when the EV is fully charged.
- Contributing to Europe's objective of creating a sustainable, lower-carbon transport system.

The project proposes different pilot experiences in various cities, requiring the existence of different infrastructures in each one to increase its geographical scope: urban, regional and cross-border. The three main pilots are located in the following regions:

- Bristol and its metropolitan area.
- Linking two Spanish cities, Pamplona and Vitoria, by creating a 100 km-long common corridor.
- Slovenia, with its main cities, Ljubljana and Maribor. It will be combining the union of two cities plus an international scope, as this pilot will count with the observers from the region of Styria in Austria.

When the project concluded in 2015, the following activities had been completed:

- Pilots harmonisation and design.
- Deployment and Implementation of the pilot.
- Global validation and tuning the pilots.
- Creation of an international platform of public-private cooperation to promote smart electromobility.

AZKARGA

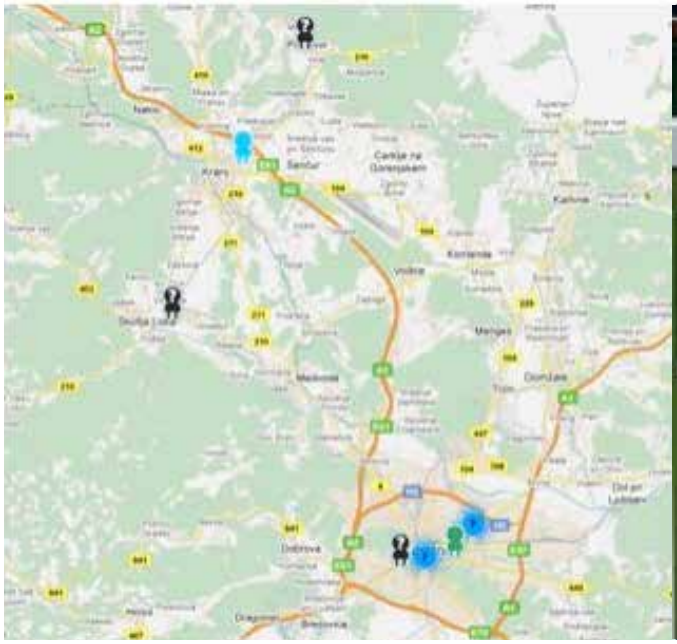
Fast, efficient and smart EV charging stations.

The main goal of the project is to develop a novel solution for fast, smart, flexible and manageable charging that fosters the widespread implementation of EVs in the worldwide fleet of urban vehicles.

This challenge is made possible thanks to the research and development of the most advanced charging technologies, communications (EV-Charger, and Charger-Manager), energy management and associated metering, resulting in a stand-alone, fast, advanced EV-recharge end product that is a world-first with Basque Country *know-how*.

To achieve the primary objective, the following specific goals must be attained:

- Increasing recharge availability for EV users by 300% thanks to an intelligent, efficient and widespread implementation of charging points and associated management network.
- Enabling enhanced EV autonomy of up to 40% by reducing charging times to under 20



Map indicating the roadside charging stations

Iberdrola's electric vehicle

minutes or making it possible to charge higher capacity batteries just as quickly.

- Obtaining a solution that allows flexible full charging in a public environment with a single DC connection between the system and the EV, as well as adding the option of high-intensity AC charging.

Connectors employed for charging electric vehicles

- Developing a rapid charging system exceeding 43 kW in AC and 50 kW in DC.
- Developing a communications solution for the charging system capable of communicating with latest-generation vehicles in accordance with standard IEC15118 via PLC (*Power Line Communication*) and with the control centre (charging station-Charge Manager communications) in accordance with future protocol OCPP 2.0.
- Creating a charging network control and management system capable of integrating the charging point into the global user system with different payment methods and physical energy metering.

REMOURBAN

REgeneration MOdel for accelerating the smart URBAN transformation.

The core objective of this project is to develop and validate a sustainable urban regeneration model leveraging the convergence of energy, mobility and ICT; to accelerate the deployment of innovative, economical and organisational technologies; and to significantly increase resource and energy efficiency, improve the sustainability of urban transport and drastically reduce greenhouse gas emissions in urban areas.

The project was launched in 2015 and, to ensure that its main objective is achieved, the following activities are scheduled:

- Developing a holistic model of sustainable urban regeneration that supports the decision-making of the main stakeholders to address the renovation and transformation of the city.
- Validating the urban regeneration model through large-scale interventions in various "lighthouse" cities, namely: Valladolid (Spain), Nottingham (UK) and Tepebasi/Eskisehir (Turkey).
- Guaranteeing the replicability of the model at European level. Two "follower" cities, Seraing and Miskolc, are also taking part in the consortium and will develop a procedure to evaluate the potential for repeating the model.

European map of the cities participating in REMOURBAN

CAPIRE

Coordination & Support Action (CSA) for Europe's Green Cars initiative.

The Coordination Action CAPIRE will prepare and support the realisation of a Public Private Partnership (PPP) sustaining and putting into practice the European Green Cars Initiative.

The project is focused on defining the potential flagship projects that could increase the competitiveness of global European Automotive Industry in the domain of electrification of vehicles, as well as the development of technologies and services to reduce Europe's CO_2 footprint. Major outcomes include: a dedicated roadmap based on an elaborated and deep analysis of R&D needs, respective milestones and supporting measures; and a joint approach of the involved economic sectors and the public authorities aimed at increasing the competitiveness of global European Automotive Industry in the domain of energy efficient, safe, non-polluting and CO_2-free vehicles.

To be broad enough, this strategy has been based on the three following technology pillars of the EGCI:

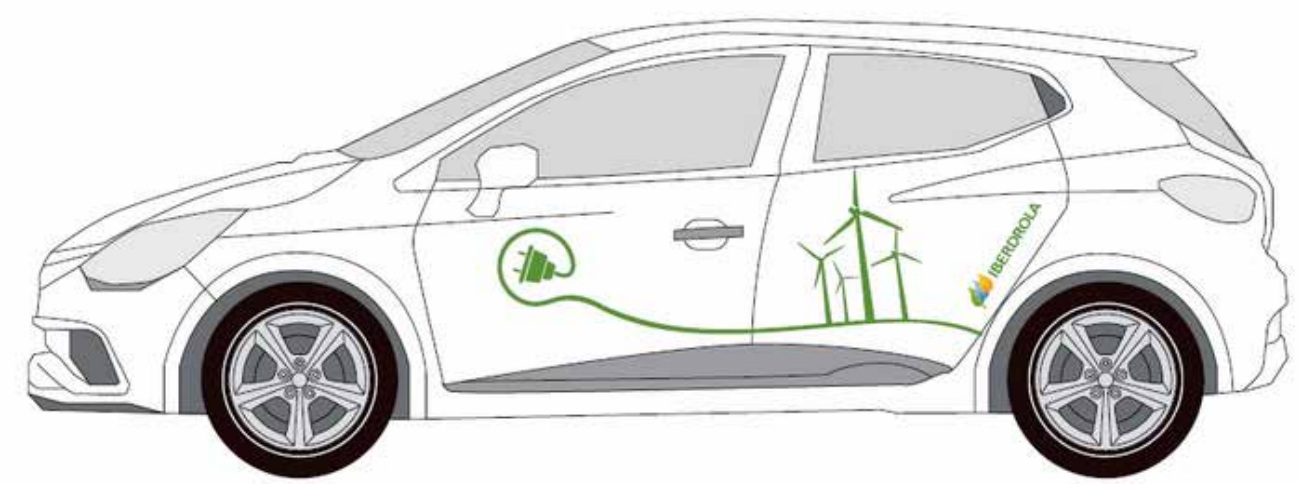
- Passenger cars and LCV: to reduce local pollution, emission of greenhouse gases, and noise by accelerating electrification of vehicles and provision of a dedicated infrastructure for the connection to CO_2-free energy sources.
- Lorries and Buses: to improve overall efficiency of transport of people and goods by accelerating the improvement of ICE technologies and their potential partial electrification.
- Logistics: to increase the efficiency of goods transport by optimising loading rate of lorries and mixing different energy saving transport vectors such as rail transport and road transport.

Your electric vehicle

Electric Vehicles for Employees

Iberdrola has launched an initiative called Electric Vehicles for Employees so that employees can move around sustainably, which is compatible with grants from the Spanish government's MOVEA plan. Throughout 2016 and 2017 it will be extended to the remaining countries so that all of the Group's employees can benefit from it. The "Electric Vehicles for Employees" plan encompasses three types of grants:

- Iberdrola is offering a special advance to buy a "zero-emission vehicle" with minimum autonomy of 40 km (only in electric mode) for the first 200 employees to request it.
- The Company is offering a grant to the first 200 employees who subscribe to a charging point through Iberdrola.
- Non-repayable grant for advertising sponsorship.



Electric vehicles for Iberdrola employees

5.5. R&D&i in the Retailing Area

Introduction

Innovation is one of the essential elements and one of the main characteristics of retail activities.

The speed at which the markets, technology and consumer preferences are changing makes constant upgrading essential.

It is vital to systematically seek out new ways and channels for interacting with customers as well as to develop and experience new business models. It is also crucial to design new offers along with new products and services that make the company's offer both appealing and unique. And to develop new management and operating processes and systems that ensure fast, efficient, quality service able to meet the increasing demands of users at a competitive cost.

In the meantime, it is essential to create new systems for retrieving, analysing, processing and managing information, affording in-depth knowledge on each user and their value to the company, their experience and perception, with the capacity to offer them the products, services and attention most suited to their specific needs.

It is also vitally important to understand and be at the forefront of technological advancements and developments that allow IBERDROLA to offer an energy supply, equipment and technologies that are ever more efficient and environmentally friendly: renewable energy equipment, microgeneration, distributed generation, energy-related control and management of facilities, buildings and homes, energy efficient equipment for industry, services and households, electric vehicles, smart grids, etc.

To that end, much of the work carried out by the entire commercial team is innovative in nature, whether in their day-to-day work or through innovation projects, clearly oriented towards problem solving and in line with business targets and the critical processes involved in retail activity.

Smartsolar

Comprehensive turnkey service for a Photovoltaic Solar Power facility

Smart Solar Iberdrola is an innovative solution that includes an integrated package comprising the design, assembly and commissioning of a custom solar facility, including financing, consulting, maintenance, management and supervision of the plant through internet tools and new apps, along with backup energy as required. Customers will be able to generate and use their own electricity, thereby optimising usage and enhancing the energy efficiency of their facility.

- **Design:** The functioning scheme and scale will be optimised to the user's needs.
- **Quality:** IBERDROLA only works with the highest quality equipment and cutting-edge technology. All equipment that is installed is of proven quality and guaranteed to function throughout the contract period.
- **Maintenance and Repair Service:** To ensure that the facility has a long service life and optimum profitability, we recommend a yearly visit to conduct a full inspection of the facility. Any incident at the facility will be dealt with by our team.
- **Security:** IBERDROLA offers advice on insurance cover for any incident at the solar facility.

Products and services included in the Smartsolar installation

- **Web Services:** All information relating to the facility, as well as programming capacity, will be available through a Mobile App for *smartphones* or via the Internet.

Customised plans

Innovative offers tailored to each customer

In September 2015, Iberdrola launched offers from its "Customised Plans". Available to over 12 million customers, these innovative offers are tailored to each customer's lifestyle and allows them to make savings at peak times.

The installing of smart meters opens up the possibility of creating offers that are tailored to each customer's needs. Customers no longer have to change their consumption habits to make savings. Rather, they can take advantage of existing offers tailored to their consumption habits and can thus save even more.

The main customised plans launched in September 2015 are:

- Stable Plan, for customers who do not use high amounts of electricity at certain times of the day.
- Nighttime Plan, for customers who use a lot of electricity at night and in the morning (10pm to 12 noon).
- Summer Plan, for customers with a summer home where they use most electricity between 15 June and 15 September.
- Winter Plan, for customers with a winter home where they use most electricity between 1 December and 1 March.
- Weekend Plan, for customers with a weekend home or who are not at home during the week and use most electricity on Saturday and Sunday.
- 8-Hour Plan, for customers who use most electricity at certain times of the day and can choose at which times they want to pay less.

Website to access the Customised Plans service

The main features of these offers are:

- Offers tailored to each customer's lifestyle and energy usage, enabling them to make savings without having to change their consumption habits.
- Looking after the customer experience when subscribing through a microsite; with a few simple questions, the customer is advised on which plan best fits their lifestyle and, therefore, affords the biggest savings.
- Monitoring and energy saving tips, offering customers advice at all times on whether they should stay with their subscribed plan or switch to another plan for bigger savings.
- Flexibility; allowing customers to switch plans, without penalty, if they change their consumption habits and needs.
- Digital communication and subscription, with all the benefits of E-Billing.

My Energy Consumption

New functionalities for providing information on energy consumption

In order to improve our commitment to our customers, since late 2015 Iberdrola has been offering customers with smart meters valuable information on their consumption,in a format specially adapted to provide the best customer experience.

The functionalities now available to customers with remote management are:

- Graphs showing changes in their consumption, with the option to see the information in different views (yearly, monthly, weekly, daily or hourly).
- Option to compare different date ranges to see how their consumption has changed over various periods.
- Estimated date and amount of the next bill.
- Tips on energy savings and efficiency
- Option to export the information to various formats.
- Access to a monthly report summarising monthly consumption.
- Tailored, proactive notifications informing customers about critical times in their life cycle (such as a higher bill due to seasonal temperature changes).

Interface for the My Energy Consumption App

All of these features are now available at the Virtual Customer Service Office and will shortly be available in the customer App. New features will soon be added to those already available, as they are developed.

GRID4EU-Customer

Large-scale demonstration of advanced solutions for smart grids providing a high level of scalability and replicability for Europe

The aim of the project is to test, at true size, innovative conceptual systems and technologies to highlight and help remove some of the barriers (technical, economic, social, environmental and regulatory) involved in the use of smart grids, and to achieve Europe's objectives for 2020. During development, smart grid's potential has been proven in areas such as the integration of renewable energies, development of electric vehicles, grid automation, energy storage, energy efficiency and customer demand management.

Furthermore, emphasis has been put on fostering complementarity between projects, promoting cross-cutting research and sharing results amongst the different partner companies.

Within the IBERDROLA customers area, a pilot has been undertaken with residential customers from Castellón (Spain), who were given real-time information on their electricity usage and costs via a touch screen connected to their *smart meter*. They also enjoyed flexible time-of-day rates to enable them to manage their energy consumption and electricity bills more efficiently. The aim of this trial is to analyse shifts in the consumer demand curve and find out how interested the customers are in home energy management.

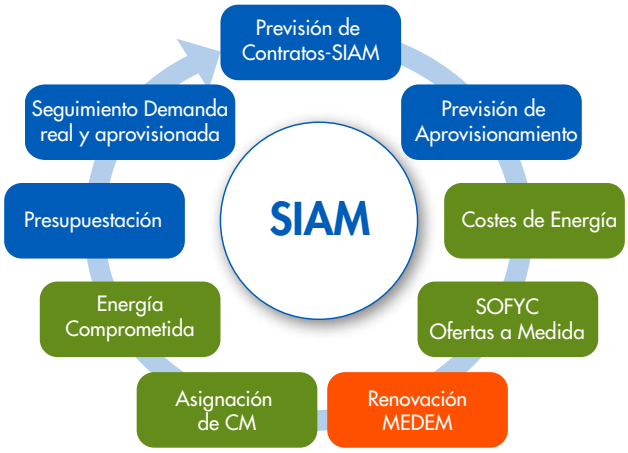
SIAM

Integrated Market Conduct System

This project aims to define a new tool for optimising relations between the different players from the electricity and gas market through advanced technological solutions that allow the company to achieve greater internal business efficiency and, consequently, greater profitability.

It encompasses the monitoring of energy from when market opportunities arise through to final settlement of the energy with the different players. Its area of action is global including such markets as Spain, Portugal, UK, France and Germany.

Diagram of customer solutions with GRID4EU



SIAM operating system

The project has been developed through rigorous analysis and a tailored design aimed at achieving the optimal solution for creating a universal tool for the energy retail area and enhancing operational efficiency, reducing waiting times and increasing the area's overall profit.

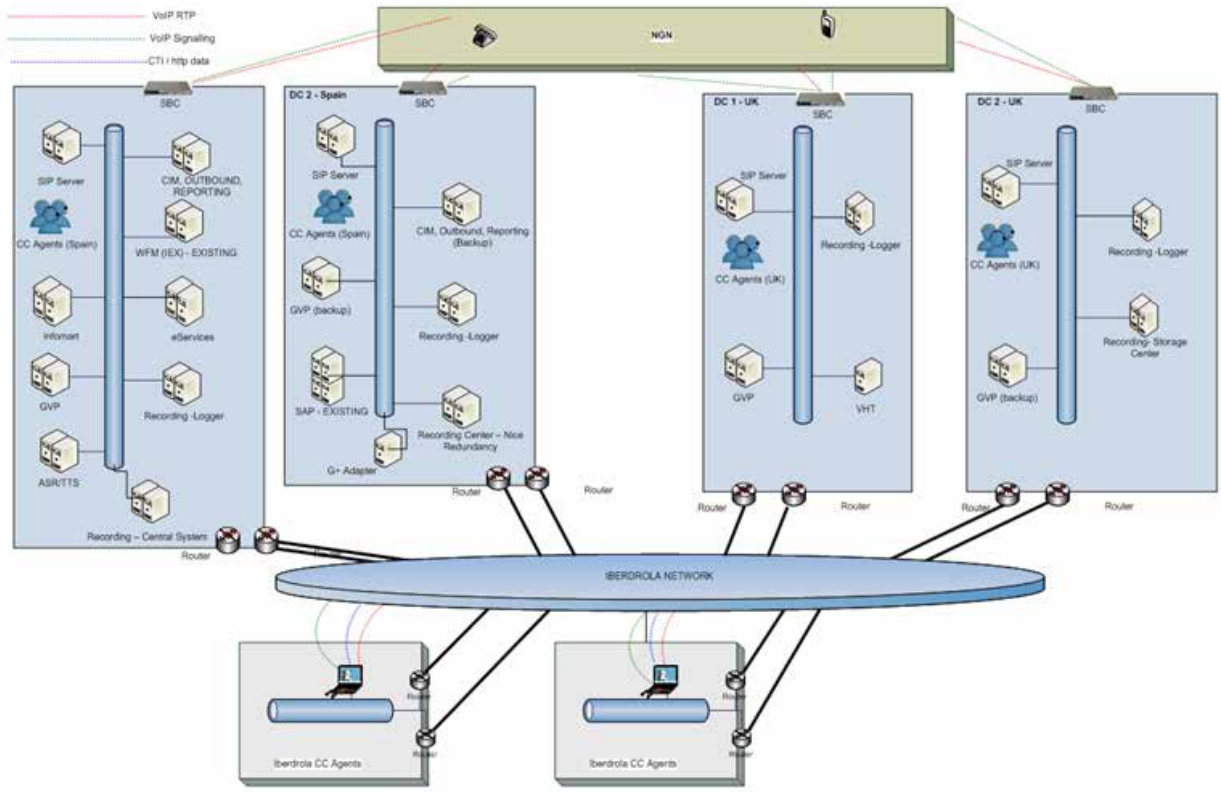
This project, which has concluded successfully, achieved the following objectives:

- A higher level of reliability in *pricing* systems and development of the interface with Wholesale, thus expanding the capacity of pre-existing tools
- Increased operational efficiency, by eliminating inefficiencies, expanding the tools with specific modules for generating offers, meter readings, control of contracts, expenses and costs associated with each managed MWh and final settlement of the energy.
- Optimisation of communications between the different system modules, including the documentation extraction and management system, as well as creating a system adapted to global business between Spain and the United Kingdom.

UCC

New Unified Contact Centre communication architecture

This project consists in unifying IBERDROLA customer relations platforms in Spain and the UK to promote a reduction in platform cost and upgrade it to increase consumer satisfaction.



Complete architecture of the solution

The system is based on four *Data Centres*, two in each country, one primary and one *backup*, hosting the main architectural elements and servers. They are interconnected via the Iberdrola network and have been developed so that, if there is a fault, the structure will remain intact and be transparent to customers.

The project concluded successfully and achieved the following objectives:

- Cost-efficiency thanks to the connection between platforms.
- Customer loyalty, seeking to maximise satisfaction by offering the best possible customer service.
- Controlling the quality and productivity of the service offered to customers.
- Centralising the control and administration of the inter-centre communication network.
- Providing the company with access to new *online* communication channels such as social media.

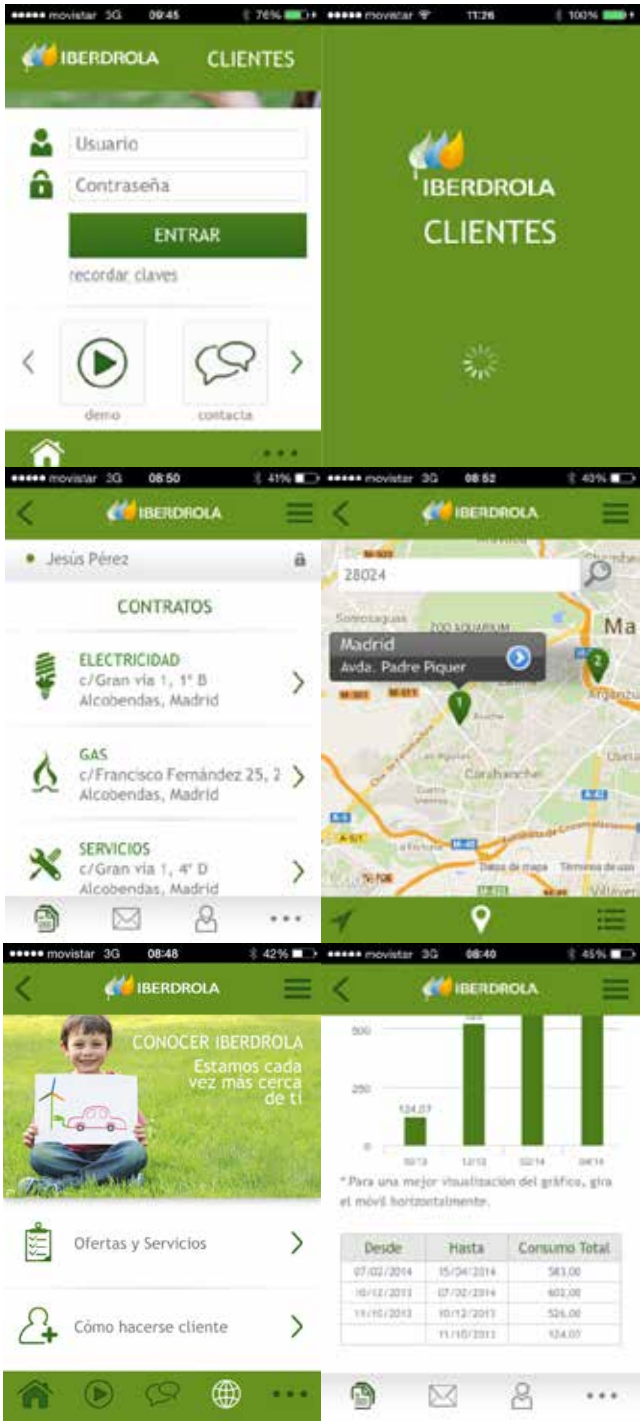
GESTICOM

Online retail management platform

The primary objective of this project is to adapt the *online* retail management platform to a new environment to integrate it into the latest mobile devices, thereby ensuring customer satisfaction by providing access to Iberdrola resources to carry out different procedures and consultations. It also makes it easier for customers to get additional information about their installation, subscribed services and consumption, having access to Iberdrola offers.

Upon its successful conclusion, the most significant improvements achieved by the project in terms of new operational processes for *online* management can be summarised as follows:

- Enabling procedures and operations through *online* access from different devices.
- Creating a mobility environment for the most popular operating systems, namely iOS and Android.



Online retail management platform

- Providing different menu types in the mobile app according to the customer's profile.
- Achieving new features that allow IBERDROLA to offer a wide range of options within the platform.
- More intuitive and efficient online management.
- Enhanced navigation between screens, striking a balance between aesthetics and functionality.

Smart UK

Deployment of smart meters in the UK

The deployment of smart meters poses many challenges in the UK, including: deployment is spearheaded by retailers (as opposed to distributors, as occurs in other countries), the need to deploy a *Home Area Network* (HAN) that offers consumers comprehensive information about gas and electricity meters, a short rollout time covering 100% of customers, and the setbacks and uncertainties surrounding the availability of the technology to be used in the project.

To overcome these challenges and prepare the enterprise for such a major undertaking, ScottishPower is carrying out various alternatives that will endow the company with relevant knowledge and help identify solutions for maximising the efficiency of the project.

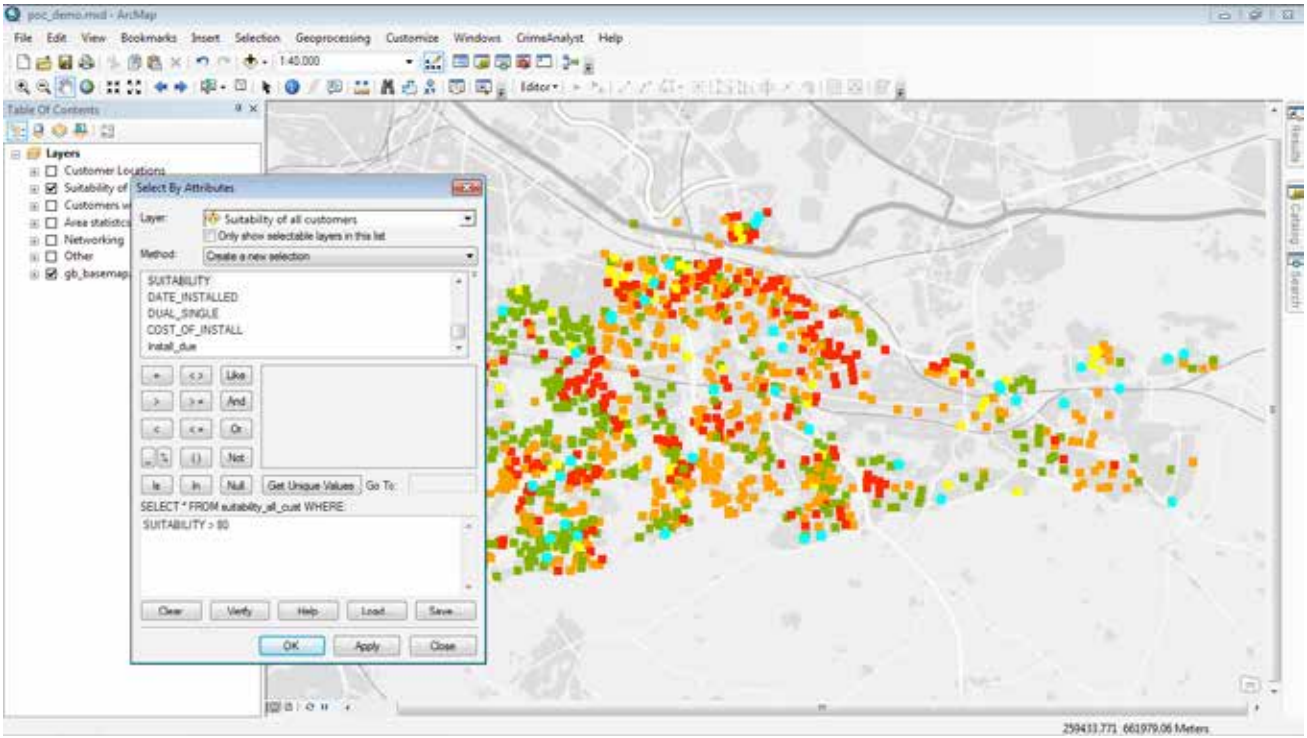
In 2014, ScottishPower began an extensive study into the deployment of HAN in homes and communities, which are renowned for presenting problems regarding wireless networks and communications.

There are two main areas of interest:

- High-rise blocks with rooms housing shared meters in the basement or on the ground floor.
- Low-rise blocks with rooms housing shared meters and/or gas meters on or around the outside of the building.

After trying out different technologies, in 2015 a deployment pilot began involving 55,000 smart meters aimed at assessing the capacity of the supply chain (manufacturers and installers) as well as identifying and detecting installation issues, for both gas and electricity meters and communication networks. Customer experience with smart meters will also be put to the test as part of the trial.

Lastly, ScottishPower is developing a deployment optimisation tool that will reduce the chances of failure when planning an installation, as well as optimising the assigning of jobs to installers to increase the overall efficiency of the process.



Smart meter deployment

Connect

Digital System for home energy management via smartphone app

ScottishPower has developed a service that provides smart control of home heating via a *smartphone* app. The system allows customers to remotely control their heating system, turn it on and off, set their home heating automatically according to such factors as the weather and their daily movements, as well as remotely adjust the temperature at home. The app and *online* applications provide customers with information about their home heating use. The service is part of the "Connected homes" initiative that aims to provide greater control, convenience, better adaptation to individual needs, and potential energy savings.

To support this product, we have created an online community to engage customers who bought Connect, to conduct *online* research through a special laboratory that will allow us to better understand the user experience (installing, setting up and using Connect), the pros and cons of each, and identify improvements and developments that users would like to see implemented, while

Energy management system App

continuing to improve the product to ensure that customers' needs are met. The service is provided through the ScottishPower App which ensures that the customer has even greater access to and control of their customer account. It allows them to manage their billing, submit meter readings and monitor their energy usage.

Unifi

Home Hub In Home Energy Monitoring

The Unifi product has been developed to enable household customers to remotely monitor and control their home and the use of electrical appliances, and includes: a screen at home or energy monitor, a smart connector for remote monitoring and on/off switching, and an Internet device for transmitting consumption data via a broadband router to view on the ScottishPower Portal and an iPhone app.

Unifi App

Digital Customer Engagement

Interaction with Digital Customers

For the last two years, ScottishPower has been dealing with the needs of a growing number of customers who wish to subscribe to products or services through digital applications (mainly web-based and mobile apps on *smartphones*).

The website has been simplified and upgraded with new features providing quicker, easier access to services, including customised bills and energy consumption graphs, change of address and online reimbursements.

ScottishPower's *smartphone* App for iOS and Android devices has been developed to allow customers to manage their own customer account. The App's features include the ability to edit account details, submit meter readings, see energy consumption graphs, switch rates, ask for *online*

ScottishPower Customer Website Interface

credit to be reimbursed, *smartwatch* integration, sale of non-energy products and services, as well as information on how to contact ScottishPower. The App also includes Connect, for remote management of home central heating.

CEC

Community Energy Coordination

The aim of this AVANGRID is to assess the potential benefits from retailing services associated with distributed energy resources on behalf of suppliers, and facilitating their interaction with consumers. Activity will be focused in Tompkins County, in the state of New York, and implemented in three phases.

The scheduled phases are:

- Connections between community and market – Identification of opportunities based on *input* from service providers and the interests and activities that exist in the community. This process also involves identifying any synergies with other activities in the community.
- Planning – Developing offers for specific services, establishing both rules and costs that must be handled by providers to encourage participation, reaching agreements therewith.
- Customer segmentation – Creating customer segments based on surveys and demographic consumption data.
- Energy retail – Actively retailing offers from service providers for customers.

Energy Marketplace

Development of a new E-Commerce platform

The project's goal is to develop a retail application for AVANGRID called "The Energy Marketplace". This application will provide customers with an integrated digital experience as well as a business opportunity for the company and its partners based on digital commerce. Customers will be able to view, buy and subscribe to the company's energy services *online* with major discounts exclusive to the app. This new business model bases its revenues on the margins afforded by Marketplace-type applications.

Once it is released, both household customers and small businesses will be able to enjoy exclusive discounts on various products.

Amongst its other features, the program will allow you to use Energy Efficiency services, Demand Management and the *Community Energy Coordination* (CEC) pilot scheme, as a communication channel between customers and suppliers of distributed energy resources.

This service will be implemented in the following phases:

- Launch of the online portal accompanied by a marketing campaign to promote the advantages of the platform and provide a retail outlet offering many products with major discounts.
- Expanding product and service offerings and running marketing campaigns specifically targeting customers who have already taken part in Energy Efficiency schemes.
- Extending the service to customers of other companies from the group and adapting the portal to be a distribution channel for new initiatives.

On Site Billing

Integrated reading and billing

This NEOENERGIA project is based on the implementation of a stand-alone on site reading and billing solution integrated into the retail system. The project's objectives were:

- Increase the efficiency of meter reading, billing, printing and electricity bill delivery processes.
- Enhance the efficiency of meter-reading visits and reduce them to a single visit.
- Shorten the submission and expiration time by anticipating retail actions.
- Increase the accuracy of information obtained from readings.

SAP HANA

Collection management through SAP HANA

The aim of the project is to implement a flexible, parameterisable system for controlling commercial information and the operational planning of collection processes by means of the SAP HANA application at NEOENERGIA. This system will allow us to ensure standardised information, organise businesses, perform dynamic analyses that afford improvements in commercial processes and operational collection planning, as well as guaranteeing the processes for handling large amounts of data with ad-hoc analysis.

The project's objectives are:

- Optimise financial resources.
- Expedite cash flow.
- Reduce non-technical losses.
- Shorten commercial information gathering times.
- Enable real-time analysis of large amounts of data.
- Develop new relationships with partners.
- Parameterise the system and make it flexible.
- Apply mathematical models.
- Run simulations of future scenarios.

Rates Book

Design and application of a new rate structure

The aim of this project is the design, simulation and pilot application of a new rate structure for

ELEKTRO customers. The new structure will be based on economic concepts, taking into consideration consumer market analyses for the purpose of demand (elasticity, revenue and energy end use), also analysing the applications for *Smart Grid* technologies and their new modalities.

This new rate structure will enable billing that is more suited to the customers' consumption profiles. Doing so can yield economic operational benefits such as: reducing grid downtime or deferring investment.

The pilot project was launched in 2015 for certain customers, who were billed under the new rate. As ELEKTRO gathers customer consumption profile data, they will be analysed for use in 2016.

New virtual customer service agency

The project's goal is to develop ELEKTRO's existing online customer service agency into a modern, intuitive product, thereby fostering a sense of trust and security in the customers. The agency will provide access to the company's main services and expand its subcontracting functionalities.

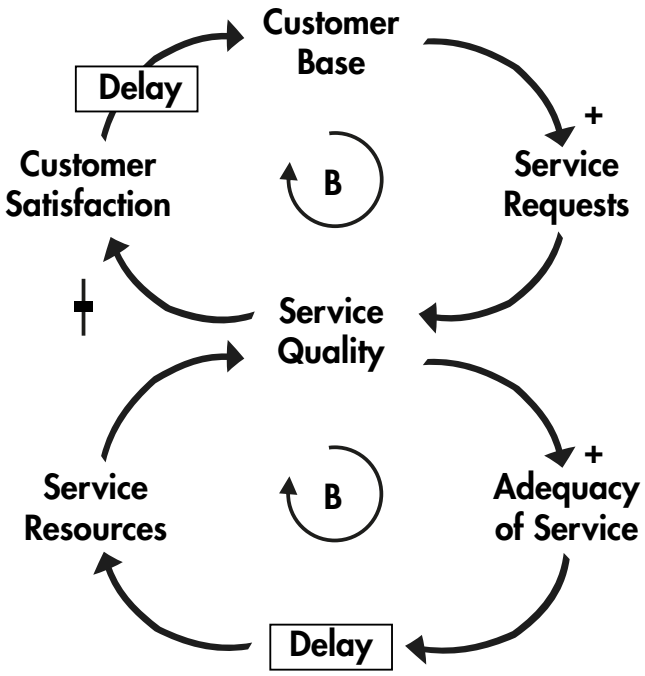
They plan to create a log-in via ID card or password, which will require an account to be set up in advance, as well as by type of access between individuals and concessionary companies. Subcontractors will have access to their asset and customer portfolio, which will be accompanied by numerous graphs and consumption or demand data.

Future consumers

Future consumer modelling

The aim of this project is to build a mathematical model, accompanied by its respective computer platform, which will serve to run reliable simulations on changes in consumption patterns at ELEKTRO and its response to new impending events, with special emphasis on studying consumer behaviour.

The introduction of *Smart Grids* will offer each customer a new rate structure, based on their personal profile and guided by regulatory and economic factors. The emergence of new technologies such as electric cars will create different yet still unknown rate structures that should be contemplated to address the new paradigms of the future. In this regard, it is thus essential to develop a predictive model to support decision-making.



Future Consumer Model

The model must run automatically and autonomously, supported by a database, and project how consumers are expected to behave when different events arise. The range of outcomes must be broad and encompass most of the aforementioned possibilities, for instance: grid expansion processes, energy procurement or occasional power cuts. The results will allow ELEKTRO to anticipate customer needs.

5.6. R&D&i in the Systems Area

Introduction

Throughout 2014-2015, the Systems area remained committed to developing innovative projects that bring value to the Group by allowing it to gain a competitive edge in the market, thus increasing its productivity and efficiency and enabling it to offer more services to end users as well as better information in line with their needs.

IBERDROLA received the "Impulso Award for ICT in Spanish Companies", awarded by AMETIC in 2015. AMETIC (Association of Electronics, Information and Communications Technologies, Telecommunications and Digital Content Companies) has thus acknowledged IBERDROLA's work in developing an innovation policy underpinned by ICT as a key element for increasing its productivity and efficiency and thus achieving a more competitive position in the market.

The main innovation projects include, in Spain, a new GIS (Geographic Information System) on distribution networks, the development of the Virtual Customer Service Office on the Iberdrola website, completion of the ONE HR project (the Group's stand-alone global Human Resources system), as well as application upgrades at renewable energy facilities. In the US, we should highlight the new Treasury system, and modernisation of the CRM (Customer Relationship Management) system has begun. In Brazil, notable projects include implementation of the Corporate Global Human Resources process and, in Scotland, work continues on the new Smart Meter Data Management System and the *Smart Foundation* as a communication platform connecting smart meters to the UK retail network.

In parallel, the conducting of innovation Proofs-of-Concept continues to be promoted in the different regions and businesses. The Proofs-of-Concept are innovation pilots that involve teams from the different businesses and help them choose new technologies that allow them to improve their efficiency and productivity and that bring added value for the end user. Amongst the Proofs-of-Concept launched over recent years in each of the Group's organisations, many are based on technologies such as geolocation, social media, the cloud, mobility solutions and augmented reality. The main characteristic of these pilots is the fact that they are low-cost, of short duration, produce fast results and have a high impact on related profit. Once tested, businesses can choose the solutions that bring most value to them.

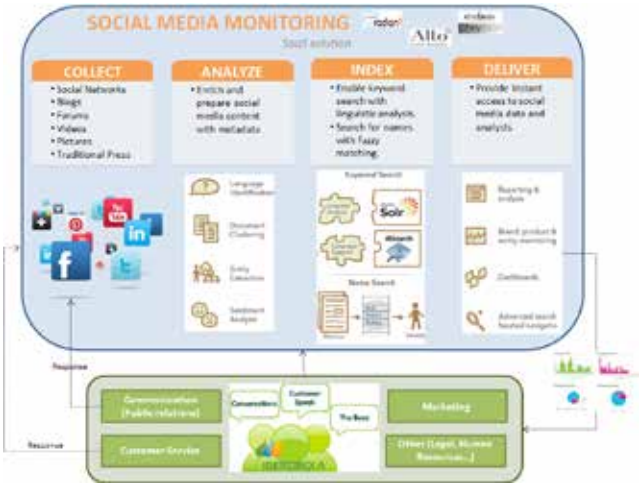
Awards to the Iberdrola IT Area

Social Media Monitoring

Social media management

The aim of this initiative is to evaluate and select a solution that optimises social media management by automating the monitoring thereof as well as extending it to additional sources of information, including Marketing, Communication and Advertising and Image. This technology will allow Iberdrola to establish comparatives and control the activities of the different media campaigns/ initiatives more efficiently.

With this solution, the aim is to strengthen and enhance Iberdrola's relationship with its customers and different stakeholders.



Social Networking Management System

Incident Dispatch

Improved incident management

On ScottishPower's distribution networks, the current process for knowing the status of a supply incident is based on the telephone, with the resulting use of time and low added value for customers.

This pilot will provide a new incident management solution allowing field operators to update incident status in real time in the **Power On** system via *smartphone*.

Notifications are produced via Windows Phone 8 and will enable the field team to see incident notification directly in PowerOn using the existing platforms.

Social Networking Management System

The introduction of this new system will afford benefits in terms of reducing the number of phone calls and notifications that have to be dealt with at the operations control centre and network management centre. A further benefit is the fact that it will improve communications between these centres and the customer service centre, thereby enhancing the service for the end user.

Print a better World

3D printing via smartphone

The aim of this pilot is to print out objects in 3D (products, utensils, tools, etc.) using a *smartphone*. With this project the aim is to use technology (cloud + mobility + 3D printing) to help vulnerable groups from less developed areas through a sustainable project, namely to design a micro-enterprise

3D printer employed in the Print a better World project

in which 16 to 20 year olds can develop and manufacture *merchandising*. It is sponsored by the Human Resources Department, with help from the Volunteerism Program as part of the commitment to corporate social responsibility. The pilot will be launched in the Canary Islands (Tenerife) by SOS Children's Villages. This NGO is partnered by Fundación Iberdrola.

Smart TV

Interaction with customers through SmartTVs

The aim of this pilot is to provide an additional communication channel between Elektro and its customers in Brazil, who will be able to access information about the company based on existing content and other dynamic information services via *SmartTVs*, and the concept of an auxiliary screen via *smartphone* will also be used, to adapt mobile capabilities to TVs.

Through this new customer communication channel, Elektro will be able to provide different services that will increase interaction between both. It will thus be possible to reduce much customer service time, and in the future, with the integration of social media, Elektro will be able to provide more information about service status, repairs, offerings more tailored to each case and, ultimately, increase customer satisfaction.

Customer communications service through a SmartTV

Cloud Big Data Solution

Optimisation of the SAP platform through Big Data

The aim of this initiative is to implement the SAP Data Warehouse in a SAP HANA-based cloud that can achieve benefits in two ways: On the one hand, the benefits of *Big Data* and, on the other, the operational benefits of having such data in a cloud.

Iberdrola has various applications built on SAP BW/BPC platforms that allow them to manage project planning. To improve current ones and pave the way for future developments, this innovative idea has been put forward aimed at transforming SAP BW (*Oracle database*) into a *Big Data* platform on SAP HANA. This will hugely improve the performance of the applications and simplify the selection of suitable technology in SAP installations under optimal conditions of security and stability.

Example of the improvement from using SAP HANA platforms

Storm Damage Assessment

Detecting damage caused by the weather

The aim of this project is to provide a web application that displays a map containing basic data on the Avangrid electricity grid and allows users, via PC or mobile devices, to enter geospatial locations where storm damage is detected. Incidents involving pylons, tress or blocked roads can thus be reported via the Internet. The information collected will be sent to Avangrid and integrated into the system along with all other internal analysis tools and information they may have on the weather phenomenon. The damaged elements will then be repaired and restored and all data, both internal and external, will be published for the benefit of

Application for identifying damage caused by meteorological elements (storms)

all parties involved (municipal agencies, emergency services, civil defence, etc.).

Augmented Reality

Improved O&M through augmented reality

The aim of this groundbreaking Proof-of-Concept is to implement an Augmented Reality mobile app using Geographic Information Systems (GIS) at ScottishPower. The built-in camera will incorporate GPS tracking technology and sensor information to be capable of processing the data and turn them into a "real" world, automatically refreshing the augmented reality as the device moves up, down or around.

This technology will enable better asset management by helping to increase efficiency in O&M tasks and reducing the likelihood of causing faults when digging trenches where underground power lines are present.

Example showing the possibilities of augmented reality

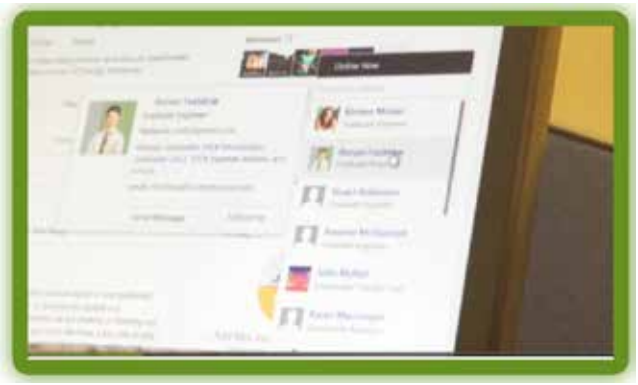
Social networking for companies

Evaluation of the commercial benefits of social networking in business

The goal is to carry out a pilot at ScottishPower to evaluate and confirm the commercial benefits of the company's social networking. They focus on the *online* use of social relationships to boost and enhance communication between people from different walks of life. Social media can therefore prove beneficial in the following areas: operations, customer services, human resources, knowledge management and, in general, they increase staff productivity.

Specifically, the main qualitative benefits that can be obtained are as follows:

- Enhancing employee commitment.
- Building more productive equipment.
- Storing knowledge on the net.
- Creating an interconnected organisation.



Iberdrola in Social Networks

Gamification: in search of lost energy

Promoting the Virtual Customer Service Office web page through digital games

The aim is to carry out a pilot to leverage digital games to promote the Virtual Customer Service Office website.

The objectives being pursued include:

- Rendering marketing campaigns more effective.
- Increasing user loyalty to Iberdrola.
- Boosting the sale of products and services.
- Providing tailored content.

Virtual Office digital game

Socialisation Network Equipment

Interaction between equipment and customers in the event of a power outage

The aim is to develop a solution capable of monitoring power outages in real time and interacting with Elektro customers on behalf of the affected equipment.

Thus, in the event of a power outage caused by a fault at a substation, the device can, for instance, send public or private messages through social media to report a power cut in a specific area and providing information about it along with an estimate as to when service will be restored. This will provide a new customer communication channel, directly via electrical equipment.

Gas leak detection system

This concept decentralises the processing and storage of data in a remote server, since the cleverness of the solution lies in each device. In the future, the solution can be incorporated into a smart grid, making the technology more viable and efficient. The solution will also join three major current trends: IoT technology, work based on the concept of distributed computing through smart networks.

Gas Leak Survey

Optimisation of Gas Leak Inspections

The aim of this pilot is to develop a mobile app solution to capture gas leaks in real time through inspections conducted by personnel and contractors in the US. The expected result from this mobile app is that it will allow proactive management of gas leak locations with detailed information, as well as monitoring the progress of a greater number of inspections, by clearly identifying on a map those areas of highest risk and prioritising their repair, thereby increasing the safety of personnel and equipment. Moreover, the data will also be more reliable and there will be savings on both time and resources, thus gaining in operational efficiency.

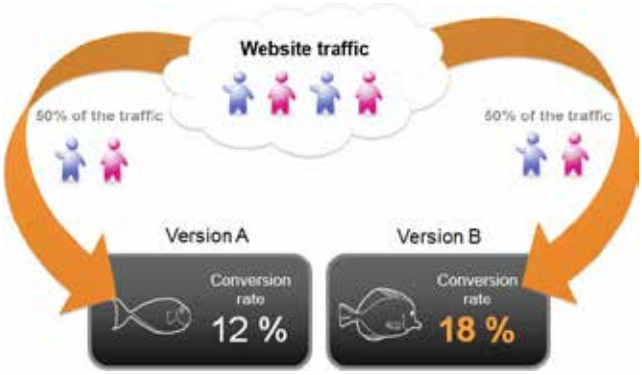
Gas leak detection system

Enhancing customer experience

Analysing and optimising the websites of Customer and Network Businesses

Today, a company's website is its finest form of promotion with respect to customers. Iberdrola is aware of this and is therefore carrying out a full Proof-of-Concept on analysing and optimising the websites of Customer and Network Businesses.

The main goal was to understand and enhance the customer experience when browsing the websites and the services on offer. To achieve this, different website design tests and configurations were performed and website traffic was analysed. This allows us to optimise the ease with which visitors can browse the websites and find content to more fully engage customers and enhance their user experience.

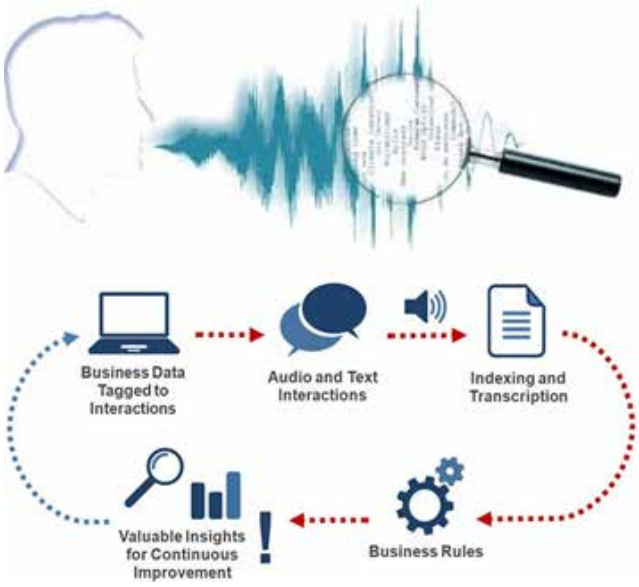


Results after improving Customer websites and Networking

Speech Analytics

Analysing calls to the customer service centre

The aim of this pilot is to obtain more and better information on calls to the ScottishPower Customer Service Centre. Currently, call data are used to review customer complaints and for training purposes. Using *Speech Analytics*, the aim is to provide intelligent information which otherwise remains hidden due to the huge volume of conversations, making them almost impossible to review manually. By analysing conversations from a linguistic and phonetic point of view, customer needs can be more clearly understood and the quality of service will improve as they will receive the most appropriate answer at all times.



Data management process through customer calls

Mobile PKI solution

Secure connection to the Virtual Customer Service Office via mobile phone

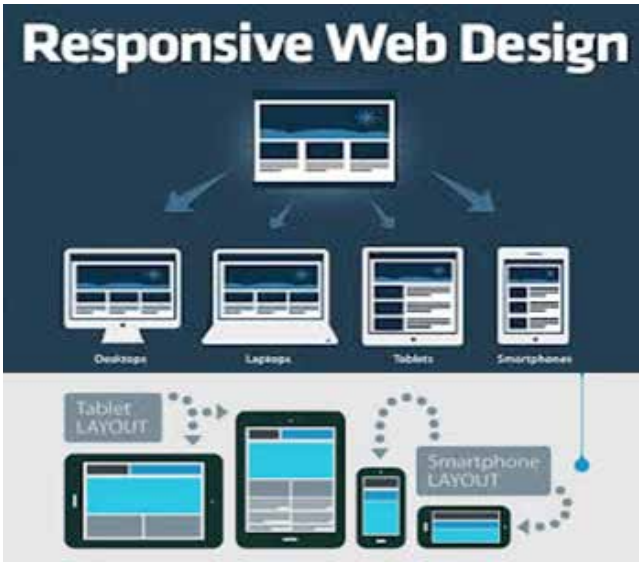
The aim of this PoC is to develop a solution that provides customers with a secure connection by mobile phone to the Virtual Customer Service Office at the Iberdrola website, other than the traditional connection by way of username and password. This PoC will assess the user experience and identify the main barriers that may impede the general public from adopting this service. In addition, they will test the ease of integration between the proposed solution and Iberdrola Mobile Connect systems, a new, secure and easy identification method for digital services. This GSMA (*Groupe Speciale Mobile Association*) initiative is spearheaded by the leading mobile operators and other companies from the sector.

The Virtual Office's new personal identification method

Responsive Web Design

New solutions and features on the Consumer Channel

The aim of this pilot is to design and deploy new design solutions and add advanced features and services (chat, remote meter management functions, notification modules, etc.) to the Iberdrola Distribución website. The Consumer Channel is to be upgraded to a *responsive* web design, whereby content will adapt to the device as well as to the position and resolution of the screen. This ease of viewing and the new features will be available on mobile phones, tablets and PCs with Android, iOS and Windows Phone operating systems, with which we hope to reach a greater number of users. This framework will also be useful for other Iberdrola web channels.



Web design adaptable to all device types

Performance testing for wind farms

Wind farm interface performance testing

The aim of this PoC is to analyse the performance of a new data bus platform's communications between the recipient of information on all Iberdrola wind farm operations and the database in real time. This goal is to optimise system performance by means of high-performance architecture, greater connectivity and operability between current platforms, and better performance in the integration between the information and business analytics.

Performance chart on communications of the new platform

Guepardo

Implementation of software that automates tax adjustment processes.

Through this project, Elektro has significantly improved efficiency in tax adjustment processes within the electricity sector, as it is no longer done manually but rather centralised in a single system. The new tool has been developed in SAP and is able to perform the entries for the main municipal, state and federal taxes, giving rise to a number of advantages:

- Major time savings and faster results.
- Minimising calculation errors, thereby increasing the reliability of the data obtained.
- Improvements to documentation submitted to the corresponding Agency.

5.7. R&D&i in the Environmental Area

Introduction

The world is moving toward a sustainable energy model that must be built upon three fundamental cornerstones: competitiveness, security of supply and respect for the environment.

Likewise, sustainability, understood to be a business management concept, is developed on three fronts: economic, social and environmental.

So, for a company like IBERDROLA, the environmental dimension is at the heart of the concept of sustainability. IBERDROLA acknowledges it importance by incorporating respect for the environment as one of the concepts that define the Company and which is therefore part of its self-image.

Within the framework of its Environmental Policy, the Company undertakes to promote innovation in this field and eco-efficiency, to gradually reduce the environmental impact of its activities, facilities, products and services, and to offer, promote and investigate eco-efficient solutions in its market and customers, thus harmonising the undertaking of its activities with the legitimate right of both present and future generations.

MiniREIS

Valuation of ecosystem services generated by the construction of infrastructures

The aim of this project is to develop a methodology for evaluating ecosystem services provided by the existence of any infrastructure and within different environmental and social contexts. This involves creating a standardised tool for calculating the value of externalities offered to the company in the form of ecosystem services that are generated once all infrastructures are completed and commissioned.

Ecosystem services comprise the goods and services that ecosystems bring to human communities, particularly their productive activities. An infrastructure transforms the ecosystem and, from that moment on, new services are generated.

In light of the lack of consistency resulting from the absence of scientifically proven, objective methods concerning the "total value" of an ecosystem service, and in an effort to overcome the different partial visions regarding how to assess the impact of an ecosystem service on a given enclave, Iberdrola seeks an alternative approach to assessment that globally encompasses the different economic, social, cultural and environmental aspects affected during an industrial production process. Doing so improves the assessment of the ecosystem services provided through infrastructures in terms of society and corporation.

Social and corporate profitability provided by investments in sustainability

Velilla

Study and characterisation of the biodiversity at the Velilla thermal power plant

A full study was proposed for the natural heritage and biodiversity around the Velilla del Río Carrión Thermal Power Plant in Palencia. This study is a highly effective way to share information on the local environment with citizens through the publication of material that can be used in environmental awareness campaigns. Likewise, the power plant's proximity to the "Fuentes Carrionas y Fuente Cobre-Montaña Palentina" national park is a point of reference that can be employed to share and raise people's awareness regarding the environmental values of the area.

Velilla thermal power plant

The project fundamentally aims to vaunt the natural elements present in the region where the facilities of the power plant are installed, and the riverbank and riverbed of the Carrión river around the plant in the town of Velilla del Río Carrión. The aims thus pursued by the project are:

- Increased understanding of the biodiversity (fauna, flora and habitat) around the plant.
- Publication of a field manual on the exotic and invasive species existing in the region.
- Analysis and processing of information gleaned for each faunal group to ascertain their importance in the river's ecology.

Hidroil

Preventive maintenance through infrared spectrophotometry.

This research project was conceived to characterise the condition of rotating equipment in generation stations employing lubricating oil and hydraulic fluids through infrared spectrophotometric analysis.

There are currently no standardised criteria for ascertaining the degradation of the different industrial fluids in terms of the variation in their physical-chemical properties. It is thus essential to establish links amongst the most important properties of the fluid to ascertain when it loses its lubrication capacity. Doing so is an attempt to lengthen the fluid's service period as much as possible without comprising the integrity of machine reliability.

The actions carried out throughout the project were:

- Creation of a database with the spectra for all new and in-service fluid types to ascertain initial conditions.
- Identification and quantification of the contaminants present in the oil.
- Drawing a link between the degradation of the base oil and the acidity index in each fluid type with a view to establishing a quantitative limit.

Arcos

Study and characterisation of the biodiversity at the Arcos thermal power plant

The Arcos de la Frontera combined cycle thermal power plant is located next to the Alcornocales mountain range within an agricultural environment heavily modified by human intervention and sprinkled with the Mediterranean hills riverside forests associated with the Majaceite and nearby streams. This power plant occupies land across two municipal regions: Arcos de la Frontera and San José del Valle.

This project aims to showcase the natural heritage preserved around the power plant and share

Arcos thermal power plant

information with citizens through the publication of material that can be used in environmental awareness campaigns.

Three primary objectives are established:

- Increased understanding of the biodiversity around the plant
- Quality assessment of the ecosystems and biotic populations in the environment around the plant.
- Publication of scientific material for dissemination and use during environmental awareness-raising campaigns.

Lesser Kestrel

Lesser Kestrel population estimate

This project seeks to securing population estimates/censuses of the Lesser Kestrel (*Falco Naumanni*) in the area of influence of Iberdrola's Cuesta Colorada, Cerro Palo, Calderón and La Muela I (Cuenca) Wind Farms.

Once the study has concluded and after implementing measures in the wind farm to reduce their influence on this species, a new project will then handle tracking while checking the effectiveness of the mitigation measures implemented in the wind farms' area of influence to forestall mortality in Lesser Kestrel populations.

Lesser Kestrel

Owl

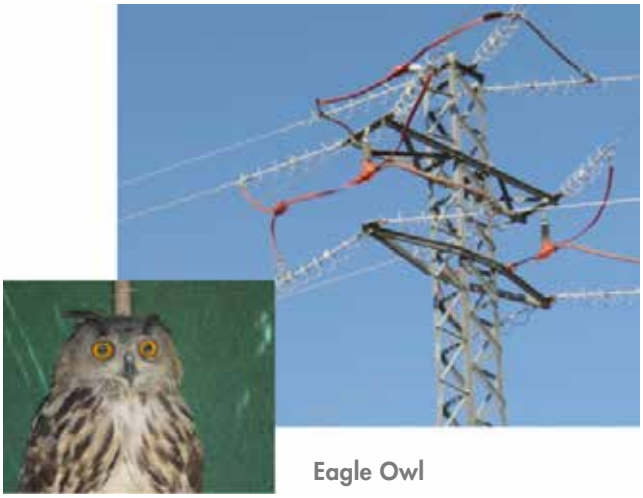
Analysis of incidents affecting the Eagle Owl species

The primary goal of the project is to study and ascertain the factors causing the elevated accident rate affecting the Eagle Owl (*Bubo bubo*) on power lines, particularly in the eastern part of the Peninsula.

In this regard, a focus will be made to define the specific objectives, primarily guided by and subsequently addressed after execution of the fundamental actions during the study period:

The study area will host the following actions:

- Study on breeding areas and diet analysis.
- Analysis of the supports with the highest number of incidents.
- Action proposals.



Eagle Owl

Samaria

Automatic reservoir water quality monitoring system equipped with micro-sensors

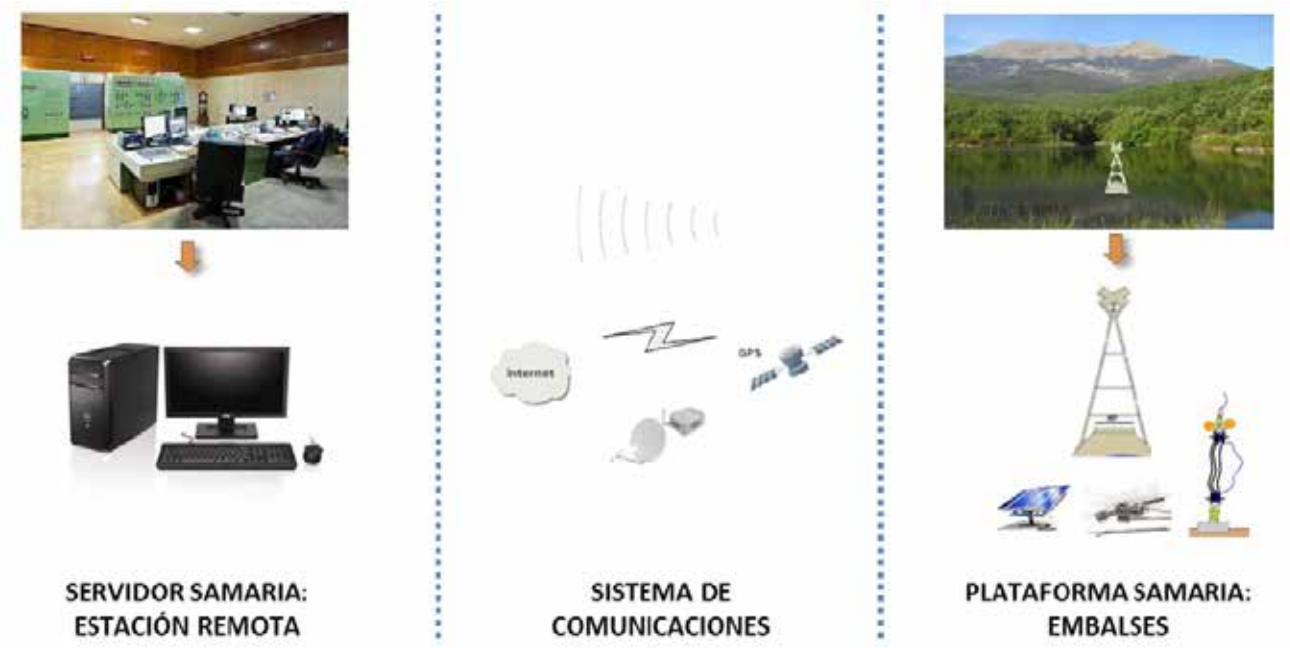
The overall purpose of the present project is to develop a new smaller, automatic and floating micro-sensorised monitoring system to remotely and continuously secure accurate real-time data on the quality of the water in a reservoir.

Some of the more prominent project objectives include:

- Developing a technology platform that meets the requirements established by the pertinent legislation currently in force for micro-sensor capture, multi-parameter analysis, data retrieval, storage and the transmission of environmental data through a communications systems via a control server for integrated reservoir management.
- Designing an industrial microcontroller with an embedded operating system, high-connectivity capacity and low consumption.
- Developing a communication system feature for sending remote controls and/or remote setpoints to instrumentation that can be configured remotely.
- Increasing the number of water quality measurement parameters to analyse in floating monitoring systems.
- Reducing the cost of taking measurements, increasing the amount of measurements available and therefore improving knowledge and control over the quality of the water in reservoirs.

The project is centred around engagement in the following areas:

- Product development: design requirements and prior analysis.
- Environmental: development of the circuit board for integrating the various analysis probes and automatic measuring system.
- Measurement platform: design of the floating platform and its anchor system.
- Energy and communications: design of the communications model and electrical power supply system.
- Information and control: application development and validation
- Production and field tests: construction of system components and their corresponding field tests.



SAMARIA operating system

CO2FORMARE

Use of CO_2 for macrofouling remediation

The main purpose of the present project is to demonstrate that the CO_2 present in the combustion fumes generated in industrial processes near the sea can be used as a substitute for chlorinated chemicals employed at said facilities as a solution to operation and maintenance issues.

Project development is currently under way at the Castellón combined cycle thermal power plant to check the effects of CO_2 as an inhibitor of the phenomenon known as *macrofouling* (equipment, components or system degradation process caused by the uncontrolled growth and attachment inside said equipment of large living organisms such as mussels, clams, etc.), a problem that causes substantial harmful effects on the facilities and their surroundings.

Macrofouling control process employing CO_2

The following will be necessary for success:

- Installation of equipment that enables constant and autonomous monitoring of the larva content of selected species, generating numeric values indicating the concentration in the medium under study.
- Prevention of waterborne incrustation organism attachment and development through a moderate decrease in cooling seawater pH by dosing CO_2 in the cooling seawater. Production of seawater currents with different CO_2 saturation values and dosing them in the Combined Cycle Thermal Power Plant's cooling seawater pumping station.
- Capture and concentration of a sufficient amount of CO_2 from the plant's chimney for subsequent dilution. Dissolution of gas phase CO_2 into the seawater to secure the desired biocidic effect.
- Development of a successful communications plan to share will all national and international stakeholders.

Vegetable-based Oil Transformers

Development of a nano-activated oil that improves the thermal efficiency of transformers employing vegetable-based oils

Neoenergía's project was conceived to develop a nanostructured magnetic additive that can increase the thermal efficiency of transformers employing vegetable-based oils. The resulting boron nitride based additive increases the effectiveness of the oil temperature gradient and therefore the transformer. Given the enormous innovative potential of this

Vegetable-based Oil Transformer

project, patents are currently pending at national and international levels.

Oil spill solution

Development of an environmental solution for lubricating oil spills affecting hydroelectric power systems

The Neoenergía Group is seeking to secure an oil certified under standardised tests recognised by the Brazilian National Petroleum Agency (ANP) based on an ISO VG 46 oil prototype, developed as a biodegradable vegetable oil that could be used in the gate cylinders at hydroelectric power plants, which would reduce the environmental impact caused by oil leaks.

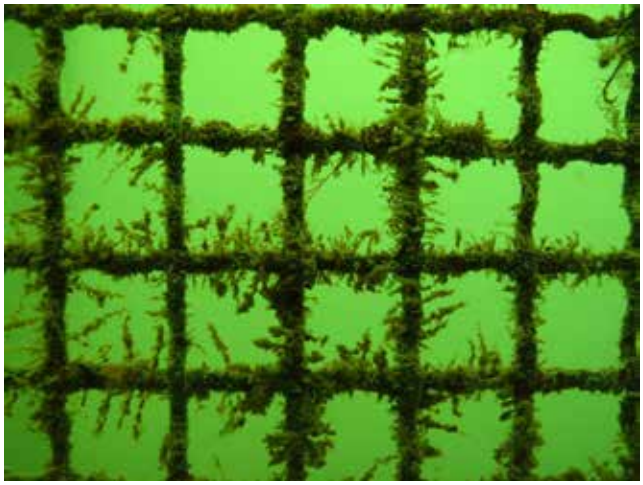
Tests with ISO VG 46 oil

Reef

Installation of an artificial reef along the Pernambuco coastline

Through this project, Neoenergía seeks to install and test the effectiveness of an artificial coral reef to help biologically repopulate the Termope artificial reef (Brazil), conducting studies on ecological reproduction that entail the inclusion and adaptation of fauna introduced into a new ecosystem with a different substrate on the marine floor.

Several units of artificial reefs were already successfully implemented in an area near Puerto de Suape.



Artificial reef at Termope

5.8. R&D&i in the Safety and Prevention Area

Introduction

Facility Safety and Occupational Risk Prevention together constitute fundamental pillars of the company's current philosophy. Moreover, their importance today has been bolstered by the outstanding progress in Information Systems insofar as innovation yields fresh points of view to help achieve the objectives set out in the different identified lines.

Turning to Occupational Risk Prevention, Iberdrola's culture of innovation together with the proactivity of our human team have resulted in new ideas and practices that enable us to carry out our daily tasks more safely. Particularly salient in this regard are the developments in connection with radiological protection within the framework of the Dosage Reduction Master Plan, where substantial improvements have been made in line with the culture of ALARA (*As Low As Reasonably Achievable*).

Turning to Safety, various innovation lines seek to guarantee the structural integrity of production facilities through projects centred on their life cycle management and include new developments that cover hypothetical events and go beyond the design bases with which these facilities were originally built.

The cybersecurity line includes not only data and system protection but also operation and maintenance procedures. Information technology security comprises the systems in charge of guaranteeing the protection of information from attacks against software and hardware vulnerabilities, and the continuity of the business through the recovery of critical work environments.

AGIL WEB

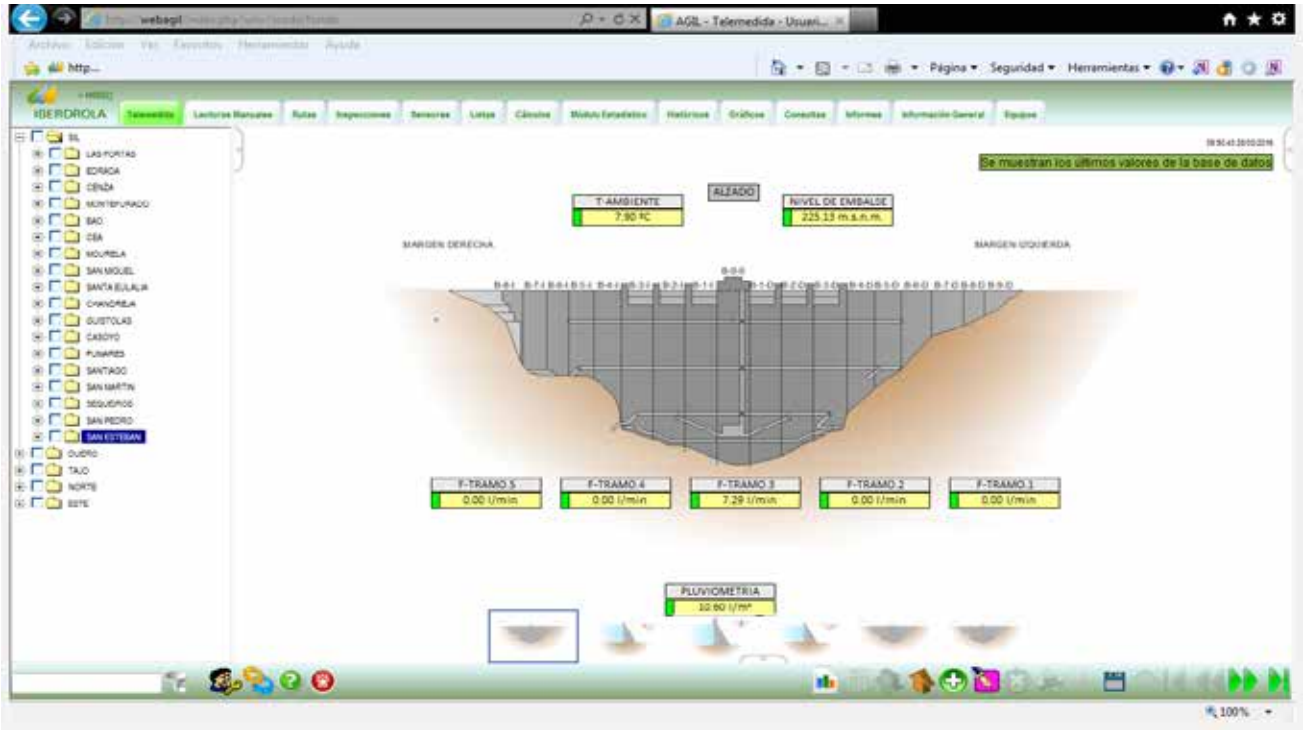
New real-time dam auscultation technology

The overall objective of the project entails the research and development of new advanced functions in the AGILWEB dam auscultation system for increasing the security and flexibility in the control over managing the structural status of dams and other structures by incorporating new data variables and modifications in advanced extensiometric calculation algorithms.

This innovative tool enables a real-time view of the status of the dam and foundations, and their potential risks during operation. It is also capable of resolving the uncertainties related to stresses, resistances, design and execution errors, and the spatial and temporal evolution of magnitudes for the purpose of reducing the risks associated with such factors.

The following specific objectives were achieved upon conclusion of this project:

- Increased dam operating safety with greater information from external variables that, together with internal variables, are useful in conducting a thorough and comprehensive analysis of their performance. Various types of alarms were established and can, as determined by the technician, provide real-time alerts of any detected anomaly whose parameters have been configured previously.
- Improved calculation and optimisation of extensometric data output, enabling a full traceability of data.
- Implementation of a universal structure auscultation system that is valid and provides the same information management possibilities for all dams/basins managed by IBERDROLA, while being adaptable and flexible in gleaning the particularities of each one.
- Optimisation of the use of human resources in running dams by reducing the frequency of trips made by personnel and the time necessary for analysing data.
- Integration of the structure auscultation data management and input programme in the Iberdrola communications network, equipping it with a redundant communications system.



Dam monitoring programme

Filtrations

New hydroelectric power station channel inspection techniques for efficient management

The overall purpose of this project entails the research and development of a new methodology for inspecting hydraulic channels through non-destructive testing techniques enabling the analysis of the characteristics of the materials of the ground and infrastructure itself as a means of early anomaly detection, thus ensuring the structural integrity of the channels and optimising the maintenance and operation tasks on hydroelectric power assets.

After selecting the applicable geophysical technologies for the study, tests were conducted in the following channels: Pontenovo, Villalba and Trespaderne.

The project was able to study, test and validate various methodologies so that the best one can be selected on the basis of a given scenario (open channel or tunnel, cross-section width or length of the section, location and access).

The project successfully concluded all its specified objectives in 2015, namely:

- Increased safety and security for the facility and potential conditions affecting third parties caused by any anomaly.
- Minimisation of the losses from using water at hydroelectric power plants.
- Increased knowledge regarding the physical fundamentals enabling the analysis of material characteristics in the ground and infrastructure for an early detection of filtration and structural anomalies such as crazing, gaps and detachment in the channels.
- Availability of a simple and robust channel inspection technology for a reasonably regular early detection with a high likelihood of success.
- Improved life cycle management of Iberdrola assets.

Geo-Radar three-dimensional contact antenna

Straight Trespaderne channel section

SOLTEC

New welding procedure for very thick materials

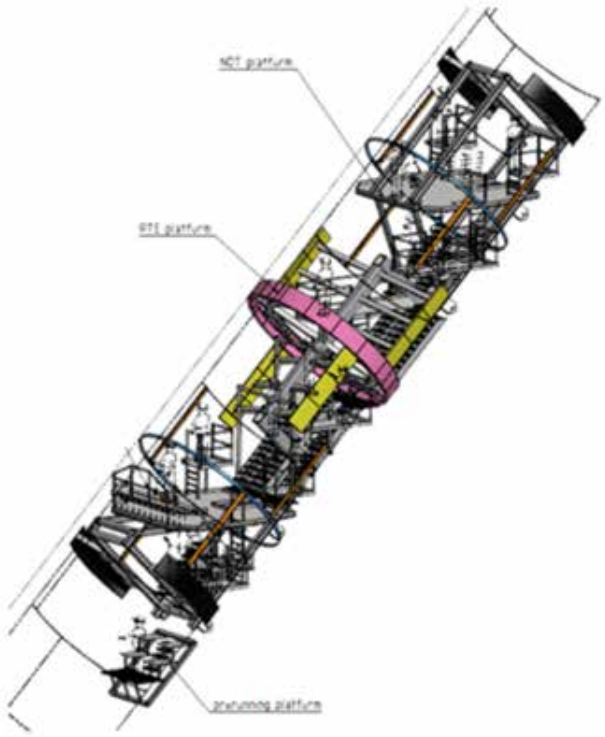
The overall aim of this project is to research the phenomena of embrittlement in post-welding thermal treatments and develop an original process for regenerating large welds for applications subject to elevated mechanical loads (critical components in large electricity generation facilities such as penstocks) based on a controlled on-site thermal treatment capable of modifying the microstructure of the weld material capable of restoring resilience lost because of an inadequate control of cooling times back to design levels.

The specific objectives of this project are:

- In-depth understanding of the physical phenomenon of embrittlement in post-welding thermal treatments, its influence on the resiliency of very thick welds and the circumstances in which it could occur.
- Developing weld repair and on-site resilience regeneration techniques suitable for application on very thick longitudinal and circumferential welds.
- Assurance of the applicability of the solution in already concreted pipes whose welding is only accessible from the interior.
- Rendering simple control over application parameters for accurate implementation of process conditions developed while maximising the process's repeatability.
- Generating new knowledge applicable in the hydroelectric power generation and other sectors regarding new welding procedures for very thick components with stringent resistance to impact requirements.

To achieve these objectives, the project is executing the following activities:

- Research into hardening embrittlement and reversible hardening embrittlement processes on very thick welding materials.
- Study of the effect of different welding cycles and measurements on the resulting properties.
- Development of welding techniques and on-site post-weld thermal treatments.
- Study of the mechanics of welding fractures to verify what welds need to be repaired or regenerated, which can be used as test cases for the selected reversible hardening embrittlement technology.
- Experimental validation in the field of the new technology and comparison with a parallel laboratory-based experiment.



Preliminary design of an RTE regeneration trolley

Accident Prevention

Improvement of 1D and 3D accident prevention methods

This project tackles the development of new one-dimensional and three-dimensional models and methodologies for analysing accident simulations at nuclear power plants to fulfil the success criteria associated with specific accidents so that the plant can operate with greater flexibility, running with operating domains and increased power capacity.

Successfully concluded in 2014, this project centred its activities around the development and validation of one-dimensional and three-dimensional models, and the following is particularly salient:

Technical feasibility study on increasing the power or operating domains at nuclear power plants to 120%, optimising fuel and maximising its combustion to reduce the number of fresh elements and highly active waste in spent fuel.

Maximisation of plant flexibility through the optimisation of thermal and mechanical ranges.

Development of new three-dimensional tools and coupling with other sub-channel codes or new thermal-hydraulic codes to preclude issues arising from one-dimensional kinetic models and the thermal-hydraulic code (TRAC-BF1/BE).

RESONUC

Development of a resonance mitigation methodology in critical nuclear power plant systems

The main objective of this project entails the research and development of a technological solution for mitigating the acoustic vibration phenomenon causing anomalous behaviour in the SRVs (*Steam Relief Valves*) based on a real-time original acoustic vibration monitoring system inside the main steam lines and a new experimental sleeve design to eliminate the generation of vortices near SRVs at nuclear power plants with BWR-6 technology (*Boiling Water Reactor – 6th Generation*).

A scale model of the main steam line was built (scaled at 1:2.59) to faithfully reproduce the phenomenon caused by dynamic pressure vibrations inside the main steam lines at the Cofrentes Nuclear Power Plant and thus ascertain the exact behaviour of the SRVs to secure their proper long-term functioning.

Final tests on the RESONUC project

Some of the more prominent technical objectives of the project include:

- Eliminating the risk of anomalous behaviour of the SRVs on the main steam lines of the emergency core cooling system, which could activate pre-emergency situations and trigger unscheduled stops at BWR-6 nuclear power plants.
- Maximising the degree of safety in the operation of nuclear power plants, eliminating the occurrence of events associated with SRVs spontaneously opening.
- Increasing the degree of availability of power generation at nuclear power plants by eliminating potential emergency situations that could cause temporary stoppage, decreased plant performance and a drop in produced and feed-in energy.
- Expanding knowledge regarding resonance phenomena affecting all SRVs on the main steam lines at the Cofrentes Nuclear Power Plant.
- Mitigating the vibrations in the main steam line at the Cofrentes Nuclear Power Plant by varying the operating mode at the plant based on the acoustic vibrations measured in real time and/or modifying the internal configuration of its components by installing the new validated experimental solution.

Objectives achieved to date:

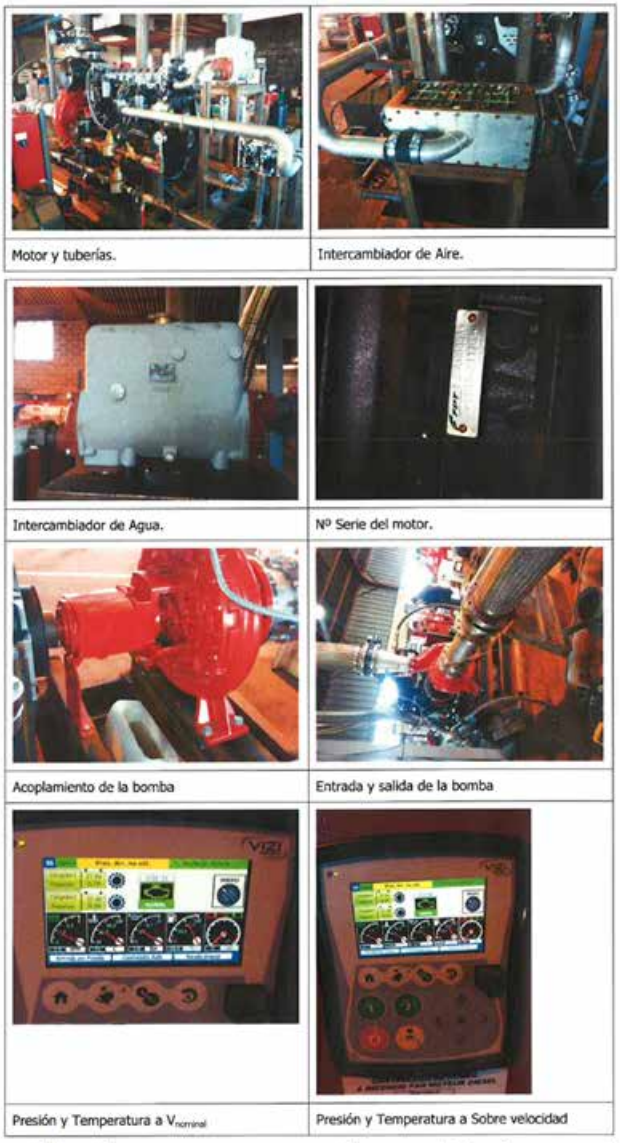
- Research into the phenomenon of dynamic pressure oscillations on the main steam line through a comprehensive root cause study.
- Design and development of possible to-scale experimental solutions on a single branch.
- Development of tests for the proposed solutions on the to-scale single branch model.
- Design and development of to-scale experimental solutions in multiple configurations
- Development of tests for the selected solution on the to-scale model in multiple configurations.

Seismic Fire Protection (Seismic-FP)

New seismic fire protection system (FP)

This project was centred around designing and developing a new seismic fire protection subsystem for the Cofrentes Nuclear Power Plant that is capable of providing water to the fire hydrants in fire areas equipped with the controls required for safely shutting down the plant in case of an earthquake. This not only provides water to the fire extinguishing and other systems, but also guarantees this supply in highly extreme seismic conditions.

The main technological and corporate objectives addressed by this project were:



Elements constituting the pumping system and control panel

- Development of a new seismic subsystem within the Fire Protection Water System.
- Development and design of the equipment necessary for correctly running this system.
- Development of the complete process defined for the nuclear power plant that must be fulfilled for the purpose of fire protection.
- Increased nuclear power plant safety insofar as incidents and accidents unrelated to operations inherent to the plant such as fire or earthquake.
- Extended knowledge of the operating processes in a nuclear power plant with a view to enabling the discovery of new substantial improvements to the plant and ultimately guaranteeing maximum safety and security of this complex.

To date, the following activities have been completed:

- Geotechnical study for developing the new seismic FP tank
- Design for the new diesel pumping system
- Development of the new motor control centre
- Integration and tests on the new sub-seismic system

Cybersecurity

Adaptation of digital processing systems to the most up-to-date cybersecurity measures

The cybersecurity project requires an in-depth approach with specific solutions for each need.

Maintaining information on the status of the plant and its overall configuration is critical, together with the need to maintain the *know-how* regarding new modifications in the plant. This entails a progressive implementation of solutions that need not come from a single service provider.

The scope of the project encompasses the following engagements:

- Inventory of critical digital assets. Creation of a database for these assets.
- Bolstering the systems and networks of already identified systems
- Mobile device management and protection plan. Network *Programmable Logic Controller* (PLC) protection.

PASIVENUC

Carbon steel passivation to prevent recontamination

The primary system is fundamentally stainless steel, with the exception of G33 (RWCU), which comprises carbon steel pipes. Its purpose is to purify the reactor water. Various systems are decontaminated during refuelling (including this system, which generates a high dose rate). While the dose obviously drops enormously when decontaminating, as a consequence of the operation dose levels are nevertheless much higher during the cycle because of the presence of physical-chemical phenomena. This project was conceived to research and draw up carbon steel passivation methods to prevent recontamination of the material after decontamination treatments.

This overall objective can be achieved by attaining the following specific objectives:

- Creation of surface treatment methods for preventing the rapid recontamination of the carbon steel in BWR cooling systems.

SAM **No SAM**

- Validation of the mitigation effectiveness of the methods selected by an implant exposure programme.
- Application of the most effective method after the next decontamination treatment in the plant.

The following processes were tested:

- Detoxification of the representative carbon steel surfaces.
- Platinum deposition (Dp), also known as Low Temperature NobleChem (*LTNC*).
- Application of the self-assembled SAM monomolecular layer.
- Platinum deposition, followed by SAM application.

Given the ambitious nature of reducing the contamination in carbon steel pipes, the period for testing the pre-selected methods lasted fifteen months. On conclusion of this period, we obtained a 70% with the Dp + SAM process, which was selected for the process engineering stage, the project's current status.

FILTRONUC

Filter at the containment building vent

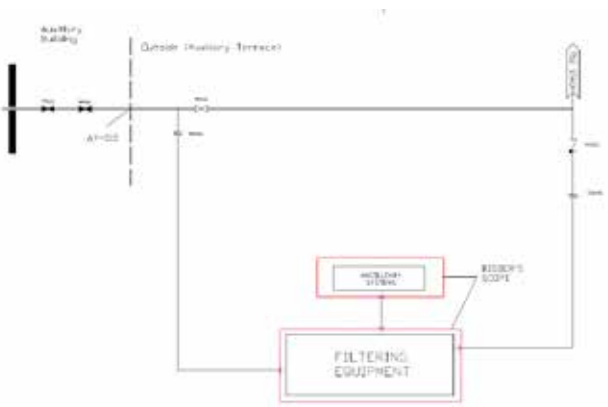
The goal of this project is to research and develop a new containment filtered venting system for BWR-6 nuclear power plants with Mark-III containment for maximising filtering performance on the venting line without compromising the safety and integrity of the facilities in the event of a severe accident (damage to the reactor core). Developed for the Cofrentes Nuclear Power Plant, the project will entail the installation of an external filter on the current containment venting system to retain particulates and radioactive species (source term) released to the exterior during a potential core damage scenario:

This overall objective can be broken down into the following specific objectives:

- Increased robustness and operability of the system in prolonged SBO (*Station Black-out*) conditions.
- Reduced need for containment venting action in a Severe Accident, thus significantly minimising the source term released to the exterior.
- Achievement of maximum efficiency, bolstering the use of mitigation measures at the plant with containment vents without affecting existing control functions.
- Development of a new filtering system without affecting the current non-filtering venting system functions insofar as their use in Emergency Operating Procedures.
- Availability of a robust system in the event of external natural phenomena or fuel gases in venting lines throughout the full operating range in case of a severe accident.
- Maximise performance of the filtering system on the vent line to the exterior in case of severe accident.

The following tasks have so far concluded:

- Analysis and characterisation of the boundary conditions of the current vent system.
- Search for technology alternatives for the filter to install in the current containment venting system.
- Definition of the requirements necessary for sizing the most optimum and effective external filter possible in severe accident conditions



Venting filter installation diagram

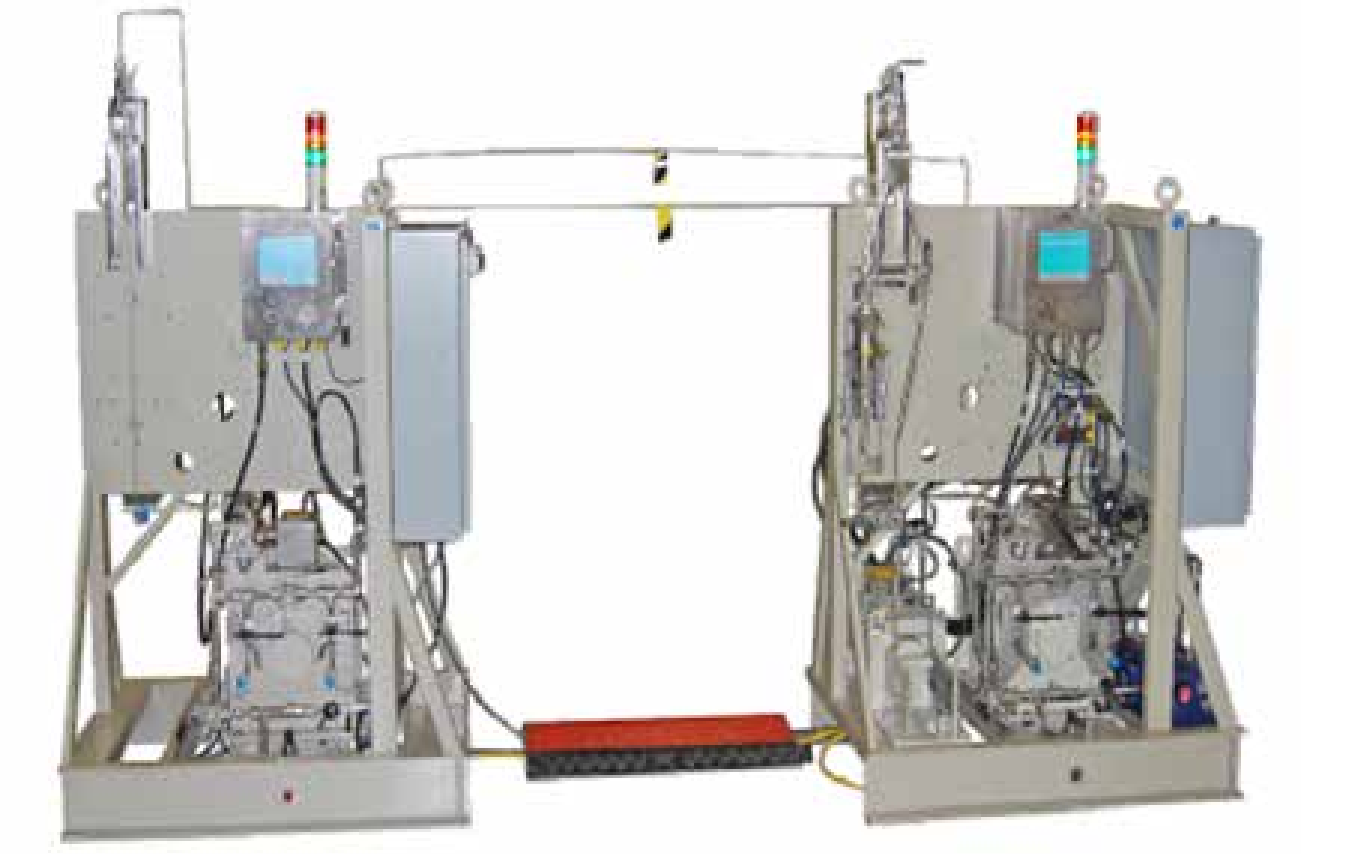
Detection

Modernisation of the Main Chimney Radiation Monitor

The Detection project has an important role in relation to the safety of personnel and the surroundings of the power plant. The objective of this project entails the research and development of a new chimney radiation control process based on the continuous measurement of noble gases, particulates and iodine.

The project successfully achieved all the initially specified objectives:

- Availability of a control process to continuously measure noble gases, particulates and iodine to cover the full operating range at the Cofrentes Nuclear Power Plant.
- Assured automatic switching between measuring subsystems in normal and abnormal ranges so that the new control process permanently covers the plant's full operating range without interruption.
- Increased knowledge of the operating status of the plant at all times through the incorporation of variables from the new radiation control process in the plant process computer.
- Modelled calibration of the noble gas detectors to be able to estimate the effects of variations in count shape on the overall detection efficiency of the counting system.
- Increased detection efficiency of the new detectors.
- Increasing the feasibility and availability of the Cofrentes Nuclear Power Plant by ascertaining the operating status of the plant at all times, which will enable the immediate engagement of protective measures upon detection of anomalies.



Sampling and detection system

NIVELCOM

Fuel pool temperature and level measurement

The overall objective of the project entails the research and development of a new seismic measurement process for the critical parameters of the spent fuel pool at a nuclear power plant to guarantee its availability at all times and secure real data for operational decision-making and secure operation.

The following specific objectives have been established:

- Increased capacity of installed equipment to respond to seismic-related accidents entailing a prolonged loss of electricity supply and not contemplated in the design bases.
- Creating a process with the instrumentation necessary for measuring levels and temperatures with the appropriate measurement ranges for situations not contemplated in the design base.
- Developing a technology to supplement the current systems at nuclear plants and minimise interference on operation and control systems.
- Ensuring that the installed equipped run effectively, providing the simplicity and robustness necessary to prioritise efforts and resources when facing extreme situations.
- Generating new knowledge in the nuclear sector regarding the new methodology for measuring and instrumentation required in reactor SFP (Spent Fuel Pools).
- Equipping Iberdrola with new, innovative technology for ensuring the safety criteria and continuing normal operation of the plant, guaranteeing the electricity supply.

Upon its completion at the end of 2015, the project successfully achieved the specific objectives established.

Rack instrumentation with level and temperature measuring equipment on gyroscopic support

Recombiners

Development of New Passive Autocatalytic Recombiners

This project is centred around the development of a new technology for passive catalytic recombiners used for eliminating the hydrogen that would be generated in a severe accident scenario caused by the loss of reactor cooling or full electricity supply black-out. This new development aims at making hydrogen react with CO, combining it with oxygen to produce water and carbon dioxide respectively and guaranteeing the integrity of the containment.

The main specific goals of the project include:

- Discovering and developing new solutions for shoring up safety at BWR nuclear power plants.
- Increasing the safety and reliability of the hydrogen elimination process by transformation to other compounds that cannot generate explosions.
- Resolving all uncertainties regarding engagements involving the reactor, containment building and dry well facing a total electricity supply failure or cooling loss.
- Increasing safety at the Cofrentes Nuclear Power Plant.

The project has been divided into two leading activities:

- Development of New Hydrogen Elimination Systems in the Containment following a severe accident: passive auto-catalytic recombination systems were able to be built based on the analysis of sequences generated by a severe accident, the simulation of oxygen flow after release and hydrogen accumulation studies in the potential failure scenarios.
- Development and engineering on the passive autocatalytic hydrogen recombiners.

RADAR

Occupational Risk Prevention Management Tool

This project entails the creation of different work groups comprising personnel of a range of different levels from each plant led by a team leader with experience in Occupational Risk Prevention.

The different work groups detect and identify conducts that do not follow the safety and ORP procedures at the power plant so that they can be managed with the RADAR computer programme.

This tool enables the organisation of personnel constituting each group, meeting creation, assignment of unsafe conduct, obligations and additional measure to each meeting, and a record of individual or group observations associated with any unsafe practice.

The application also allows the generation of reports showing the data entered in the application grouped and sorted according to specific criteria to be analysed at a later date.

All of the information entered in the application is recorded in a database that can be queried from any PC connected to the internal Iberdrola network (online application that need not be installed because it runs via the web browser).

Card

New ID Card functions to improve occupational risk prevention

Execution of this innovation initiative has considerably improved occupational risk prevention at the generation facilities based on the new functionalities developed through the use of the ID card that every employee must always wear.

Workshop machinery: the development of an ID card reading system adapted to workshop machinery ensures that only qualified and authorised personnel who have received previous training in the use of the machine may operate it. This eliminates the risk of accident caused by the use of these machines by unauthorised personnel. The pilot was run in

collaboration with the Escombreras, Tarragona and Arcos combined cycle plants.

Evacuation procedure: In the event of an emergency with evacuation, rapid evacuation of personnel from the plant is not assured, since the counting mechanism is difficult and slow. Two card readers were installed as a solution, one at the entrance and another at the meeting point so that data could be cross-checked to ascertain whether the evacuation is complete or whether someone is missing. The pilot was installed at the La Muela hydroelectric power plant and the Cofrentes Nuclear Power Plant.

SIROCO

Improvement on the management procedure in the Company Activity Control Programme

The overall objective of this project is to design and develop a new system, referred to as SIROCO, at energy generation plants to increase the plant access and task execution efficiency of external companies and develop new control functions, safety and Occupation Risk Prevention. The Cofrentes Nuclear Power Plant is the pilot for this project.

This primary objective was achieved by attaining the following specific goals:

- Defining and controlling the main specific particulars of personnel from subcontracted companies attempting to access the facilities at the nuclear power plant.
- Analysing the status of the scheduled and executed work by the personnel from subcontracted companies at the nuclear power plant.
- Creating a new system to manage the documentation of workers with access to generation plants to easily check whether there is any missing document necessary to permit a worker to access the facilities.
- Reducing the resources employed when processing plant safety related data, thus increasing the efficiency of the involved processes.

SAPLA

Plant Activity Supervision

General plant activity supervision application that assesses the different aspects regarding the quality of the work carried out and in compliance with occupational risk prevention. This application aims to increase the number of jobs executed with direct supervision with a view to correcting any

Web environment for Siroco system access

anomalies observed. It applies to all the facilities and comprises various sorts of activities throughout the entire site for one year. At the beginning of the year, the plant's Prevention Coordinator will draw up the scheduling in consideration of plant-specific activities and so that all Activity Supervision Managers conduct at least one supervision of each type per year. Every Activity Supervision Manager must carry out one per month, though the date and time can be freely decided. The manager must select the job based on the activity type corresponding thereto in the month and according to the weekly maintenance programme schedule.

The application enables tracking, monthly and yearly reporting, etc.

ASAMPSA

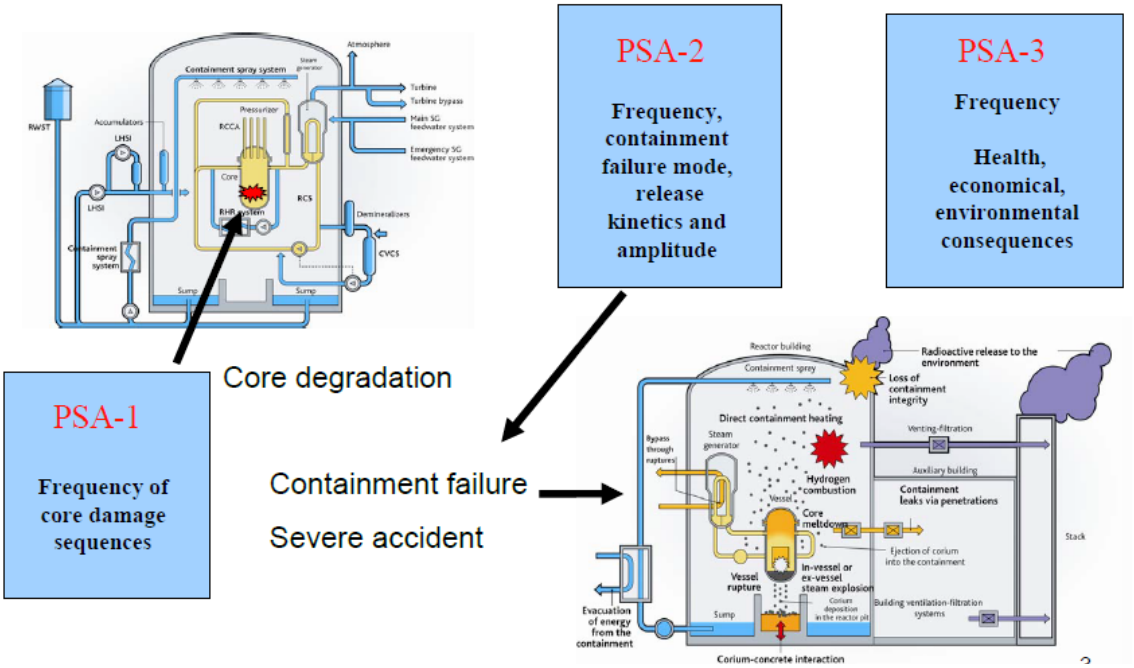
Methods for conducting a Probabilistic Safety Analysis (PSA)

This project was created to render an in-depth examination of the extent of the PSA method's capabilities to identify any significant risk included by interaction between a nuclear power plant and its surroundings, and, on the basis of this analysis, generate technical recommendations for PSA developers and users. The project is open to organisations responsible for developing and applying PSAs in response to the requirements of the European regulating body.

This European Union backed coordination action has the participation of 28 European centres and companies with extensive experience in the nuclear industry.

Some of the most representative tasks developed are:

- Identification of the needs, objectives and scope of the PSAs with external events.
- Modelling of the external post-initiating events and integration in the PSAs.
- Scope and application of the PSAs by external events.
- Level 2 Shutdown PSA.



Probabilistic Safety Analysis Types at nuclear power plants

6.

Annexes

6.1. Innovation policy

The Board of Directors of IBERDROLA, S.A. (the "**Company**") steers innovation within the Company and the entities integrated in the Group whose parent company, as defined by law, is the Company (the "**Group**"), towards an increasingly efficient management of available resources and knowledge, while assuring that the most appropriate technologies are introduced efficiently to generate benefits and competitive advantages for shareholders, customers, employees, and other Company stakeholders.

1. Purpose

Innovation is a strategic variable that affects all Group businesses and all of the activities it develops.

This *Innovation Policy* is an harmonised extension to the values of the Group regarding innovation and aims to define and disseminate the strategy for empowering the Company and its Group to be the innovation leaders of the energy sector with the core for their activities in this field comprising sustainable development, the promotion of renewable energies and emerging technologies, always in strict compliance with the pertinent legislation in force and all other Group-assumed commitments.

The Company understands innovation as a decentralised and open process. Decentralised because it is carried out independently within each business unit with the support and coordination provided by the Company's Innovation, Environment and Quality Department, depending on the Chairman's Area. Open because the Company views itself as a technology-driven entity and, as such, its aim is to involve the Group's technology suppliers such as universities, technology centres and equipment manufacturers in the innovation process.

Likewise, the Company believes that the innovation process should be consistent throughout all business units and, to do so, the Innovation, Environment and Quality Division is responsible for standardising in this regard.

2. Basic principles of action

The *Innovation Policy* is based on the following engagement principles:

a) Foster research, investigation and innovation activities (R&D&i) centred on efficiency, oriented towards a constant optimisation of the operations of Group businesses, management of the useful service life of facilities and equipment, reduction in operation and maintenance costs, decreased environmental impact, and the development of new products and services to satisfy the needs of our customers.
b) Vault the Group to the cutting edge of new technologies and disruptive business models by engaging in an "innovative culture" impregnated throughout the entire organisation for fostering motivating work environments that favour and incentivise the generation of ideas and innovative practices rendered by professionals, the acceptance of risks and the recognition of creative contributions.
c) Achieve innovations that benefit sustainable growth and efficient resource management while contributing to the social and economic development of the environment in which the Group carries out its activities.
d) Develop projects to render power services universal based on sustainable environmental models that are economically feasible and socially inclusive.

e) Integrate innovation in all the training provided by Group companies through specific courses and programmes to develop creativity-related capabilities.
f) Implement an innovation management system that includes the establishment of annual targets and objectives within a process of continuous improvement, managing the company's human and intellectual capital as genuine supports to the entire creative and innovative process.
g) Promote a technological surveillance and prospecting system for identifying opportunities and challenges for Group businesses, and detecting the innovation-related needs of its processes or services to thus anticipate technological changes in the market.
h) Promote collaborations and alliances with academic circles and other stakeholders through links created with a view to multiplying the Group's innovative capabilities.
i) Disseminate generated knowledge internally so that professionals understand the best practices applicable to their activity in seeking to increase the efficiency and effectiveness of Group processes.
j) Safeguard the results of innovation processes, appropriately and ethically managing intellectual and industrial property, which in any case entails observing the rights of this sort held by third parties.
k) Boost innovations that afford added value to users and increase the satisfaction of shareholders, customers, employees and other stakeholders.

3. Innovation strategy of listed Group *subholdings*

The present *Innovation Policy* is binding in any case notwithstanding the reinforced autonomy that the listed *subholdings* of the Group enjoy to define their own innovation strategy, which must nevertheless be consistent with the strategy established for the rest of the Group and in line with the present *Innovation Policy*.

This *Innovation Policy* was initially approved by the Board of Directors on 18 December 2007 and most recently modified on 23 February 2016.

6.2. Knowledge Management Policy

The Board of Directors of IBERDROLA, S.A. (the "**Company**") is aware that intellectual capital constitutes a basic pillar for the creation and protection of its corporate value, and thus acknowledges the need for implementing an adequate *Knowledge Management Policy* as a strategic objective to promote initiatives, procedures and tools to enable the Company to effectively harness its intellectual capital.

1. Purpose

The ultimate aim of this *Knowledge Management Policy* is to disseminate and share the Company's existing knowledge, continuous learning and cultural exchange to increase operating efficiency through the appropriate use of intellectual capital, yet always acting in the interest of the Company and the entities integrated in the Group whose parent company, as defined by law, is the Company (the "**Group**"), and notwithstanding other specific policies that could be established in certain companies of the Group.

In a world where traditional production assets are increasingly accessible, intellectual capital marks the differences between competitive and non-competitive companies; between companies that create value sustainably and those that are gradually losing their wealth-generating capacity.

The intellectual capital of the Company depends largely on the whole of its personnel, but also on its operative and organisational structures and on its internal and external relationships with all stakeholders. Therefore, learning at the personnel and organisational levels must be permanent, continuous and aligned with the Group's strategy.

The markedly strategic nature which the Company imposes on knowledge management requires constant efforts for improving initiatives and applying these to all of the Company's business units.

2. Basic principles of action

To achieve the aforementioned objectives, the Group assumes and promotes the following basic principles of action that must preside over all activities in the field of knowledge management:

a) Consideration of the Group as a system of existing connections between persons and working groups. The knowledge existing in each working group should be identifiable and accessible to the whole, thus giving rise to knowledge-based operating leverage.
b) Recognition of the value of knowledge existing in the Group and promotion of its development as a basic tool for the creation of value.
c) The integration of the Group's tangible and intangible assets to provide the objective conditions necessary to structure an intelligent organisation capable of constantly learning and innovating.
d) Alignment of knowledge management and the skills and requirements defined by the Group's strategy.
e) Definition of the models needed for management, measurement, processes and systems by integrating the vision of different business units to understand and develop the mechanisms for freeing knowledge flows within the existing organisational structure. In this manner, experiences are shared and continuous attention to the organisation's operation as a whole is guaranteed.

f) Full enhancement of knowledge-sharing within the Group by facilitating the resources needed for its development, internal dissemination through training actions, and efficient use. This shared intelligence is by nature creative and innovative and superior to the simple sum of individual intellectual capacities. Emphasis will be placed on the creation and improvement of organisational connections (networks) and the cohesion of the groups.
g) Consistent and sustained long-term evaluation of the intellectual capital in the Group to be able to assess the effectiveness of initiatives undertaken under this Knowledge Management Policy, correcting defects and promoting new engagements.
h) The implementation of improvement actions that bring the Group ever closer to excellence in knowledge management.
i) Observance in Group knowledge management of the intellectual and industrial property rights of third parties.

3. Knowledge management strategy in the listed Group *subholdings*

The present *Knowledge Management Policy* is binding in any case notwithstanding the reinforced autonomy that the listed *subholdings* of the Group enjoy to define their own knowledge management strategy, which must nevertheless be consistent with the principles contained in the present *Knowledge Management Policy.*

This *Knowledge Management Policy* was initially approved by the Board of Directors on 16 December 2008 and most recently modified on 15 December 2015.

6.3. Public project funding

Some of the projects described in this Report are co-funded by different public administrations, as detailed in the following table.

Funding programme	Projects
Junta de Castilla y León Ade Inversiones y Servicios	COEBEN
2008-2011 National Plan for Scientific Investigation, Development and Technological Innovation Unión Europea Fondo Europeo de Desarrollo Regional "Una manera de hacer Europa" Gobierno de España Ministerio de Industria, Turismo y Comercio plan avanza2	Work Order Manager, (TSI-020100-2009-581), GIDIN (TSI-020302-2010-68), E-PREVENCIÓN (TSI-020302-2009-80), SMARTSYS TSI-020100-2009-365), GESCOM (TSI-020100-2009-604), CPD (TSI-020100-2009-471), IMPULSO (TSI-020100-2009-389), SURTIDOR (TSI-020302-2010-127), AVANZA EÓLICO (TSI-020100-2010-663)
Sustainable Nuclear Energy Technology Platform (SNE-TP) Ministerio de Economía y Competitividad CDTI Centro para el Desarrollo Tecnológico Industrial Unión Europea Fondo Europeo de Desarrollo Regional "Una manera de hacer Europa"	MEDECOM, ENDS, SASIRE, DALIA, ITER Blankets, TBM, TECHNOFUSIÓN, PROCESS BUS, LABCON, ZEBRA MUSSEL, SOLTUBE, INSROCA, ECRIGEN, COEBEN II, DESOX, SIRO, LOWIMPACT FOUNDATION, MIGRES, GTCONTROLFLEX, RESONUC, FILTRONUC
CENIT PROGRAMME Unión Europea Fondo Europeo de Desarrollo Regional "Una manera de hacer Europa" Gobierno de España Ministerio de Ciencia e Innovación CDTI	SOST-CO_2, OCEANLIDER, AZIMUT, VIDA

Funding programme	Projects
INNTERCONECTA CDTI Centro para el Desarrollo Tecnológico Industrial GOBIERNO DE ESPAÑA · MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD · Unión Europea · Fondo Europeo de Desarrollo Regional FEDER - INNTERCONECTA "Una manera de hacer Europa"	DESEO
EEAGRANTS ICELAND LIECHTENSTEIN NORWAY eea grants CDTI	SMARTCOX, NEWPLAVOL, FILTRATIONS, SMARTWIND EES2, TABON, TLPWIND, WIND CCC
SEVENTH FRAMEWORK PROGRAMME	ADDRESS, OPEN-METER, OPEN-NODE, MERGE, GREEN EMOTION, TWENTIES, CAPIRE, INTEG-RISK, ASAMPSA2, NOZZLEINSPECT, CAPSOL, Grid4EU, GRID+, FINSENY, HESCAP, METER ON, ADVANCED, DTOCEAN, Igreengrid, DISCERN, LEANWIND, BESTPATHS, SIRBATT, GRID+STORAGE
BASQUE GOVERNMENT (GAITEK-ETORGAI) EUSKO JAURLARITZA GOBIERNO VASCO	MUGIELEC, FLOTTEK, ARIADNA EDCI, SIRENA, SAREBAT, SUARO II, H2SAI2, SAGERII, PLIDII, DIBADIS, SIRENAII, UHINDAR, MARINEL, ESStoZEB, AZKARGA, SAMARIA, ITSASERAUPEN

Funding programme	Projects
INNPACTO	EFESOT (IPT-120000-2010-22) DEPOLIGEN (IPT-120000-2010-31) EMERGE (IPT-120000-2010-017) EXTRADIS (IPT-120000-2010-037) EXTRASUPER (IPT-120000-2010-038) DATOS SUBS (IPT-120000-2010-039) PRICE-RED (IPT-2011-1504-920000) PRICE-GDE (IPT-2011-1490-920000) PRICE-GEN (IPT-2011-1507-920000) PRICE-GDI (IPT-2011-1501-920000) PROINVER (IPT-2011-1373-920000) SIGMA (IPT-2011-1137-920000) OpenFOAM (IPT-2011-1693-920000)
State-run R&D&i oriented to challenges facing society	MATUSALEN (RTC-2014-1908-3) HIDRASENSE (RTC-2014-2232-3) SILECTRIC-LL (RTC-2014-3147-3)
PLAN E	LIGNOCROP (RTC-2014-1908-3)
LIFE +	BEST4VARIOUSE, UROGALLO, BIOENERGY & FIRE PREVENTION, CO_2 ALGAEFIX, BRIO, CO_2FORMARE
International Cross-Company Programme	ACCIÓN NUCLEAR, ACCIÓN GREEN CARS, EÓLICO
Framework programme for competitiveness and innovation (CIP)	ICT4SMARTDG RESERVICES ICT4EVEU
European Institute of Innovation and Technology (EIT) through KIC-InnoEnergy	HIWave

Funding programme	Projects
HORIZON 2020 	LIFE 50+ UPGRID REMOURBAN HPC4E OPERA PROMOTION
Intelligent Energy Europe	MARTKET4RES
Innovative private purchasing 	ATEMPO
Innovate UK Innovate UK	TLPWIND UK PILE DESIGN IN CHALK
Wave Energy Scotland wave energy SCOTLAND	HIDRIVE

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