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Befesa and R&D

We have a technological commitment to seek and research the most advanced technologies and those that are the most respectful of the environment for waste and water management.

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Befesa's R&D Strategy

Befesa's research and development strategy is geared towards results and value creation by proposing new technologies in alignment with sustainable development.

Befesa's strategic research and development plan pursues the following objectives:

- To become a technologically competitive leader in aluminum and galvanized steel waste recycling.
- To develop new technologies for industrial waste management.
- To lead the field in desalination technology and become technologically competitive in wastewater treatment and reuse.

Research in the field of aluminum waste recycling seeks to improve performance in the recovery of aluminum raw materials and waste, optimize operating procedures and product quality, and develop new, improved technologies in aid of sustainable development.

The steel and galvanic wastes recycling area has recently formed a new company, Befesa Steel R&D,

S. L., with a view to bringing organizational structure in line with the new model, expand the various lines of activity and widen and improve our range of services so as to exceed market expectations and enhance both delivered and customer-perceived value.

The industrial waste integrated management area is developing new technologies along with ongoing change in environmental law. The company prioritizes its management methods based on a hierarchy headed by reuse, recycling and valorization as against merely eliminative treatment. We are also diversifying into new environmental markets and widening the range of treatable wastes.



In the water area, the company's goal is to lead the desalination field, become technologically competitive in potabilization and urban and industrial wastewater treatment and reuse, and entrench its leading position in hydraulic infrastructure and water resource management models and systems.

One of the main vectors of Befesa's research and development strategy is to enter into external partnerships with institutions and universities. Major partners include the Fundación Euskoiker and the Escuela Técnica Superior de Ingenieros Industriales de Bilbao, as part of the activities conducted by the Aula Befesa higher education unit in training and research. The company has also engaged in cooperation with Spanish government bodies in the form of subsidies or partnerships with the Spanish Ministry of Industry, Tourism and Trade (MITyC), the Andalusia devolved regional Department of Innovation, Science and Enterprise, CDTI, Inasmet, University of Valladolid, Programa para el Fomento de la Investigación Técnica (PROFIT), Corporación Tecnológica de Andalucía, Laboratorio Inatec, Insesca and Alcan, among others.

Befesa's R&D Center

In 2009 Befesa launched a new R&D center that will centralise the company's R&D activities. The center, which is located in Dos Hermanas (Sevilla), is an important milestone in the company's history and will be a fundamental element in achieving Befesa's ambitious innovation objectives.

The facilities have state-of-the-art and sustainable infrastructures equipped with scientific and technological resources that will give Befesa a leading technological position as well as making it an international leader in the areas in which it operates, such as integral water cycle management (especially desalination and reuse) and industrial waste treatment.

The building has been designed and constructed incorporating methods and features that make the center a model for sustainability:

- Energy and atmospheric sustainability: it includes systems for capturing solar energy, such as the orientation of the building, glazed areas to make use of natural light and high performance artificial systems; as well as the use

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- of renewable energies with photovoltaic solar panels and heating systems for sanitary hot water.
- Interior environmental quality: high performance air conditioning using the thermal inertia of the ground and thermal insulation in the building, as well as water curtains to reduce the thermal load on the building.
- Water efficiency: systems to reduce water consumption, treatment of clear grey water and its reuse in cisterns, including the collection and treatment of rainwater for reuse in onsite irrigation.
- Recycled resources and materials: Ferrosite in partition walls, galvanised external cladding made from recovered zinc oxide.
- Site sustainability: habitat protection, maximisation of the open space, prevention of heat island effect.

- Facilities control and management system: intelligent control of the building's facilities to save energy. Inventory of CO₂ emissions in order to reduce them.

The Center also has extensive office areas and other innovative spaces designed to showcase Befesa's activities in a simple and visual way.

The Center is distributed over two storeys and includes the following areas:

- A visitor reception and exhibition area. The objective is to provide an illustrative and dynamic explanation of what Befesa is and the activities it carries out, providing solutions that contribute to sustainable development. The exhibition room has therefore been fitted with

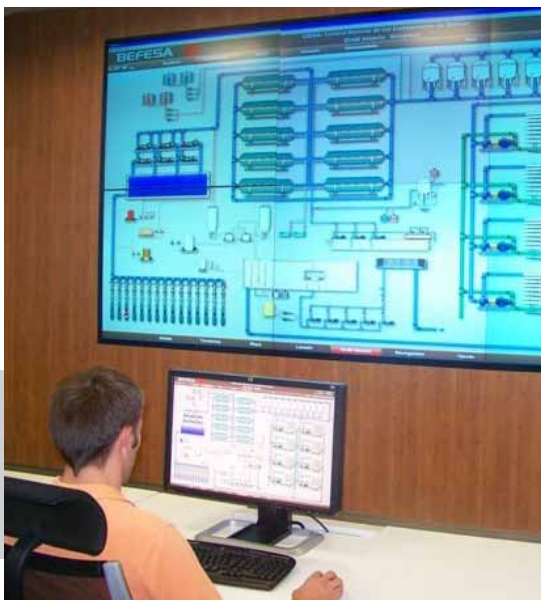


visual elements (posters, plasma screens, photographs) and materials (samples of products and examples of technology).

- Control room. This area is equipped with sophisticated technology that holds all the information required to remotely monitor the operations of the plants or systems Befesa operates worldwide.
- Experimental area. This is where all the experimentation equipment is housed and is where all the experimental pilot experiments are conducted in general, including demonstrations of the R&D projects currently being developed by Befesa.
- Multiuse room. This room can seat 130 people and is equipped with audiovisual equipment, including a simultaneous translation booth.
- Analysis and classification laboratories. This is where clean water, waste water and other

wastes are comprehensively analysed and classified. It has an independent capacity for physical, chemical and microbiological analysis of the main parameters for the base materials involved in Befesa's activities, for different types of water and wastes. The instrumentation is state-of-the-art.

- Offices. For R&D researchers and personnel.
- Workshop. For constructing and assembling R&D pilot plants for projects. It has all the necessary mechanical and lifting equipment.
- Services area for the Experimentation area. It includes the water and waste storage and distribution systems for the pilot plants, the power supply with different voltages and currents, etc.



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Befesa Innovation Highlights of 2009

Befesa Gestión de Residuos Industriales' strategic research and development plan seeks to entrench the company's leadership in waste management and adapt to ongoing changes in environmental law. Specific objectives include:

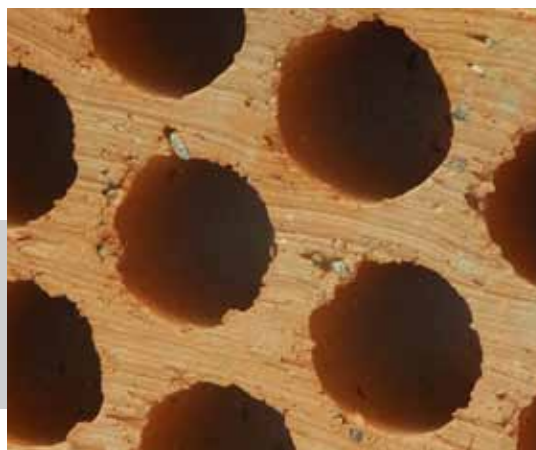
- Gradually replacing elimination treatments with recovery and energy valorization approaches.
- Reinforcing technological leadership in industrial waste management by developing environmentally safe and energy-efficient treatments.
- Widening the scope of the market by offering industry news services and extending the range of treatable wastes, while diversifying into new environmental markets.

The strategic research and development plan develops technologies that offer an environmentally friendly and sustainable treatment alternative to

prevailing practices in waste management, by using the material and energy resources of waste material through recycling and valorization processes. The technology activities associated with the strategic plan include:

- Production of waste-based fuels as alternatives to fossil fuels.
- Acquisition of substitute raw materials for industry.
- Development of the best available technologies for treating wastes and contaminated soils.
- Development of technologies to diversify into new markets and opportunities.

Befesa Agua's strategic research and development plan pursues the goals of leading the way in desalination, becoming technologically competitive in potabilization and urban and industrial wastewater treatment and reuse, and underscoring its leading position in hydraulic infrastructure and water resource management models and systems.



Befesa Agua's strategic R&D plan relies on four main vectors of advance:

- In-house resources, such as the R&D department and Befesa's research and development center.
- R&D aid and subsidies awarded by a range of public authorities.
- Collaboration agreements with universities.
- Technology partnership agreements.

R&D Programs

Befesa's R&D is structured into two core research and development programs: the Industrial Waste Recycling Program and the Water Program.

Industrial Waste Recycling R&D Program

The Industrial Waste Treatment Program is structured into three strategic lines of action:

- Steel and galvanic waste recycling.
- Aluminum waste and salt slag recycling.
- Industrial waste recycling.

Some of the highlights of our research and development in 2009 are outlined below.

Treatment and Preparation of Raw Materials

This project is aimed at managing and finding uses for the co-products of treating spent pot lining (SPL) from the electrolytic cells used for primary aluminium production. The research will widen Befesa's recycling market

Development of Products and Applications

One of the company's main goals is to demonstrate the potential uses of the alloys produced at its facilities and their applications in various fields. Secondary aluminum alloys can be used to replace primary aluminum to manufacture sand cast parts called on to bear high mechanical responsibility. Alloys commonly used for aluminum injection can be alloyed by up to 1.8 % without impairment. A new modifier can be created for the structural phases of iron present in the alloys, which makes them brittle.



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New Applications of Paval/BFA/Serox

The company has developed a Paval+polyester component that fulfills the innovation requirements for a range of urban architecture and street furniture projects. The invention now needs to be followed through with its final touches: specifications of the production process; color schemes; development in polystyrene casts and complex forms; introduction of fibers, etc. The trademark has been registered in the name of ONN, a company that uses Paval® (a trademarked form of aluminum dross residue) to make architectural and street furniture.

Production Process Improvements

This innovation project enhances the equipment itself as part of the production process in both aluminum smelting and in molten salt recycling, so as to optimize the process and lower costs. A highlight of equipment enhancement is to develop a new refractory inner lining for rotary kilns. Salt recycling has been improved by lowering the humidity of the molten salts at the crystallization

exit, making savings in the natural gas required to produce steam, and enhancing the process of drying the salts and Paval, and further conditioning the Paval on its exit from the production line.

Introduction of the Greenhouse Gas Emissions Inventory

Over the course of 2009, the company advised on the introduction of the new greenhouse gas emissions inventory in all companies within this business unit in accordance with Abengoa's internal rules and regulations. The move involves setting objectives and framing plans and specific measures to reduce carbon dioxide emissions across the group's various facilities.

Design of New Dust Recycling and Waelz Oxide Lixiviation Plants

The company has undertaken engineering projects and services for the design of two new plants. One will serve as the central purification unit for unwashed Waelz oxide produced by the common steel waste recycling division, while the other,





currently installed in southern Europe, is intended to accommodate expanded capacity for the treatment and valorization of steel mill dust by means of the Waelz process. We have located the ideal site for each project and filed applications for the required administrative permits for implementing our plans.

Improving Existing Processes and Products

The company is assessing a range of innovative processes for enhancing the quality of our products. We are searching for economically viable applications for a Waelz process co-product called Ferrosita®, which has been tested successfully as an input material for making various kinds of bricks

and concrete counterweights for elevator systems. In addition, the galvanic waste recycling division has conducted research to produce a commercial quality zinc oxide through valorizing low-zinc-content concentrates.

Development of Oxygenated Additives Derived from Glycerin for use in Liquid Fuels

The aim of the project is to use excess crude glycerin from biodiesel production plants to make high-value-added products. A specific area of interest is to synthesize glycerin esters for use as oxygenated additives for diesel fuels. Finding a use for the large surpluses of crude glycerin – for which there is no market in Spain at the moment – will improve the life cycle of biodiesel, support sustainable development and mitigate adverse environmental impacts. Befesa Gestión de Residuos Industriales' (BGRI's) research and development department is working on this project in partnership with the Fundación de Investigación Tekniker and the thermal machinery and engine research team of the University of Seville.



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The project has attracted funding from the Spanish Ministry of Industry, Tourism and Trade (MITyC), the CDTI, the Department of Innovation, Science and Enterprise of the devolved regional government of Andalusia (Agencia IDEA) and Corporación Tecnológica de Andalucía (CTA).

New Construction Materials Made from Recycled Waste

This project is concerned with stabilizing inorganic wastes which can then be used as construction materials – bricks, mortar, sound and heat insulation, etc. The company hopes to validate techniques for stabilizing inorganic industrial wastes in silicon matrices using gentle hydrothermal processes that do not require high energies.



Project partners include the solid-state chemistry research team of the University of Seville and the private enterprises Cerámicas Malpesa and Cementos Barrero S. A.

The project has attracted grants from the Spanish Ministry of Education and Science (MICINN) and the Department of Innovation, Science and Enterprise of the devolved regional government of Andalusia (Agencia IDEA).

Restoration of Contaminated Soils using Non-Hazardous Wastes and other Byproducts

The project is intended to validate remedial techniques for metal and hydrocarbon contamination. The proposed methods involve fixing the contaminants using nonhazardous industrial gypsum wastes and other byproducts, such as modified or organic clays. The arrival of a new regulatory framework on contaminated soils management has prompted the development of techniques that prioritize on-site treatment of the terrain as against techniques requiring mass displacement of soils.

Research partners include the CSIC (the Spanish national research council), the IRNA (the Spanish Institute of Natural and Agro-biological Resources), the ICMS (the Seville Materials Science Institute) and the University of Barcelona. The project has attracted a subsidy funded by the Spanish Ministries of Education and Science (MICINN) and of Environment (MARM).

Water R&D Program

Befesa Agua's strategic R&D plan is structured into three areas: desalination, potabilization-purification-reuse and water cycle sustainability.

The Desalination area focuses on improving the efficiency of the reverse osmosis process and lowering its investment, operation and maintenance costs.

The Potabilization Purification Reuse area seeks to optimize membrane-based water treatment processes so as to save energy and produce less sludge, develop sludge treatment and elimination technologies and undertake research on supercritical oxidation.

The Water Cycle Sustainability area seeks to optimize energy use in water infrastructure, develop hydro power and marine energy capabilities, create sustainable water management models, and develop and apply sustainability criteria in the design of the company's solutions.

Some of the highlights of our research and development in 2009 are outlined below.

Pilot Plant for High-Efficiency Desalination

The aim of the project is to lower energy use for desalination purposes to less than 2.5 kWh per cubic meter of water output. Befesa Agua has researched and developed reverse osmosis membranes and energy recovery systems and implemented process improvements to minimize energy use. The project is now at the pilot phase in that a high-efficiency pilot plant has been built and experimental campaigns are being conducted.

The project has secured grants from the Department of Innovation, Science and Enterprise of the devolved regional government of Andalusia and from the Spanish Ministry of Environment.

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Seawater Pretreatment System using MF/UF Membranes

This project is directed to developing an advanced seawater pretreatment system using membrane technology. The company has conducted real-site tests on seawater at the pilot plant scale to evaluate the performance of commercially available micro- and ultra-filtering systems in comparison to one another and to conventional schemes. The results have then been used to design a proprietary system based on MF-UF membranes.

The project has won grants from the Department of Innovation, Science and Enterprise of the devolved regional government of Andalusia and from the Spanish Ministry of Environment.

Desalination Plant Remote Control and Monitoring System (Befel-CRIBA)

This project is aimed at developing a remote control system affording real-time vision of the state of operation of Befesa's desalination plants across the world. If successful, the system will be a key tool for optimizing the operation and maintenance of Befesa Agua's plants. The company has created an IT platform for remote control and monitoring, a communications system, an information management system and a control room. Now in its demonstration phase, the platform is being tested with data from one of Befesa Agua's desalination plants.

The project is funded by subsidies from the Department of Innovation, Science and Enterprise of the devolved regional government of Andalusia and from the Spanish Ministry of Industry's PROFIT scheme.



Advanced Wastewater Treatment for Reuse (TRASOS)

The ability to reuse wastewater stands to be a key factor in sustainable development, and offers high potential as an alternative source of water. The goal of this project is to optimize wastewater treatment processes by taking account of the specific type of wastewater concerned and its intended future use. The company is researching membrane technologies such as biological membrane reactors and micro- and ultra-filtering systems.

The project is now at the stage where a pilot plant is under construction and experimental campaigns are scheduled for 2010. The company is awaiting a decision on its application for funding from the CDTI technology program.

Wastewater Treatment Plant Sludge Removal using Supercritical Oxidation

With Befesa Agua acting as coordinator, this project has been undertaken in viability of supercritical oxidation technology for eliminating wastewater treatment plant sludge. A pilot plant has now been designed and built, experiments are already underway, and by 2010 tests will be extended to other types of sludge.

The project is funded by subsidies from the Department of Innovation, Science and Enterprise of the devolved regional government of Andalusia, the Corporación Tecnológica de Andalucía and the Spanish Ministry of Environment.

