Abengoa and Innovation

Abengoa and innovation

Introduction

The existing model of industrial and economic development is not sustainable given the planet's limited capacity to continue providing raw materials that generate value for our economy, and to absorb all the wastes, emissions, discharges, etc. generated by economic activities. Due to this exhaustion of raw materials and saturation of the environment in its current guise as a cesspool for industrial activity, our environment is undergoing great change that is leading to major challenges and opportunities. Abengoa believes in the capacity of technological innovation, research and development as the tools required to change our treatment of the environment and also to put an end to unsustainable production systems. To this end, large investments will have to be made in sustainable production systems. In turn, these investments will be capable of replacing consumption as the driving force behind the global economy in these difficult times.

Global warming must be seen not only as a serious risk to the environment, but also as an element that has a very negative impact on the world economy, where, up until now, the external costs of industrial and economic activity in decision-making processes only received very discreet consideration, meaning environmental and social considerations have only very rarely been included in customary economic criteria.

Innovation in Abengoa

Research, technological development and innovation are a necessary source of solutions for sustainable development, which is Abengoa's primary objective. Their implementation has been fundamental in positioning the company as a leading figure in the generation of new technologies, processes, and know-how focused on providing innovative environmentally-friendly solutions that not only afford competitive advantages but also generate long-term value. Undoubtedly, technological innovation is a fundamental factor in evolving towards a sustainable world with high quality of life for all countries and individuals. Experts agree that almost 80% of long-term growth in any economy will result from technological achievements.

At Abengoa, we are fully aware that the innovation process is dynamic and responds to a society in constant evolution. It must therefore be tackled from all fronts utilizing all the resources available in the knowledge, science and technology society. As a large company, Abengoa adopts the so-called "innovation ecosystem" and fosters collaboration with universities, government agencies, public research institutions, technology centers and other companies. This is the only way it can generate the required know-how and provide answers and solutions to the new challenges to be faced. This innovation system includes demonstration projects, research and development facilities in different countries and external collaboration agreements.

Most of Abengoa's investment in R&D&i goes on applied research and development of technological innovation focused on attaining strategic sustainability objectives and new products. Abengoa's investment in R&D for 2008 was 84 M€ , up 53.8% on the previous year, which ranked the company 7th in the list of Spanish companies investing in R&D, and 246th on the European list, according to the EU Industrial R&D Investment Scoreboard 2007. Table 1 shows the evolution by sector of Abengoa's investment in R&D in recent years.

Abengoa R&D&i Investment

Main Projects	2005 M€		2006 M€		2007 M€		2008 M€	
Solar Energy	31.7		17.4		12.9		29.5	
Biomass convertion to Bioethanol	13.5		26.2		13.1		19.5	
Enhancement Bloethanol efficiency (residual starch)	1.1		1.6		3.4		3.7	
Hydrogen Technology	2.7		2.1		1.8		2.0	
Electricity, environmental.oil and gas control centers	6.8		7.6		8.5		9.2	
Road and nail traffic, and ticketing systems	3.6		5.6		3.9		4.4	
Public Administration support systems	2.1		2.2		4.5		5.2	
Geographic information Systems (GIS)	2.2		2.3		3.0		3.2	
Industrial Waste Management	0.0		0.5		0.5		0.6	
Vitrificacion	0.0		0.4		0.1		0.7	
Desalination	0.0		1.0		0.8		0.1	
Environmental Technology Center	0.0		0.0		0.1		0.8	
Treatment of wasterwater	0.2		0.4		0.3		0.2	
Development of polypropylene	0.0		0.1		0.1		0.2	
Other Projects	2.0		1.1		3.0		4.7	
Total R&D&i Investment	**65.9**	**3.3% o/sales**	**68.5**	**2.6% o/sales**	**56.0**	**1.7% o/sales**	**84.0**	**2.2% o/sales**

Innovation must create competitive advantages for Abengoa, and these must be measurable and quantifiable through different indicators.

The most common indicators utilized for R&D assessment are:

Investment "Input"

- costs (capex, opex) obtained from in-house financing and public grants,
- human and material resources at the service of R&D&i,

Results "Output"

- increase in productivity,
- increase in production,
- reduction of costs,
- improvement of quality,
- increased Cash Flow,
- appropriation of differential results,
- generation of industrial and intellectual property rights,
- marketing of new products,
- increase in revenue attributable to the innovation,
- incorporation of the new knowledge and know-how gained during development of the technological innovations,
- enhancement of market image (visualization of intangible assets in economic, social and environmental aspects).

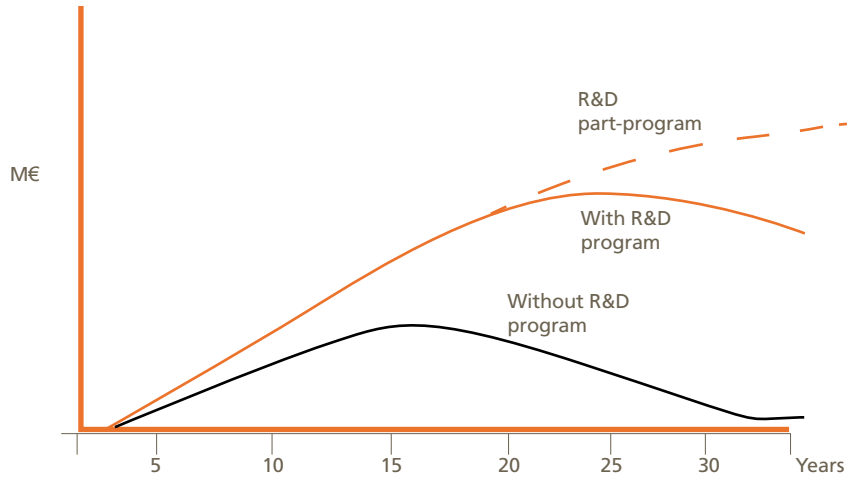
Evaluation of innovation at Abengoa is based on broad lines of research, technological development and innovation geared towards a generic product (desalination plants, bioethanol facilities, hydrogen fuel cells, etc.).

The top graph shows the increase generated in sales of a generic product thanks to the implementation of R&D programs to produce it, and incidence on its costs. When there is no R&D program, the products or services become obsolete after a certain time period due to rapid changes in the market. With investment in R&D, their lifetime is lengthened by incorporating the improvements obtained through research, which optimize the performance of the product or service in question.

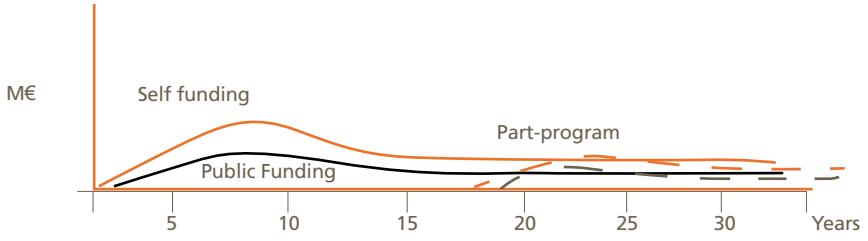
R&D&i projects must be aligned with Abengoa's strategy and their exploitation must be long-term (up to 30 years). They must likewise be undertaken in partial programs (10 years) and specific projects (3 to 4 years).

The bottom graph shows a possible financing option for a specific product or service by combining public and private funding, with the inclusion of a partial program.

Products generated revenue



R&D costs



Abengoa and its commitment to sustainability

On the basis of its innovation policy and strategy, Abengoa, together with all its business units, places its trust firmly in sustainable harnessing of resources and raw materials throughout their entire lifecycle. Each one of Abengoa's business units conducts different technology innovation projects to this end.

Abengoa is an undisputed leader in technological development in the field of energy production from renewable energies. Abengoa Solar works on producing electric energy by replacing conventional sources with renewable sources such as solar thermal or photovoltaic energies. It also works on developing technologies that allow energy storage.

Abengoa Bioenergy produces biofuels to replace traditional fossil fuels. Hynergreen develops new systems for hydrogen production utilizing renewable sources, and for the use of hydrogen in latest generation fuel cells. Inabensa focuses on implementing improvements in energy efficiency and on CO_2 capture and valorization programs.

The promotion and implementation of these technologies for energy production based on renewable sources and energy efficiency are part of a new sustainable development economy, and will help to curb greenhouse gas (GHG) emissions while breaking the stranglehold of more traditional sources. It will also free states from the usual geopolitical pecking order imposed by the owners of these traditional energy sources, which is linked to current causes of insecurity and scarcity of supply.

Likewise, Abengoa. through its Environmental Services Business Unit, with Befesa as the parent company, provides integral water cycle and industrial waste management solutions.

Telvent, the Business Unit dedicated to Information Technologies, conducts development and innovation activities focused on being able to offer its customers innovative solutions that contribute to sustainability and security via technology.

The business units and technological innovation

Abengoa Solar

Upgrading existing and developing new technologies are a priority for Abengoa Solar. The objective is to offer technologies capable of generating clean energy at a cost that is competitive with fossil fuels, while taking the cost of emissions into account.

To this end, an ambitious research and development plan has been established. This plan will allow the company's investments, together with those of other institutions and companies in the sector, to meet this goal. Abengoa Solar's effort is channeled through a team of more than 60 professionals at Abengoa Solar New Technologies (with research centers established in Sevilla and Madrid, in Spain, and Denver, in Colorado, U.S.A.), who are researching the two large suites of priority technologies photovoltaic and high temperature solar thermal energy. Throughout 2008, this team continued to grow and develop its capacities in the main areas of research, while strengthening its partnerships with the world's leading institutions (Ciemat in Spain, NREL in the US, and DLR and Franhoufer in Germany) and also building pilot facilities that allow them to test new technologies under real operating conditions.

The R&D&i carried out by Abengoa Solar is based on four stages:

- Stage 1, where the project is specified and preliminary research activities conducted.
- Stage 2, where theoretic analysis and modeling of the solution is carried out.
- Stage 3, where a prototype or demonstration plant is built.
- Stage 4, where the demonstration system is analyzed and validated prior to commencement of the commercial stage.

In 2008, several projects entered stage 3 and even stage 4, meaning we can expect significant advances in forthcoming years. Furthermore, Abengoa Solar was highly successful in obtaining grants from public institutions worldwide for the groundbreaking R&D projects it is launching:

- In Spain, Abengoa Solar will head – for 4 years – the CENIT Consolida project which, with a 24 M€ budget, aims at developing more efficient solar thermal technologies for electricity production.
- In the US, the company has been awarded Department of Energy grants for two R&D projects focused on storage technologies. These can now be added to the three projects for which grants were awarded towards the end of 2007 and on which activities commenced in 2008.
- The European Union also awarded a grant to the Abengoa Solar led Solugas project aimed at developing new high temperature power towers.

All the above allows Abengoa Solar to undertake its three major R&D&i challenges with renewed optimism:

1. To develop solar thermal technologies capable of producing electricity at large plants at prices able to compete with fossil fuels. Two of these projects are already at stage 3 and will progress to stage 4 in 1Q 2009.
   - The high temperature power tower with superheated steam. Following several years' work, the 2 MW pilot tower at the Solúcar Platform has been completed. The tower was built from the experience gained from the PS10 and PS20 power plants and will allow the company to test the second generation of towers, which produce superheated steam and will become vastly more efficient when the technology becomes commercial.
   - Parabolic trough collector with direct steam generation. A pilot plant using this brand new technology has also been constructed at the Solúcar Platform. This will allow the company to reduce construction costs while increasing efficiency of the system compared to the oil technology currently in use. In addition, work has been ongoing on upgrading the technologies associated with parabolic trough plants with the first pilot oil plant outside the United States. This facility has allowed us to optimize the technology we employ at the Solnova 1 and 3 plants, and also at newer plants, and to pinpoint possible improvements to the optics and components, such as support structures, mirrors, ball joints, flexible joints and pipes. Moreover, work was conducted on the design, testing and validation of new parabolic troughs. In Spain, Abengoa Solar developed the ASTRØ collector, which leads to significant reductions in manufacturing costs and time, simplifies transportation needs and enables ease of assembly while reducing assembly costs on-site. Several designs were initially put forward, two of which were eventually selected for the prototype manufacturing stage. After both were duly tested on a test bench at our participated company Eucomsa, one was selected as the reference design.

Meanwhile, in the United States, another more efficient collector is being developed, in collaboration with the NREL, based on the collectors currently utilized for industrial facilities. Also in development are advanced reflective materials and the use of new heat-bearing liquids in parabolic troughs combined with thermal energy storage.

Solar platform with installations employing diverse technologies

Abengoa Solar's efforts in R&D also include other energy generating technologies, where the company has focused on the design and construction of several Stirling dishes at the Solúcar Platform. This will enable it to gain direct experience in designing, constructing and operating this technology in order to validate its potential for the future. Modularity is the advantage of Stirling dishes. They can be utilized for distributed generation, largely due to the fact that they do not require a turbine to operate. Nevertheless, their current cost is much greater than that of the other technologies.

2. To develop efficient energy storage systems. Energy storage is essential to increase availability from solar thermal power plants: it improves the annual capacity and efficiency of the energy conversion cycle, thereby reducing the number of plant start-ups. High-temperature solar thermal energy has the great advantage over other renewables in that it can be stored and is therefore manageable – either by hybridization with other energy sources or through the use of storage systems. One of the priorities is to test and develop new technologies for energy efficient storage systems. The company is currently working on two key projects in this line:

- Molten salt storage system based on sensitive heat. Abengoa Solar has completed construction of a pilot plant that will allow it to validate, measure and optimize these types of systems for subsequent commercial use.
- New latent-heat thermal storage systems. Several projects are currently at stage 1 and will lead to new more efficient and less costly systems in the future. Abengoa Solar has worked, together with several research centers, on a project to develop new energy storage technologies applicable to solar power plants. On this project, work has been conducted to validate technologies close to commercialization, and also on technologies that will require significant development over forthcoming years. One of the most promising concepts on which Abengoa Solar has been working in recent years has been storage via phase change latent heat (PCM).

3. To develop lower-cost distributed photovoltaic systems. At present, photovoltaic technology is more costly than high temperature solar thermal but, in the future, it could become a very efficient means for distributed generation needs or for small or medium-sized power plants. This is why it is vital for Abengoa Solar to contract and develop efficient photovoltaic technologies. The company is currently working on low, medium and high concentration photovoltaic systems. More specifically, we have analyzed production from several concentration systems installed at the Solúcar Platform, including low concentration and high concentration systems by disc and by point focus systems. We have also rolled out a research program focused on developing the concentration systems of the future.
   In 2008, a photovoltaic laboratory was set up to test and measure the performance of all types of photovoltaic system under real operating conditions while utilizing different tracking systems. The aim of the project is to create an experimental tool with which to analyze energy production costs by employing different technologies and configurations, prevent and resolve problems during the life-cycle of the photovoltaic systems, and identify the optimum technology and configuration for different types of facilities. The photovoltaic laboratory is located at the Solúcar Platform and possesses the infrastructures and equipment required to measure and characterize photovoltaic devices and systems.

2008 was a crucial year for consolidating R&D&i in solar energy by strengthening human and material resources, capacities, collaboration activities and partnerships. Funding for new and important projects was obtained and decisive headway was made in others. 2009 will be a key year in which we must continue to advance the company's main objectives and to guarantee a future with clean and efficient energies from the sun.

Abengoa Bioenergy

The mission of Abengoa Bioenergy New Technologies is to develop and demonstrate technological solutions through science and innovation to meet the objectives established in Abengoa Bioenergy's ptrategic plan, which includes:

- Developing and commercializing biomass technologies at competitive prices.
- Increasing the added value of existing co-products and developing new co-products.
- Upgrade existing dry mill technology.
- Fostering the development of energy crops.
- Developing the biomass market.
- Developing end-use programs for biofuels.

For the use of new raw materials as carbon sources, efforts are focusing on enzymatic hydrolysis and catalytic gasification processes.

As regards gasification and catalysis, work continued on the thermochemical technology development program for biomass to bioethanol conversion and quite promising intermediate results were achieved in both analysis and proposal of process configurations and in research into heterogeneous catalysts to convert synthesis gas into ethanol and alcohols. The company also explored different opportunities for demonstrating biomass gasification technology on an industrial scale, for steam and electricity production, or to be combined with solar thermoelectric energy facilities for valorization of both forest biomass and energy crops.

In 2008, Abengoa Bioenergy worked to develop, evaluate and validate new processes to revalorize the co-products obtained from cereal grain-bioethanol production processes, thereby enhancing nutritional values.

Enzymatic hydrolisis biofuel demo plant in Castilla y León.

Improvements have also been made to the bioethanol production process at the pilot plants, resulting in an increase in ethanol/cereal performance. At the same time, new enzymes are being experimented with to assess any improvements in performance and reduction of impacts to be had.

Raw materials represent between 60% and 70% of biofuel production costs and, during their life cycles, between 30% and 40% of greenhouse gas emissions, according to JRC data. Abengoa Bioenergy has therefore developed programs aimed at reducing the economic and environmental impact of raw materials destined for biofuel production, and at identifying and developing alternative species for the use of first and second generation production technologies. In addition, it has launched programs to evaluate the potential of other resources such as forest, industrial and agricultural wastes, and the use of different varieties of cereal obtained from different types of seeds. Simultaneously, the company is looking into and evaluating new ways of collecting and supplying large quantities of biomass to the processing plants.

Well aware of the environmental benefits of the use of biofuels, the company is conducting demonstration programs to promote the use of e85 and e95, and studies on ethanol-diesel mixture to develop stable blends that meet the requirements of petrol and diesel engines. These demonstration programs for new applications of ethanol as the end product have focused on implementing the use of ethanol-diesel mixture (or e-diesel) in captive fleets of heavy vehicles: buses and worksite machinery. Fuel analysis has focused strategically on obtaining knowledge of the stability of blends, performances under engine bench testing and durability of the engine components when e-diesel is utilized.

Another concept the company is focusing on is Biorefining, with which products with market value will be obtained from biomass. At present, the company is developing the conceptual model and conducting market studies into the potential products. Given the consumption required to obtain ethanol from biomass in its different forms, to

carry out the biorefining processes we have launched projects to select suitable enzymatic blends and to design the engineering process required to obtain ethanol on site at the production plants.

To increase business sustainability, work has commenced on evaluating the potential of using photosynthetic organisms (microalgae and cyanobacteria) as CO_2 capturers. Likewise, the company is evaluating the potential of biomass generated for use as a raw material for biofuel production and the potential for use of these organisms to produce other high added value metabolites.
The most important projects are listed below.

Project I+DEA

Abengoa Bioenergy New Technologies (ABNT) heads this multidisciplinary consortium whose main objective is to generate knowledge for utilization of ethanol as fuel.

The specific objectives included in the project are:
- Development of energy crops for existing and second generation technology.
- Development of enzyme blends for the enzymatic hydrolysis process that reduce the impact of this stage on the total cost of manufacturing.
- To make significant progress on ethanol synthesis catalysts.
- Complex process designs and in-depth analysis.
- Analysis of stability of blends, performances and durability of engine components.
- To demonstrate the use of e-diesel in bus and machinery fleets, as well as on-board metering of emissions.
- To initiate development of new applications: burners, marine and high load and motorcycles/mopeds.
- Development of regulations governing tank design and soil remediation following ethanol spills.

Biosynergy

The Biosynergy project is geared towards using biomass for synthesis of bioproducts (chemical or material) and producing secondary energy carriers – transport fuels, energy and/or CHP – through development of biorefining. The research is focused on advanced and innovative development of fractionation and conversion processes, combining biochemical and thermochemical pathways, and on developing the process from laboratory scale to pilot plant scale.

The objective of Abengoa Bioenergy's activities is to generate the data required to assess the different options for physical or chemical fractionation of the pretreatment of the pretreated feedstock and the post-treated materials. This data is required to configure the process under development and to select appropriate equipment for the biorefinery. The activities also include development of a conceptual plan for a biorefinery that converts energy crop agricultural waste into ethanol and high added value co-products.

Main milestones reached:
- Evaluation of some of the biorefining concepts under consideration using technical, economic and environmental criteria.
- Study of the main bioproducts that can be produced from the different fractions of the biomass.
- Techno-economic analysis of different pretreatment options.

Singular Strategic Project (SSP) involving energy crops

Abengoa Bioenergy, Ecoagrícola and ABNT are participating in this project launched by the Spanish Government

to develop energy crops for different applications (heat, electricity, and biofuels). The consortium comprises many different partners from the energy sector.

Milestones reached:
- External repercussions associated with the use of cereals as energy crops.
- Development of a tool capable of identifying the cereal consumed in ethanol production facilities and associating them with GHG emissions along the production and supply chain.
- Selection of the first batch of cereal varieties optimized for ethanol production.
- Agronomic development of Jerusalem artichoke and sweet sorghum (cultivation techniques, periods and harvesting techniques, sugar yield, etc.).

Project Hybrid

Abengoa Bioenergy New Technologies is heading the execution of this project. The main objective is to design, construct and operate the 100 Mgal commercial biomass and starch hybrid plant.

The specific objectives of the project include:
- To demonstrate commercial feasibility of the biomass to ethanol conversion process.
- To prove that the technologies developed are adaptable to existing and future plants.

The subsidiary ABNT has been selected to design, construct and operate the US DoE's large pilot biorefinery. A grant from the DoE will partially fund the project. The biorefinery will be located next to a starch ethanol plant, forming a hybrid complex in Hugoton, Kansas, U.S.A..

The conversion capacity of the biorefinery will be at least 700 t/day and will consist of two processes: Enzymatic Hydrolysis (EH), and Gasification. The EH process will convert biomass (400 t/day) into ethanol, lignin, and animal feed. The Gasification process will convert 300 t biomass/day into syngas which will be combusted to generate steam. The steam will be utilized in the biomass plant and any excess will be sold to the adjacent starch plant.

Milestones reached:
- $38 M grant secured from the DoE for phase 1 of the contract.
- Personnel and offices contracted for the project.
- Property and water contracts signed.
- Pro-forma approval secured for the starch/biomass hybrid plant.
- Project pre-construction and EPC program approval secured.
- Enzymatic hydrolysis and gasification simulation models completed.
- Selection of the starch technology.
- Appointment and contracting of architectural and engineering consultants.

New projects

Project Bioref-integ

The purpose of project Bioref-integ is to study and develop biorefining concepts utilizing existing fuel producing industrial complexes in order to increase their competitiveness via co-production of new products. Within the project, different market sectors are analyzed: bioethanol, biodiesel, pulp/paper, oil refining, energy production,

the food industry and the agricultural sector. Evaluation of the biorefining concepts developed under the project includes assessment of the technology, as well as an economic analysis and study of emissions.

The objective of Abengoa Bioenergy's activities is to provide support for projects to identify existing industrial complexes in the bioethanol sector and potential products that might be co-produced at such complexes, and also to develop biorefining simulation models integrated into the bioethanol sector.

SOST CO_2

This project is financed by the CENIT program (Ministry of Industry, Tourism and Trade). Coordinated by Carburos Metálicos (Air Products Group). General aim: to develop sustainable technologies for utilization of CO_2. ABNT is to collaborate with the Polytechnic University of Valencia, Seville University, Cener and Inabensa. ABNT's specific project objectives are:

- To develop the selective catalysts for hydrogenation of CO_2 for ethanol synthesis.
- To develop the process to produce ethanol from CO_2 and renewable hydrogen.
- To produce microalgae utilizing CO_2 from fermentation, for use as biomass.
- To evaluate the life cycle of the proposed alternatives and their impact on the life cycle of existing ethanol from cereal grain production technology.

Befesa

R&D&i strategy at Befesa is focused on obtaining results and the creation of value by developing new technologies, with sustainable development in mind at all times.

The objectives of Befesa's R&D&i strategic plan are:

- To lead the way and be technologically competitive in the aluminum and steel waste recycling industry.
- To develop new technologies for industrial waste management.
- To lead the way in desalination technology and be technologically competitive in wastewater treatment and in water reuse.

In the aluminum waste recycling business unit, R&D&i activities seek to enhance performance in recovery of raw materials and aluminum waste, optimize the operation processes and quality of the products, and develop new and better technologies that contribute to sustainable development.

The R&D&i projects developed by the steel and galvanization waste recycling business unit focus on design and construction of facilities that allow optimization of process performance, as well as research aimed at discovering new uses for the materials recycled by Befesa.

The integral industrial waste management area focuses on developing new technologies to adapt to constantly evolving environmental legislation, prioritizing the management methods based on a hierarchy marked by reuse, recycling and valorization as against disposal treatment processes, diversifying towards new environmental markets and increasing the number of treatable wastes.

In the water division, Befesa's R&D&i centers on optimizing the energy efficiency of desalination processes, reusing wastewaters, minimizing process costs and environmental impact and upgrading hydraulic infrastructures.

The array of R&D&i investments and programs have been rolled out to attain the objectives established in the strategic plan:

1. In aluminum waste recycling, R&D&i projects seek to enhance the quality of the molten salts while minimizing salt slag production: improve aluminum casting and automation on the ingot lines; optimize salt slag recycling to increase process productivity and minimize costs; and lastly, develop projects aimed at adding value to Paval as a market product.
2. The R&D&i department will use the experience gained from the steel waste recycling plants to design and construct new more efficient steel powder treatment facilities. This will not only include metallurgic and economic aspects but also the environmental impact of these activities. Another important line is the development of new steel powder recycling activities that will enable us to develop new products for the construction and cement industries.
3. Befesa's industrial waste management projects seek to reduce disposal treatment processes by promoting energy recuperation and valorization, and to strengthen the company's technological leadership in industrial waste management by means of environmentally sound and energy efficient treatment processes.
4. Befesa Agua's projects are intended to optimize and develop reverse osmosis desalination; to develop treatment technologies for urban and industrial wastewaters to allow their regeneration; to develop supercritical oxidation technology that is for eliminating sludge generated in water treatment and potabilization processes; and lastly, to upgrade hydraulic infrastructures in line with sustainability criteria for the integral water cycle.

Befesa's R&D&i program includes the construction of an Environmental Technology Center for research into environmental technologies related with water treatment and industrial waste management. It will be equipped with everything required to allow Befesa to carry out its R&D&i. It is a sustainable center, not only because of the activity that will be carried out there, but also because it is being designed and constructed under sustainability criteria, with mechanisms to neutralize the CO_2 emissions produced during the center's life cycle. It is scheduled to be brought into operation in 2009.

The most important R&D&i projects of the different business units are detailed below.

Aluminum waste recycling

Development of aluminum recycling techniques. New process to enhance the technology:

This project involves three processes: the objective of the first is to analyze and study the behavior of the fluxes in aluminum smelting processes; the rotary furnace has been used for such purpose, numerous smelting tests have been conducted and improvements for treatment of the furnace gases have been incorporated; the second process is to study the reactivity of salt slags, which is being developed in collaboration with the University of Valladolid, the aim being to predict, by computer, the advance of the reaction of the salt slags and to confirm that the model works with a pilot plant; lastly, work was conducted on harnessing the energy of the steam boiler gases and obtaining the corresponding energy savings. This project aims to save natural gas utilized at the plant to produce steam and for drying the salts and Paval.

Steel and galvanization waste recycling

New products from treated waelz oxide (D-L.W.O.®). Work continued on the lines of research initiated in 2007 for lixiviation of treated waelz oxide (D-L.W.O.®) with other lixiviate agents, both acid and basic, other than

baker's salt to obtain high-purity (99.99%) zinc oxide (ZnO) and other new higher added value products such as zinc metal. The conclusion reached is that the results from the acid-based lixiviation tests are much more promising and, therefore, future research work will focus on this line.

Industrial waste management

Energy valorization of WDF (waste derived fuel), R&D&i work carried out in previous years has led to the attainment of a waste derived fuel – Comat – designed originally for cement manufacturers, and its declassification as a hazardous waste. This opens the doors to other possibilities of energy valorization in less energy intensive thermal processes that satisfy existing regulations governing waste valorization. The project, initiated in 2008, aims to pinpoint the technical innovations required to valorize energy from Comat in conventional solid fuel boilers and to adapt to the European Union's recently approved legal framework.

The exploitation of energy from waste, the objective of the project, will allow sustainable development in the waste sector by recovering the energy content of waste while curbing consumption of non-renewable primary resources.

Water

High efficiency pilot desalination plant project. The objective is to reduce the desalination energy consumption to values below 2.5 kWh/m^3 of produced water. To this end, the company has conducted studies and developed the reverse osmosis membranes and energy recovery systems. Enhancements have also been made to the process to minimize energy consumption. The project has received grants from the Department of Innovation, Science and Enterprise of the Regional Government of Andalucía, and from the Ministry of the Environment and Rural and Marine Affairs.

Befesa Water. High-efficiency reverse osmosis desalination pilot plant

Befesa Water. Advanced pre-treatment systems pilot plant.

Elimination of WWTP (Wastewater Treatment Plant) sludge through supercritical oxidation. The objective is to demonstrate the technical and economic feasibility of supercritical oxidation technology for elimination of WWTP sludge. A pilot plant has been constructed for this purpose. The project is being subsidized by the Department of Innovation, Science and Enterprise of the Regional Government of Andalucía, the Technology Corporation of Andalucía and the Ministry of the Environment and Rural and Marine Affairs.

Telvent

One of the main tools for Telvent strategy deployment is investment in research, development and innovation to create technological solutions.

Of the numerous lines of research active in 2008, the following were especially noteworthy:

Energy

Telvent's technological strategy for the utilities sector is to be found under the title "Smart Grid Solutions Suite" (SGS). Three areas are analyzed from a global and integrated solution point of view: "Smart Network", "Smart Operations" and "Smart Metering". Telvent offers solutions based on its traditional products together with new products for substation automation.

Among other advantages, SGS provides grid energy efficiency, improves consumer service, reduces frequency and duration of outages, and provides previously unavailable possibilities for smart management of demand.

Smart Grid focused research activities conducted in 2008 included:

- Continuation of project Denise by a powerful consortium from the Spanish electric sector focused on researching smart distribution networks.
- Project Cariel, which researches the use of high-speed communication network substation control systems.
- Development of solutions by Telvent DMS for complex management of outages and clearing of incidents integrated into Responder (OMS).
- Securing of the IEC 61850 Standard Conformity Certificate issued by Kema Consulting, which includes interesting new features and represents a new concept of information organization at substation level, allowing more efficient real-time handling of the information required for operation of the electric network.

Transportation

Development of solutions for urban and interurban road traffic and rail traffic, noteworthy among which are: Traffic Control Systems (MIST), with extensions for centralized and distributed adaptive control (Itaca, OPAC), traffic regulators (RMY, RMB, and RBY). Centralized Traffic Control railway systems (CTC based on OASyS) or Traffic Data Systems (SmartNET).

Development of Toll, Ticketing, and Parking System management solutions, noteworthy among which are: Toll network management systems (SmartToll), Ticketing management systems (Mobifast) for railway and metro networks, Ticketing management systems (ValTick) for road transportation, and Parking space control management systems (Web.Park). Solutions were also developed for "Open Road Tolling" systems aimed at preventing traffic congestion.

As regards innovation in Enforcement systems, which has achieved excellent results in reducing road accident figures, a significant effort was made in 2008 on technical integration and on developing a complete driving offence detection, capture and management solution.

In addition, project ViaSens was set up to obtain useful roadside information for improving mobility and safety in areas where, up until now, this has not been viable due to the need to invest in costly infrastructures. The overriding purpose of the research is to develop low-cost sensors and make use of low broadband communication infrastructures.

Environment

The objective in this field is to develop advanced technological solutions based on Information Systems, allowing us to meet the challenges of sustainability head on.

In 2008, we completed development of the cloud height sensor (ceilometer) – Cirrus 100 Ceilometer. This is essential for weather observation at airports and is now included in Telvent's catalogue of aeronautical meteorology products together with the Revolver transmissometer.

Work on project Terwis 2 was also completed. This is a Road Weather Information System that includes a tool to help decision making (MDSS) on efficient use of resources, while improving road transportation safety.

Through the Tesemat initiative, a weather forecasting software platform has been designed jointly with Abengoa Solar. This allows for advance knowledge of the energy generated by a solar power plant, thereby enabling more efficient and sustainable plant management. The project received a Ministry of Industry, Tourism and Trade grant.

Also of note is the RESTE platform which, by combining real-time information on air quality, meteorology and traffic, as well as predictions of the same parameters obtained with modeling tools, will allow for more global traffic management taking in account variables such as speed, driving conditions, routes followed, etc., with an emphasis on sustainability and emissions reduction.

Public Administration

Public Administration R&D&i activity is geared towards two aspects, a strategic line of Security R&D focused on aspects related with immigration management and document control, and another strategic line – eGovernment – focused on electronic signing and billing.

Of the many innovative initiatives conducted in 2008, we would highlight projects such as INTEGRA (Research into Technologies for Migration Management), the main objective of which is to develop, against the backdrop of the Ministry of Industry, Tourism and Trade's CENIT program, technologies applied to migration management (Management=Prevention+Control+Integration), focused on solving real problems detected by the end users.

In 2008, thanks to the grant and loan from the Ministry of Science & Innovation, work continued on the development of the Identica project, the main objective of which is advanced identity verification through biometry and personal documentation in secure environments, thereby responding to the current need of unequivocally proving an individual's identity by verifying his/her physical presence.

Telvent Energy presentation at an international conference.

The Globe (European Global Border Environment) initiative is part of the strategic e-immigration line of activity established by the European Commission. It sets a series of Institutional objectives, thereby establishing an integral command framework for taking strategic decisions (policies and procedures) and operative decisions (tactics) from the Information. Standardization and Integration Systems (Identification of users, Identification and analysis of information sources and systems, Identification of needs, and Design of the integrated solution), and also Technological objectives. New, scalable and reliable solutions were developed over the course of the year.

Healthcare

In the field of Healthcare, R&D&i for 2008 focused primarily on the technological areas of hospital information system management processes, the medical processes of managing and handling multi-modal (CAT, MRI, etc.) medical imaging, and on the management of multiple sources of information on personal, environmental, position and distributed location parameters in order to provide solutions in relation to the health and well-being of people with chronic health issues or those who are dependent based on all of the information gathered.

The MIND project is one of the initiatives undertaken in 2008 in the healthcare area. This project, within the framework of the CENIT program attached to the CDTI, focuses on research and integration of knowledge from numerous biotechnological areas, essentially medical imaging and omics (genomics, metabolomics and spliceomics), as well as tutoring in assistance procedures though advanced management of interdisciplinary knowledge. The objectives of the project involve the paradigms currently defined in medical practice and research, which, in the case of Alzheimer's disease (the key objective of the project research), require a globalized and parameterized perspective of the basic environment in the life and circumstances of patients and their caretakers.

In 2008, the PMAI (Image-Assisted Medical Processes) initiative, which began life in 2006, succeeded in developing the medical image integrated viewer in 2-D and 3-D for flexible application within the TiCares suite for planning and executing invasive medical procedures, such as radiation therapy or surgery.

Thanks to funding obtained from the CTA, development continued in 2008 of eQECM (eSurgicalSuite: Multimedia Collaborative Environment), which was undertaken in 2006 to plan the development of functionalities associated with the e-SurgerySuite or Intelligent Operating Room, which is essentially the strategic control center for clinical activities involving invasive procedures.

Along the same lines, the PPC-RFID (Critical Process Patients – Radio Frequency IDentification) projects involve the development of a computer solution for automatic and continuous identification of the agents involved in clinical processes, patients and medical professionals. During the second phase, new modules have been developed, enabling the supply of automatic and continuous information on the location of people and material components. The SIMFO (Forensic Multimedia Information System) research project encompasses a global set of solutions for optimizing all stages and scenarios in medical-forensic activity involving the presence of the human body.

Finally, we must again point out the Nuadu project, involving collaboration on a European level within the framework of the Eureka-ITEA program, and subsidized by the Spanish Ministry of Industry, Tourism and Trade. The project tackles the technical risks in providing a residential ambient intelligence environment, and mobility for services in the area of health and well-being with the aim of improving the quality of life of users through effective and efficient solutions from service providers. The activities carried out through this project over the course of 2008 enabled the development of networked component architectures for constant remote monitoring of people with healthcare needs based on obtaining data from sensors employing off-the-shelf communication technologies (RFID, ZigBee, Bluetooth, etc.), as well as new emerging technologies.

Abeinsa

Abeinsa's R&D activities center on high potential areas such as hydrogen, energy efficiency and new renewable energies.

Most research and development activities are articulated through Abeinsa New Horizons, Abeinsa's project incubator that centralizes the R&D efforts. This incubator includes:

- ZeroEmissions, a company dedicated to emissions management of CO_2 and other greenhouse gases.
- Hynergreen, a company focused on developing hydrogen and fuel cell technologies. This involves significant synergies with other Abengoa areas, such as:
  - R&D in new renewable energies: generation of renewable hydrogen.
  - R&D in energy efficiency: utilization of fuel cells.
  - CO_2 capture and storage: generation of non-renewable hydrogen without emissions.
  - Inabensa: installations linked with hydrogen technologies.
  - Abengoa Solar: hydrogen produced with solar energy.
  - Abengoa Bioenergy: bioethanol reforming.
- Capture, storage and valorization of CO_2.
- Energy efficiency.
- New renewable energies, such as ocean wave energy.
- Other projects, such as characterization of biomass for bioethanol production.

The level of maturity of each of these lines of research determines its status within the company. Thus, some fields have become companies, as in the case of ZeroEmissions and Hynergreen, whereas some are divisions within other companies, and others are simply projects at the embryonic phase.

Some of the projects undertaken, partially or in full, by Abeinsa's different subsidiaries in 2008 are listed below:

Project Hércules

The objective is to establish a renewable hydrogen service station in Sanlucar La Mayor (Sevilla), where the hydrogen will be produced utilizing solar energy. A fuel cell powered vehicle that utilizes the hydrogen supplied by the service station is also being developed. The overall budget for the project is more than 9 M€ . It is receiving backing from the Innovation and Development Agency of Andalucía (IDEA), and the Ministry of Science and Innovation, which considers it a Singular Strategic Scientific-Technological Project. Project Hercules is an Andalusian initiative globally coordinated by Hynergreen and promoted by eight partners, comprising five companies, one public agency and two research centers: Hynergreen, Abengoa Solar NT, Santana Motor, Carburos Metálicos, GreenPower, the Energy Agency of Andalucía, INTA, and AICIA. The 42-month project commenced in January 2006 and, in 2008, the consortium worked on developing the prototypes, with testing thereof being left for 2009.

Project Electra

Trials in the testing station at the Hynergreen laboratory

Inabensa. BCRU aviation electronic converter project (autoclave thermal trial).

The objective of this project undertaken by Inabensa is to design, develop and evaluate a prototype of a matrix converter for use in distributed generation, with the possibility of stand-alone operation or connected to the utility's grid.

The main application of the matrix converter is conditioning of the energy from microturbines without the need for a direct current intermediate circuit. In this way, alternating energy with a certain frequency and voltage is converted directly into another alternating energy with a frequency and voltage suited to a specific application (AC-AC). This project could open the door to the use of these types of converters in other types of distributed generation technologies.

PSE CO2

The objective of this project is the study of advanced CO_2 generation, capture and storage technologies. It includes sub-projects dedicated to studying different technologies: CO_2 separation technology in precombustion, CO_2 capture by oxycombustion, geological storage of CO_2, and acceptability and governance in CO_2 storage processes.

Project NanoGLOWA

Project NanoGLOWA, "Nanomembranes against Global Warming", aims at developing new materials based on Nanotechnology for use in membrane-based separation and purification processes. In particular, the aim is to demonstrate its feasibility in gaseous effluents from thermal power plants as an alternative to reduce CO_2 emissions.

In this project, Inabensa is providing the necessary industrial engineering work to bridge the gap between the new materials and their industrial feasibility within the electric sector.

The project is to run for 5 years, from 2006 to 2010. Its global budget is more than 13 M€ , and funding is from the European Union under the 6th Framework Program for Research (NMP3-CT-2007-026735).

Project mIO!

This project, on which Inabensa's Communications Division is participating, is partially financed under the CDTI's (Center for the Development of Industrial Technology) CENIT program.

The objective of project mIO! (technologies for providing mobility services in the future intelligent universe) is to realize technologies enabling us to provide ubiquitous services in an intelligent environment adapted to each individual and to his/her context, using mobile handsets as the basic tool for interaction with services provided by companies and with microservices created and provided by the mobility users themselves, in areas as diverse as:

- Mobility services technologies created and provided by individuals.
- Interface access technologies.
- Context and personalization management technologies.
- Mobility services technologies created and provided by companies.
- Communication and connectivity technologies.
- Support techniques for the frequent transfers resulting from nomadism in an environment with intelligent infrastructures, new capacities and services deployment models via NGN and IMS architectures, etc..