R&D&i

R&D&i

Introduction

Abengoa has continued to increase its efforts in R&D&I in 2003 (in spite of the prolongation of the world technological crisis). The Group is convinced that the only manner in which this effort will bear fruit is through continuity which cannot be allowed to be interrupted by crisis or economic cycles.

Furthermore, it has strengthened its presence, and leadership in some cases, in different institutions and public and private forums where cooperation between large technological companies is encouraged and short and long term decisions on R&D&I activity are taken.

Abengoa's Innovation Strategy

- Corporate Structures.
- Results Oriented.

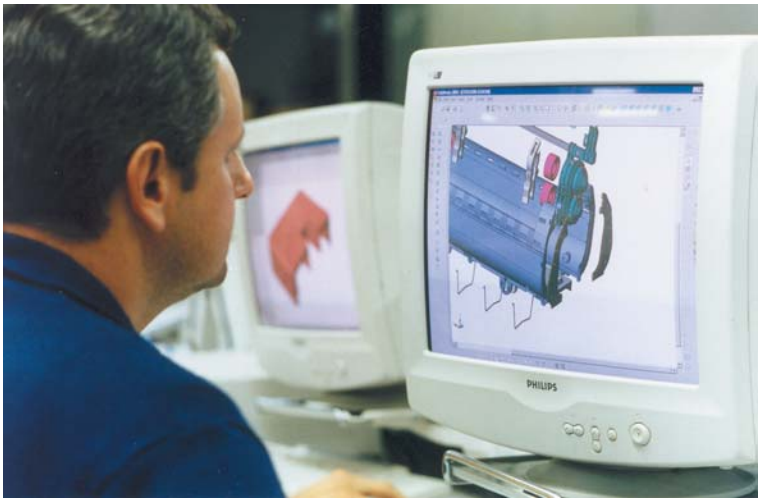
Abengoa's policy is oriented towards the creation of value and its upkeep. Its innovation activities are results oriented while pursuing three groups of tangible objectives:

- Diversification: new Products and Services.
- Differentiation: improvement and adaptation of exiting products and services.
- Process improvement.

Its intangible objectives pursue the acquisition of essential competencies and, above all, the generation of options for the future. The latter is especially related to value through growth expectations and the development of new lines of business.

Project Types

Innovation in Abengoa is carried out in several ways. Firstly, there is internal execution focused on offering solutions to particular customers or for in-house development purposes. Then there is also external execution based on collaboration agreements with Universities, Public Research Bodies (PRB's), or with third parties; this type of execution is normally shared. On other occasions, technology is acquired. Strategic



financial participations have recently been taken out in technological companies; in this case, the initiative is usually a corporate one although subsequent management is left to the specific companies.

Innovation Economy: Financing

- External resources.
  - Fiscality.
  - Public Subsidies.
  - University, (Public Research Institutions).
  - Shared R&D.
  - Customers.
- In-house resources
  - Investment.
  - Annual expense.

Innovative Groups and Characteristics

- Bioenergy: radical and incremental innovation, mixed financing (Department of Energy of the United States, DOE, Framework Program).
- Solar and Fuel Cells: radical and incremental innovation, mixed financing (Framework Program).
- Telvent: incremental and radical innovation, mixed financing (Framework Program).
- Befesa: incremental, dispersed, in-house financing, external execution.

Distinctions

R&D&I Awards (2003)

- Excellence and Best Practices Award for Technological Innovation, to Sainco Telvent. AENA.
- ComputerWorld Prize for Technological Innovation in Andalusia, to Telvent Outsourcing.
- Nebraska Business Innovation Award (USA), to Abengoa Bioenergy Corporation.
- Technological Innovation Prize in the Recovery Sector, to Deydesa 2000. Spanish Recovery Association.

- Best Project Prize for 2003, to Hynergreen. Eighth Grove Fuel Cell Symposium.

R&D&I Awards (1993-2002)

- Academia Dilectae Prize (First Edition), in acknowledgement of its innovative trajectory: Abengoa. Engineering Academy, December 2002.
- AEC Prize, for its work in R&D&I related to Environmental Protection: Abengoa. Asociación Española de Científicos AEC, Madrid, November 2001.
- Greatest Value Innovation Prize: Sainco's Velflex Product. European Wind Energy Conference, Copenhagen, June 2001.
- National Quality Prize 2000 and 2003, for efforts and achievements in Quality Management activities, to Teyma Uruguay. Government of Uruguay, February 2001.
- European Union Prize for the Best Industrial Initiative in the Use of Renewable Energies, for the use of bioethanol in the "Renewable Energy for Europe. Campaign for Take-Off" project: Abengoa, Repsol-YPF and Cepsa. European Union, Toulouse, October 2000.

- Prince Felipe Business Excellence Award, for Business Competitiveness: Abengoa. Ministries Of Industry and Energy and Commerce and Tourism, March 1996.
- Prince Felipe Business Excellence Award for Technological Effort: Abengoa. Ministry of Industry and Commerce, March 1996.
- Prize for the Best Project presented at the "Distribution Automation & Demand Side Managemnet-94 Europe" conferences, to Sainco and Unión Fenosa. Paris, September 1994.
- Gold Medal Award for Technological Innovation, to Sainco. National Association of Equipment Manufacturers (SERCOBE), 1993.

Innovative Projects

The Demonstration Project

Abengoa believes that the Demonstration Project is the key instrument that enables the execution of an innovation policy focused on developing new products for the market. The Demonstration Project achieves the operational validation of an innovative product, system or process and its market proving. It also facilitates a knowledge of its cost in order to set a first true price which could be subsequently reduced by means of the experience curve. On the other hand, demonstration projects produce a real demand of the Public R&D Systems that enables Science to continue to serve the needs of society.

Therefore, Abengoa's companies always have multiple demonstration projects under way, which are market oriented and focused on the creation of value. These are usually carried out in collaboration with multiple scientific institutions and different technological agents. Many of these projects incorporate public support.

We would especially mention, in the Bioenergy sector, the research being done on the production of bioethanol from lignocellulosic biomass (this is currently achieved from cereals). The objective of this project is to convert corn stover and the straw from other cereals (as well as other agricultural wastes) into bioethanol. This will result in new benefits for farmers, will lower the cost of production bringing it closer to that of petrol and reduce the greenhouse effect through the absorption of CO_2 by plants – raw material for bioethanol production – through the chlorophyll function. The project, with a foreseen investment of 35.4 M. US$ over five years, has received significant financial backing from the Department of Energy of the Federal Government of the United States, the DOE, amounting to 17.7 M. US$, 50% of the total investment.

We here-below offer a selection of the other innovation projects our companies have been carrying out throughout 2003:

Bioenergy

- **Conversion of waste starch**. Construction of an experimental plant in York (Nebraska-USA) to increase the current level of starch conversion to bioethanol (2.6 gallons/bushel) to 2.9 gallons/bushel. The project is being co-funded by the DOE (Department of Energy of the USA).
- **Enzymatic hydrolysis of biomass**. Conversion of lignocellulosic agricultural wastes into sugars and bioethanol. The research is being co-funded by the DOE. Construction of the technology demonstration plant in Babilafuente (Salamanca), under the EU's 5th Framework Program.
- **Thermo-chemical conversion of biomass**. Development of renewable fuels for advanced engines. RENEW project under the EU's 6th Framework Program.
- **Improvement of DGS**. Extend its application as a feedstock to the poultry farming and pig sectors. Its current composition only allows it to be used in the cattle sector.
- **FFV**. Experimental tests program to use bioethanol in flexible fuel vehicles FFV.
- **Fuel Cells**. Bioethanol reforming project to produce H_2 and feed a fuel cell. The objective of the research being carried out is to apply bioethanol as a fuel in future fuel cell powered vehicles. Co-financed by the Ministry of Science and Technology.
- **E-Diesel**. Commercial use of bioethanol and gas oil blends in diesel vehicles.

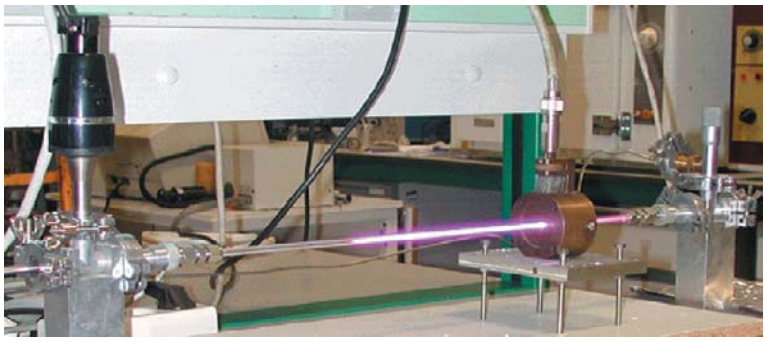
Environmental Services

- **Optimus**. Development of technologies to optimize the recycling of aluminum in a cap furnace.
- **Minirex 2003**. Minimization of waste production from aluminum recycling activities.
- **Cálido 03**. Improvement of the process and quality obtained during the continuous running out production of long aluminum products.
- **The application of Paval for cement flooring production.** Paval is a salt slag generated during secondary aluminum production. It is an insoluble solid and a hazardous waste. The application is focused on its use as a raw material in the construction of transport infrastructure.
- **The application of paval in the fabrication of isolating materials,** as a substitute for bauxite.
- **Optimization of the Waeltz furnace process.** Energy recovery from waste through air injection.

- **Reduction of mercury in the steam phase in Waeltz furnace gases**, through the adding of acid sodium carbonate in the conditioning tower.
- **Improvement of the settlement capacities in the Waeltz furnace washing plant,** through the incorporation of new technologies.
- **Experimental plant for the reuse of organic nature industrial wastes.** In collaboration with the CENIM. Ministry of Science and Technology's PROFIT Program.
- **Treatment of lands contaminated with heavy metals.** Stabilization tests with calcium phosphate in collaboration with the University of Murcia. Ministry of Science and Technology's PROFIT Program.
- **Use of byproducts to stabilize hexavalent chrome** and other potentially poisonous elements, in collaboration with the University of Cartagena.
- **Low content magnesium applications in environmental technology,** as a substitute for the lime reagent in waste inerting processes. In collaboration with the Department of Chemical Engineering and Metallurgy of the University of Barcelona. Ministry of Science and Technology's PROFIT Program.
- **Formic acid neutralization and stabilization project,** using byproducts from the aluminum industry.
- **Demonstration plant for sludge treatment by gasification.** Reduction of the volume of sludge and synthesis gas production to generate electricity, carried out in Badiolegui treatment plant, in Azpeitia (Guipúzcoa).

Information Technologies

- **Smartoll**. **Design and construction of an Electronic Transaction System** using Spanish technology to be applied in the toll system sector and develop a "free flow" multi-lane channel-free dynamic toll system.



- **Adaptes**. Design and development of a state-of-the-art Urban Traffic Control System, incorporating Adaptative and Expert control subsystems that enable the cooperative association of algorithmic character processes with knowledge based processes. Ministry of Science and Technology's PROFIT Project.
- **Visitran**. Use of the latest advances in vision systems applying them to new transport system utilities.
- **Regula**. Development of an integrated railway regulation system that enables optimum overall operation of the lines under economic criteria through the regulation of a General Circulation Plan. Ministry of Science and Technology's PROFIT Project.
- **SIP–Semáforo Inteligente Polivalente**. Design and development of a state-of-the-art traffic light system that incorporates important technical, design and functionality novelties.
- **Trafing**. Advanced urban traffic control system.
- **Avantis**. Advanced Tunnel and roadway management and control system.
- **ValTick**. Design and development of a new Bus Centralized Control and Management System, incorporating significant novelties such as prepayment by means of basic payment, implemented with a contact-free card. Ministry of Science and Technology's PROFIT Project.
- **CancelBus–Canceladora para autobús**. Design and development of a bus ticket canceling machine with Contact-free Technology, a unique aesthetic and cost competitive solution, and a differential value proposal in the market.
- **Mobility**. Advanced control and payment system for the transport sector.
- **e-Park**. Parking areas management and control system.

- **Rotar**. Feasibility study and pilot test of a multi-owner system for the 100,000 parking spaces belonging to residents currently in existence in Madrid. Ministry of Science and Technology's PROFIT Project.

- **ComPlug**. Development of a new PLC technology in the access segment that enables the provision of broadband voice and data services over the electricity distribution network.

- **Multiportadora MT**. Arrangement of a new PLC telecommunications technology over the Medium Voltage electricity network, adapted to current and future needs, offering better services than those that currently exist on Cenelec regulated frequency bands, reducing the per point cost through the use of inductive non-irruptive connection devices and optimization of the existing capacitive connections. Ministry of Science and Technology's PROFIT Project.

- **Technological maintenance** of the Saitel 2000 family (Saimed and Saimet+).

- **Families**. Consolidation of the CMMI (Capability Maturity Model Integration) standards, security in dynamically deployable distributed systems, quality variability techniques in dynamic derivation of applications, studies case on the development of families based on "Model Driven Architecture", family integration processes, assets recovery from third parties based on open code. Eureka Project..

- **Osmose**. "Open Source Middleware for Open Systems in Europe". Code-free middleware for open systems in Europe is a project led by Telvent in which the R&D centers of leading European companies (Bull, France Télécom, Philips, Telefónica, Thales, etc.), research institutes and universities (Charles University, EPFL, INRIA) are participating. The development of an open platform for distributed systems will be validated on a broadband residential services platform. Eureka Project.

- **Jules Verne**. Testing of industry's interactive digital diffusion potential as regards the creation of contents and the capacity of future terminals and domestic networks. Eureka Project.

- **IDEAL**. Defining, development and operation of a dedicated and shared housing services platform, for business information systems, information portals and trade platforms through the internet network. Ministry of Science and Technology's PROFIT Project.

- **OASyS DNA**. Industry's leading real time Information and Operation Management System. In its third year of development, in 2003, it has incorporated new operating, reliability and security levels.

Industrial Engineering and Construction (ICI)

- **Microcell**. Miniature 50 MW fuel cell. In collaboration with the AICIA and partially financed by the Department of Employment and Technological Development of the Regional Government of Andalusia.

- **Homecell**. Development, construction and validation of an electricity generator with fuel cells for domestic applications. In collaboration with the AICIA and partially financed by the Department of Employment and Technological Development of the Regional Government of Andalusia.

- **Solo-H**. Assessment of the applicability of H_2 obtained from industrial waste sources, purification by means of PSA procedure absorbents and use in fuel cells. In collaboration with the Catalysis and Petrochemical Institute of the CSIC and the UNED. Ministry of Science and Technology's PROFIT 2003 Project.

- **Hidrocom**. Electricity generating system for communications based on fuel cells and multi-gas reformer. In collaboration with the CSIC's Material Science Institute of Seville and the AICIA. Partially financed by the IFA and the CDTI.

- **Telepem II**. Experimental design and validation of a 1 kW PEM type fuel cell for telecommunications systems. Ministry of Science and Technology's PROFIT 2003 Project.

- **Alter**. To validate rated calculations. Solúcar and CIEMAT have replaced the active nucleus of the Almeria Solar Platform TSA air cycle thermal storage system, consisting of 12 tons of 9 mm diameter aluminum spheres, with 12 tons of 1/4 inch thick saddle shaped cordierite elements. PROFIT Program.

- **Aquasol**. Proposal for a seawater desalination plant based on multi-effect distillation (MED). It has a heat pump to recover the energy carried by the waste brine and the system will be fed with two-stage solar energy. The plant was designed in 2003. In collaboration with Ciemat, Aosol and Ineti, from Portugal and Entropie, from France. EU's 5th Framework Program.

- **Cac-PV**. Controlled atmosphere photovoltaic concentrator (20X-40X). The Cac-PV module is a semi-cylindrical parabolic collector that situates the photovoltaic cells in its focal. The system closes with a glass window that protects the reflector surfaces and the photovoltaic cells from environmental agent degradation. EU's 5th Framework Program.

- **Inditep**. Enlargement of the DISS collector to produce steam directly through the fabrication and parallel installation of a 200 m long Eurotrough technology collector. The end objective is the construction of a 5 MW GDV power plant. Solúcar has manufactured and installed the collector in the PSA and the test campaign has commenced. In collaboration with the Ciemat, DLR, Flabeg Solar, Iberdrola, Gamesa, Initec, Siemens and ZSW. EU's 5th Framework Program.

- **Solair 3000**. Modular conception volumetric receiver to generate air at 800ºC. The 3 MW thermal Solair 3000 prototype enables a simple approximation to receivers by replication of around 50 MWt for large plants. Solúcar has manufactured and installed the prototype that is currently being tested in the PSA's CESA-1 tower. Other participants in the project include DLR, Ciemat, Heliotech, from Denmark, and Saint-Gobain, from France. EU's 5th Framework Program.

- **Soltronic**. Development of heliostat control systems and photovoltaic trackers for solar power plants. Solúcar carried out the complete project, developing control logistics based on a network of programmable automats in three level communication architecture. PROFIT Program.

- **Solgate**. Integrated pressurized volumetric receiver with 250 kWe gas turbine to exploit air expansion solar radiation energy, according to Brayton cycle schemes. Solúcar has carried out the installation works for all the equipment of the complex installation of the PSA. In collaboration with DLR, Ciemat, Ormat, from Israel and Tuma, from Switzerland. EU's 5th Framework Program.

- **Tilt Roll PV**. Development of photovoltaic concentration concepts based on lenses instead of mirrors. The technological novelty lies in the attempt to reduce the investment costs related to the unit of produced electricity, through the use of concentration photovoltaic modules that incorporate Fresnel lenses subjected to a mean concentration (of around 20X) and "Tilt Roll" type two axis sun tracking. PROFIT Program.

- **Motronic**. Governance system for Motor Control Centers: design and development of a distributed control system in which relay logics is replaced by a microprocessor system in each of the carriages. In collaboration with the Electronic Technology Group from the Superior College of Engineers of the University of Seville. PROFIT Project.

- **Plactor**. Study of the technical feasibility and design of a reactor based on a discharge barrier to eliminate contaminated gases, using a plasma reactor that operates at environmental temperature. In collaboration with the Materials Science Institute of Seville of the CSIC and the Electronics Technology Group from the Superior College of Engineers of the University of Seville. PROFIT Project.

- **Check card**. Design and development of a checking system for the main products manufactured in the Alcalá de Henares Workshop. Subsidized by IMADE.

R&D&i

Significant Innovative Lines

- Bioenergy.
- Solar Energy.
- Hydrogen H_2 Technologies.
- Broad band transmission over the Electricity Network.

R&D&i Scenario

- Incremental innovations: they improve efficiency.
  - Waste starch conversion.
  - Fiber Conversion.
  - DGS Valorization.
- Radical innovations: they transform the business.
  - Lignocellulosic biomass.
  - Fuel cells.
  - E-diesel.
  - Biorefinery.

Public Subsidies for Bioenergy

- The Department of Energy of the Government of the United States and from the European Commission through the 5th Framework Program.
- National R&D Plan.

Our Plants

Ecocarburantes Españoles, Cartagena

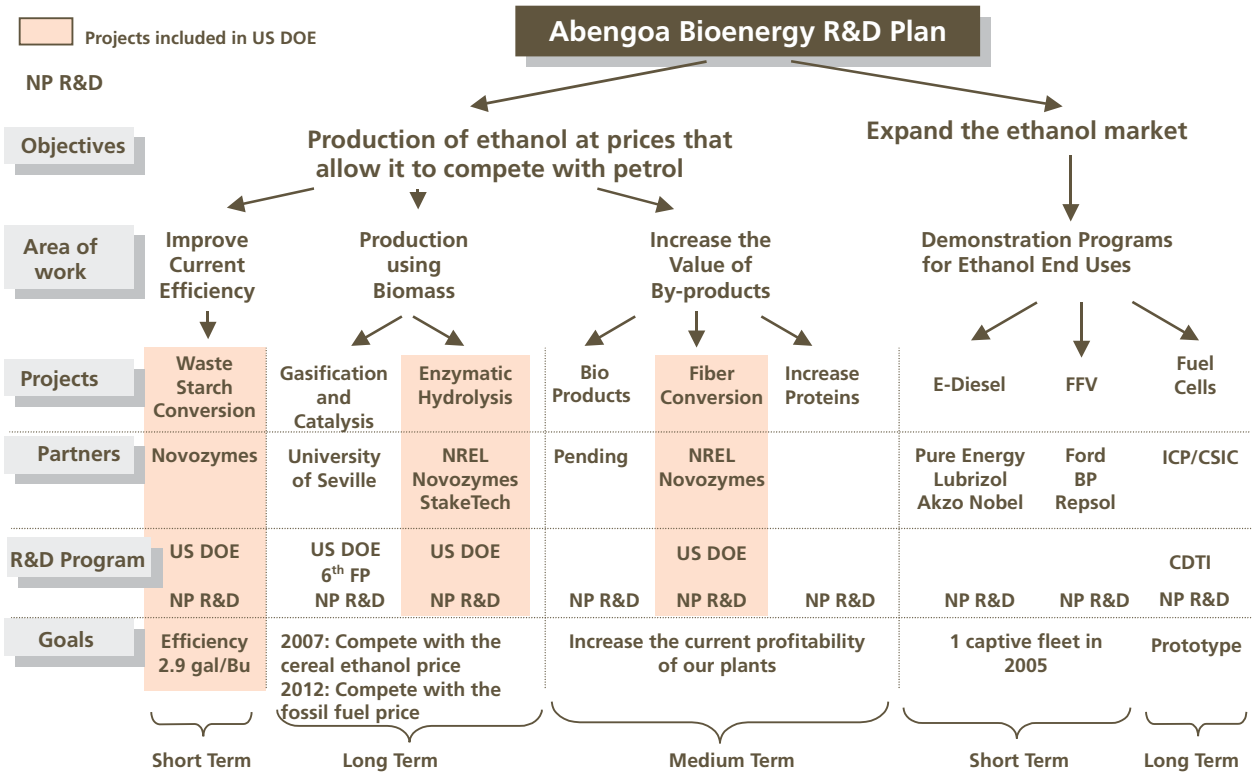
Bioetanol Galicia, La Coruña

York, Nebraska

Colwich, Kansas

Portales, Nuevo México

R&D Objectives 2003-2006



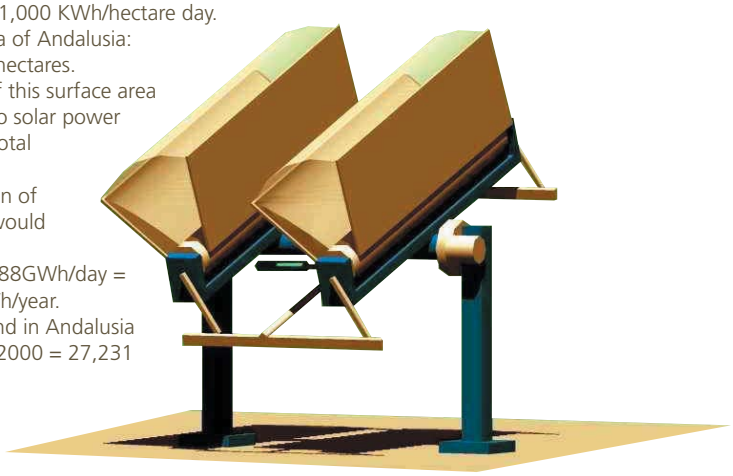
Sun-power

- Energy received over the entire earth surface:
  - 100,000 continuous terawatts (TW).
  - Equivalent to 10,000 times that of world energy production (10 TW continuous).
  - The annual energy received is equivalent to the energy contained in a 200 mm thick layer of petroleum around the earth, or else 1.5 million barrels of oil per square meter.

- Efficiency: KWh/energy heliostat incidence
  - Current technology 17%.
  - Technology 20 years >30%.

Current technology foreseen for the Sanlúcar Solar Project

- Potential > 1,000 KWh/hectare day.
- Surface area of Andalusia: 8,800,000 hectares.
- With 1% of this surface area dedicated to solar power plants the total electricity consumption of Andalusia would be covered.
- Production 88GWh/day = 32,000 GWh/year.
- Total demand in Andalusia in the year 2000 = 27,231 GWh.



Solar Energy

Photovoltaic

- **Simple**
- **High installation cost**
- **High generation cost**

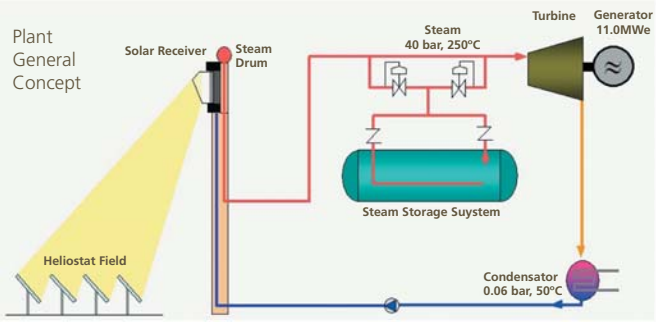
Solar thermal parabolic collectors

- **Large Plants**
- **Efficient land use**
- **Steam temperature 400ªC**

Solar thermal tower

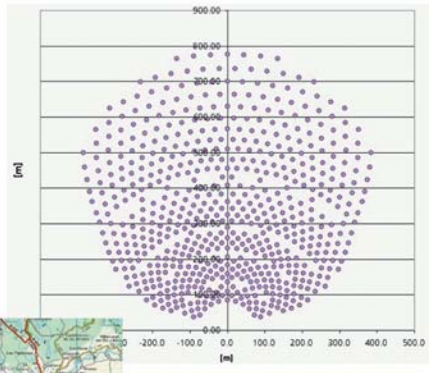
- **Medium-sized Plants**
- **High temperatures**
- **Reasonable cost-land**
- **More complex**

Sanlúcar Solar: 11.0MW Thermosolar Power Plant

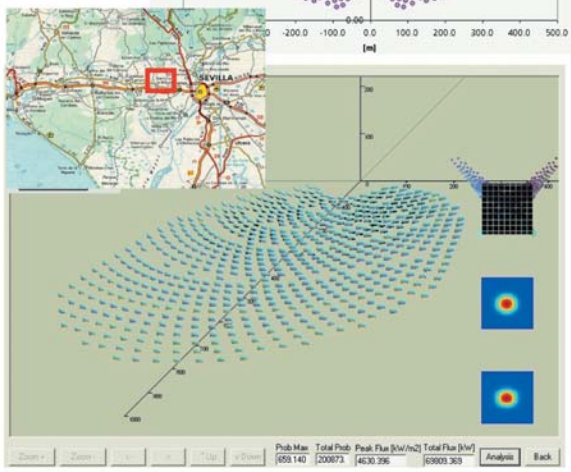


General Description		
Emplacement	Sanlúcar M. (Sevilla), Lat 37.4°,Lon 6.23°	
Nominal Power	11.02MWe	
Tower Height	90m	
Receiver Technology	Saturated Steam	
Receiver Geometry	Cavity 180°, 4 Pannels 5m x 12m	
Heliostats	624 @ 121m2	
Thermal Storage Technology	Water/Steam	
Thermal Storage Capacity	15MWh, 50min @ 50% Rate	
Steam Cycle	40bar 250°C, 2 Pressures	
Electric Generation	6.3kV, 50Hz -> 66kV, 50Hz	
Land	60Has	
Annual Electricity Production	24.2GWh	
Nominal Rate Operation		
Optical Efficiency	77.0%	67.5MW -> 51.9MW
Receiver and Heat Handling Efficiency	92.0%	51.9MW -> 47.7MW
Thermal Power to Storage		11.9MW
Thermal Power to Turbine		35.8MW
Thermal Pow. -> Electric Pow. Efficiency	30.7%	35.8MW -> 11.0MW
Total Efficiency at Nominal Rate	**21.7%**	
Energetical Balance in Annual Basis		
Mean Annual Optical Efficiency	64.0%	148.63 GWh(useful) -> 95.12 GWh
Mean Annual Receiver&Heat Handling Efficiency	90.2%	95.12 GWh -> 85.80 GWh
Operational Efficiency (Starts Up/Stops)	92.0%	85.80 GWh -> 78.94 GWh
Mean Annual Thermal Ener. -> Electric Efficiency	30.6%	78.94 GWh -> 24.2 GWh
Total Annual Efficiency	**16.3%**	

Geometrical Arrangement for 624 Units in the Heliostat Layout at PS10 Plant

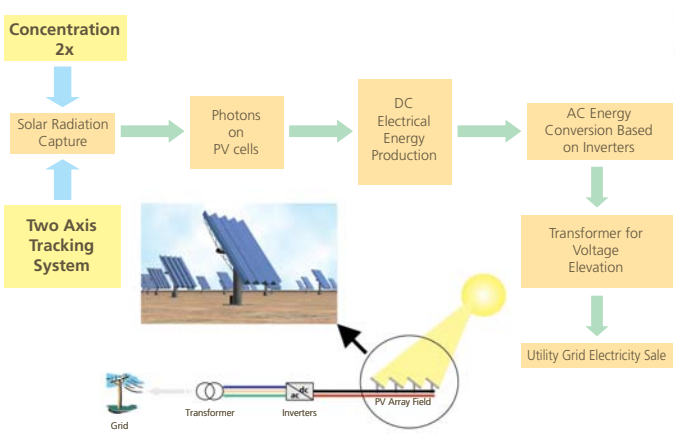


Location



Concentrated Radiant Flux Calculation and Simulation

Sevilla PV: 1.2 MW Photovoltaic Power Plant



- **Hydrogen Technologies**

In 2003, within Abengoa's strategy in the hydrogen and fuel cell sectors, we would especially emphasize the establishment, in March, of the company called Hynergreen Technologies, S.A. (Hynergreen) to encourage the use of these technologies in the Group's different Business Units.

Its undertakings include – apart from complementing Greencell's line of strategy: the production of renewable hydrogen from bioethanol – the production of pure hydrogen from other Environmental friendly sources and its use in fuel cells.

To achieve this, Hynergreen is currently working on a series of Medium Term objectives, such as:

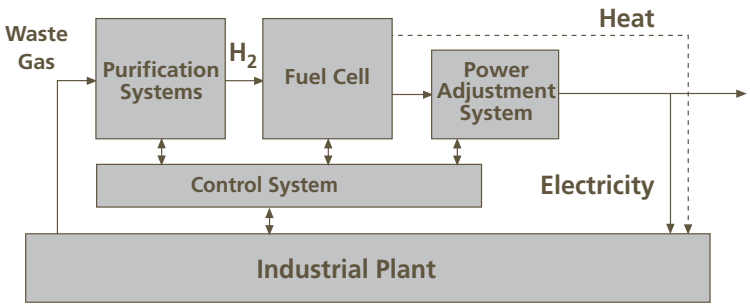
- The use of hydrogen-rich industrial waste gases to be used, subsequent to suitable cleansing and treatment, in fuel cells; this would enable plants that produce them to be partially self-sufficient as regards electric or thermal energy, or to sell the same to the network.

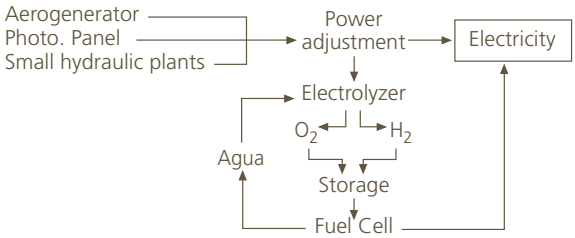
- The integration of Renewable Energies with the "Hydrogen Vector" to exploit the synergy of both technologies and help on the road to sustainable energy development.

- The use of alternative means for hydrogen storage, such as metallic hydrides or chemical hydrides.

- The use of direct methanol fuel cells for small portable applications, such as, for example, the telecommunications sector.

Moreover, Hynergreen participates on national as well as international standardization committees, to help elaborate suitable legislation on hydrogen and fuel cells to favor the development of these technologies and reduce their associated costs.





10 Mbytes/s Broadband Transmission over the Electricity Distribution Network.

- Low cost technology that allows the conventional electricity network to be used as a means of transmission for residential networking applications and broadband access to internet at speeds up to 10 Mbytes/s.

- Market segments:

  - Residential (prototypes being tested):

  – Creation of residential networking networks without the need for new cables.
  – Application for small office local networks.

  - Urban (currently under development).

    – Providing broadband access services (Last Mile) over the Low Voltage electricity network from transformer centers.

    – City Node, with connection to the backbone through broadband links over the Medium

Voltage network or alternative means, such as fiber optics in the transformer centers.

- Abengoa's history in the business:
  - 1987. Emetcón: medium voltage line electronic carrier system.
  - 1992. Sailink: DSP technology carrier system for Medium Voltage lines.
  - 1997. Policom: ASIC-DSP technology carrier system for low voltage lines.
  - 2002. Insonet: 10 Mbytes/second broadband system for Residential Networking applications.
  - 2003. Complug: broadband PLC system currently being developed to provide broadband access services over the electricity distribution network.

Investment in R&D&i

	2001		2002		2003		2004 (F)	
	M€	% of Sales	M€	% of Sales	M€	% of Sales	M€	% of Sales
Bioenergy								
Abengoa Bioenergía R&D	0.0		0.0		2.8		7.4	
Business Unit Total	0.0	0.0%	0.0	0.0%	2.8	0.9%	7.4	2.4%
Environmental Services								
Befesa Zinc Aser + Commercial	0.0		0.3		0.2		0.0	
Salt Slags	0.0		0.0		0.0		0.1	
Aluminum Recycling	0.0		0.0		0.1		0.4	
Industrial Waste Management	0.0		0.0		0.0		1.3	
Others of lesser importance	0.0		0.1		0.0		0.1	
Business Unit Total	0.0	0.0%	0.4	0.1%	0.3	0.1%	1.8	0.4%
Information Technologies								
Arce sistemas	0.3		0.4		0.7		1.1	
Telvent Energía y Medio Ambiente	2.2		2.4		2.4		2.6	
Telvent Tráfico y Transporte	1.1		3.1		2.7		2.0	
Sainsel	0.2		0.1		0.0		0.2	
Telvent Interactiva	0.2		0.7		1.1		1.3	
Telvent USA	0.0		0.0		0.7		0.2	
Telvent Canada	0.0		0.0		3.1		2.8	
Telvent Housing	0.0		0.5		0.8		0.0	
Business Unit Total	4.0	0.3%	7.3	3.1%	11.5	3.8%	10.2	3.0%
Industrial Engineering and Construction								
Abener	2.4		1.0		0.0		0.0	
Abentel	0.9		0.3		0.0		0.0	
Inabensa	0.3		0.6		0.8		0.2	
Hynergreen	0.0		0.0		0.0		0.2	
Greencell	0.0		1.5		1.9		0.3	
Solucar	0.0		0.1		0.1		0.0	
Business Unit Total	3.6	0.3%	3.4	0.7%	2.9	0.6%	0.7	0.1%
Aggregated Total	7.6	0.5%	11.1	0.6%	17.5	1.1%	20.1	1.2%

2001		2002		2003		2004 (P)	
M €	% of Sales	M €	% of Sales	M €	% of Sales	M €	% of Sales
7.6	0.5%	11.1	0.6%	17.5	1.1%	20.1	1.2%