

05.2 Intellectual capital



Technology, a key component of the Abengoa business model

Technological development continues to be Abengoa's main competitive advantage in delivering high value-added projects anywhere in the world. Not only does today's society value technological solutions contributing to sustainability, but the number of geographies with a requirement for them is constantly growing.

Keenly aware of this, Abengoa wholly backs sustainable technology as an essential pillar for company growth and access to new markets, which are inaccessible for conventional products and technologies. These solutions, like many others, would not be possible without the technological development and results obtained through the company's effort dedicated to research, development and innovation. Abengoa continues to develop R&D projects because it has confidence in the ability to anticipate future trends and technologies in helping the company to identify new lines of business and acquire new skills that will enable it to reposition itself in the market as a consolidated brand.

In 2015, investment in technology was € 345.2 M, 6 % of total sales. Despite the difficulties, the company has continued forward with investment, albeit with the corresponding figure having decreased by 42 %. [ID_3](#), [ID_4](#)

In terms of patents applied for, a cumulative figure of 332 patents was achieved, representing an increase of 6 % compared with 2014. [ID_1](#) Additionally, the total number of employees dedicated to R&D and innovation was 797. [ID_2](#)

What makes us different

In 2014, Abengoa's decision to back a business model driven by innovation compelled the company to unify the management of proprietary technology, promoting scientific synergies and facilitating swifter and more efficient management in line with the needs of the business.

This structure was consolidated in 2015 and today has the capability to homogeneously manage the diverse technological areas in which the company operates:

Energy

- › Solar thermal energy production and storage.
- › New technologies and new photovoltaic power concepts.
- › Biotechnology, biofuels and bioproducts.
- › Hydrogen production and storage.

Water

- › Desalination and treatment of municipal and industrial wastewater.

Power transmission

- › Power systems.

Abengoa's technological model is unique in Spain: a technological innovation center with objectives in line with business strategy which at the same time embraces the challenge of generating new knowledge, in addition to positioning itself in the international scientific community.

With these goals in mind, Abengoa has promoted the **creation of a network of strategic collaborators** consisting of internationally recognized universities and research facilities through the development of specific projects and medium and long-term collaboration agreements to facilitate the exchange of researchers and the transfer of knowledge.

The company also holds special ties with the University of Loyola in Andalusia through the "Loyola - Abengoa Research" center. Additionally, in 2015 a joint research facility was created with the Ecole Polytechnique Federale de Lausanne (EPFL - Abengoa Research Center) which serves to promote the joint research being conducted in the field of photovoltaic technology based on the perovskite mineral.

Main lines of technological development

Energy

Abengoa is currently carrying out diverse lines of research in the energy sector. The aim is to make these newly developed technologies marketable in the near future, occupying new market niches.

Solar thermal energy production and storage

Abengoa is working on designing more efficient solar thermal plants, with thermodynamic cycles that require high-efficiency solar receivers and materials with the capacity to operate at high temperatures. Under these operating conditions, new surface treatments are needed to improve the solar energy absorption properties of receivers.

Abengoa develops coatings that maximize the energy input into the system and minimize loss due to radiation, thereby harnessing more energy and achieving a subsequent increase in receiver performance.

Among the most significant projects to employ this technology, the presence and development of two major projects in South Africa are noteworthy: **operational startup of the country's first solar thermal plant**, which is also equipped with a molten salt-based energy storage system developed by Abengoa, and the **completion of construction of Khi Solar One toward the end of 2015**. As the **world's first superheated steam power tower to operate commercially**, the plant, located in South Africa, boasts a capacity of 50 MW.

Additionally, construction began on the photovoltaic plant integrated into South America's largest solar thermal project, located in the Atacama Desert (Chile). This facility combines molten-salt tower (110 MW) and photovoltaic (100 MW) technologies, including an energy storage system employing molten salts and batteries, which will enable non-stop production of renewable energy 24 hours a day, with the capability to respond to grid demand at any time.

High-concentration photovoltaic power

High-concentration photovoltaics are characterized by the use of extremely high-efficiency multi-connection technology-based photovoltaic cells. These cells are utilized in the space industry because of their high efficiency, markedly stable behavior over time and excellent performance under adverse temperatures and conditions.

Left photo: team for executing multilayer PVD coatings

Right photo: high-performance proprietary paint





Left photo: cell connection with the secondary optics and the thermal dissipation system, which is known as a CPV engine



Right photo: butanol production via fermentation at the laboratory level

Their use in land applications necessitates the utilization of concentrating optics in order to minimize the area of the semiconductor due to the fact that these cells carry a high manufacturing cost.

Abengoa has developed a system that features unique characteristics resulting in high competitiveness when compared to conventional silicon-based photovoltaic technology. Noteworthy among its characteristics is the high concentration, which renders considerably low usage of solar cell material, therefore representing a minimal part of the cost of the system while providing high efficiency. Also worth mentioning is the fact that the system is designed to maximize the performance of module assembly operations, which makes the investment toward industrializing the technology very low.

Biotechnology, biofuels and bioproducts

Abengoa is carrying out projects related to raw material consumption that are part of the change in biotechnology and chemical processes.

Fermentative Butanol

Fermentative butanol production technology aims to convert sugars from first-generation biofuel plants into butanol. In this process, the raw material input involved in the process (sugars from corn and sugar cane or of second-generation origin from agricultural waste and municipal solid waste) is fermented by means of bacteria in two consecutive phases, rendering high added-value alcohols such as butanol and, to a lesser extent, acetone and ethanol. This affords an improvement in the economic return of today's first-generation plants.

The program for developing fermentative butanol seeks to increase the added value of current plants through the production of bioproducts. In the coming years, bioproducts are anticipated to replace a significant number of petroleum-derived chemical products in a sustainable and economically competitive manner.

Hydrogen production and storage

Catalysis and Materials

The Catalysis and Materials project focuses on developing new systems for producing, separating and purifying hydrogen by means of reforming reactions in renewable alcohol vapor.

To this end, **new onsite hydrogen separation systems** are being designed with the capacity to extract hydrogen from the blend of gases using a selective membrane. This would achieve a reduction in the cost of separating and purifying hydrogen, given that this system would replace the separation and purification units currently utilized in the industry. The process could contribute to significantly lowering system size, achieving a reduction of up to 60 % under optimal operating conditions. In addition, this technology operates at moderate reaction temperatures (500 - 600 °C) given that hydrogen is continually being extracted from the system, displacing equilibrium toward product formation.

This helps to prevent the utilization of high temperatures, which increase the cost of the materials employed in manufacturing the system, as well as the operating costs.

Water

Water desalination and treatment

Industrial water treatment

Eliminating chlorinated and nitrogenous contaminants present in wastewater, including domestic, industrial, natural and water apt for human consumption, is a

fundamental challenge in the water treatment field due to the ever-growing rise in discharges of these types of toxic and carcinogenic compounds. The increase in consumption and utilization of water resources, coupled with the growing population and industrial development, **necessitates the development of new and effective technologies for eliminating these types of pollutants**, which are difficult to eradicate due to the inherent technical difficulties and high costs of treatment.

The use of catalysis applied to water treatment enables the elimination of a wide variety of contaminants. The application of catalytic systems in treating aqueous effluents has yielded promising results, reaching high efficiency levels at a competitive cost.

One of the projects being carried out by Abengoa in this area is the **Nitralim project**, which seeks to develop innovative technologies based on new catalytic systems featuring high activity, selectivity and stability in **treating contaminated water at a low cost**.

Power transmission

Power systems

Smart solar plants with synchronous power control technology

Abengoa aims to integrate a power control technology referred to as SPC (Synchronous Power Control) into its photovoltaic generating units and battery-based energy storage systems. SPC is a registered Abengoa technology that enables power converters to provide advanced support services to the electrical power grid and which increase power system stability and reliability.

Plants employing SPC technology are compatible with conventional synchronous generating systems, do not cause power grid disruptions and inherently meet the grid connection codes demanded of renewable plants, mainly involving photovoltaic and wind power technology.



Power converter based on the synchronous power control concept patented by Abengoa