

# RESEARCH AND DEVELOPMENT

## RESEARCH AND DEVELOPMENT COSTS

Research and development challenges for TOTAL can be defined along four main lines:

- knowledge of the resources and their quality, mainly oil and gas, but also for biomass and renewable energies;
- competitiveness, renewal and quality of products, including the ability to meet market needs, their life cycle and their impacts;
- efficiency, reliability and duration of production facilities, notably their energy output;
- environmental challenges with regard to water, air and soil on production sites, and the future of residual gases such as carbon dioxide.

These challenges are addressed in synergy rather than competitively. The approach varies according to the different business segments.

### Main focus of business segment R&D

#### Exploration & Production

Upstream R&D has a number of themes, including:

- seismic data acquisition and processing;
- digital simulation and characterization of reservoirs (such as low permeability or very deep reservoirs), sour gas processing and chemical conversion of gas;
- oil recovery in operated reservoirs and issues connected to heavy oil recovery are two major concerns which led the Group to increase the Research budget;
- CO<sub>2</sub> capture and geological storage in “depleted” gas reservoirs the subject of a major new project in France.

#### Gas & Power

The main R&D themes concern energy conversion: new technical options for LNG terminals, new processes for GTL (Gas to Liquids), notably including the emergence of DME (Di-Methyl-Ether) production, the Group's commitment in direct production processes and CTL (Coal-to-Liquids) processes to convert coal into liquid hydrocarbons. This business segment is also committed in power generation (the means to improve output) and CO<sub>2</sub> capture in power plants.

For renewable energies, major themes for R&D concern possible evolutions of photovoltaic technology with the new cell generation and power generation from biomass. TOTAL also entered into a partnership in wave power.

#### Refineries

For refining and marketing, TOTAL is preparing to include in its activities resources of the future, whether from non-conventional oil or from first or second biomass generation. TOTAL is also developing new high performance fuels, additives and lubricants adapted to the market, car manufacturers and energy. This business segment is also developing processes and catalysts, considered as two major R&D drivers, to improve productivity and reduce environmental impacts.

#### Petrochemicals

In Petrochemicals, R&D is directed toward the discovery of new resources from gas, coal or renewable energies and also the improvement of the energy efficiency of the facilities, as well as the development of new specialized polymers, the products of the future.

#### Specialties

Atotech is part of the rapid global development of microelectronics, dealing with engraving, brasing and electroplating technologies.

Hutchinson is innovating in the field of clean production technologies connected to thermoplastic products and attractive systems for major clients.

Bostik is focusing its research and innovation program on developing functional adhesives that do more than just assemble parts into a whole but also offer new properties: better acoustics for building and transport applications and recyclability and compostability for hygiene and packaging applications.

Bostik and Cray Valley-Sartomer are working on the development of new products derived from clean technologies, notably using biomass resources.

#### Environment

Controlling and reducing the environmental impact of its activities is a challenge common to the whole Group, such as the reduction of gas emissions, the reduction of water contamination to comply with the European water framework and the REACH directives, as well as the reduction of greenhouse gas emission whether through the improvement of energy efficiency or efforts leading to carbon capture and sequestration.

#### R&D organization

TOTAL's management is considering the Group's research and development trends and the optimal organization of the Research Department to adapt to a new context that requires both a strong research in all business segments as well as improved cross-disciplinary cooperation. Within the framework of a change in the management, this movement led to a reorganization of this Department which now reports directly to the Group's Management.

The Group has 22 major R&D centers worldwide and developed approximately 500 active partnerships with other industrial groups, university research or special research institutes. In addition, TOTAL benefits from a network of academic scientists worldwide committed to scientific watch and analysts useful to the Group's R&D activities.

