



## CO<sub>2</sub> activities and organisation

To fight against global warming, Gaz de France complies with the CO<sub>2</sub> emission quotas imposed on energy-producing industries as part of the Kyoto protocol, has pre-empted regulatory measures by reducing its own greenhouse gas emissions. The Group's 2007 target is to achieve a 10% cut in direct emissions relative to 1990. In particular, Gaz de France is a member of France's Association of Companies for the Reduction of the Greenhouse Effect (AERES),

Gaz de France also supports its customers in their measures to control and manage their own greenhouse gas emissions. Gaz de France Group is promoting energy efficiency as a competitive advantage by selling highly energy-efficient equipment, conducting energy efficiency checkups, providing assistance with the upgrading of existing facilities.

Gaz de France is a member of the Prototype Carbon Fund (PCF) whose goal is to collect funding for projects designed to reduce greenhouse gas emissions in developing countries. This fund is based on the Clean Development Mechanism (CDM), which aims to strengthen cooperation between the Developed World and Third World countries, and to stage Joint Implementation Actions (JIA) in East European countries.

Since 2001 Gaz de France is actively involved in developing processes for the capture, transportation and geological storage of CO<sub>2</sub> within several national and international research projects and spends a significant part of R&D expenditures on this sustainable development option.

In addition, Gaz de France is involved in operational CO<sub>2</sub> reinjection sites :

- Gaz de France is currently reinjecting CO<sub>2</sub> since 2004 into a depleted gas field offshore K12B in the dutch North Sea,
- is taking part into an industrial project which involves injecting CO<sub>2</sub> into a salt aquifer in the Snøhvit gasfield, Norway,
- is starting a pilot injection into Altmark german field, the second largest depleted gas field onshore in Europe.
- And has other potential CO<sub>2</sub> storage opportunities in the near future.

## R&D competences in Carbon Capture and Storage areas

To optimise and to provide up-to-date scientific support to operational CCS cases within Gaz de France, several R&D activities are especially developed.

For many years, Gaz de France has been investigating technical and economical feasibility of CO<sub>2</sub> capture, transport and storage notably by taking part in several R&D projects and by operating CO<sub>2</sub> injection pilot units.

### *From oxyfuel combustion to post-combustion capture with amines*

Within the R&D activities on capture processes, Gaz de France is focusing on the three main options for capture, i.e. oxyfuel/chemical looping, pre-combustion and post-combustion including incremental development (capture with solvent) and new designs. Regarding CO<sub>2</sub> transport, Gaz de France is studying both transport by pipe and ships including infrastructures and procedures to implement.

Gaz de France is the coordinator of a national project TACoMA (*Advanced Combustion Techniques to Control Atmospheric emissions*) whose objective is to evaluate, test and develop flameless oxyfuel combustion techniques with Flue Gas Recirculation (flameless oxy-FGR) for CO<sub>2</sub> capture. This TACoMA project began in December 2006 and will last 3 years. Its industrial target is the revamping of existing industrial furnaces as well as the building of new ones. In this scope, a new design of furnace will be tested in order to prepare the building of new furnaces. The only drawback of oxyfuel combustion not assessed in this project is the problem of the oxygen cost. In the long term, it should be possible to get rid of the costly ASU<sup>1</sup> in some cases by using chemical looping combustion. On this topic, Gaz de France is taking part to a project on chemical looping combustion, CLC-Mat, which is coordinated by the IFP. The goal of the CLC-Mat project is to develop new oxygen vectors for the chemical looping combustion and to identify uses of this technique apart from power generation.

Gaz de France is a partner of the CASTOR project (*CO<sub>2</sub>, from Capture to Storage*, funded by the European Union 6<sup>th</sup> Framework Program for Research) which focuses on CO<sub>2</sub> capture in flue gases and its

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<sup>1</sup> Air Separation Unit

geological storage (2004-2008). Headed by IFP, the CASTOR project involves 30 private and public partners from 11 European countries. Within the R&D activities on the post-combustion capture process, studies aiming to develop, test and optimize new processes are conducted by partners. A large capture pilot plant has been built in a modern coal-fired power plant operated by Dong Energy in Esbjerg (Denmark). This pilot plant with a capacity of 1 t CO<sub>2</sub>/hour has been operating since early 2006 in order to validate the new processes developed within the project. As part of this project, IFP and Gaz de France made a study on process optimisation of absorber and desorber loop for CO<sub>2</sub> capture. These studies on process optimisation are continuing within a national project focusing on CO<sub>2</sub> post-combustion capture in power plants, steel and cement works.

In the past, Gaz de France was involved in a national project in partnership with the French energy and environment agency (ADEME) on "Technical and economic study of CO<sub>2</sub> transport for subsequent storage". The objective of this project was to assess the technical and economic aspects of CO<sub>2</sub> transport, primarily by pipeline but also by CO<sub>2</sub> ships. These studies are continuing within a new French project whose objectives are to optimize the whole chain from the onshore CO<sub>2</sub> capture to the offshore injection with CO<sub>2</sub> transport by ships (cold CO<sub>2</sub> or high pressure) including infrastructures and procedures to implement.

### ***R&D studies on CO<sub>2</sub> storage in depleted fields and deep aquifers***

Regarding geological storage, Gaz de France is conducting a series of studies on CO<sub>2</sub> storage into depleted hydrocarbon fields and deep saline aquifers as part of National or European projects. In France, Gaz de France is conducting a series of studies on CO<sub>2</sub> storage into depleted hydrocarbon fields and deep saline aquifers as part of the GEOCARBONE projects, in partnership with the French National Research Agency. These projects are focusing on potential storage sites selection and characterization, caprock and wells integrity, reservoir injectivity, monitoring tools and mineral carbonation.

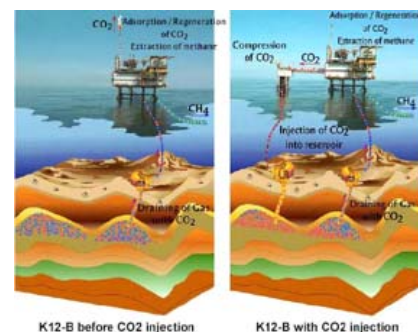
In the Netherlands, Gaz de France is currently re-injecting CO<sub>2</sub> into an offshore and a nearly depleted natural gas field. The gas produced at one of ProNed's platform, the K12-B platform, contains a relatively high concentration of CO<sub>2</sub> (about 13%). In order to meet export pipeline specifications, this CO<sub>2</sub> is removed from produced gas and re-injected. In association with TNO, this operational project aims to investigate the feasibility of CO<sub>2</sub> injection in a nearly depleted natural gas field. It consists of three phases :

- **A feasibility study** was carried out in 2002 (phase 1). The purpose of phase 1 of the ORC project was to investigate the feasibility of CO<sub>2</sub> re-injection and storage in an offshore and a nearly depleted natural gas field, by using existing installations, with the aim of creating a permanent CO<sub>2</sub> injection facility.
- **The pilot injection phase** (phase 2) began in May 2004 and is underway. It was the first time worldwide that CO<sub>2</sub> has been re-injected into the same reservoir from which it was initially in place (Figure 3). Phase 2 consists of two tests at different locations in the K12-B reservoir.

Test 1 (May – December 2004, 11,000 ton CO<sub>2</sub>) is a CO<sub>2</sub> injection into a single-well depleted reservoir compartment (K12-B8 - Figure 1). Test 1 showed that CO<sub>2</sub> injectivity is quite good despite the low permeability of the reservoir. The reservoir response and the behavior of injected CO<sub>2</sub> are within the expected range.

Results of test 1 were used to optimize the measurement program of test 2 (March 2005 - underway) with CO<sub>2</sub> injection into a nearly depleted reservoir compartment. Objectives of test 2 are to test predictability and enhanced gas recovery potential with simulation and tracers injections. Furthermore, well integrity studies are underway within the CASTOR project.

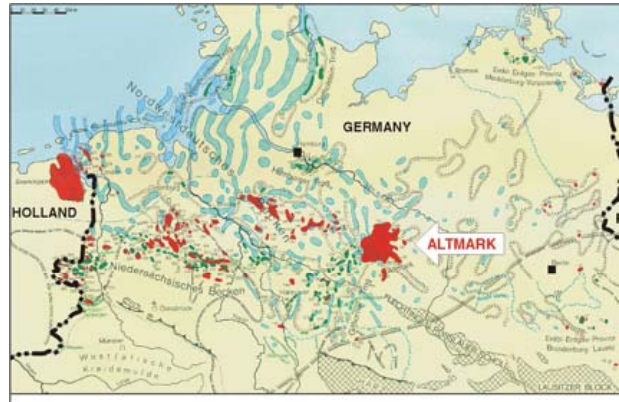
- The **scale-up to subsequent industrial phase** (phase 3) will also include the possibility for future re-use of injected CO<sub>2</sub>. The injection potential is about 310,000 to 475,000 t/year of CO<sub>2</sub>.



### ***Towards CO<sub>2</sub> storage in the Altmark gas field ?***

In Germany, Gaz de France is currently investigating the technical and economical feasibility of injecting CO<sub>2</sub> with enhanced gas recovery in the depleted Altmark natural gas reservoir situated in the Federal State Sachsen-Anhalt, in Northern Germany.

After 37 years of gas production, the field has reached a cumulative production of 206 billion m<sup>3</sup> of gas and a recovery factor of 78%. On top of being the largest onshore gas field in Europe immediately available for CO<sub>2</sub> storage, the field has very favourable conditions with its well explored reservoir, proven seal integrity, low reservoir pressure and existing infrastructure (more than 200 wells). The total volume of CO<sub>2</sub> to be stored could reach 500 M tons. At the same time the gas field with its high recovery rate offers an excellent opportunity to study enhanced gas recovery by injecting CO<sub>2</sub> into the reservoir.



The injection phase is envisaged to be accompanied by a site-specific research and monitoring programme.

Most of these actions are supported by european and national technology development programs (FP6 and FP7 at EU level, ANR, Ademe and A2I in France, Geotechnologien in Germany, CRUST and MONK in the Netherlands, and the Research Council of Norway).

A selection of joint R&D Projects :

- Castor, Recopol, Gestco
- TransCO<sub>2</sub>, Tacoma
- Picoref, Geocarbone ANR, Metstor

Gaz de France also participates in several Exchange Networks such as CO<sub>2</sub>Net, CO<sub>2</sub>GeoNet, ZEP Platform, ClubCO<sub>2</sub>,...

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