The In-Salah CCS experience
Sonatrach, Algeria

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Sonatrach, Algeria
Sonatrach & Climate Change
Who is Sonatrach?

- Created in 1963
- Processing Capacity
  - Liquefaction of NG: 45 Mm$^3$/year
  - LPG Separation: 9.1 MT/year
  - Refining: 21.3 MT/year
- Transportation Network
  - 14,500 Km of oil, gas LPG and condensate pipelines

In Salah
Who is Sonatrach?

Sonatrach is the Algerian National Oil & Gas company

- 11th largest oil company
- 1st African company
- 3rd largest NG exporter
- 1st largest LNG exporter
Sonatrach adopted few years ago; an ambitious Health, Safety & Environmental (HSE) Policy.

It shows a strong commitment to protect the Environment and to contribute to the sustainable development effort of the country.

One of the main environmental objectives of Sonatrach is reducing atmospheric pollution including greenhouse gases.
Sonatrach’s efforts to tackle climate change

- Associated gas flaring reduction program
  - Voluntary efforts since 1970
  - GGFR member (CDM project)

- Carbon Capture & Storage projects
- Voluntary projects
  - **First experience:** In Salah gas Project
  - **Second experience:** Gassi-Touil Integrated Project
In Salah Gas Project
In Salah Gas (ISG) is a Joint Venture between:

- Sonatrach (35%),
- BP (33%)
- Statoil (32%).

ISG Project involves the development of seven natural dry gas fields in the southern central part of Algeria (Sahara desert).
• **1st Phase**: Started in 2001, first gas produced in 2004

• **2nd Phase**: after 2011
In Salah Gas Project

- The objectives of this JV are: Exploration, Appraisal, Development and Joint Marketing of natural gas produced.
  - First treated gas in July 2004,
  - Estimated gas reserves: 340 bcm (230 bcm recoverable).
  - Dry Gas production plateau: 9 bcm/yr for about 13 to 16 years
  - Contract duration: until 2027.
  - The global investment is around 2.7 billion US$ (1.7 billion US$ for Phase I).
In Salah Gas Processing Plant

Krechba → CO₂ removal → CO₂ removal → Gas Dehydration → Gas Dehydration → Natural Gas Compression → CO₂ Reinjection wells

Teg → Gas Dehydration

Reg → Gas Dehydration

CO₂ Compression

Export to Hassi R’mel (455 km)
Krechba Processing Plant

- CO₂ Re-injection
- CO₂ Removal & Dehydration
In Salah Gas CO2 emissions by source

CO2 from produced gas

CO2 heat and power generation

Only the separated CO₂ (yellow) will be stored – the combustion CO₂ (blue) will be vented

Source: Iain Wright (CO2Project Manager, BP Group Technology) SBSTA Meeting Bonn May 20th 2006
## CO₂ content for each reservoir

<table>
<thead>
<tr>
<th>Fields</th>
<th>Reservoirs</th>
<th>CH₄ (%)</th>
<th>CO₂ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Krechba</td>
<td>Tournaisian (Carboniferous)</td>
<td>91</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Gedinian (Devonian)</td>
<td>89</td>
<td>9 to 10</td>
</tr>
<tr>
<td>Teguentour (Teg)</td>
<td>Devonian</td>
<td>90</td>
<td>8 to 10</td>
</tr>
<tr>
<td>Reg</td>
<td>Devonian</td>
<td>94</td>
<td>2 to 4</td>
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<td>Garet el Befinat</td>
<td>Emsian</td>
<td>94</td>
<td>2 to 4</td>
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<td>Hassi Moumene</td>
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<td>In Salah</td>
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<td>Gour Mahmoud</td>
<td>Devonian</td>
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The carbon content in the natural gas produced from the In Salah project ranges between 4 – 9%.

The target market for the Algerian natural gas is Europe, where the market requires incoming natural gas to contain no more than 0.3% CO₂.

So, ISG is required to separate the carbon before export natural gas.
CCS, an alternative option to CO2 venting

- The industry business as usual practice is to first separate CO$_2$ from the natural gas and then vent it into the atmosphere.

- A commitment by the shareholders to manage down the emissions footprint of the project and not to employ atmospheric venting of the CO$_2$ stream resulted in a need to an alternative solution to be identified.

- So, rather than venting CO$_2$, the project compresses it and injects it into a large underground aquifer lower than the gas reservoir at 1,800 metres depth.
ISG-CCS is an Industrial-scale demonstration of CO₂ geological storage

1 million tons per year of CO₂ will be geologically stored:

About 17 million tons of CO₂ will be re-injected during the whole life of the project

CCS reduce GHG emissions of the project by 60%. This is equivalent to:

- To take 250 000 cars off road
- Or, 200 km² of forests

Project cost: 100 million US$

CO₂ capture & storage cost: $6 per tonne
The overall objectives of In Salah Gas CCS project

First, to demonstrate to stakeholders that industrial-scale geological storage of CO₂ is a viable greenhouse gas (GHG) mitigation option.

Second, to assure people that secure geological storage of CO₂ can be cost-effectively verified and that long-term assurance can be provided by short-term monitoring;

and third, to set precedents for regulating and verifying geological storage of CO₂ - ultimately to allow eligibility for Clean Development Mechanism (CDM).
CO₂ Removal and Compression

(CO₂ Capture)
For carbon removal purpose, two trains have been built,

CO₂ is extracted by absorption using chemical solvent (Ethanol - Amino solution).

The solvent is then regenerated and CO₂ recovered.

NG is then dehydrated by Glycol absorption.
The CO₂ is compressed through 04 compression steps up to a max of 200 bars.

After the 3rd phase of compression, CO₂ is dehydrated by absorption using tri-ethylene glycol (TEG).

CO₂ is cooled after each compression stage and before re-injection.
CO$_2$ Geological Storage
The selection criteria considered to choose the injection site are:

- A robust sub-surface storage sites close to the planned In Salah Gas process facilities.
- A demonstrated reservoir cap seal integrity,
- The availability of sufficient storage capacity to meet the predicted CO₂ volumes estimated at ~ 12 Standard Bcm,
- A moderate to good storage reservoir properties (porosity, permeability...)
- A reservoir pressure below 6000 psi.
Several opportunities for storage were evaluated during the design stage and ranged from distributed storage at each field location, to a single centralised facility and storage site.

The high cost and increased system complexity associated with distributed storage, primarily around the need to employ multiple CO$_2$ stripping units, precluded this as an option.

So, a single facility was one preferred and Krechba field was selected to be the location.
The need therefore was to identify subsurface CO₂ storage locations proximal to the Krechba field area.

A number of reservoir options for the CO₂ storage were investigated close to Krechba, taking in consideration both the shallow Carboniferous and the deep Devonian structures.

Why Krechba?

- All Processing facilities are located in one site,
- Seismic data available,
- Existence of exploration and appraisal wells,
- The shallowness of the Carboniferous structure,
- The reservoir has a big storage capacity with a good insulation.
CO2 injection

Amine CO2 Removal

4 Gas Production Wells

3 CO2 Injection Wells

Processing Facilities

Carboniferous Reservoir ~20 metres thick

Gas

Water
CO\textsubscript{2} injection wells location

3 peripheral injection wells were required to ensure that CO\textsubscript{2} is retained within the aquifer zone and does not enter the main field area until after it has been depleted and abandoned (after 25 to 30 years of production).
Injector well: Kb-501

Krechba 501
1250 metre Horizontal Section
The studies demonstrated that the CO₂ stream injected into the aquifer zone of Krechba Carboniferous reservoir will over time migrate back towards the main Hydrocarbon accumulation and into structural trap.

It is predicted that during the early years of injection (up to 10 years), the CO₂ will be retained within the aquifer zone near the injector locations.

However, over the long term, as volumes build in the reservoir, the CO₂ will slowly migrate up-dip towards the structural crest of the main gas accumulation, moving into the main field area only after the field is depleted and abandoned.

Prediction of the injected CO₂ behavior has been modeled both analytically as well as by numerical simulation.

The results confirmed that CO₂ breakthrough into the main field area would not occur until after field abandonment (after 25 years of production)
Future CO₂ behaviour simulation

5 years

15 years
Conclusion

- In Salah gas project is one of the largest CCS schemes in the world.

- The project demonstrated that complexity and project size are not blockers to achieving the extraordinary outcome, with large scale atmospheric disposal of CO2 no longer seen as an acceptable option.

- ISG CCS project is expected to lead in setting precedents for monitoring, regulation and verification of geological CO\textsubscript{2} storage and establish CCS as eligible for Kyoto Protocol Clean Development Mechanism.

- The eligibility for CDM is very important to promote CCS in developing countries such as Algeria and OPEC members.

- Carbon Credits will enhance the project economy and help to achieve GHG mitigation at lower costs.
Thank you

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