In Salah CO_2 Storage Project: Monitoring Experience

Iain Wright, JIP Programme Manager

UNFCCC SBSTA CCS Workshop, September 8th 2011, Abu Dhabi

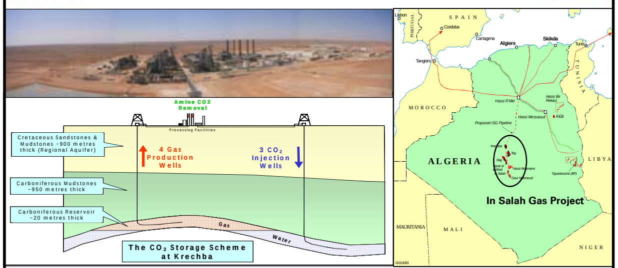
Agenda

- **In Salah CCS: Context & Overview**
- **In Salah JIP Phase 1 Lessons:**
  1. Site Selection
  2. Project Boundaries and Accounting
  3. Monitoring
  4. Risk Assessment
  5. Informing Regulation
- **Summary & Discussion**

Agenda

- **In Salah CCS: Context & Overview**
- In Salah JIP Phase 1 Lessons:
  1. Site Selection
  2. Project Boundaries and Accounting
  3. Monitoring
  4. Risk Assessment
  5. Informing Regulation
- Summary & Discussion

In Salah CCS Project: Overview

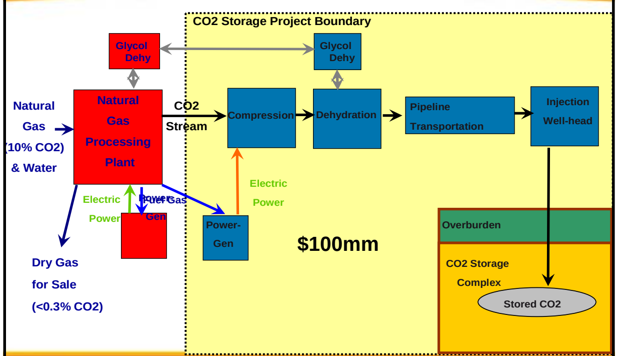


Project Summary

- Industrial Scale Demonstration of CO_2 Geological Storage (Conventional Capture)
- Storage Formation is common in Europe, USA & China
- Started Storage in August 2004 at 1mmtpa. 3.65 mmt CO_2 stored at end 2010
- $100mm Incremental Cost for Storage. No commercial benefit
- Test-bed for CO_2 Monitoring Technologies: $30mm Research Project

---

In Salah CCS Project: Additional Investment



SBSTA Synthesis Report: Categories

- **New Methodology for CCS was submitted in 2009**
  Publicly available at: www.insalahco2.com

	ISG CCS NM
1. Site Selection	Yes
2. Project Boundaries and Accounting	Yes
3. Trans-boundary Issues	
4. Risk/Safety Assessment	Yes
5. Monitoring	Yes
6. Permanence and Liability	Yes

Agenda

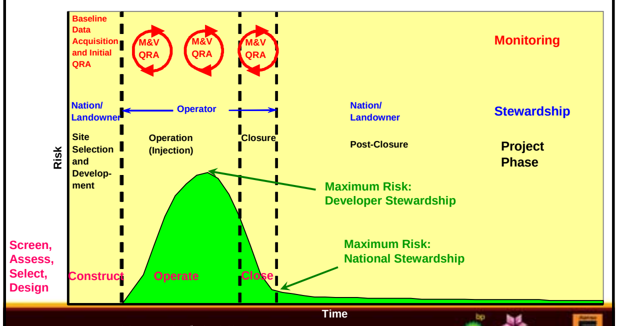
- In Salah CCS: Context & Overview
- **In Salah JIP Phase 1 Lessons:**
  1. **Site Selection**
  2. Project Boundaries and Accounting
  3. Monitoring
  4. Risk Assessment
  5. Informing Regulation
- Summary & Discussion

Risk-Management Process (EU CCS Directive)

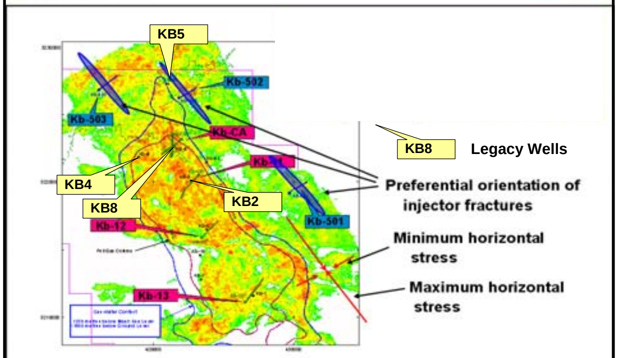
(Ref: CO2QUALSTORE, DNV 2009)

CO_2 Storage: Generic Risk Profile

Risk Profile of a CGS Project



Risk Management: Project Design



Site Selection and Operation

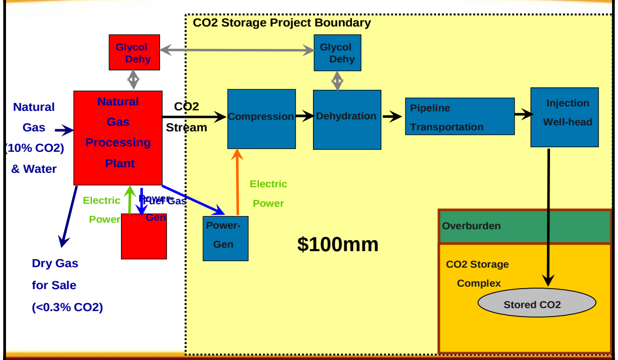
Quantified Risk Assessments (QRA) should be used to manage seepage risk
- During site selection, project design and updated periodically during operation
- Several methodologies are available

- Monitoring should be in the Field Development Plan (FDP) and Field Operations
  - Designed around an early assessment of seepage risks
- Initial appraisal and development of a CO_2 storage project should collect a comprehensive set of baseline data
  - To adequately characterise the Storage Complex / Area of Review
- At In Salah:
- ***Baseline data acquisition should have begun earlier & been more-comprehensive***
- ***Top Three risks were: Integrity of wells and caprock, plus CO_2 migration direction***

Agenda

- In Salah CCS: Context & Overview
- In Salah JIP Phase 1 Lessons:
  1. Site Selection
  2. **Project Boundaries and Accounting**
  3. Monitoring
  4. Risk Assessment
  5. Informing Regulation
- Summary & Discussion

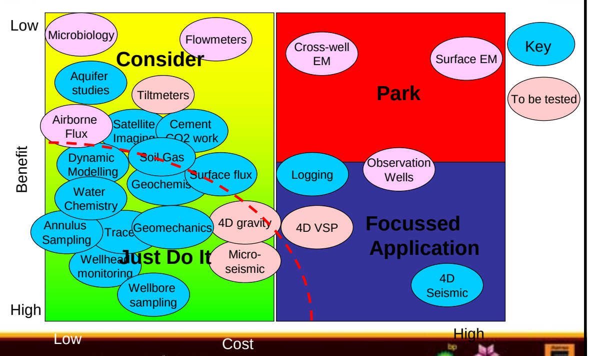
Project Boundaries and Accounting



Agenda

- In Salah CCS: Context & Overview
- In Salah JIP Phase 1 Lessons:
  1. Site Selection
  2. Project Boundaries and Accounting
  3. **Monitoring**
  4. Risk Assessment
  5. Informing Regulation
- Summary & Discussion

Monitoring Technologies: Evaluation



Monitoring: Low-cost Options

- Low-cost technologies can be very effective CO_2 monitoring tools

At In Salah: these included:

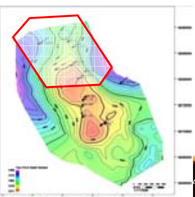
- *Wellhead (pressure & flowrate) annulus monitoring (including tracers)*
- *Soil-gas surveys, permanent soil-gas detectors, microbiological sampling*
- *Gas surface flux (using laser surveys),*
- *Shallow aquifer sampling*

Monitoring: Seismic

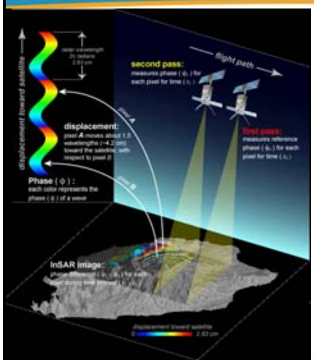
- **Acquisition of a high-quality, pre-injection 3D seismic baseline is a vital**
  - for characterising the overburden and the injection horizon
- **The value of subsequent (time-lapse) 3D surveys will depend on rock quality and the density difference between in-situ fluids and the injected CO_2**
- **A comprehensive understanding of the interaction of rock-physics, fluids and fractures is required to adequately model Seismic responses to CO_2 injection**

At In Salah:

- *4D may never be a good option for CO_2 monitoring (due to poor rock quality and insufficient density contrast between fluids)*



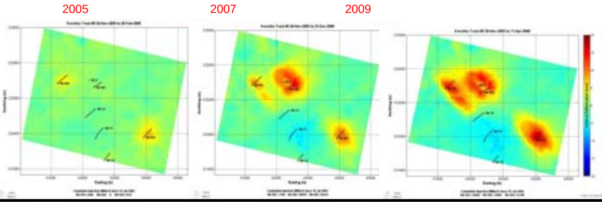
Monitoring: Satellite Imagery - Generic



- **Interferometric Synthetic Aperture Radar (InSAR)**
- **Technology developing rapidly due to:**
  - **Publicly available data**
  - **Better data resolution (satellite)**
  - **Improved processing capabilities**
  - **Competition between providers**
- **Provides accurate information on ground surface deformations over time**
  - **Surrogate for pressure (not CO_2)**
- **Not Specific to CO_2 Monitoring**

Monitoring: Satellite Imagery - At In Salah

- InSAR (combined with geo-mechanical modelling), has been key to understanding the subsurface distribution of pressure fronts and CO_2 plumes
  - *Benchmarked by CO_2 observation at KB5*
  - *Significantly influenced the 2009 seismic survey and Quantified Risk Assessment*
  - *Future value could be restricted as the CO_2 moves into the depleted zone*
  - *Data is available since 2003 (pre-injection), C-Band (Envisat and Radarsat2)*
  - *Inversion using diversity of research partners and techniques*
  - *Used as an observation constraint for geo-mechanical modelling*



Agenda

- In Salah CCS: Context & Overview
- In Salah JIP Phase 1 Lessons:
  1. Site Selection
  2. Project Boundaries and Accounting
  3. Monitoring
  4. **Risk Assessment**
  5. Informing Regulation
- Summary & Discussion

Risk Assessment

- Quantified Risk Assessment (QRA) is an invaluable tool to understand, manage and communicate the performance of a CO_2 storage operation
  - Should be periodically repeated over the life of a CO_2 storage project
- Several methodologies are available

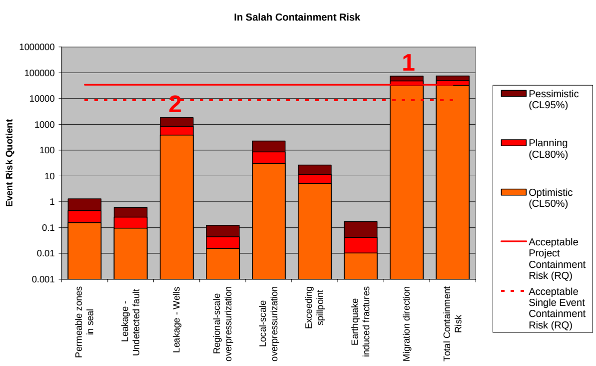
At In Salah:

- *Pre-injection risk assessment highlighted the key risks and informed the baseline data acquisition programme and early monitoring*
- *Evaluated QRA methodologies: CCPCF, URS, FEP, Oxand*
- *The QRA is updated regularly and used to inform injection and monitoring strategies*

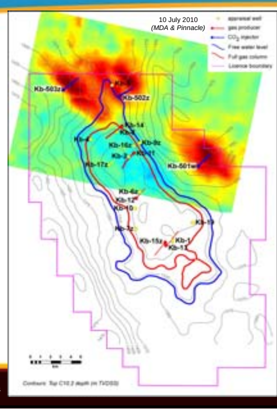
Acceptable Seepage Risk?

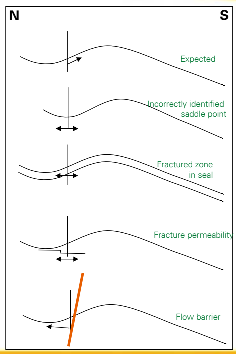
- **IPCC Special Report on CCS:**
  - **"the fraction [of CO_2] retained in appropriately selected and managed geological reservoirs……… is likely to exceed 99% over 1,000 years"**
- **At In Salah:**
  - **17mm tonnes x 0.01 x 0.2 = 34k tonnes**
  - **" " 0.05 = 8k tonnes**

In Salah Quantified Risk Assessment

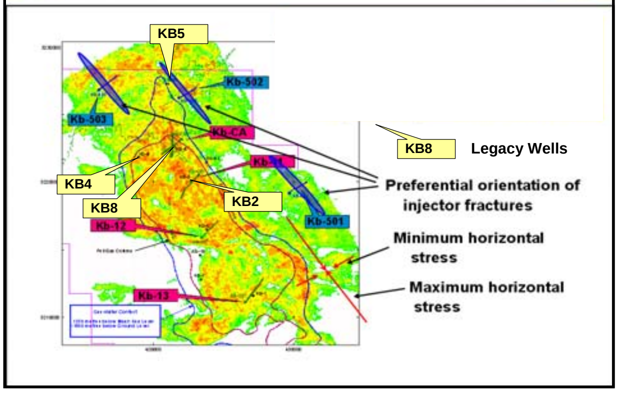


Key Risk #1: Migration Direction Risk

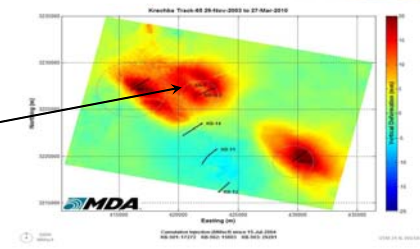




Key Risk #2: Legacy Wells



Legacy Well: KB-5

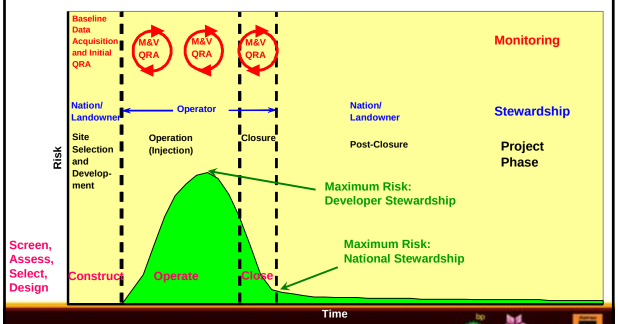
- Drilled in 1980 and temporarily suspended (no integrity to gas)
- 1.5 km NW of KB502 CO_2 injector (expected CO2 migration direction)
- 0.1 tonne CO_2 seeped in 2007 (valve leak – not pressure on gauge)
- Caused by lack of well & wellhead integrity (physics not chemistry)
- KB5 now fully decommissioned with CO_2 resistant cement

Agenda

- In Salah CCS: Context & Overview
- In Salah JIP Phase 1 Lessons:
  1. Site Selection
  2. Project Boundaries and Accounting
  3. Monitoring
  4. Risk Assessment
  5. **Informing Regulation**
- Summary & Discussion

CO_2 Storage: Generic Risk Profile

Risk Profile of a CGS Project



In Salah and EU Directive

Colour Key: Compliant / Compliance possible / Non or difficult compliance

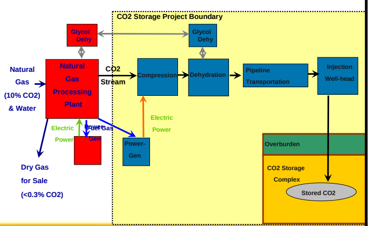
In Salah CO2 Storage vs. EU CCS Guidelines

Sectio	Category	Activities	Directive MPCP	Assessment (Appraise)	Characterisation (Select/Define)	Development (Execute)	Operation (Operate)	Closure (Decommission)
GD1	Life Cycle Risk Managem							
2.1	Life Cycle Risk Management	Periodic Risk Assessment and Management						
		Model and performance Uncertainty assessment						
3.3	Life Cycle Phases							
	Characterisation	Characterisation/assessment of storage complex						
		Detailed Risk Assessment						
		Develop injection, monitoring, corrective measures plans						
	Development	Detailed engineering design of the storage scheme						
		Baseline pre-injection monitoring						
	Operations	Reporting of monitoring results to Competent Authority (CA)						
		Development of Corrective measures plan						
		New data used to update models and risk assessment						
		Monitoring plans to be updated and verified						
		Notify CA of any leakage or significant irregularities						
	Closure	Develop monitoring plan with targets and methods						
		Conduct post closure monitoring						
		Updated site characterisation and risk assessment						
		Inspections by CA post closure						
	Pre-Transfer to CA	Prove long term containment of CO2						
		Monitor and assess for **20 years**						
		Site sealed and facilities removed						
6	Risk Management for Geological Storage	Use CO2Qualstore risk assessment methodology (DNV 2010a)						
		Dialogue on Risk management with CA						

In Salah and Kyoto Protocol: CDM

New Methodology for CCS was submitted in 2009

Publicly available at: www.insalahco2.com



Agenda

- In Salah CCS: Context & Overview
- In Salah JIP Phase 1 Lessons:
  1. Site Selection
  2. Project Boundaries and Accounting
  3. Monitoring
  4. Risk Assessment
  5. Informing Regulation
- **Summary & Discussion**

Summary: Lessons Learned

1. **Monitoring should be part of the Field Development Plan (FDP) and routine field operation**
   - **In service of risk assessment:** designed to address site-specific risks
   - Acquisition, modelling and integration of a full suite of initial **baseline data is essential**
2. **QRAs should be carried out prior to injection and periodically throughout the operation**
   - Several methodologies are available
3. **The main seepage risks are driven by:**
   - Legacy well-bore integrity
   - Cap-rock integrity
   - CO_2 plume migration direction
4. **Compared to hydrocarbon developments, CO_2 storage projects require the integration of a wider-scope of datasets (InSAR, soil gas, seismic) over a greater aerial/vertical extent**
   - A diverse suite of technologies should be deployed and integrated
5. **Injection strategies, rates and pressures need to be linked to geomechanical modelling**
   - Of both the storage formation and **caprock**
6. **CO_2 plume development is not homogeneous**
   - Reservoir characterization and modelling requires high-resolution data
7. **In Salah CCS is regulated under Algerian Hydrocarbon Law**
   - If required, In Salah CCS could also comply with the EU CCS Directive and the Clean Development Mechanism

Questions?

www.insalahco2.com