

Exploring Opportunities for CO2-EOR in OPEC member countries

Current Technical Activities on EOR-CO2/ CO2 opportunities Plan

Misfera Al Qahtani

Kuwait
7-8 February 2012

Content

- Introduction
- Current technical activities on EOR-CO2:

-Case Study: North Kuwait Pilot Area Simulation for EOR Processes

- CO2 Opportunities Plan

Introduction

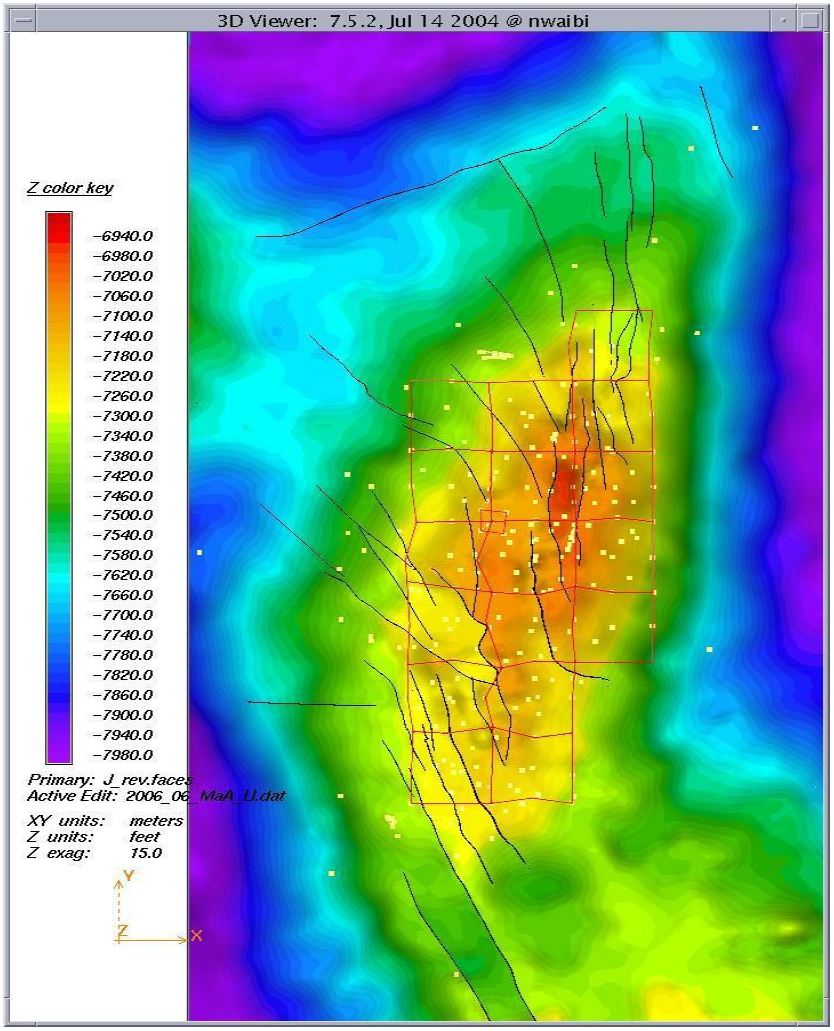
- CO2 injection became a leading EOR technique for light & medium oils by 1970's
- Motivators for developing CO2 EOR projects
  - potential to sequester CO2;
  - reduce global emission of Green House Gases (CO2);
  - optimization of CO2 storage while increasing oil recovery from reservoirs
- Miscible gas injection (particularly CO2) was recommended for more than 80% of the light oil reservoirs in Kuwait

Pilot Area Simulation for EOR Processes in NK Reservoir

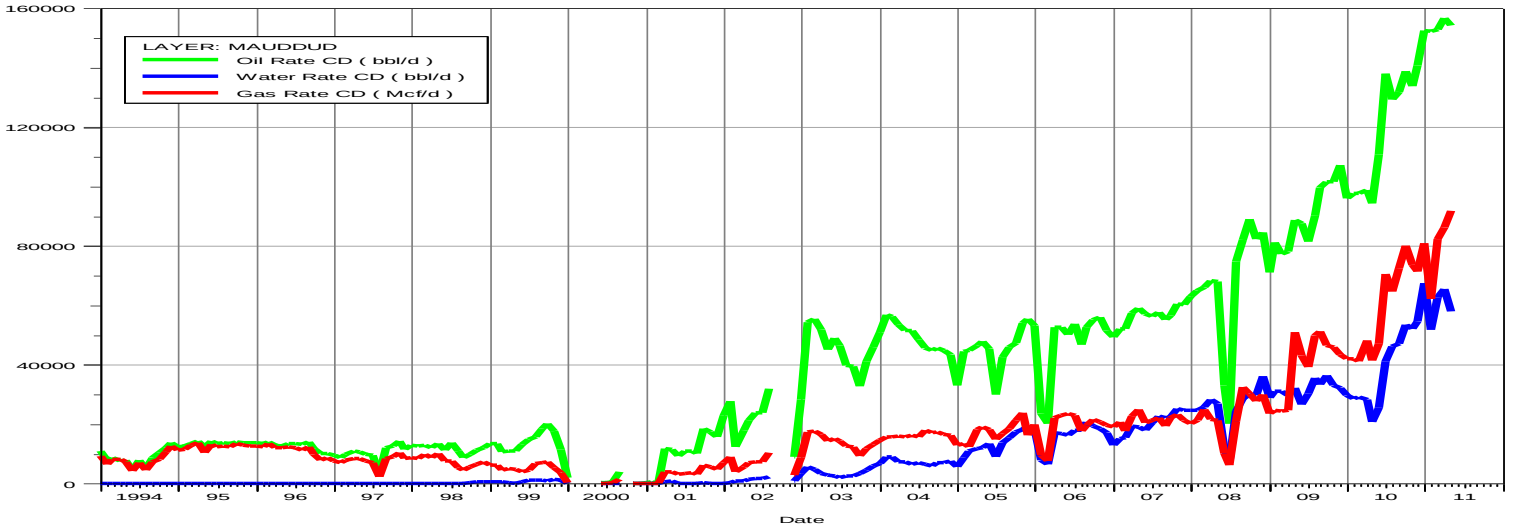
North Kuwait, Reservoir Description

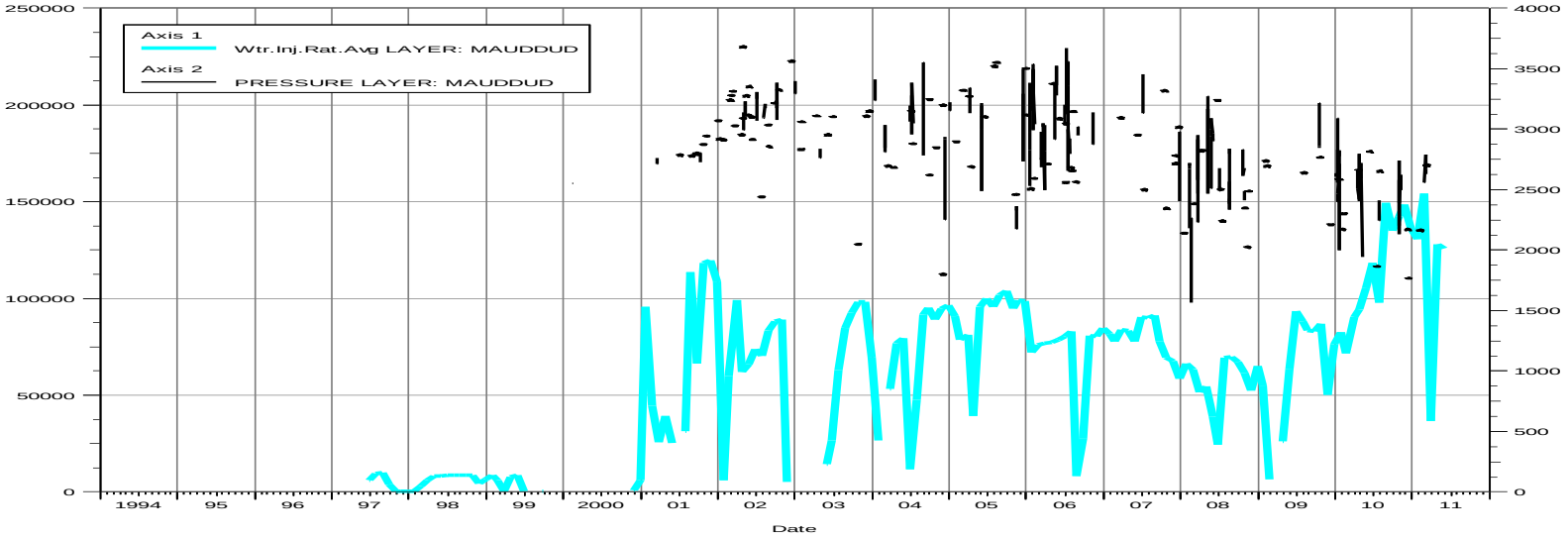
- 400’ thick Carbonate , 1957 discovered
- Faulted Anticline
- 18-29° API, 50-450 scf/stb GOR
- Under i-9 spot WF since 2000

-Depletion drive reservoir
-With water flooding



Production And Injection Profiles





Pilot Area Simulation for EOR Processes in NK Reservoir

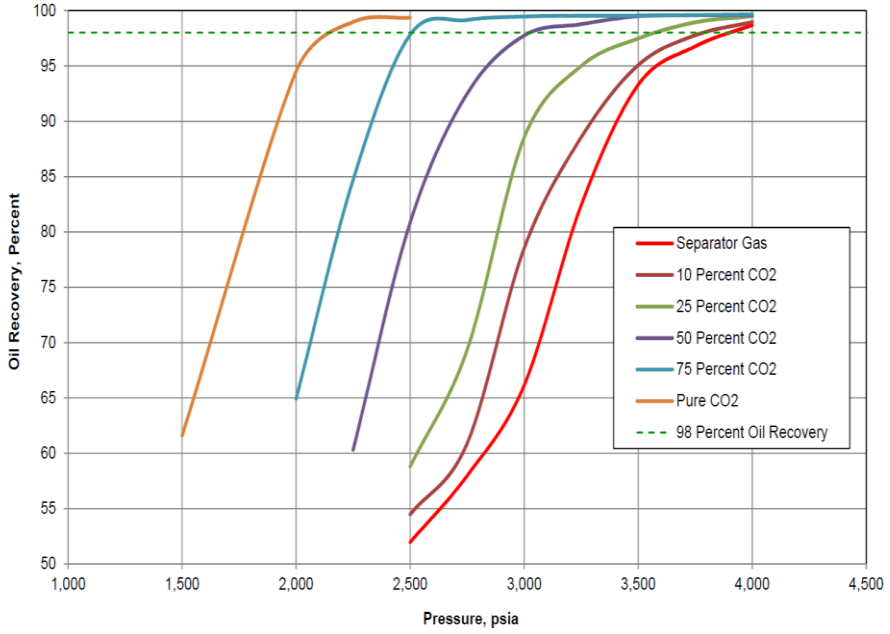
Objective

- Demonstrate the viability of applicable EOR process as an IOR technique using simulations
- Perform fit-for-purpose simulation studies on NK reservoir for EOR processes of miscible CO2 WAG and chemical flood
- Revise field pilot budget based on simulation results.

Preliminary Results from Sector Simulation Model Reservoir

Case Description	HCPV Injected Water	HCPV Injected Gas	Oil Recovery Factor (percent)
Depletion	-		13.2
Maximum Water Injection	1.79	-	35.9
Base Case Waterflood	1.02	-	28.4
Continued Gas Injection			
Pure CO2		1.60	45.1
25% CO2 and 75% Separator Gas		1.53	43.9
50% CO2 and 50% Separator Gas		1.61	42.9
WAG Injection			
One year CO2 and one year water[1]	0.40	0.34	33.5

HCPV - Hydrocarbon pore volume at reservoir conditions.
Minimum Oil Rate was 5,000 bbl/d.
[1]WAG injection started on Jan-1-2018 with one year of gas injection and one year of water injection.
Several more simulations are in progress, which consider different WAG ratio, IFT impact etc.



Pure CO2 Injection Case with Minimum BHP of 2,400 psia

- The slimtube simulation results suggest that the oil and CO2 would become miscible at the pressure of 2,400 psia.
- The oil recovery factor was estimated to be approximately 45.1 percent for the case with the maximum well GOR of 15,120 scf/bbl. The
- cumulative CO2 injection volume was estimated to be approximately 8.2×10^{12} scf for a (0.6 M Tons) period of 112 years, which was approximately 1.6 HCPV CO2 injected.
- For the case with the maximum GOR of 5,670 scf/bbl or 15 times as much as the initial solution GOR of the oil, the oil recovery of 28.9 percent was estimated by the sector model for a cumulative CO2 injection volume of 2.7×10^{12} scf (0.2 M Tons) for a period of 74 years, which was approximately 0.6 HCPV CO2 injected.

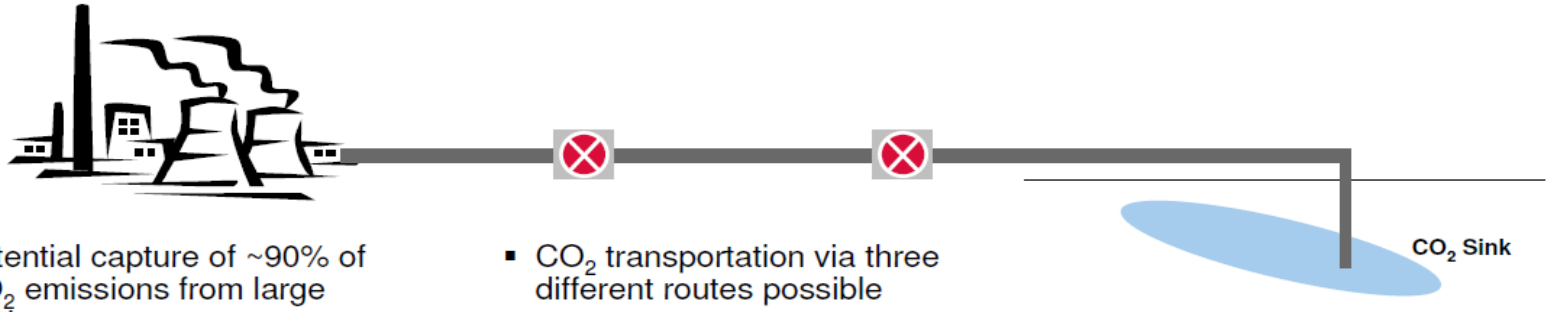
CO_2 Opportunities Plan
Short Term Plan : Pilot Implementation

	Short Term	Long Term
Opportunity	EOR Pilot	1. EOR & Field Implementation 2. CCS
Challenges	• Source and Volume of CO_2 • Where to start • Criteria for CO_2 • Economic Justification • Environmental	• Preparation of Reservoirs for CCS Once EOR option is depleted. • Source and Volume of CO_2 • CCS Roadmap • Capture Technology Advancement. • Environmental
Source of CO_2	PIC	PIC, KNPC, MEW
Volumes Available	600 Tons /D by 2013 500 Tons /D by 2014	3.3 M ton/D by 2030

CSS involves a collection of technologies for the capture, transport and storage of CO_2

Value Chain of CCS

Carbon Capture → **Transport** → **Sequestration**



- Potential capture of ~90% of CO_2 emissions from large stationary sources
- May be applied in the power, oil and gas, steel and cement industries
- Three technologies available
  - Post-combustion
  - Pre-combustion
  - Oxyfuel

- CO_2 transportation via three different routes possible
  - Pipeline (supercritical CO_2)
  - Ocean tankers (similar to LNG)
  - Railway or trucks (limited transport capacity - more suited to small scale pilots)

- CO_2 storage possible in different sinks
  - Oil and gas fields (depleted fields and during Enhanced Oil Recovery operations)
  - Coal seams
  - Saline aquifers
  - Deep ocean storage (environmental concerns)

A number of critical questions need to be answered to assess the potential deployment of CCS in Kuwait as of 2020

Determining Questions for the Implementation of CCS as of 2020

1 EOR Storage Potential	▪ What are the CO_2 injection requirements for oil fields? ▪ Can permanent storage be ensured in oil fields following EOR operations?
2 Emission Capture Potential	▪ Will sufficient emissions be available for capture, in the power and oil and gas sectors, for significant GHG abatement and to meet EOR requirements?
3 Availability of a Capture Technology	▪ Will a suitable capture technology be available at commercial scale to meet capture requirements?
4 Transport Solution	▪ What will be the preferred transport technology and what configuration will it take?
5 Economic Attractiveness	▪ Will the economics of integrated projects be attractive?
6 Regulatory Framework	▪ What regulatory framework elements are required at national level to support the implementation of CCS?

The implementation of CCS with EOR should follow a roadmap staged in three phases

HIGH LEVEL

CCS Roadmap

2010 — 2015 — 2020 — 2025 — 2030 →

	Preparation	Demonstration	Rollout
	♦ Formation of the CCS Steering Committee	♦ Demonstration capture and EOR storage	♦ Initial large scale deployments
Technology Development and Implementation	▪ Confirm the potential for permanent storage in EOR operations ▪ Confirm the economics of EOR operations (recovery rates, etc) ▪ Build "capture ready" capacity in the power generation sector ▪ Identify potential nominal point-to-point source to sink configurations ▪ Prepare for demonstration project	▪ Implement an integrated CCS demonstration project with EOR ▪ Integrate learnings and prepare for rollout at commercial scale ▪ Confirm main source to sink configurations ▪ Refurbish gas pipeline network to allow for CO_2 transport, if required	▪ Deploy integrated CCS-EOR projects focusing on one or two capture technologies at commercial scale ▪ Monitor to ensure permanent storage of CO_2 in EOR operations
Regulatory and Commercial Framework	▪ Form Steering Committee with joint KPC-MEW team to drive CCS ▪ Establish partnership with a capture technology provider for a demonstration of CCS/EOR ▪ Develop the regulatory framework required to enable CCS ▪ Appoint a regulatory entity to oversee the CCS sector	▪ Define business models (e.g. EOR-sink vs integrator) and main terms at interfaces ▪ Develop and enact the required legislation at national level, especially regarding storage liability ▪ Develop template contracts across entities to deal with interface issues (KPC internal divisions, MEW, etc)	▪ Realize EOR cost offset benefits ▪ Pursue CDM opportunities if applicable(1)

THANK YOU