EOR and IOR in the Middle East

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إستشارة و إدارة مشاريع الطاقة






Agenda

1) **EOR and IOR in the Middle East**

2) Case Studies: Oman and Bahrain

3) Carbon Capture in the Middle East

4) Challenges of EOR in the Middle East

Introduction

- Enhanced oil recovery tackles three major challenges:
  - Increasing maturity of fields, with large volumes of non-recovered oil
  - Shift towards technically / geographically / politically risky projects
  - Need to reduce CO_2 emissions

- Mature fields account for over 70% of the world's oil and gas production, with many in the secondary or tertiary production phases.

- The average recovery factor for gas is 70% and for oil is only 35%.

- Every percentage point increase in recovery could generate a two year global supply of hydrocarbons.

- Middle East countries are increasingly struggling to meet gas demand for reinjection:
  - Gas demand for re-injection in the UAE is expected to grow from around 18 bcm in 2008 to approximately 45 bcm by 2020
  - To a lesser extent, Oman and Qatar also face an increase in gas demand for re-injection
  - Gas is also required for steam generation (Oman)

We have run out of oil many times already…

1885
"The amazing exhibition of oil [is] a temporary and vanishing phenomenon - one which young men will see to come to its natural end."
State Geologist of Pennsylvania

1943
"Ultimate global recovery 600 billion bbl Wallace Pratt, Standard Oil"
(Total to 2008 ~1100 billion)

1977
"*We could use up all of the proven reserves of oil in the entire world by the end of the next decade*"
Jimmy Carter

1989
"Global production has peaked"
Colin Campbell

1919
"World oil production to peak by 1928"
David White, USGS

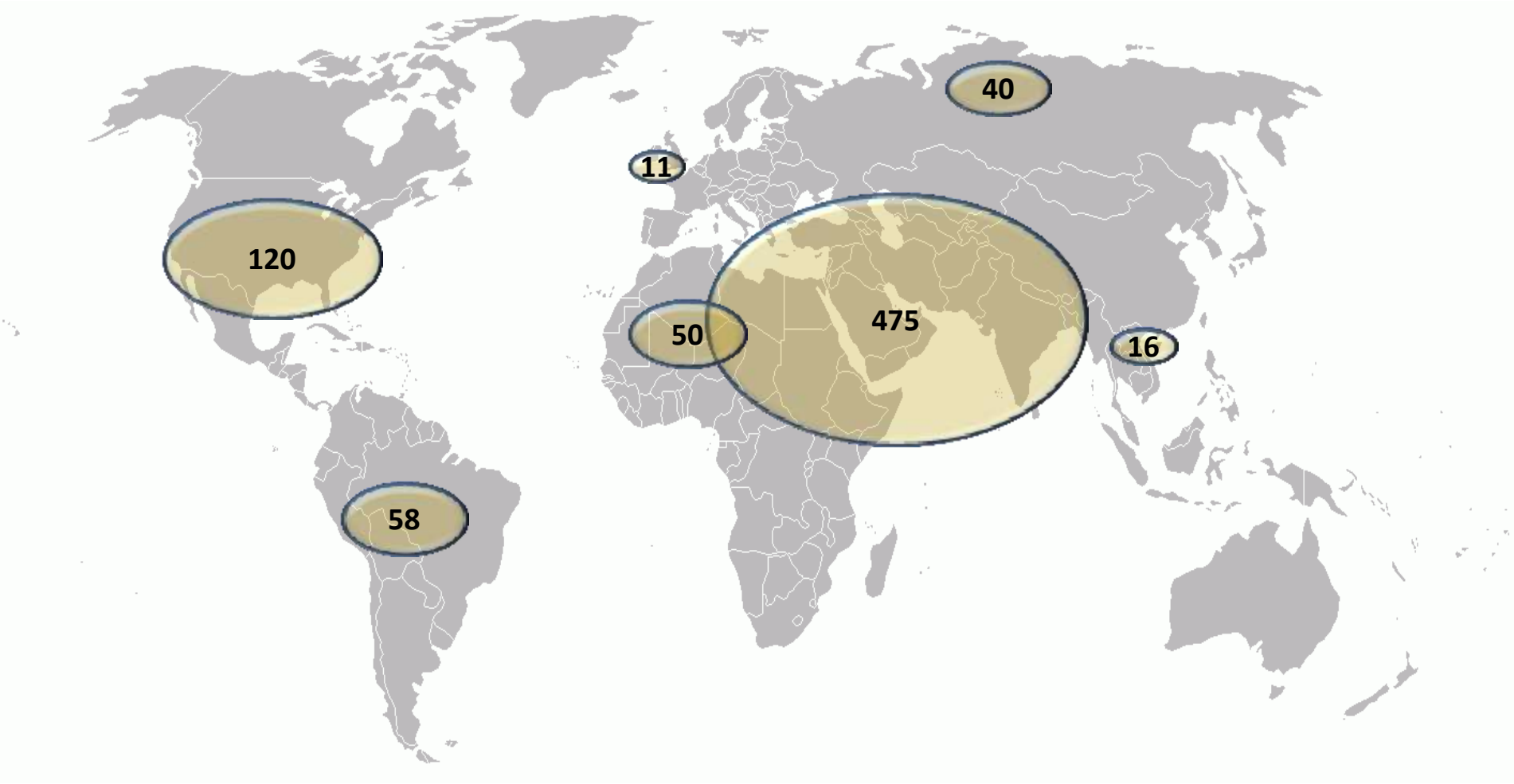
1956
"Global production to peak 1995-2000 at 33 million bbl/day"
M. King Hubbert, Shell

1980
"*…world production of oil probably will begin to decline in the mid 1980's*"
US Government

2005
"Peak will be December 16th, 2005"
Kenneth Deffeyes,

2008
"The world needs to increase current production by 45 million barrels per day just to keep pace with current levels of demand. That means bringing four new Saudi Arabias on stream between now and 2030" EIA

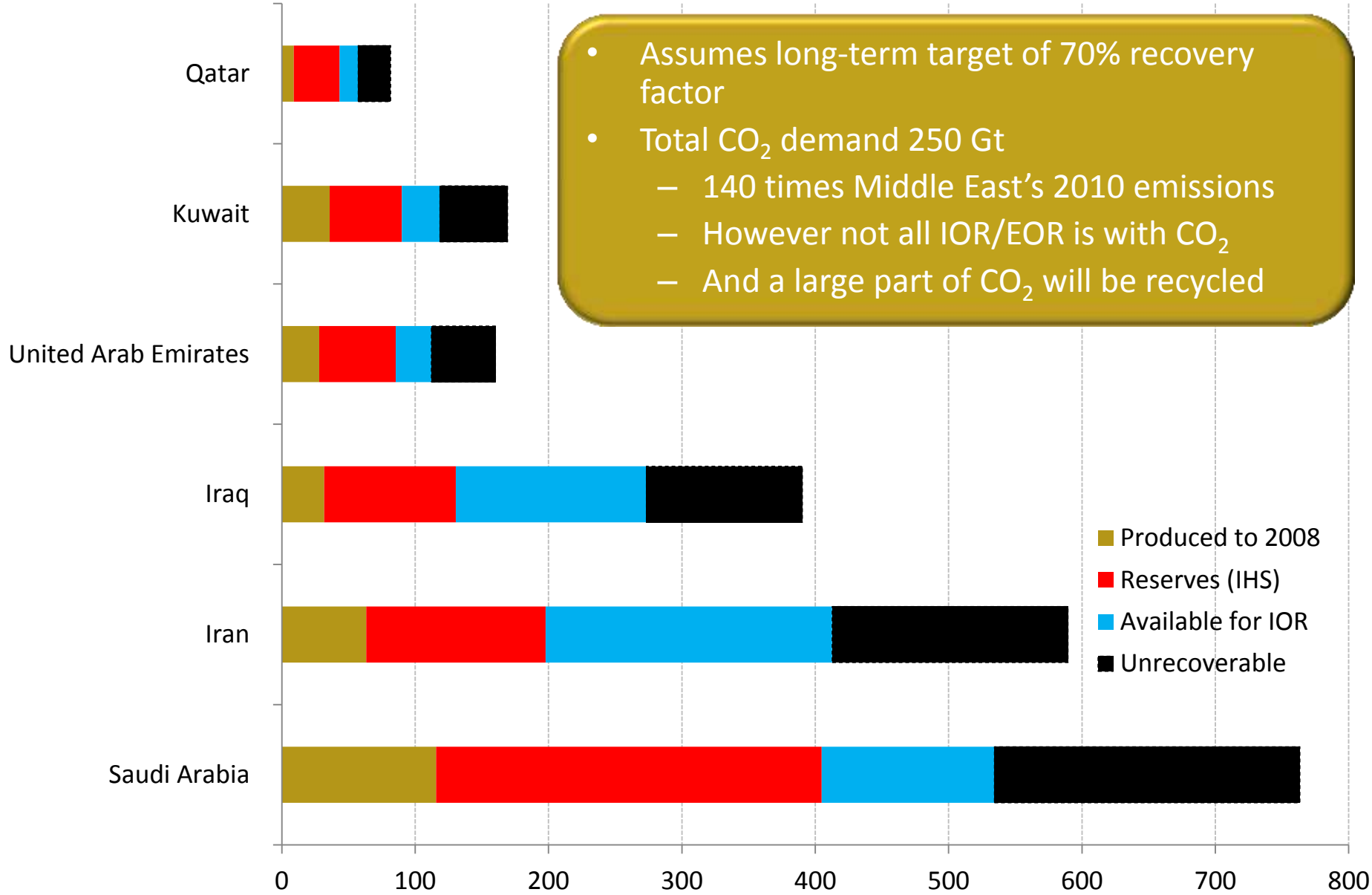
Global EOR potential (bln barrels)



Middle East has by far the world's largest EOR potential

Source: Society of Petroleum Engineers

The size of the prize: >500 billion bbl for IOR in the Middle East?



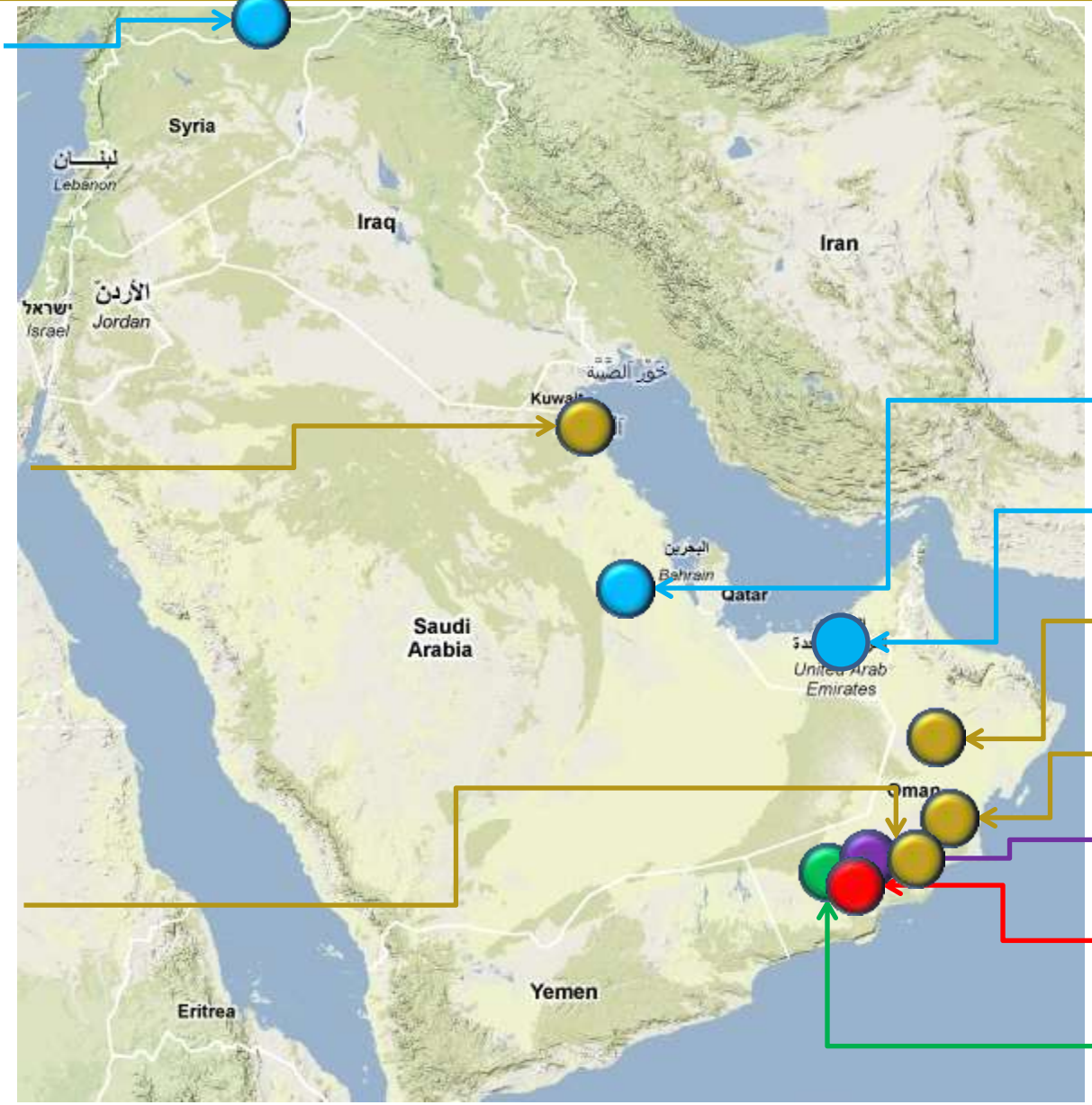
- Assumes long-term target of 70% recovery factor
- Total CO_2 demand 250 Gt
  - 140 times Middle East's 2010 emissions
  - However not all IOR/EOR is with CO_2
  - And a large part of CO_2 will be recycled

EOR: Current Projects

Bati Raman
CO_2-EOR

Wafra
Steam flood

Amal
Steam
injection



Current projects

Ghawar CO_2-EOR trial

Masdar
CO_2-EOR

Qarn Alam
Thermal GOGD

Mukhaizna
steam flood

Marmul polymers

Nimr in-situ
combustion

South Oman
miscible gas

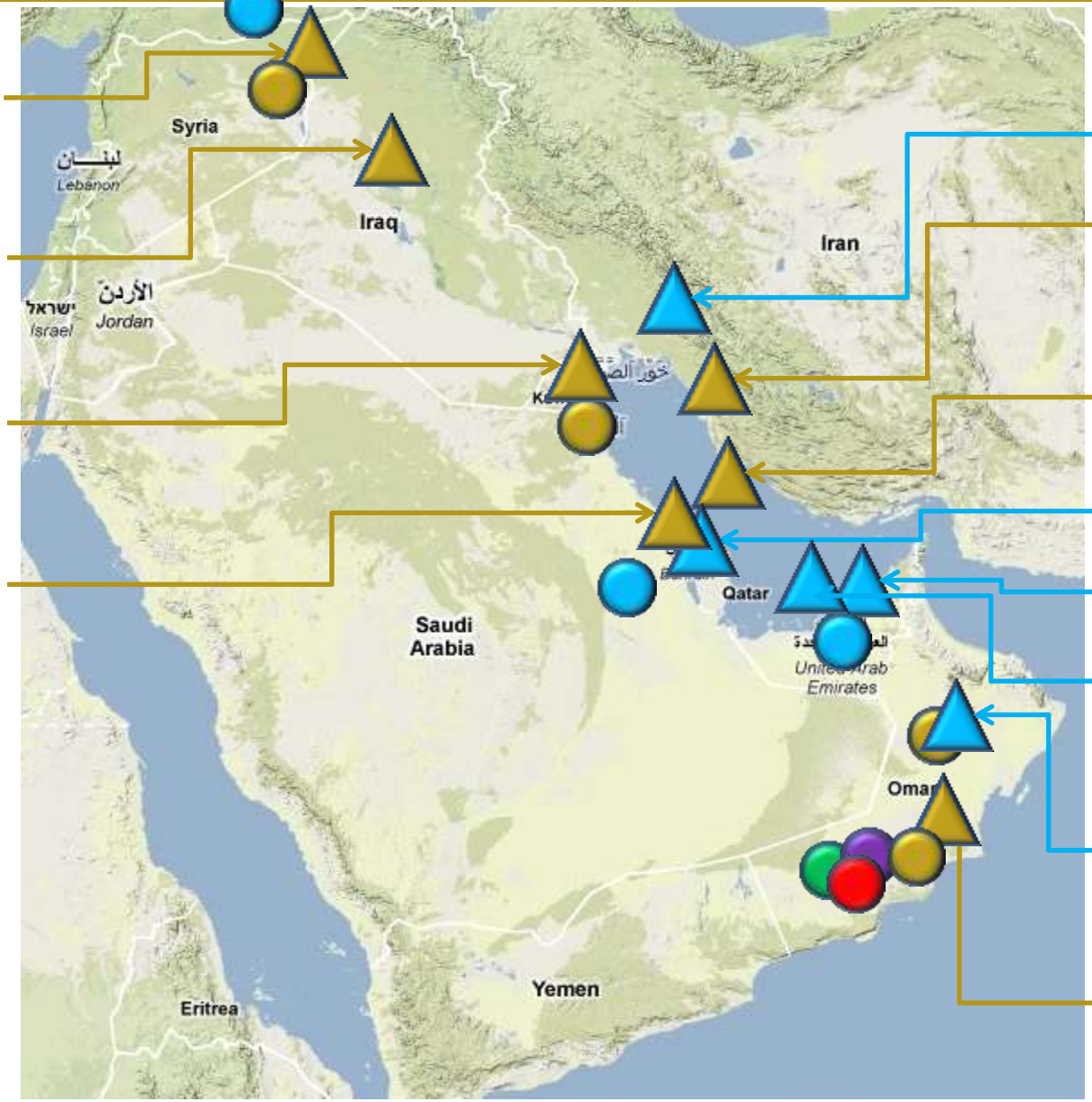
EOR: Future Potential

Suwaidiyah
Steam flood

Najmah / Qaiyarah
Steam flood

Lower Fars
Steam flood

Bahrain
Steam flood



Iran CO_2-EOR

Kuh-e Mand
Steam flood

Farsi / Golshan
Steam flood

Qatar CO_2-EOR

Dubai CO_2-EOR

Abu Dhabi offshore
Chemical EOR

North Oman
CO_2-EOR

Block 54
steam flood

Current projects

Future potential

Technical challenges in typical Middle Eastern reservoirs

- Heavy oil resources in the Middle East are generally found in carbonate reservoirs; highly heterogeneous
- Many carbonate formations are fractured; complicating flow in reservoirs.
- EOR (steam, CO_2, miscible gas) in carbonates requires a good understanding of the fracture network, which itself is a major technical challenge.
- The fracture network can sometimes enhance the efficiency of steam injection by aiding the heating of the oil; it can also detract from the EOR process by allowing steam to bypass much of the oil.
- The fracture network can change as a result of production, such as the closing of fractures.

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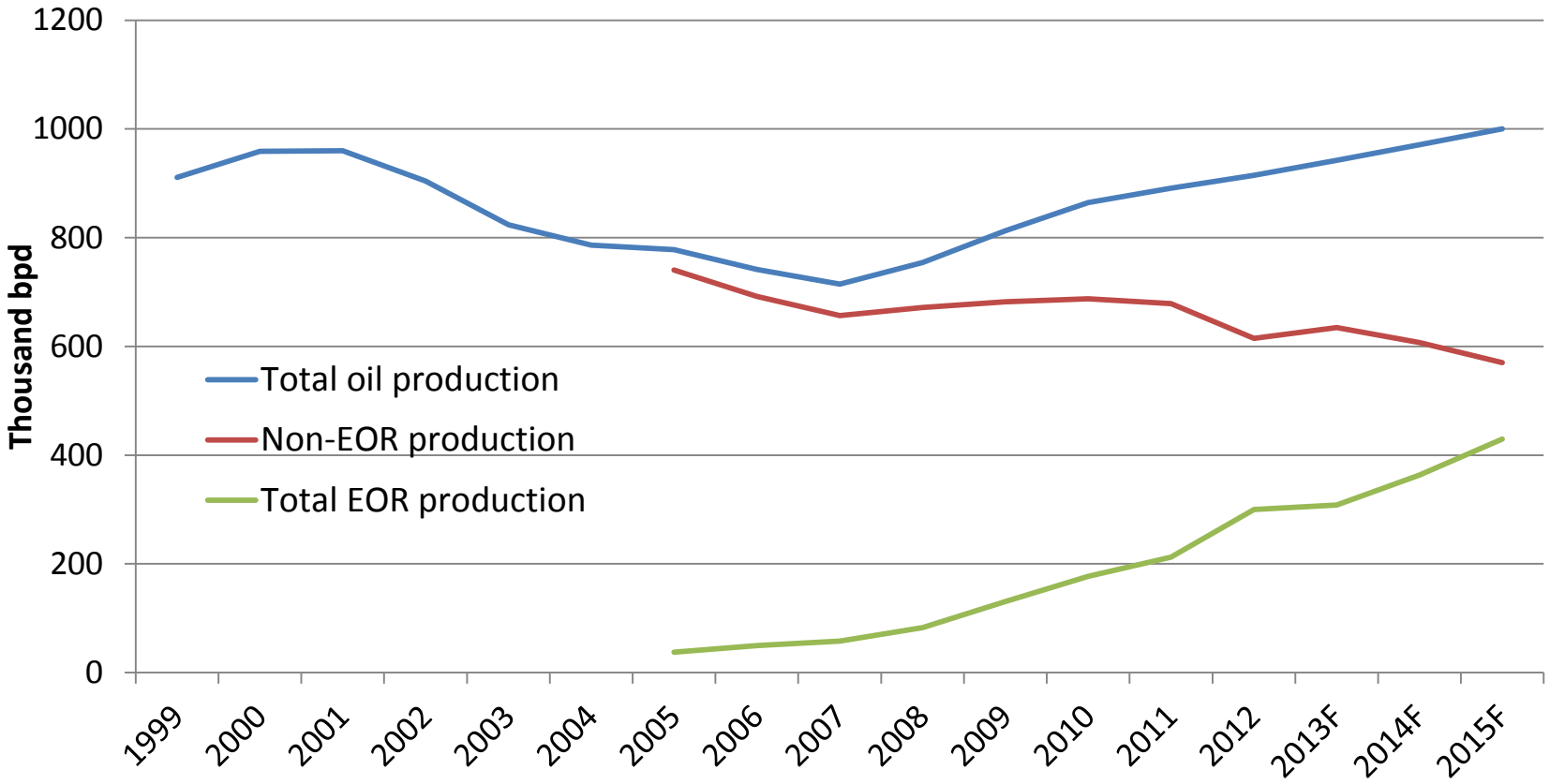
PDO's forecasted portfolio of future oil and gas extraction techniques

- Thermal EOR: increase production at both Amal-East & Amal-West to 23,000 bbl/d by 2018
- Steam injection: increase production at Qarn Alam 40,000 bbl/d by 2015
- In-situ combustion: increase production at Nimir to 35,000 bbl/d in the short-term
- Miscible gas: increase production at the Harweel Cluster by 100,000 bbl/d by 2016

"Chemical EOR is the future"- John Malcolm, PDO's Managing Director

Source: PDO Annual Report, 2010

Oman increasing oil production from EOR

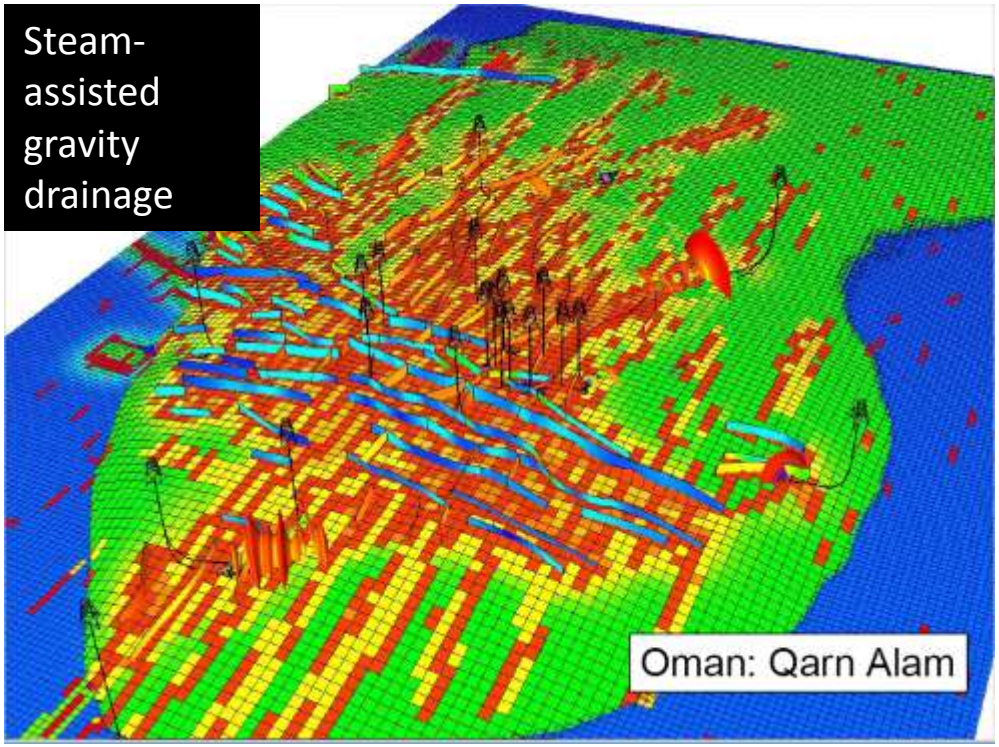


- Between 2001 and 2007 Oman's oil production fell by 27%, but by 2012, due mostly to EOR projects, oil production had increased by 28%.
- In 2012, Harweel EOR project added approximately 30,000 bbl/d to production.

Case Study: Qarn Alam, Oman

- 1.35 billion bbl in place
- 16° API, 220 cp oil
- Heavily fractured carbonates
- Primary recovery factor 4%

- Plan to initiate steam-assisted gravity drainage
- Oil drains from matrix via fractures to producing wells
- Recovery factor with steam-flood 32%+
- 149 new wells
- Plateau production 30 000 bbl/day



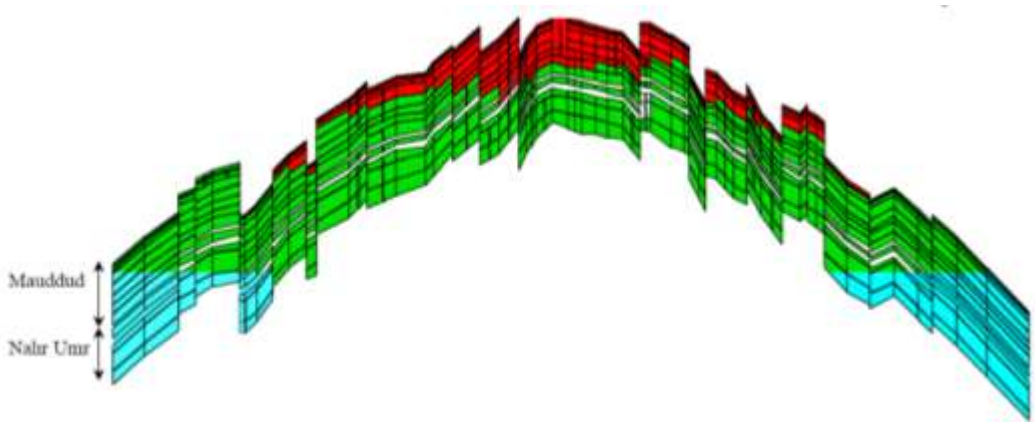
Oman: Solar thermal EOR process

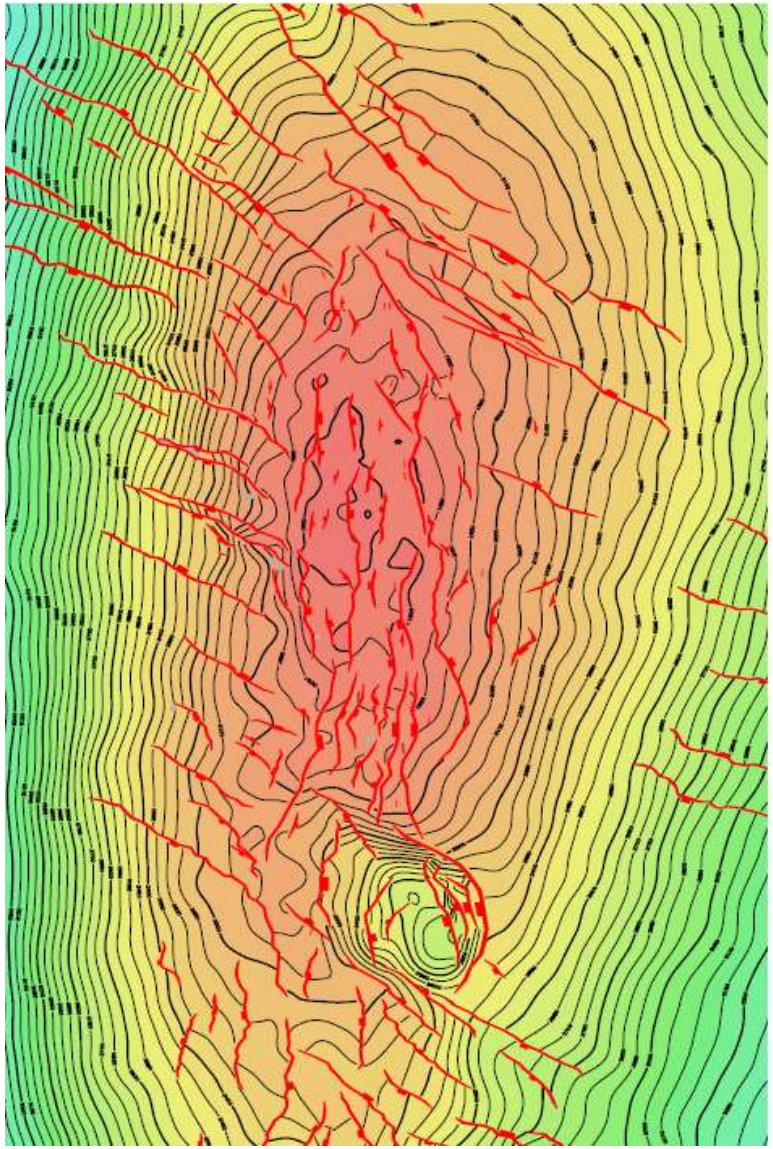
- Oman is building the first solar-enhanced EOR recovery pilot in the Middle East
- 7 MW solar EOR system for PDO
- The solar EOR will use concentrated thermal energy from the sun to heat water and generate steam which is then injected into an oil reservoir
- The goal of solar EOR is to reduce the amount of natural gas burned for thermal EOR, utilizing gas for higher value applications such as power generation, desalination, industrial development and export
- It can reduce the amount of natural gas used for EOR by 80%
- Cost of solar EOR scheme is equivalent to $3/MMBtu gas price

Plan for Oman's solar EOR project

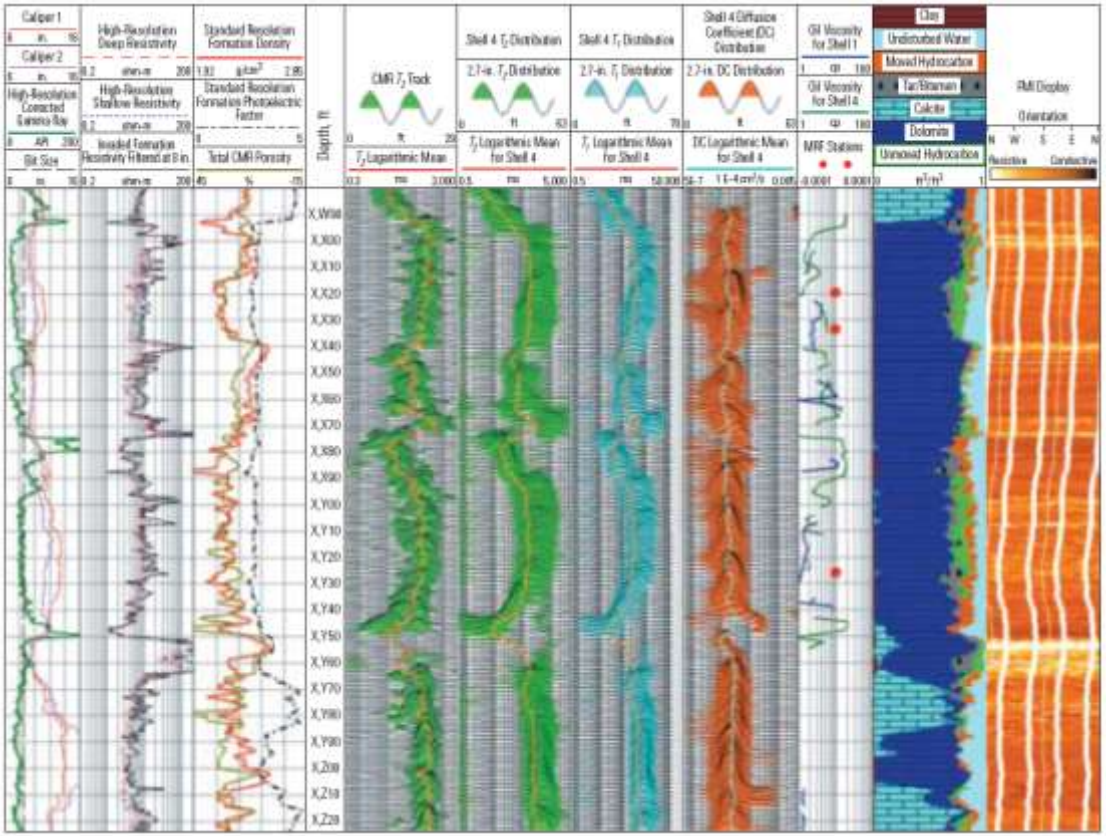
Mature Field Management: Bahrain

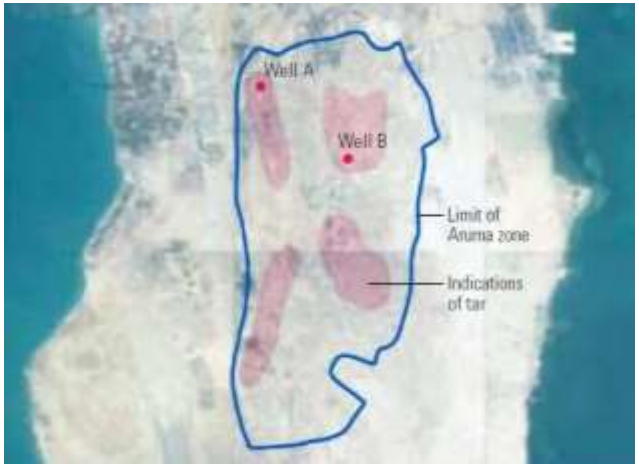
- The largest part of increased Middle East oil recovery is not exotic EOR methods, but industry best practices from elsewhere
  - 3D seismic
  - High-resolution sequence stratigraphy
  - Modelling of natural fractures
  - Horizontal and multilateral wells
  - Water handling
  - Integrated reservoir simulation
  - Waterflood optimisation
  - Developing bypassed pay and minor reservoirs





Heavy oil: Bahrain Field, Aruma Zone





- Older interpretations suggested Aruma zone heavy oil had viscosity 20000 cp
- Integration of NMR logs with image logs, drilling data and fluid samples revealed presence of producible oil (5 cP)

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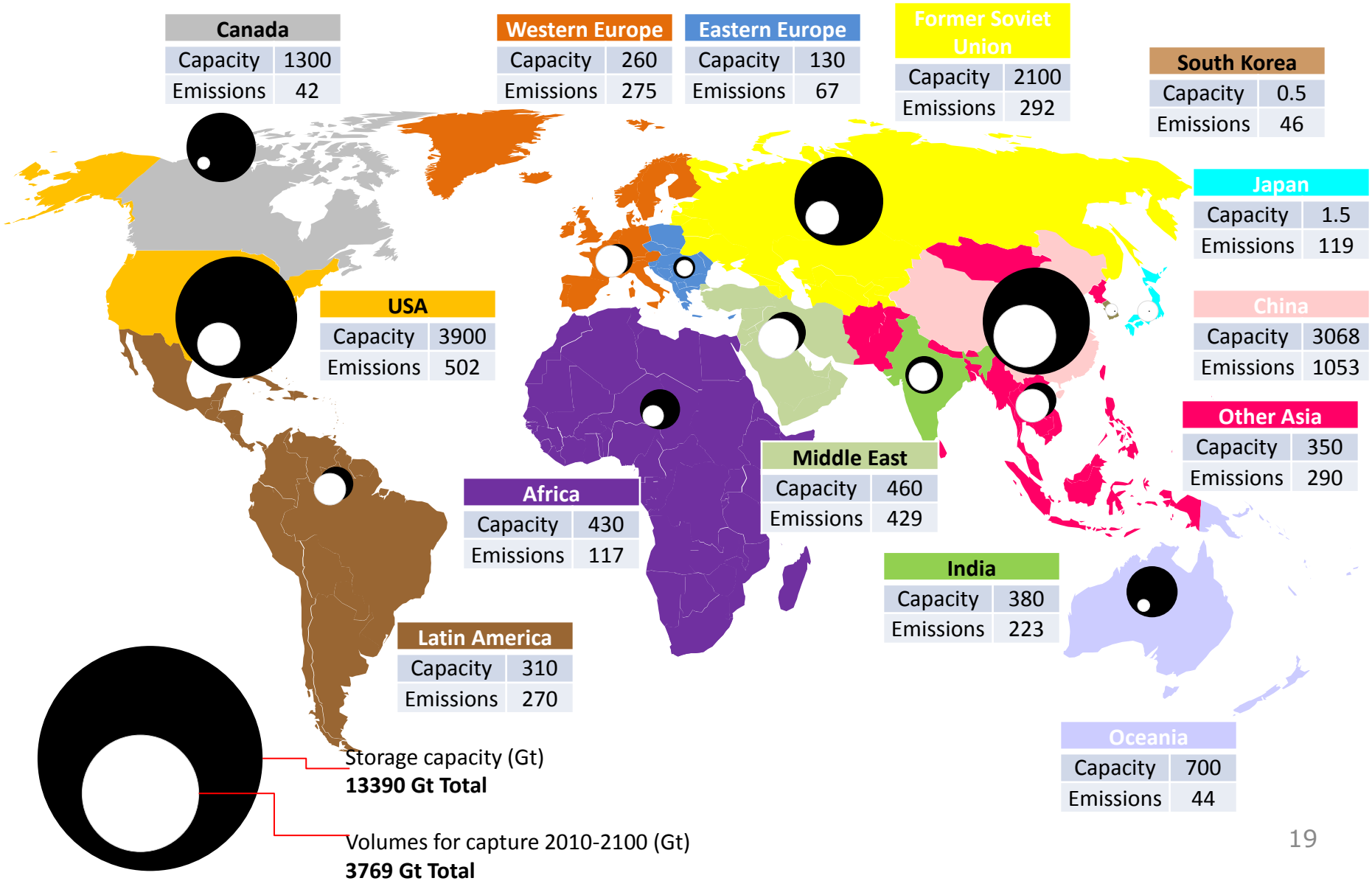
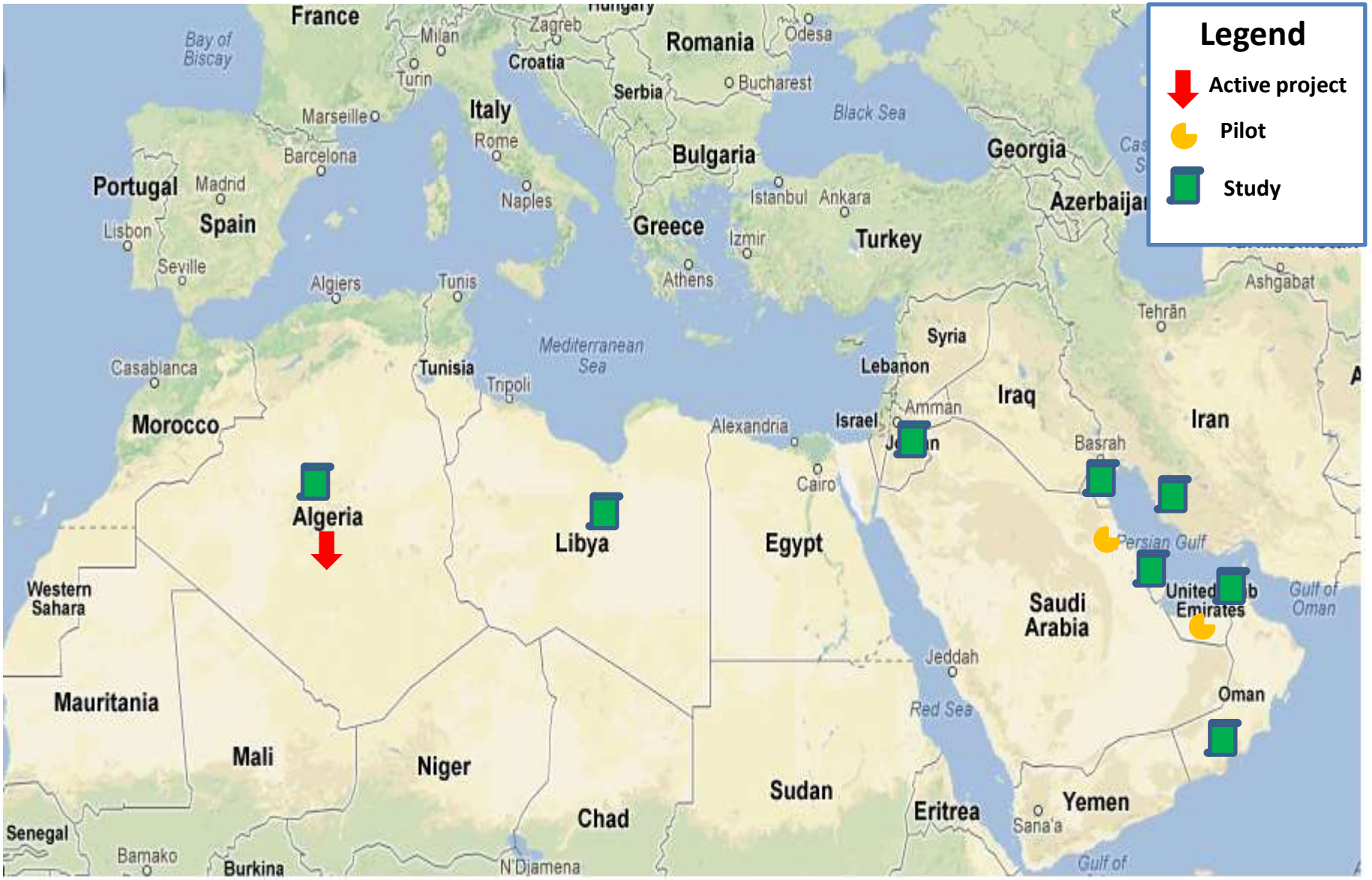
CO_2-EOR

- Growing interest in CO_2-EOR in the Middle East
- Masdar-Hydrogen Energy (BP/Rio Tinto) project in Abu Dhabi
  - CO_2 capture from a natural gas fired pre-combustion capture power plant
  - CO_2 used for EOR in Abu Dhabi's oil fields, displacing valuable natural gas currently used for reinjection
  - Some commercial obstacles
- Proposed trial in the world's largest oil-field, Ghawar (Saudi Arabia)
- Some interest in Qatar (CO_2 from GtL plants) and Oman (from coal power)

Storage capacity versus emissions



MENA CCS projects



Importance of carbon capture & storage

Good for Middle East	Bad for Middle East
Creates ‘carbon space’ for oil and gas exports	Supports continuing coal use
Potential for EOR in Middle East	Potential for EOR outside Middle East
Can displace gas used for reinjection	Can make high-carbon unconventional oil more acceptable (oil sands, coal-to-liquids)
Important to reduce carbon footprint of gas-to-liquids plants	Reduces ‘carbon leakage’ effect
Reduces future CO_2 mitigation costs	

Drivers and blockers for MENA CCS

Drivers	Blockers
Growing environmental awareness	Environmental awareness still limited
Substantial oil & gas experience	Limited CCS expertise
Large, low-cost EOR potential	Larger producers do not need EOR yet
Replacement for gas used for pressure maintenance	National oil companies are technically conservative
CO_2 storage in deserts/offshore, remote from habitation	Low, subsidised energy prices
Public acceptance of oil industry	Limited institutional capability
Terrain straightforward for CCS pipelines (mostly flat desert)	(In some countries) conflict and international sanctions
Ample storage space	General global issues: lack of carbon price; technological uncertainty; high cost

Ranking of MENA countries by promise for CCS

Country	Environmental commitment	Investment climate	CCS capability	CO_2-EOR importance	CO_2 capture potential	Transport	Overall
UAE	1	1	2	1	2	3	**1**
Qatar	3	3	8	3	1	4	**2**
Bahrain	5	2	5	4	6	1	**3**
Oman	2	4	3	2	8	5	**3**
Algeria	6	7	1	5	5	11	**5**
Saudi Arabia	7	6	4	10	3	6	**6**
Kuwait	8	9	5	9	9	2	**7**
Egypt	4	5	9	8	7	10	**8**
Libya	10	8	7	7	10	7	**9**
Iran	9	11	10	6	4	9	**10**
Iraq	11	10	11	11	11	8	**11**

Ranking is subjective

Findings on CCS

- Impact of CCS on the Middle East is complex and country-specific
  - Probably negative in the short term, but increasingly positive and important in the longer term
  - CCS is a vital part of making oil & gas part of a sustainable energy future
  - Impacts vary greatly depending on the country considered
  - UAE, Qatar, Bahrain, Oman currently appear most promising MENA countries for CCS
- MENA is badly under-represented in global CCS projects
  - Lack of institutional capacity; environmental awareness; funding; etc
- Need for more cooperation of MENA countries with major CCS centres worldwide (Australia (e.g. GCCSI), US, Canada, EU (e.g. ZEP), etc)
  - Research on specific MENA issues (e.g. EOR in carbonate reservoirs; CCS on gas-fired plants; industrial processes e.g. GTL)
  - Joint demonstration projects

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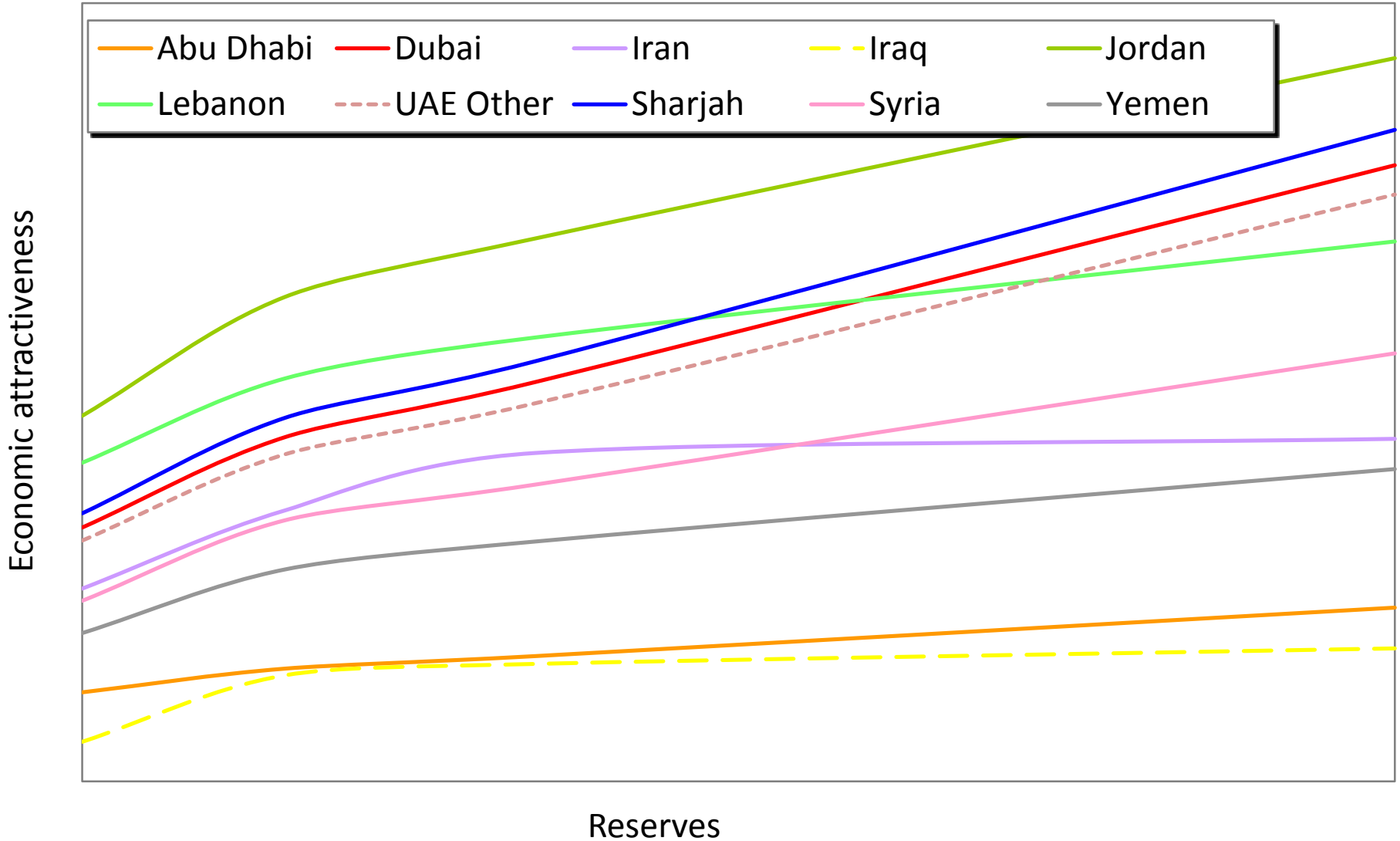
Technical challenges are different between Middle Eastern countries

	Iran	Iraq	KSA	UAE	Kuwait	Bahrain	Qatar	Oman	Yemen	Syria
Water handling	✓	✓	✓		✓	✓		✓		✓
Heavy oil	✓	✓	✓		✓	✓		✓		✓
Reservoir management	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Secondary recovery	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
EOR			✓	✓		✓	✓	✓		
GOGD	✓	✓						✓		
Complex geology			✓					✓	✓	
Tight gas			✓		✓			✓		
Sour gas	✓			✓			✓	✓		

- Dominance of single-country NOCs, political barriers and isolation of some countries leads to a degree of ‘re-inventing the wheel’
- However, there are increasingly lively fora for knowledge-sharing across the Middle East

Fiscal Terms in the Middle East

- Middle East fiscal terms are often too tough and regressive to incentivise improved oil recovery



EOR Investment Conditions in the Middle East

- Limits to technical capabilities of IOCs and NOCs
- Barriers to best-practice sharing
- Tough investment conditions for IOCs
  - Current fiscal terms – regressive, penalise risk-taking
  - Dominant NOCs
  - Lack of small, entrepreneurial independent IOCs
- How competitive will EOR oil be against unconventionals (shale oil)?
- Will CO_2-EOR get sufficient boost from environmental advantages?
- Need for fresh thinking
  - Oman today
  - Perhaps UAE, Qatar, Saudi Arabia tomorrow