

“Deployment of Carbon Capture, Use and Storage in the Arab Region:
Challenges and Opportunities”
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CCUS in GCC: Economic, Institutional Drivers and Potential Development Paths Post COP22

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- Status brief of CCUS in GCC
- GCC INDCs
- Economic diversification in GCC
- Affecting Factors
 - Institutions
 - Operation systems
 - Competing & future technologies
- Potential Development Paths of CCUS in GCC
- Conclusion

Large Scale CCS Projects in GCC

- Large Scale CCS projects

Project name	Country	Operation date	Source	Capture type	Capture capacity (Mtpa)	Transport type	Use
Uthmaniyah CO ₂ -EOR Project	Saudi Arabia	2015	Natural Gas Processing	Pre-combustion capture	0.8	Pipeline	EOR
Abu Dhabi ESI CCUS Project	UAE	2016	Iron and Steel Production	Industrial Separation	0.8	Pipeline	EOR

- CO2 Use project

Project name	Location	Stage	Capture Capacity (Mtpa)	Use
SABIC Carbon Capture and Utilisation Project	Saudi Arabia	Operational	~0.5	Mainly methanol and urea, with a portion of purified CO ₂ available for the food and beverage industry

Source: GCCSI

Regulatory domain	Bahrain	Kuwait	Oman	Qatar	KSA	UAE
CO ₂ classification	X	X	X	X	X	X
Ownership of surface facility		X		X	X	
Transboundary CO ₂	X	X	X	X	X	X
EIA						
CO ₂ impurity	X	X	X	X	X	X
CO ₂ capture regulation		X		X	X	
CO ₂ transportation regulation		X		X	X	
CO ₂ storage regulation*	X	X	X	X	X	X
Liability during the post-closure period	X	X	X	X	X	X
Regulation for CCS with EOR	X	X	X	X	X	X
Incentives			X			

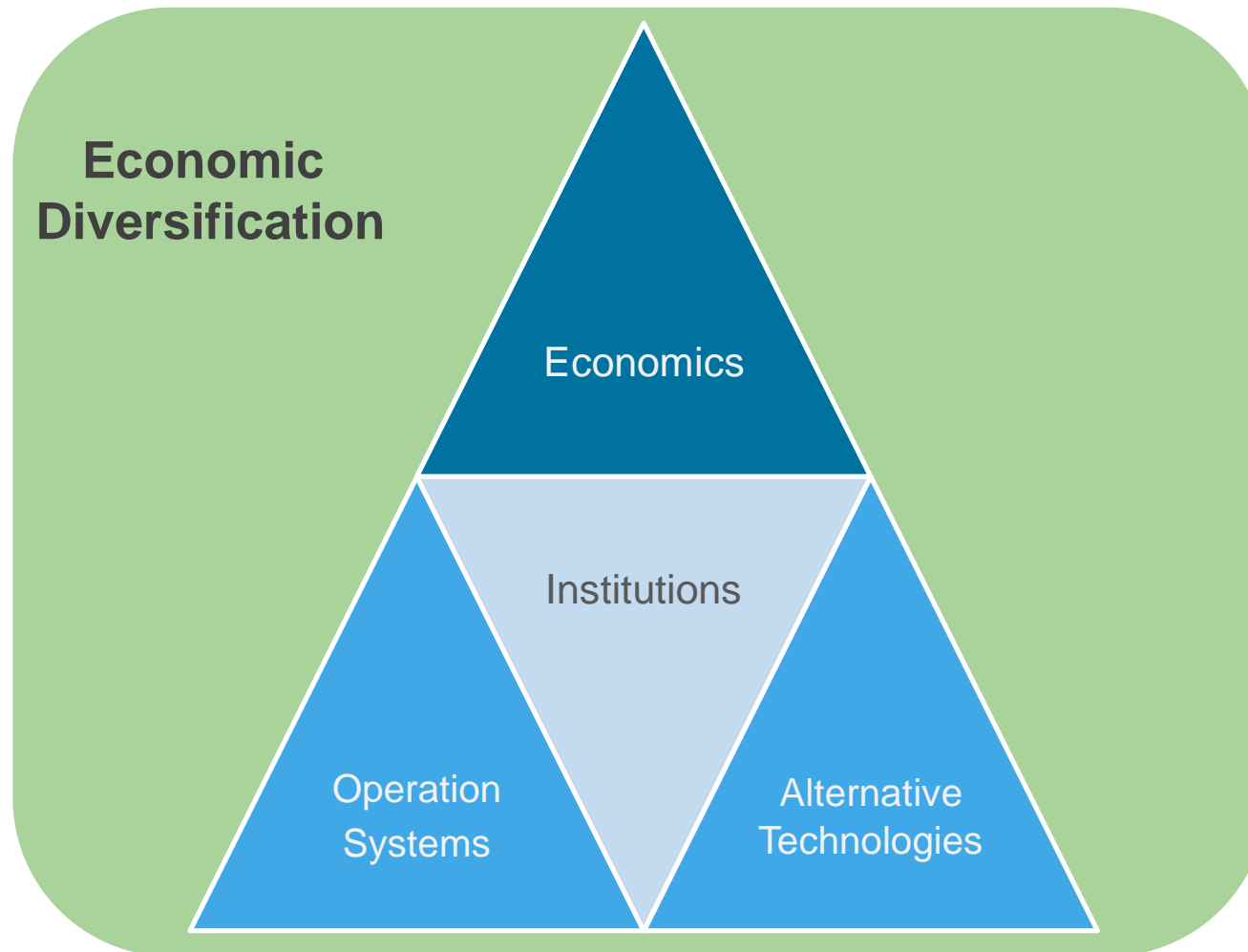
- Little (or no) progress after Nov 2013 review.
- Kuwait Environmental Protection (EP) Law No. 42 of 2014 includes GHG as subject of regulation, enacting a EP funds under EPA (not specific to climate action). No classification of GHG.

- Inclusion of CCUS as mitigation measures:

Country	CCS	CO ₂ -EOR
Bahrain	X	
Kuwait		
Oman	X	
Qatar		
Saudi Arabia	X	X
UAE		X

- INDCs proposed before COP21; CCS accepted as part of future CDM during COP22.
- Bahrain, Qatar, Saudi Arabia, and UAE emphasized **Decision 24/CP.18: “Economic diversification with mitigation co-benefits”** as central pillar of climate action.
- All emphasized financial, technology transfer and capacity building.
 - Saudi Arabia: CCUS technology development as a response measure.

- Prospective of CCUS in GCC?



Country	Plan	Diversification strategy summary
Bahrain	Economic Vision 2030	<ul style="list-style-type: none"> ▪ Support of private sector and attracting foreign direct investment. ▪ Declining role of government in many industries other than education and health.
Kuwait	State Vision 2035	<ul style="list-style-type: none"> ▪ Envisages government-led investment in infrastructure, transportation means and trade facilities. ▪ Necessity of institutional reform is mentioned
Oman	Vision 2020	<ul style="list-style-type: none"> ▪ Diversification and industrialisation into logistics infrastructure and new manufacturing industries. ▪ Privatising poorly performing state-owned enterprises (SOEs) and lessening the role and effect of the oil industry.
Qatar	National Vision 2030	<ul style="list-style-type: none"> ▪ Extending investment in infrastructure, oil and gas, and other traditional industries such as aluminium, steel and petrochemicals. ▪ Gradual and careful diversification is envisaged.
Saudi Arabia	Long-term Strategy 2024	<ul style="list-style-type: none"> ▪ Increasing role is planned for the private sector while the government will keep investing into oil, petrochemicals and some other related industries.
UAE	Vision 2021	<ul style="list-style-type: none"> ▪ Government led diversification plan from finance to tourism to manufacturing industries. ▪ Plans for investment to infrastructure and logistic sectors to attract foreign expertise and capital.

■ Drivers:

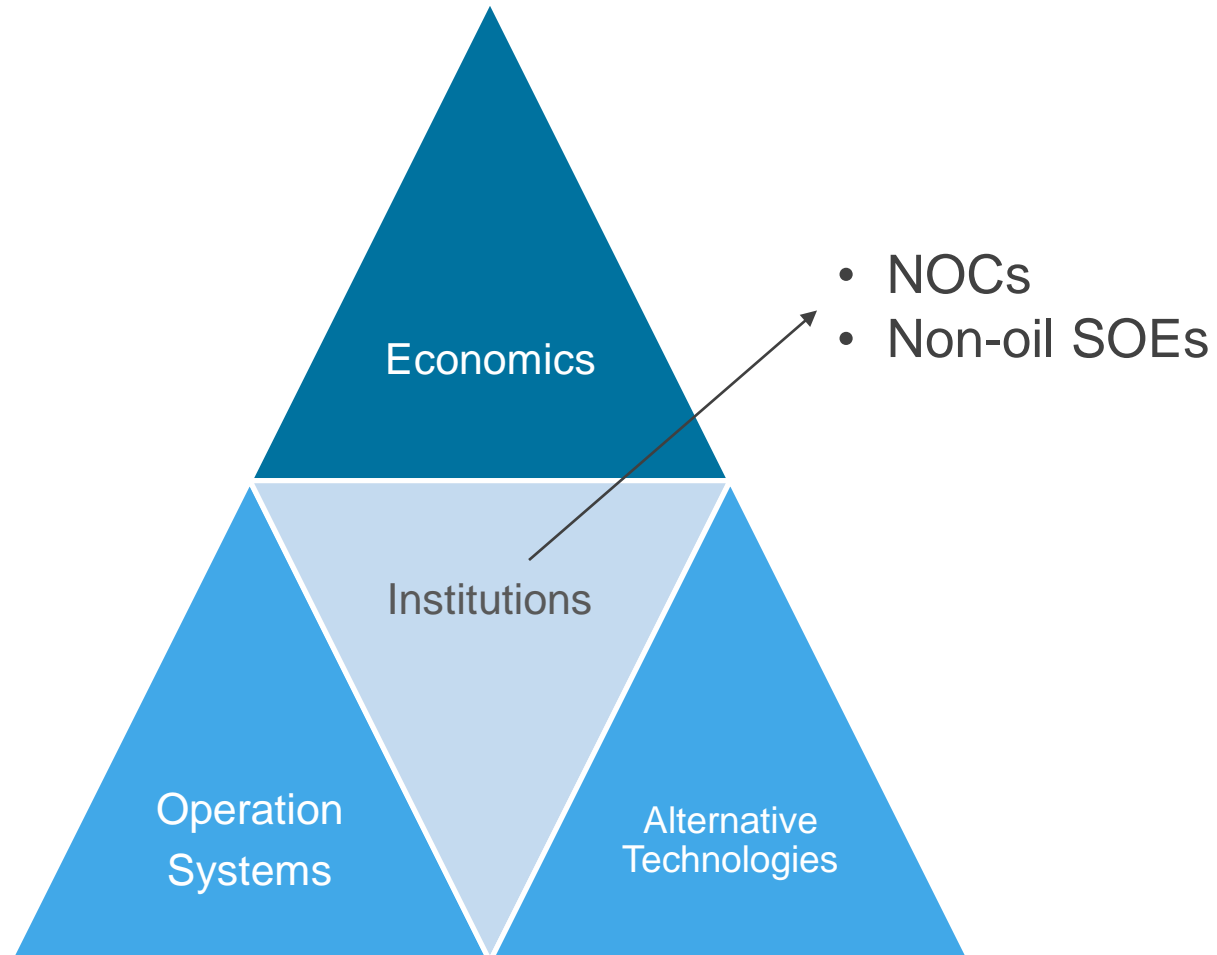
- Advancement of unconventional fossil fuel (e.g. shale oil/gas) and renewables.
- Depletion of easy oil in ME.

■ Strategies:

- Pre-2000's: vertical diversification of oil sector (e.g. petrochemical).
- Post-2000's: horizontal diversification into non-oil sectors.

■ Approaches:

- State owned enterprises (SOEs)
 - Developed as industry champion, de facto natural monopoly.
 - Targeting capital-intensive & lower risk sectors.
- Privatization
 - State-sponsored funding for private business entities.
 - Primarily asset light, higher risk and knowledge-intensive sectors.



- **Contemporary drivers of institutional setting:**
 - Creating jobs for nationals
 - Advancing endogenous R&D capacity
- **Institutional settings critical to CCUS:**
 - State ownership of strategic asset (oil and gas).
 - Underground pore holes and surface infrastructure also mostly state owned.
- **New development:**
 - SOEs expanding to non-oil sectors, providing non-oil jobs for nationals.
 - Non-oil SOEs-local research institute collaboration is cultivating local R&D capacity.
 - Non-oil SOEs, as industry monopoly, become main sources of industrial CO₂.
- **Implications:**
 - Dominating role of the state in the entire CO₂-EOR value chain (from source to sink).

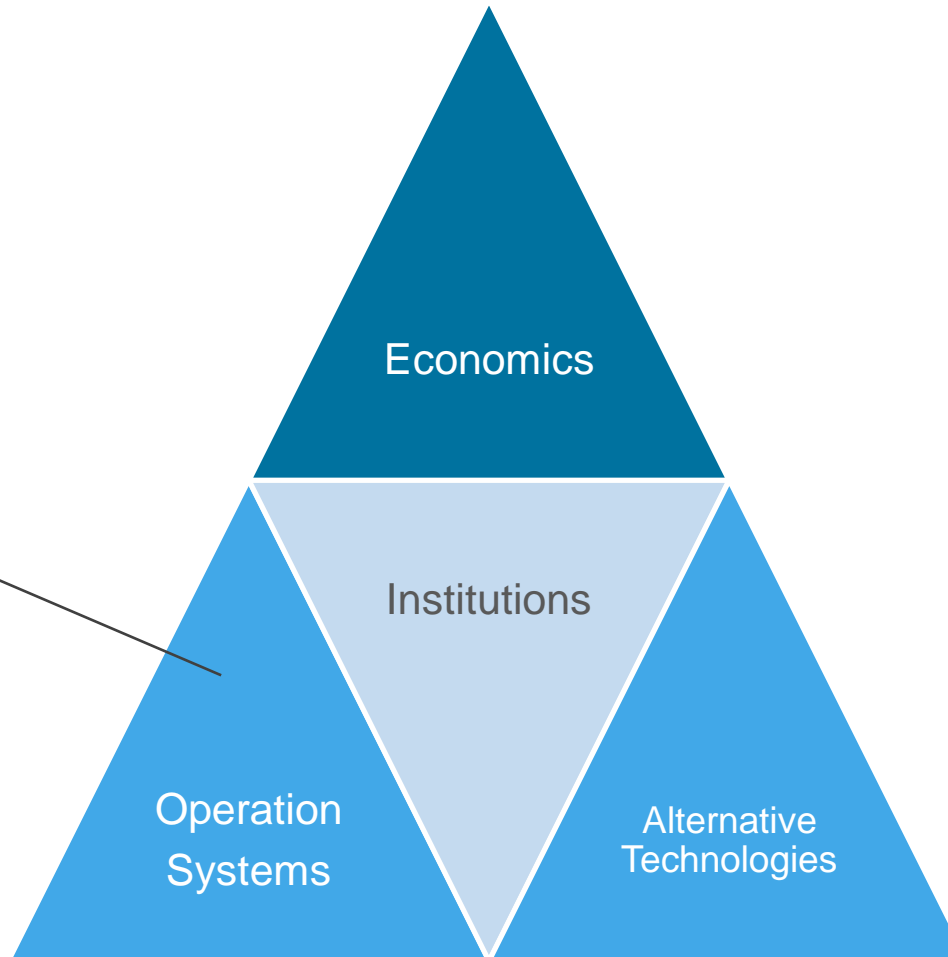
Oil and Gas legislations in GCC

Country	Sectors under state control by law	Related laws and decrees
Bahrain	Oil and gas exploration, production, distribution	Regulated by National Oil and Gas Authority (NOGA). Key parties include state owned Bapco, Tatweer Petroleum (JV), BANAGAS and GPIC.
Kuwait	Oil and gas exploration, production, distribution, refinery and selling of petroleum products	Regulated by the Ministry of Oil. Article 3 of Law No. 6 entrusts state-owned Kuwait Petroleum Corporation for all oil and gas related activities
Oman	Oil and gas exploration, production, distribution	Regulated by Ministry of Oil and Gas following Sultani Decree 8/2011 (Oil and Gas Law). State-owned companies play major role in producing Oman's oil and gas, private sector actively engaged by government. Key parties include state-owned Oman Oil Company, Oman Gas Company, Oman LNG, PDO, and ORPIC.
Qatar	Oil and gas exploration, production, distribution, refinery and selling of petroleum products	Regulated by the Ministry of Energy and Industry under Laws No. 3, 4, 8, 10, 15, 30. Except for Dolphin Pipeline, oil and gas businesses in Qatar are operated by state-owned Qatar Petroleum, with foreign firms subject to Amiri Decree.
SAUDI ARABIA	Oil and gas exploration, production, distribution, refinery and selling of petroleum products	In the absence of explicit law, state-owned Saudi Aramco has the sole concession for oil and gas extraction, process, transportation and selling. Since 2015 Saudi Aramco is no longer overseen by the Ministry of Petroleum.
UAE	Oil and gas exploration, production, distribution, refinery and selling of petroleum products	No federal law in UAE on oil and gas. Emirate of Abu Dhabi has laws that grant all rights of oil and gas activities to state-owned ADNOC subject to regulation by the Supreme Petroleum Council. Similar practice in Dubai.

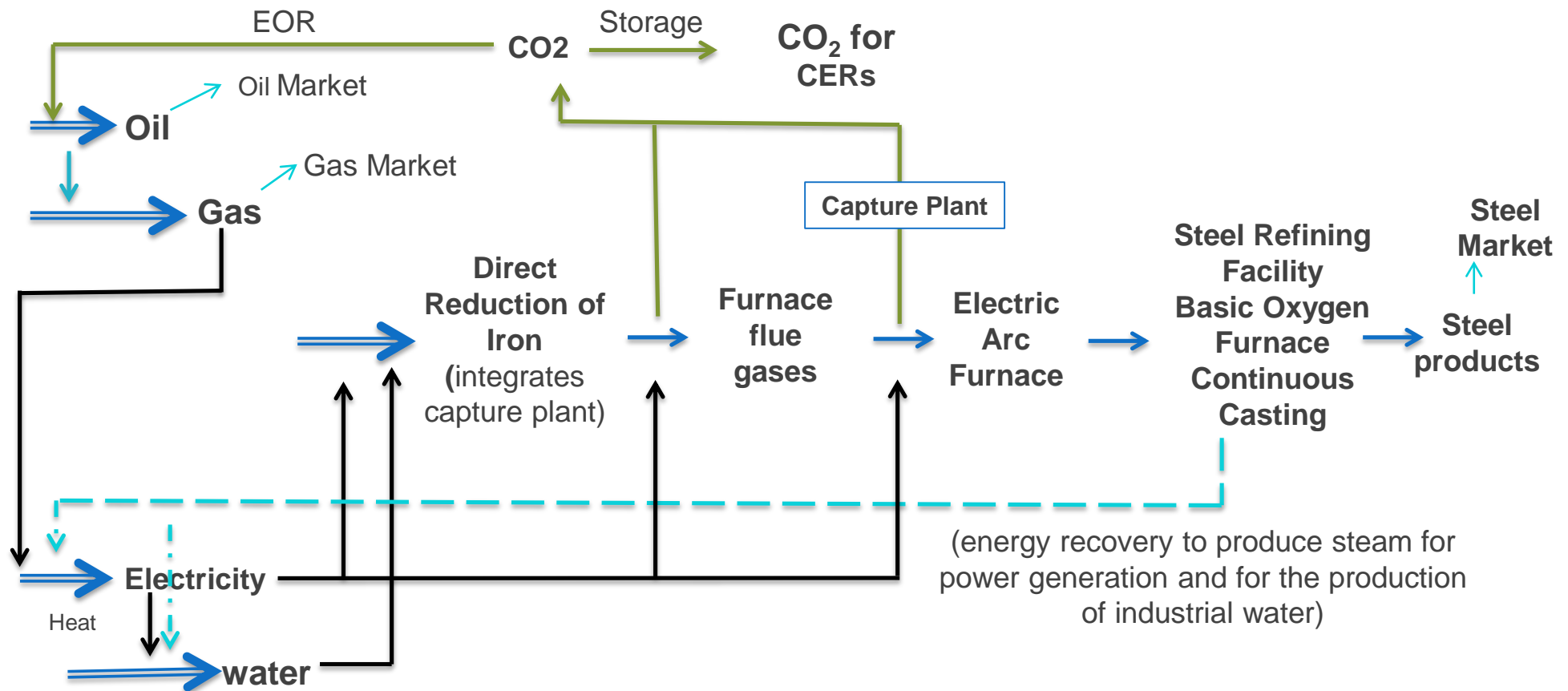
SOE Number by Industry and Countries (2014)

		Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE	Total
Primary sector	Oil and gas		1	1	2	1	4	9
Secondary sector (infrastructure)	Telecom	1	1	1	1	2	2	8
	Utilities	1				1	5	7
	Transport					2	1	3
Secondary sector (resource intensive)	Agriculture		5					5
	Steel				1			1
	Aluminium	1					1	2
	Petrochemical	1		1	2	1	1	6
	Cement		1	2				3
	General industry		2		1	2	1	6
Secondary sector (technology intensive)	Aviation					1	1	2
	Automobile						1	1
	Military					1	4	5
	Shipbuilding						1	1
	Semiconductor						1	1
Tertiary sector (service)	Real estate				1		1	2
	Finance	2	3	4	2	8	10	29
	Airlines	1	1	1	1	1	2	7
Total		7	14	10	11	20	36	

- Utilities
- Industries



Schematic Diagram of Materials Flows in ESI CO₂-EOR project



■ WEF nexus in GCC:

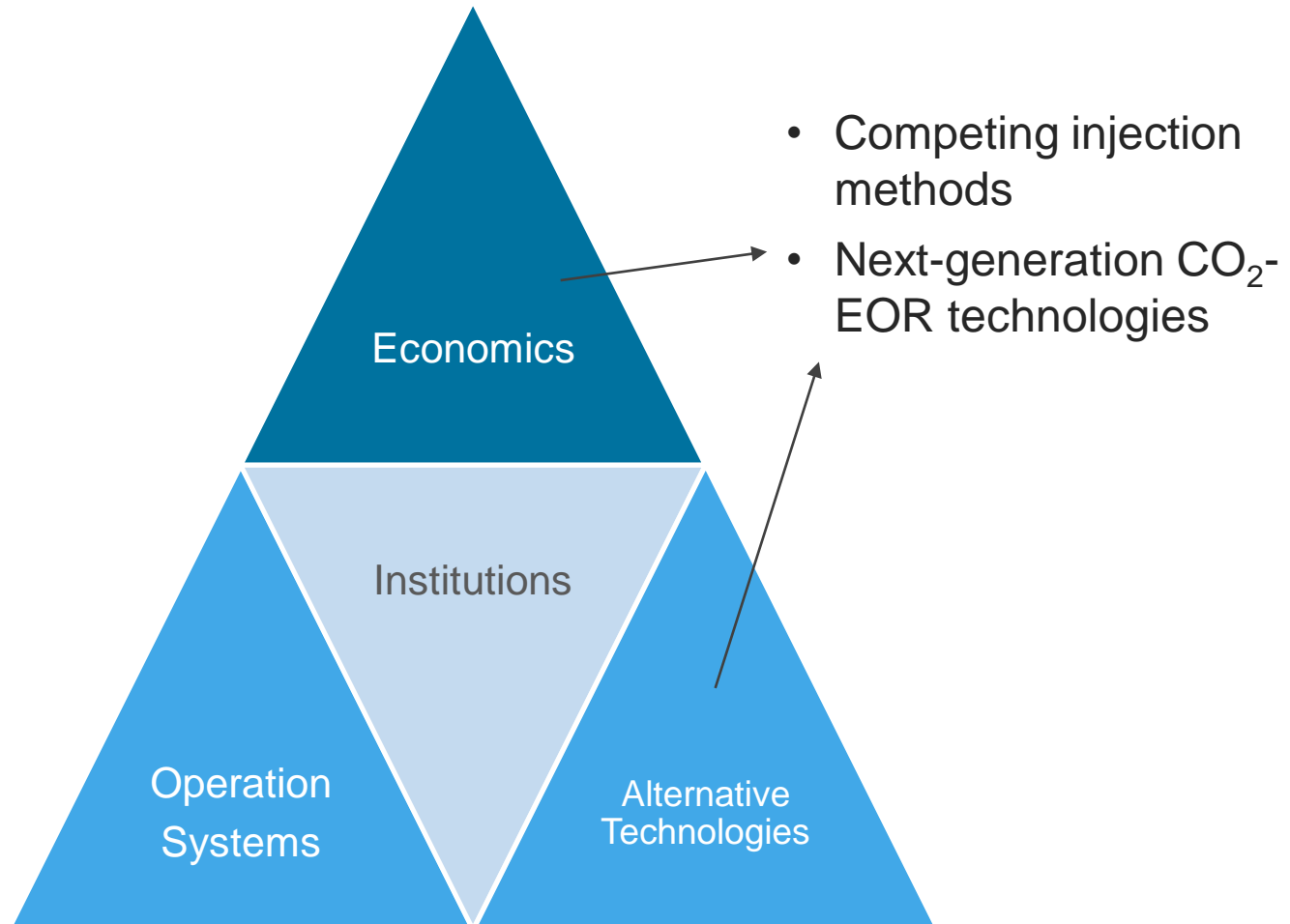
- Highly climate sensitive.
- Coupled water and electricity production; relying heavily on fossil fuel as feed stocks.
- Heavy energy subsidy.
- CCUS as part of the WEF nexus.

■ New development:

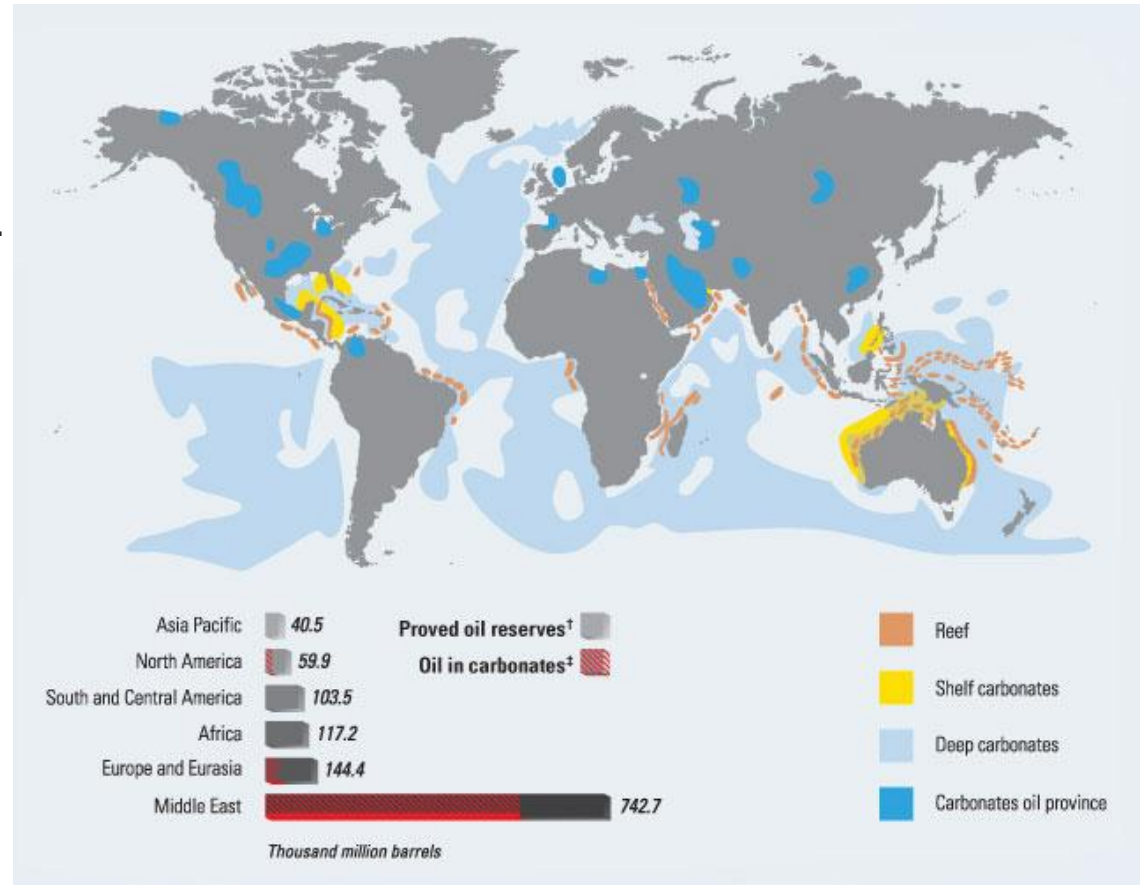
- WEF policy reform: key response to low oil price & climate change.
 - Increasing utility tariffs to cut water & fuel consumption
 - Saudi Arabia and UAE: cutting subsidy for farming, increasing imports of food.
 - Abu Dhabi in the process of removing gasoline subsidy.

■ Implications

- Less CO₂ from utilities and more from industrials; increase heterogeneity.
- Volume of industrial CO₂ affected by economic diversification progress.

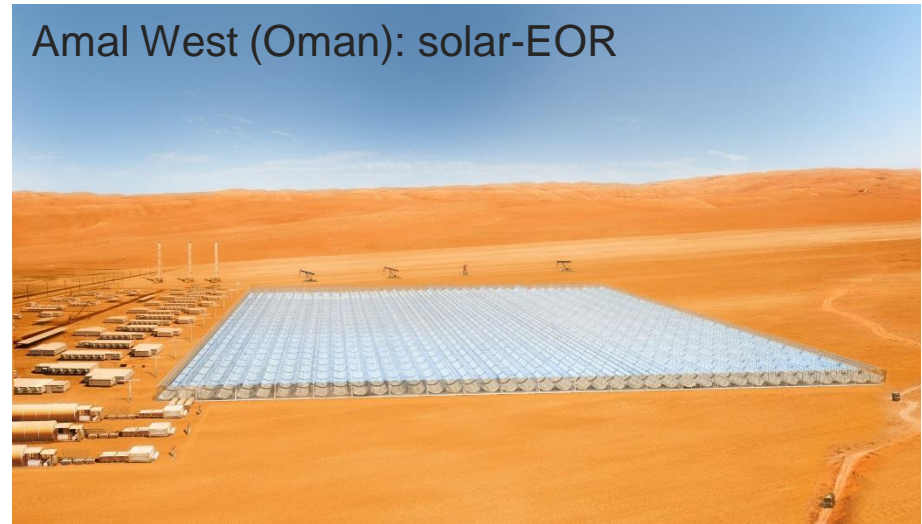


- **EOR:** essential for GCC with depletion of easy oil
 - 2000 → 2013: Kuwait, Qatar, Saudi Arabia and the UAE production grew 33% at 109% growth in well numbers.
- **Oman:** regional leader in EOR; other GCC states are following up.
- **Projects:** tend to have long lead time and are capital intensive.
- **Challenges:**
 - Dominating carbonate reservoirs; highly heterogeneous.
 - Fracture formation; complicating flows in reservoirs.
 - Technical challenging to understand the fracture network for EOR in carbonates.



- **Alternative methods:** gas, water, thermal, chemical, polymer, etc.
- **Key decision factors of injection method:**
 - Reservoir characterization
 - Existing recovery method
 - Availability of injection means
- **Ongoing EOR projects in Oman:**
 - Harweel Field (miscible gas)
 - Qarn Alam Field (thermal)
 - Mukhaizna Field (thermal)
 - Marmul Field (polymer)
 - Amal Field (thermal)
- **New development:**
 - Kuwait: steam-EOR for Wafra field; 80,000 bbl/d by early 2017.
 - UAE: ADNOC & Wintershall MOU on chemical-EOR.
 - Saudi Aramco: evaluating miscible gas-EOR in addition to CO₂-EOR.

Amal West (Oman): solar-EOR

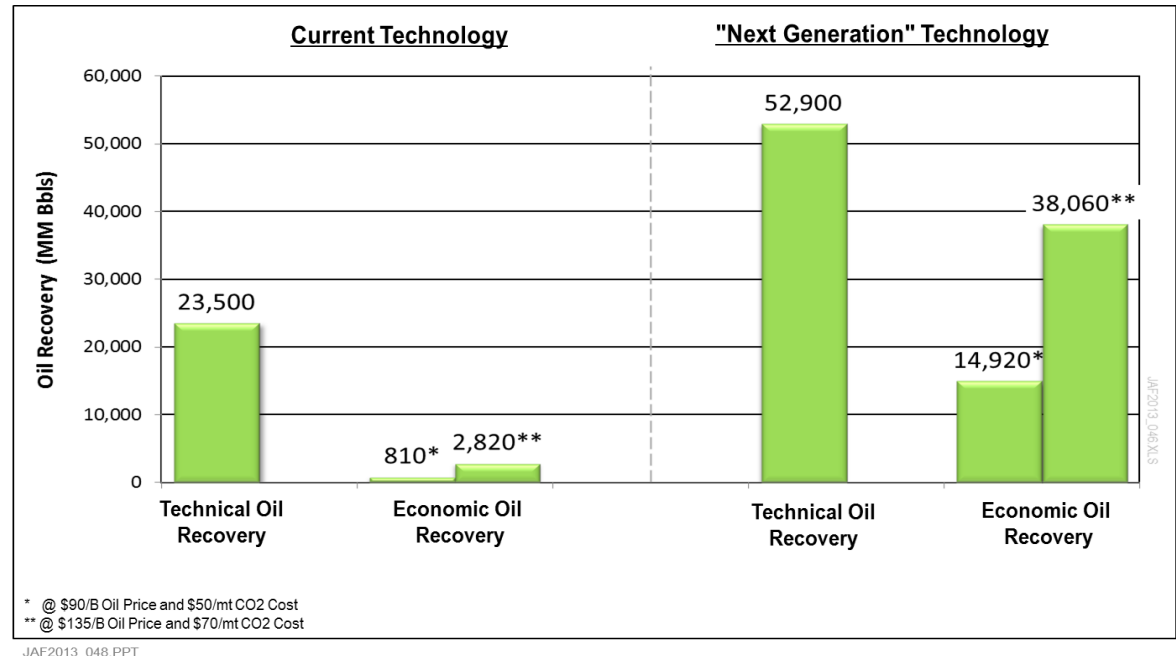


■ Features:

- Improve reservoir characterization.
- Optimize injection well layout and flood design
- Real time operation optimization.

■ Performances:

- Improves oil recovery efficiency by 50%
- More efficient use of CO₂ + higher recovery rate → greater number of offshore oil fields becoming economically viable.



Source: US DOE National energy technology Laboratory report, 2014

■ Implications:

- CCUS currently driven primarily with internal needs to tap into EOR.
 - Availability of external funds (CDM, CCF, etc.) remains unclear.
- Technology advancement in CCUS can significantly bring down cost, increase business scope, and accelerate CCUS deployment.
- Project level cost on both production basis (operation cost) and levelized basis (life cycle cost) shall be clearly quantified.
- Selection of technology used for each field affects development of CCUS network.

- **CO₂-EOR: main driver of large scale carbon capture and injection**
 - Focus will be on oil-max versus CO₂-max.
 - Can be done without revisions of institutions.
 - Easy to coordinate SOEs when proper cost & revenue sharing rules are defined.
 - Concerted move focusing on ultimate recovery versus immediate recovery dictated by short term profits is important.
 - This can be achieved by early planning of CO₂-EOR.
- **Challenges:**
 - Cost efficient capture technology
 - Optimal integration of CO₂-EOR with production technology in the fields.
 - Optimal infrastructure network development.
 - Optimal alignment of capture and injection as network expands.

- **CCS: likely to remain a longer term objective**

- Emissions credit certification may involve 3rd party monitoring & auditing → mostly unacceptable to NOCs.
- CCS cost may be reduced by leveraging infrastructure developed for CO₂-EOR.
- **Challenges:**
 - New business model is needed for CCS.
 - New regulations to govern ownerships and access rights of infrastructure for CO₂-EOR and CCS joint use are needed.

■ CCUS in GCC

- Now driven primarily by internal rationale versus external incentives.
- Currently part of a state dominated industrial eco-system.
- No immediate urgency for explicit regulations:
 - CO₂-EOR: collaboration achievable among SOEs upon acceptable cost/revenue sharing rules.
 - CCS: lack of clear business models.
- Discrete decision on technologies to deploy is critical.
- Summary: CCUS can be beneficiary of GCC's economy diversification strategy if carefully structured and when proper policy and technology is in place.

■ Actions needed

- Quantifying the economy of CO₂-EOR and CCS on levelized basis with pilot projects.
- Developing clear technological roadmaps for local conditions.
- Advancing domestic R&D capacity for local CCUS deployment.
- Identifying business model and optimal regulation to extend from CO₂-EOR to CCS.
- Clarifying strategic relationships between CCUS and renewables.
- Sharing data for best practice.