CARBON CAPTURE AND STORAGE

International Energy Agency

Global impacts and issues with CCS through EOR

4th IEA International CCS Regulatory Network Meeting
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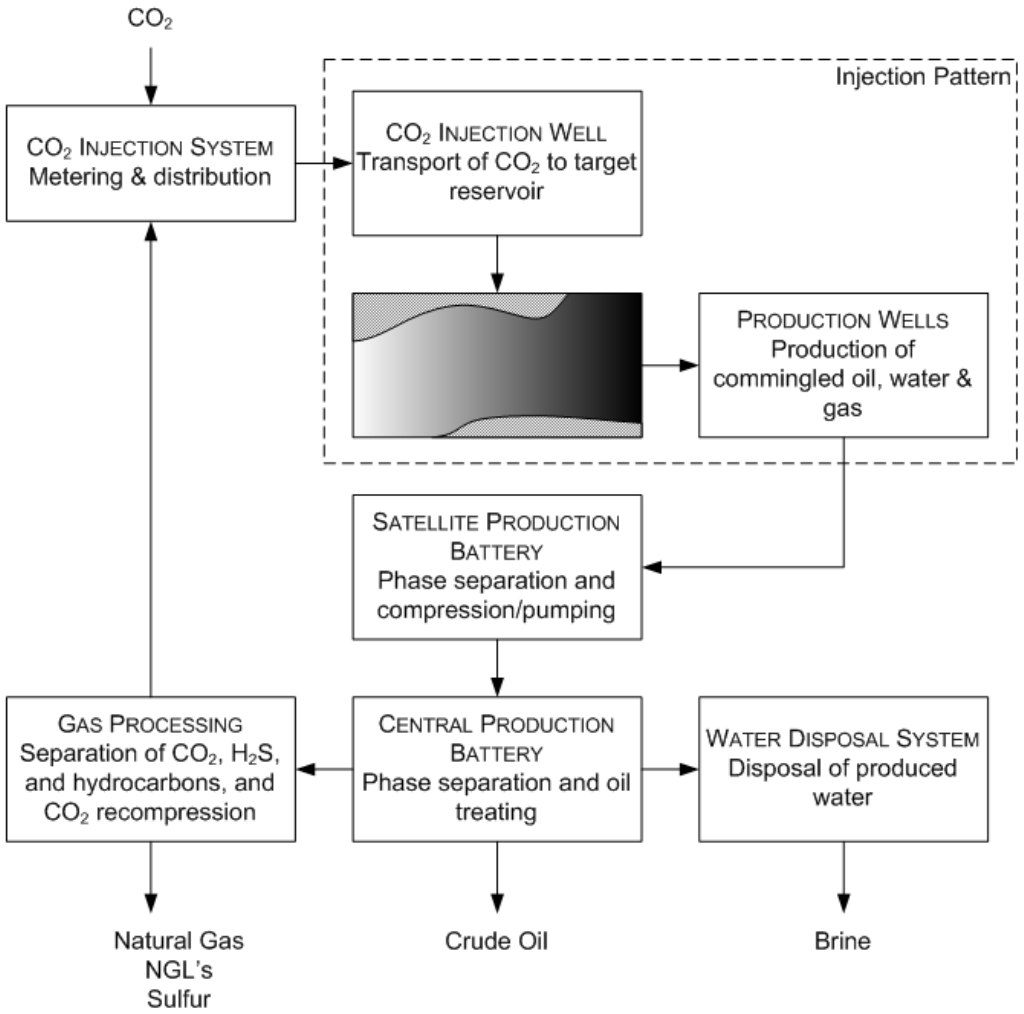
Three key messages

1. CO_2-flood enhanced oil recovery (CO_2-EOR) is a technically proven and well understood process that is applied commercially today
2. CO_2-EOR results in storage of CO_2, however the emissions reduction benefit is dependent on design of the project and the policy environment
3. There are barriers to designing and operating a CO_2-EOR project as part of a CCS project that need to be resolved for CO_2-EOR to play a role in reducing emissions

CO_2-EOR: Using CO_2 to improve oil recovery



Source: McCoy, 2008

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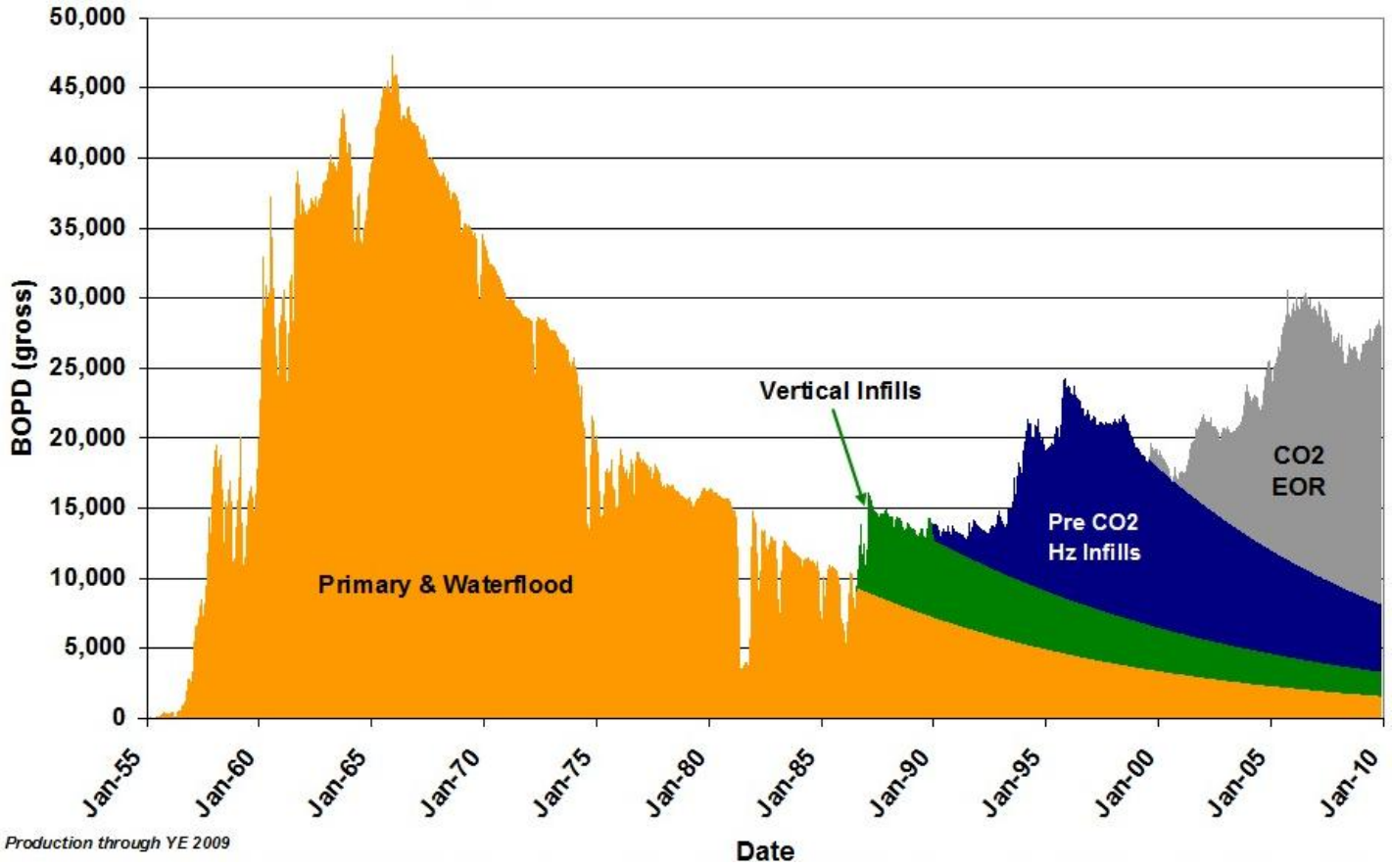
How does CO_2 improve oil recovery?

- Two types of CO_2-EOR processes exist:
  - *Immiscible*: injected CO_2 displaces oil from the reservoir and drives it towards production wells
  - *Miscible*: injected CO_2 forms a single-phase mixture with the oil, effectively reducing the density and viscosity of the oil, improving ability of the oil to flow
- *Miscible* CO_2-EOR tends to recover more oil than *immiscible*, but uses less CO_2 per barrel
  - The type of CO_2-EOR process depends on reservoir pressure and oil composition (MMP)
- Majority of projects are *miscible* CO_2-EOR projects

Increased oil production from the Weyburn Unit under miscible CO_2-EOR



Around 30,000 bbl/day total production, over 20,000 bbl/d due to CO_2-EOR

Figure: Cenovus Energy/Malcolm Wilson, PTRC

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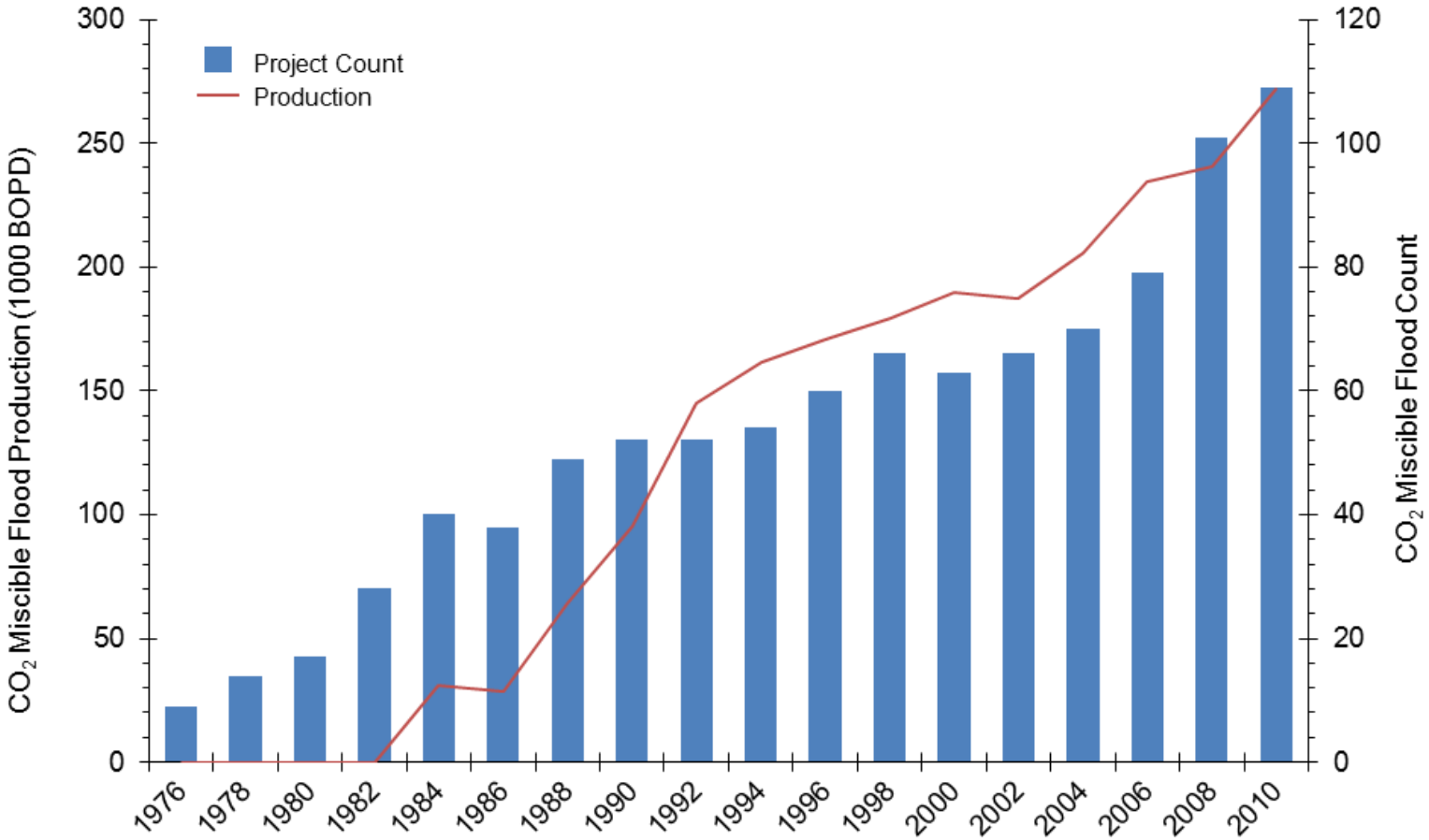
An upwards trend for US miscible projects and production from CO_2-EOR



Data: Oil & Gas Journal, 2010

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The boundaries used to assess emissions from CO_2-EOR matter

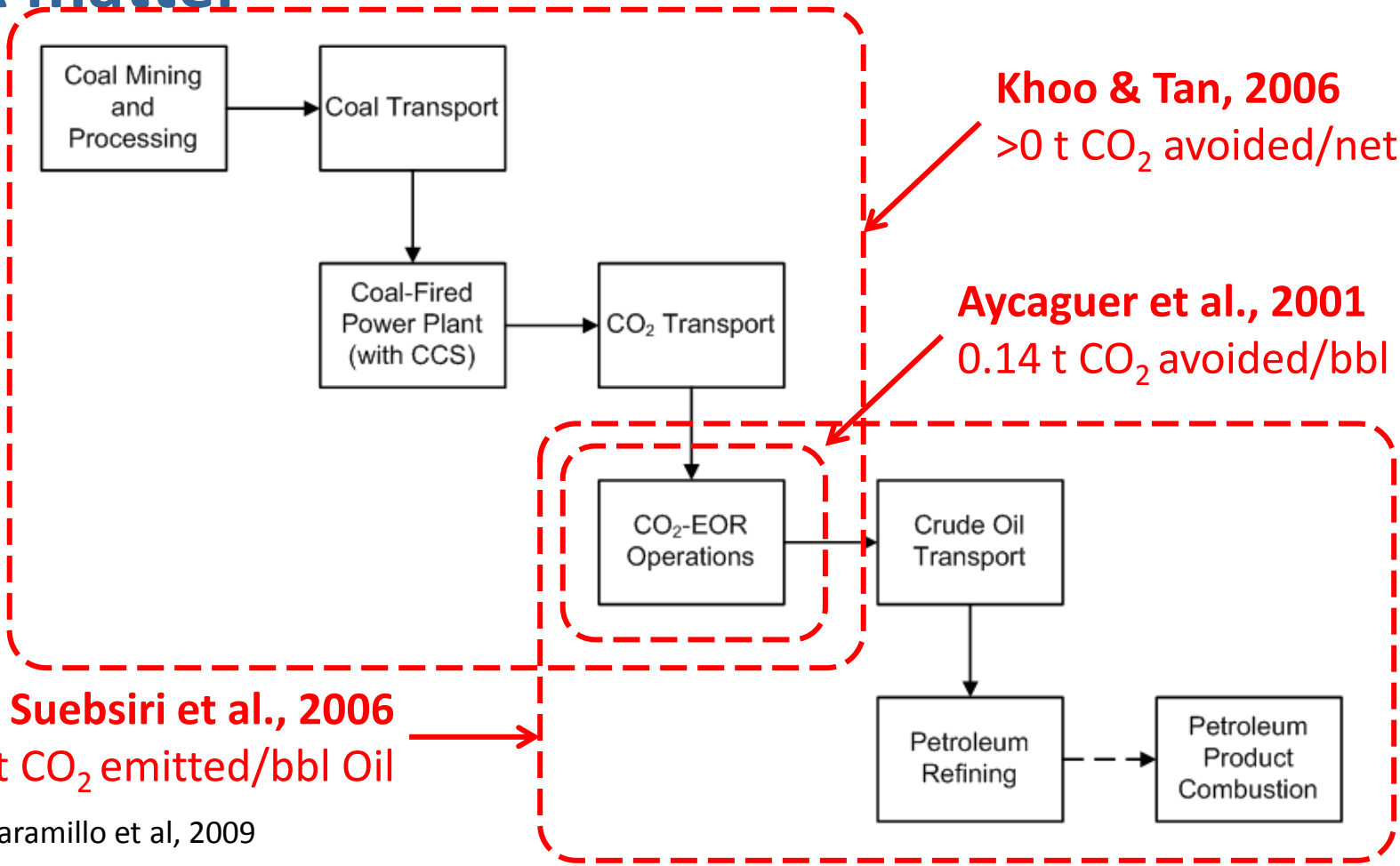
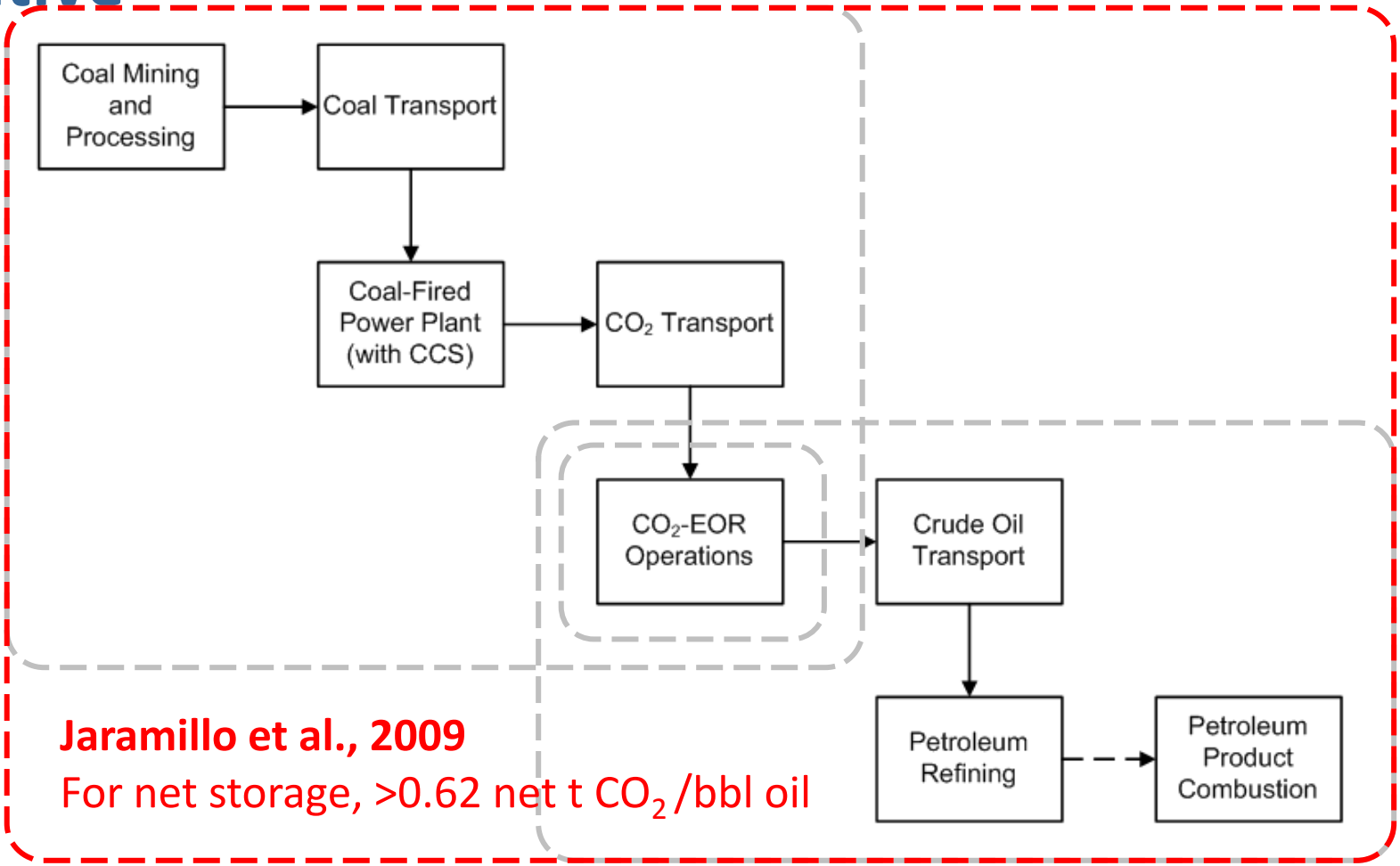


Figure: Jaramillo et al, 2009

Cradle-to-grave emissions from CO_2-EOR are positive



Emissions can be reduced through displacement

Marginal Barrel Displaced (kg CO_2e/bbl)	Marginal Generation Displaced (kg CO_2e/MWh)	Emissions Reduction Efficiency			
		Project 1	Project 2	Project 3	Project 4
Current Average Consumption-USA (529)	Current Average Generation-USA (652)	71%	68%	70%	73%
Canadian In-Situ SCO (600)	Uncontrolled IGCC (894)	140%	128%	137%	145%
	NGCC (425)	87%	75%	83%	92%
Saudi Arabian Light (521)	Uncontrolled IGCC (894)	94%	92%	93%	95%
	NGCC (425)	41%	38%	40%	42%
	Carbon-free Electricity (0)	-8%	-10%	-8%	-7%

McCoy et al, 2010

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Important observations from past life-cycle assessment research

1. Emissions **depend on boundaries**:
   a) Including emissions from oil production makes business-as-usual (BAU) CO_2-EOR a net emitter
   b) Changes to design and operation of BAU CO_2-EOR could decrease the CO_2 footprint
2. **If** energy-related emissions that **would otherwise be produced** from an equivalent system are displaced, CO_2-EOR reduces emissions
3. Emissions reduction efficiency is **a function of energy displacement and CO_2 utilization**
   a) Displacement of CO_2-intensive power and oil results in a larger emissions reduction than would otherwise occur

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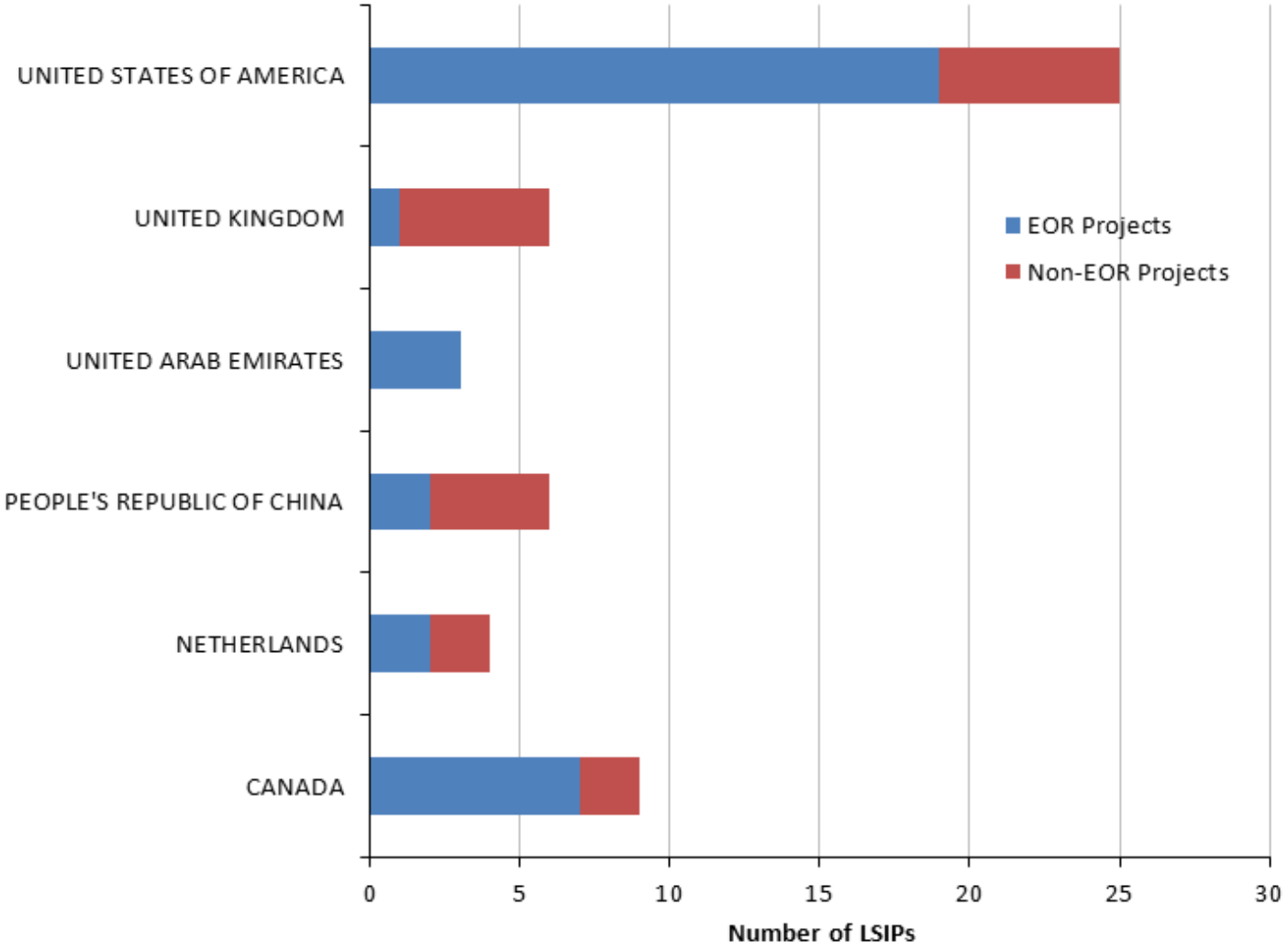
Attributes of CO_2-EOR operations necessary for qualification as storage

Technology	Energy Policy	Climate Policy
• Increase net CO_2 utilization through changes to design and operation (?) • Monitoring, measurement, and verification of similar stringency to that applied to saline aquifers • Abandonment to ensure long-term retention of stored CO_2	• Law and regulation to enable CO_2-EOR as a oil recovery process • Regulation to ensure that CO_2-EOR is undertaken safely for humans and the environment	• Measurable emissions reduction goals and accompanying policy • Laws and regulation enabling CO_2-EOR as climate change mitigation option • Accounting rules that accurately award credit for emissions avoided

Numerous planned CCS projects rely on CO_2-EOR



Data: GCCSI Project Database, 7 Nov. 2011

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Barriers to private investment in CO_2-EOR

BAU CO2-EOR	CO_2-EOR for Climate Change Mitigation
• Low valued investment option in IOC portfolios • Lack of low cost CO_2 for injection in many places • Competition with other EOR processes • Mismatch in business cases for capture versus injection	• Those for BAU CO_2-EOR, PLUS: • No return on additional cost for storage • Cost for monitoring, measurement, and verification • Cost for ensuring long-term containment

Can incentive policies address these issues?

If so, how?

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Questions?

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