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Assessing Climate Mitigation Benefits of Public Support to CCS-EOR: An Economic Analysis

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18th IAEE European Conference - July 26, 2023

CCS-EOR is the Most Readily Deployable CCS Technology…

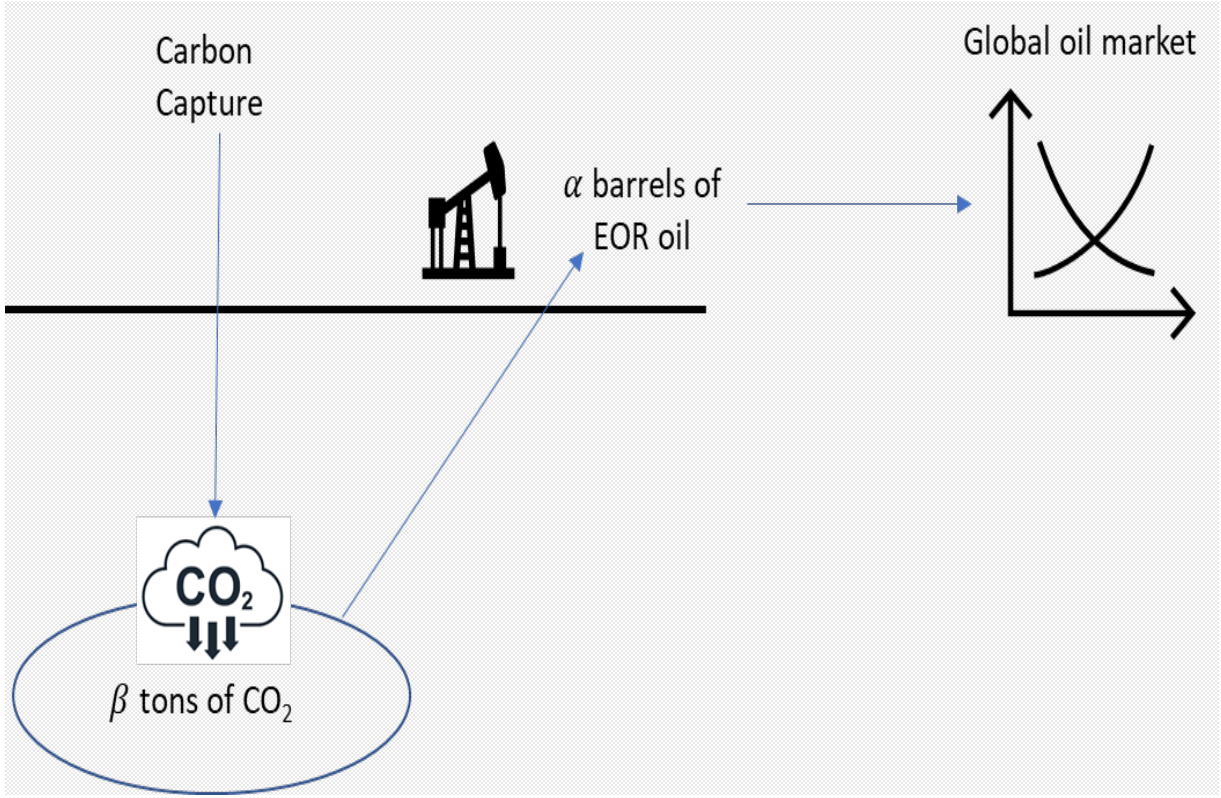
- Concerns arise due to the perceived trade-off between increased oil production and environmental benefits
- Addressing the potential impact of CCS-EOR projects on global CO_2 emissions has policy implications
  - Fiscal incentives granted by governments to support CCS-EOR as a climate-change mitigation technology should be commensurate with their resulting reduction in emissions

Does CCS-EOR Reduce Global CO_2 Emissions

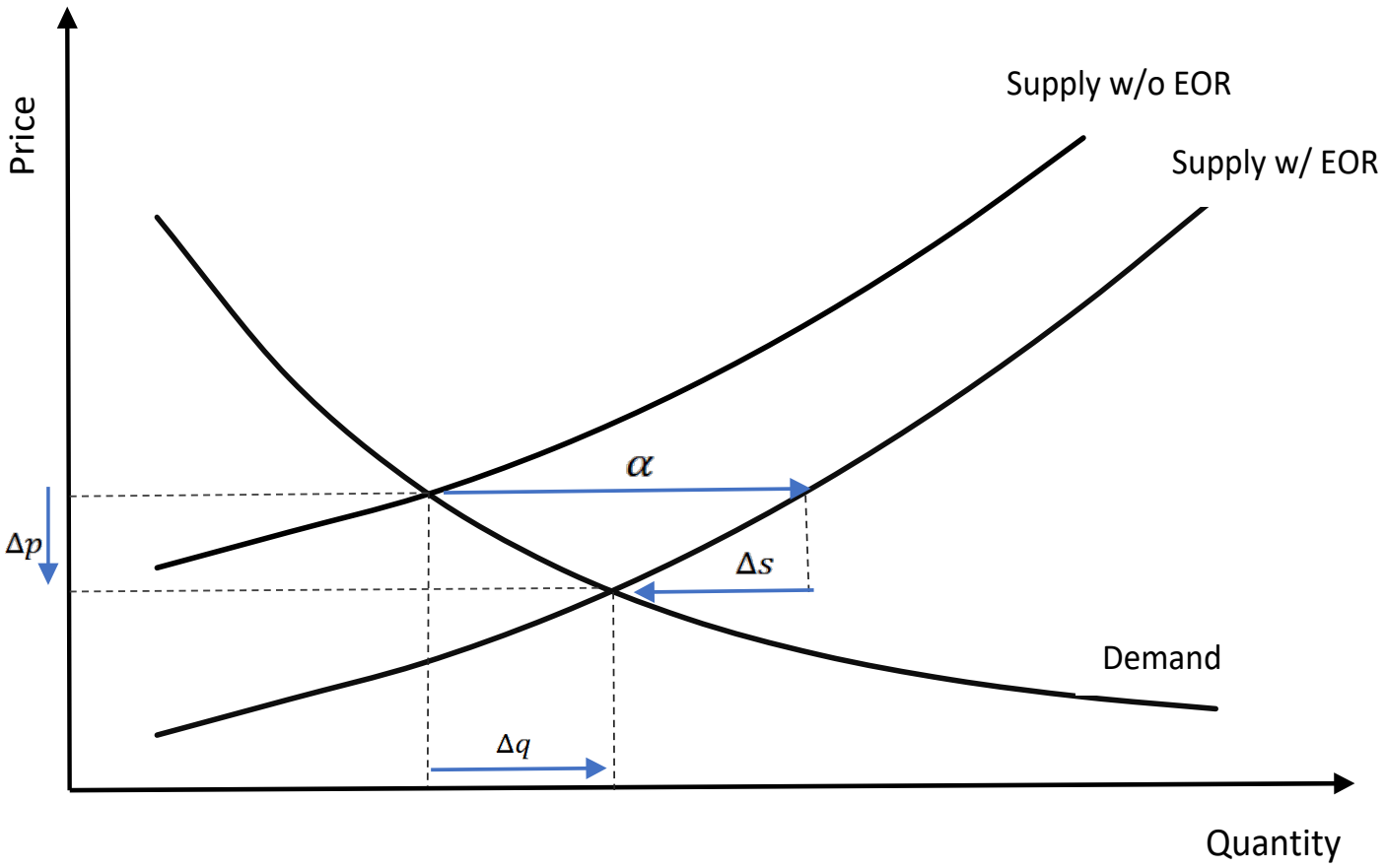
- Attribution of emissions from additional oil production to the CCS-EOR process is a critical question that lacks consensus in the lifecycle assessment literature
  - Some argue that emissions from consuming additional barrels produced by EOR should be attributed to CCS-EOR technology
  - Others invoke the 'displacement assumption,' suggesting that these barrels replace those from other oil suppliers

A Fresh Perspective on CCS-EOR's Effect on Global Emissions

- Analytical formulas to gain insights into the effects of incentivizing CCS-EOR projects on global emissions
  - Grounded in marginal reasoning consistent with economic decision-making
  - Employs a simple, partial-equilibrium framework
- Quantify the volume of oil that can be decarbonized by storing a ton of captured CO_2 through EOR from different perspectives



Impact of CCS-EOR projects on the Global Oil Market



The number of barrels displaced by the EOR oil

$$-\Delta s = \frac{\alpha}{1 - \frac{\varepsilon_d}{\varepsilon_s}}$$

Impact of CCS-EOR Projects on Global Emissions

- **Capturing a tonne of CO2 does not necessarily imply an equivalent reduction in emissions at the point source**
- **Assume r is the actual reduction in emissions from capturing a tonne of CO2**

Total amount of global emissions *E* attributable to CCS-EOR projects is the sum of:

- Reduction in emissions due to the capture and storage of CO_2, $r\beta$ tonnes;
- Increase in emissions due to the EOR oil produced, $(u + f)\alpha$ tonnes;
- Saving in emissions due to the oil displaced, $-(v + g)\Delta s$ tonnes, with $-\Delta s = \frac{\alpha}{1 - \frac{\varepsilon_d}{\varepsilon_s}}$

$$E = -r\beta + \alpha\left(u + f - \frac{v + g}{1 - \frac{\varepsilon_d}{\varepsilon_s}}\right)$$

Impact of Capturing and Storing a Ton of CO_2 on Global Emissions

The impact on global emissions of capturing a tonne of CO_2 and storing it through EOR

$$e = -r + \frac{\alpha}{\beta}\left(u + f - \frac{v + g}{1 - \frac{\varepsilon_d}{\varepsilon_s}}\right)$$

Capturing and storing a tonne of CO_2 with EOR reduces global emissions when:

$$u + f < \frac{r\beta}{\alpha} + \frac{v + g}{1 - \frac{\varepsilon_d}{\varepsilon_s}}$$

Environmental Benefits of CCS-EOR From Different Perspectives

Perspective adopted	Reduction in emissions
Well-to-wheel economic perspective	$r - \frac{\alpha}{\beta}\left(u + f - \frac{v + g}{1 - \frac{\varepsilon_d}{\varepsilon_s}}\right)$
Well-to-wheel accounting perspective	$r - \frac{\alpha}{\beta}(u + f)$
Upstream economic perspective	$r - \frac{\alpha}{\beta}\left(u - \frac{v}{1 - \frac{\varepsilon_d}{\varepsilon_s}}\right)$
Upstream accounting perspective	$r - \frac{\alpha u}{\beta}$

Illustrative Calibration (1/2)

Based on IEA, EOR oil produced per tonne of CO_2 stored

- Conventional EOR+ : 3.33 barrel/ton
- Advanced EOR+ : 1.67 barrel/ton
- Maximum-storage EOR+ : 1.11 barrel/ton

Emissions of a gas power plant with a combined cycle:

- The efficiency of the plant is 51.5% without capture and 45.7% with capture, with a capture rate of 90% (Global CCS Institute (2017))

Reduction in emissions from capturing a tonne of CO2: r = 0.87

Transport of the CO_2 from the point of capture to the EOR field: 0.001 tonne (Azzolina et al. (2017))

Illustrative Calibration (2/2)

- A barrel of EOR oil displaces half a barrel of oil from the global market, since $\frac{1}{1-\frac{\varepsilon_d}{\varepsilon_s}} = 0.51$
- The displacement generates a saving in CO2-eq emissions equal to 0.29 tonnes per barrel of EOR oil

	Conventional EOR+	Advanced EOR+	Maximum storage EOR+
Reduction in emissions due to capture and storage	-0.87	-0.87	-0.87
Increase in emissions due to EOR oil produced	1.80	0.90	0.59
Reduction in emissions due to the oil displaced	-0.97	-0.49	-0.32
Total impact (e)	-0.05	-0.46	-0.60

How Much Oil Can Be Decarbonized by Capturing and Storing a Ton of CO_2

Perspective	Calibrated value	
Upstream accounting perspective		12.48
Upstream economic perspective	Conventional EOR+	14.40
	Advanced EOR+	13.45
	Maximum storage EOR+	13.12
Well-to-wheel accounting perspective		1.62
Well-to-wheel economic perspective	Conventional EOR+	3.41
	Advanced EOR+	2.52
	Maximum storage EOR+	2.21

Conclusions

Economic approach that helps to clarify the potential impact on global emissions of capturing CO2 and storing it through EOR

CCS-EOR technology has the potential to mitigate global emissions. However, after accounting for the need to decarbonize the EOR oil produced, the reduction in emissions is much less than the stored quantity of CO_2

The 2022 United States Inflation Reduction Act offers a $60 tax credit for CO_2 captured from industrial facilities and used for EOR and $85 for storage in a saline reservoir. The tax credit is slightly higher than the amount that our calculations would justify based on displaced oil

Our calibration should be refined and complemented by sensitivity analyses with respect to elasticity values, since these values are not precisely known