What's with Article 6 and 45Q?

Two New Research Questions

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The Extraordinary Luxury of Time

- Thanks for the opportunity to deliver a keynote address to the 24th AIM workshop.
- The AIM research team has been at the cutting edge of research for three decades and I'd like to talk about two issues that are on the frontier
- One that AIM began work on 2 years ago—Fujimori et al. (2016)
- The other is just emerging—45Q

The 23rd AIM International Workshop

The Value of Article 6

The Paris Agreement and Article 6

- The Paris Agreement uses a bottom up approach—Nationally Determined Contributions (NDCs)
  - Each member of the agreement determines what it can contribute to achieving the goals of the Paris agreement
- **Article 6 allows countries to jointly implement NDCs**

Source: http://www.carbon-mechanisms.de/en/introduction/the-paris-agreement-and-article-6/

How Valuable is Article 6?

*What is the **potential** economic value of implementing Article 6?*

- What is the **potential** size of the carbon market?
- Who would be the sellers and who would be the buyers?
- How much could costs be reduced?
- How much additional ambition is enabled by cost reductions?

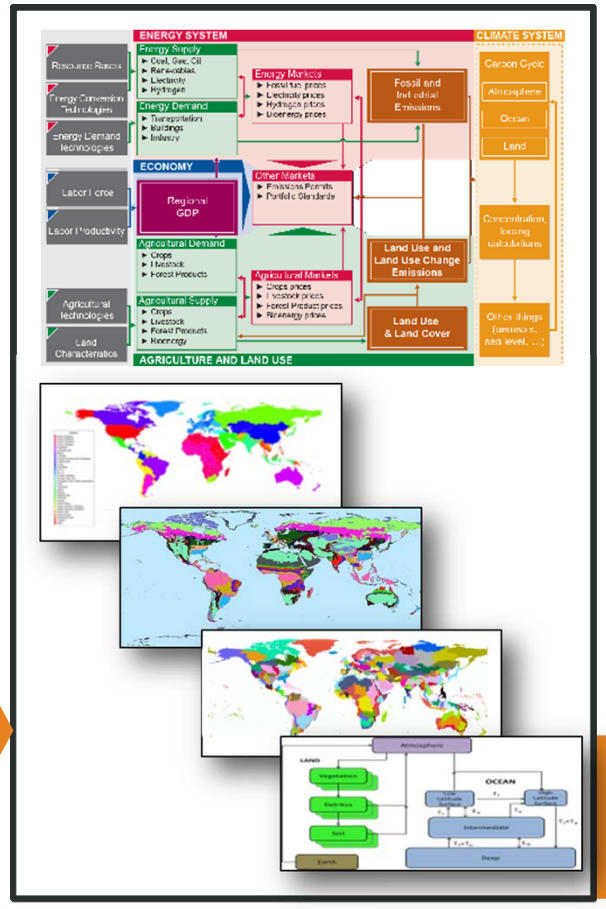
Source: https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf

We build on earlier work by Shinichiro Fujimori, et al. (2016)

The Global Change Assessment Model (GCAM)

Scenario Assumptions

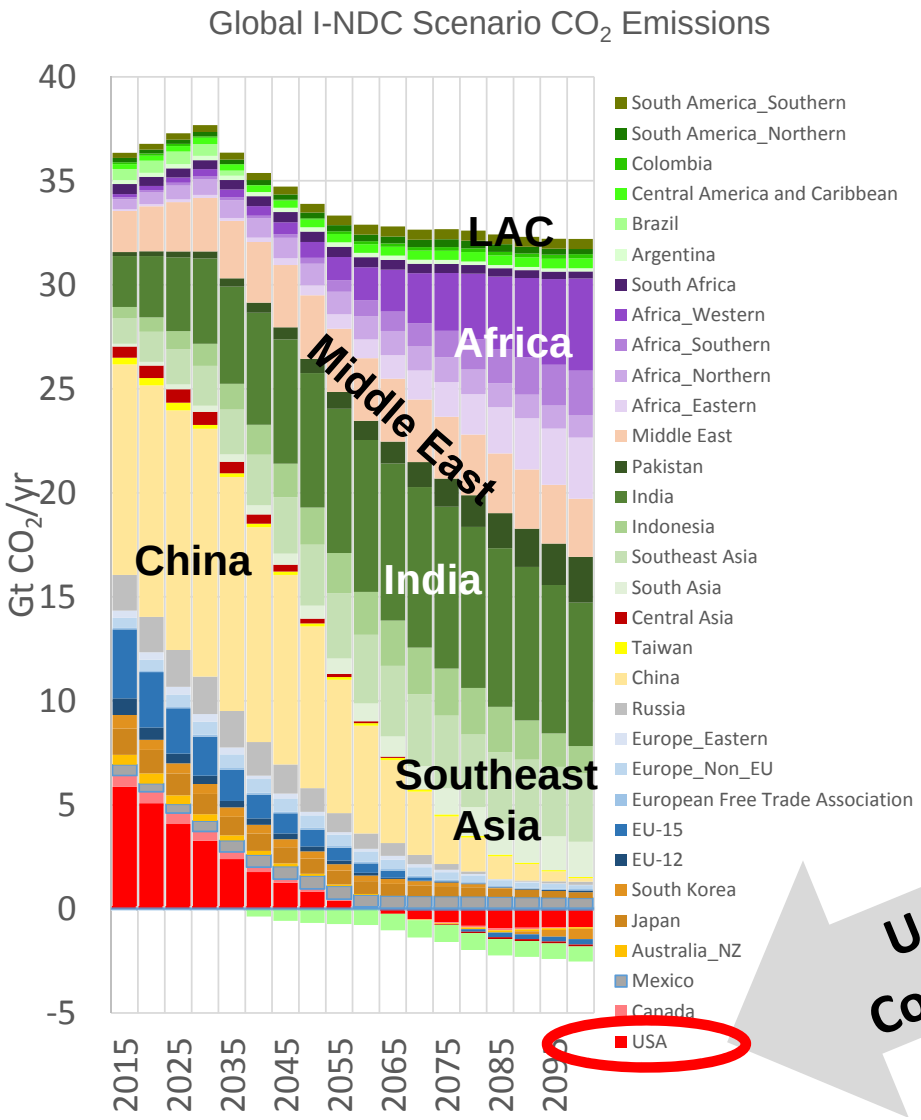
- **Socioeconomic assumptions** (population, GDP)
- Energy, land use, and water **technologies**
- **Policies, company actions and preferences**
- **Resources**



Scenario Outputs

- **Prices and production quantities**:
  - Energy sectors
  - Transportation
  - Primary energy resources
  - Agricultural products
- **Land use**
  - Crops (by type)
  - Pasture
  - Unmanaged
- **Water demand**
  - Raw demand by sector
  - Response to scarcity
- **Atmosphere-Climate**
- **Economic indicators**
  - Economic losses
  - Income transfer

NDC Emissions: Independent Implementation



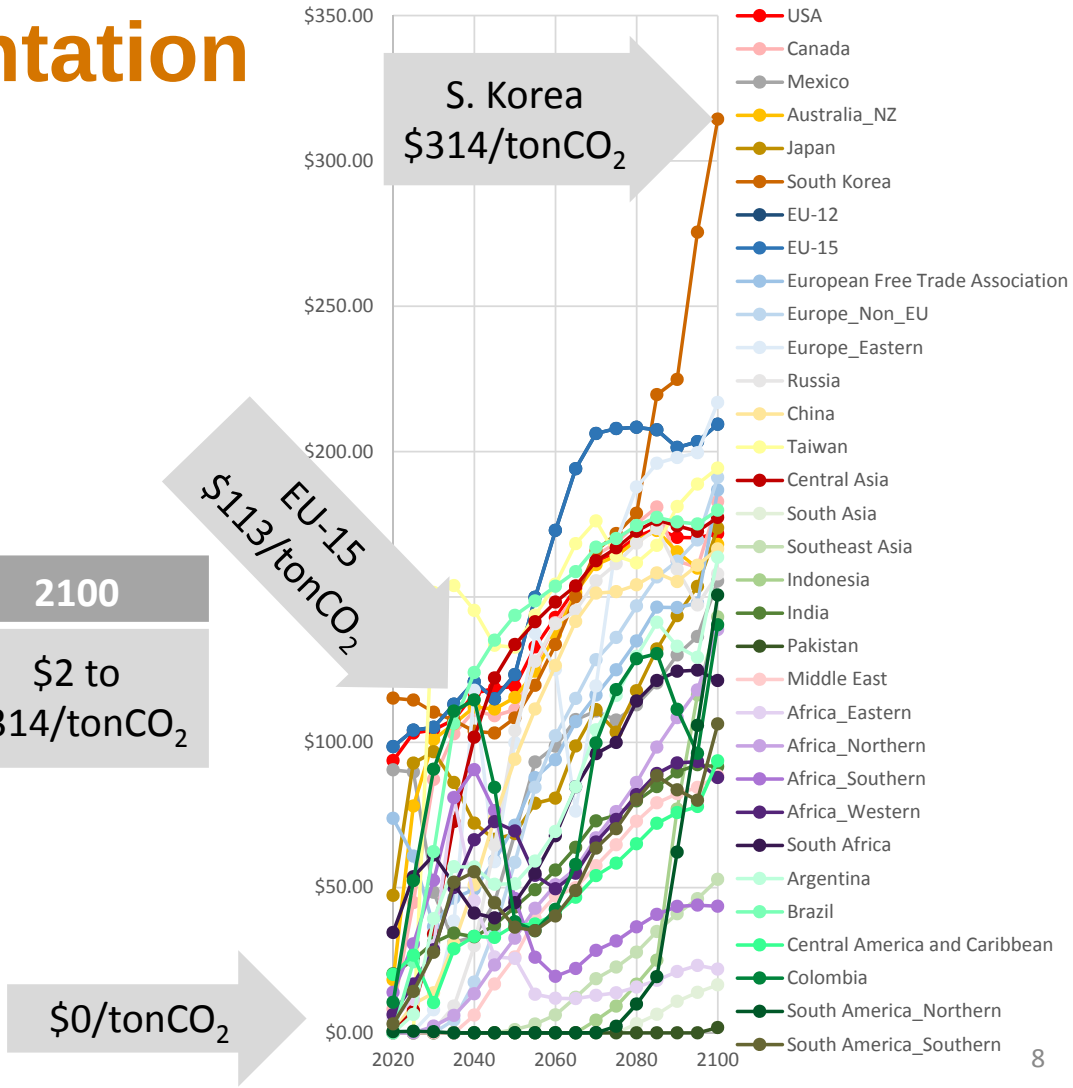
- Significant decline in emissions
- The level of emissions reduction varies by country

NDC Shadow Prices: Independent Implementation

- Wide range in shadow prices

	2030	2050	2100
I-NDC Range	\$0 to \$152/tonCO_2	\$0 to \$144/tonCO_2	\$2 to \$314/tonCO_2

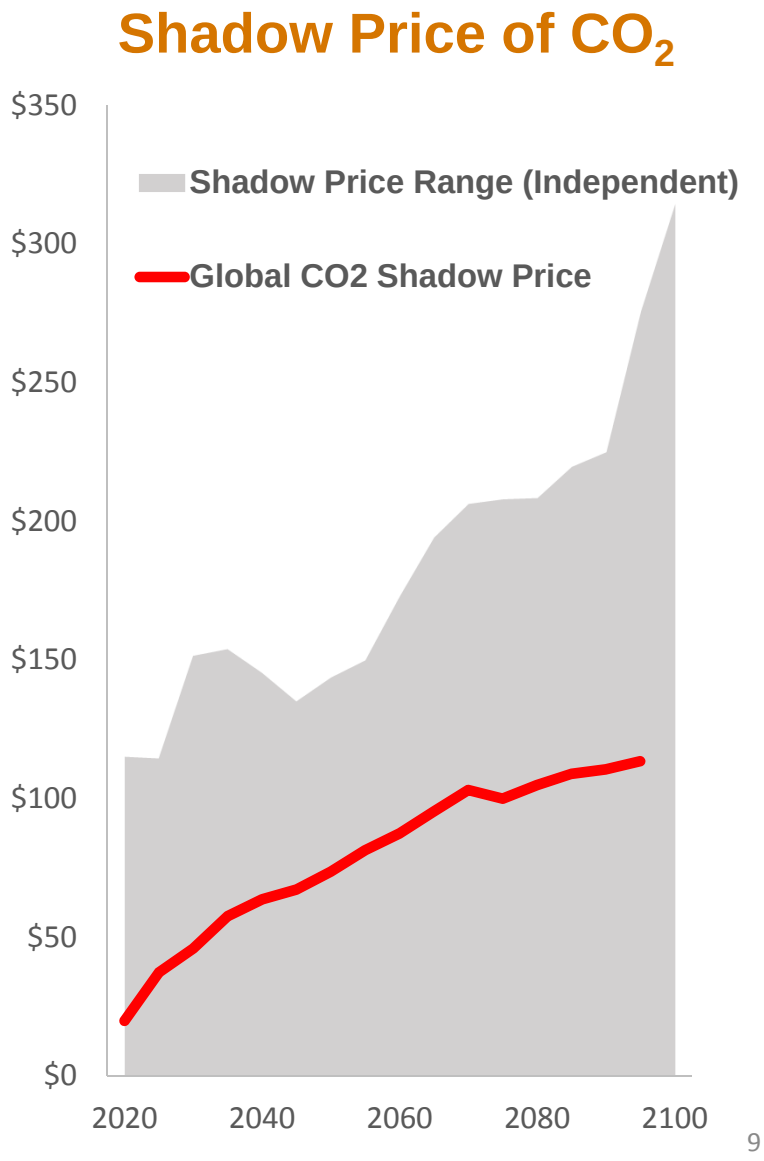
Shadow Price of CO_2



NDC Shadow Prices: Independent vs. Joint Implementation

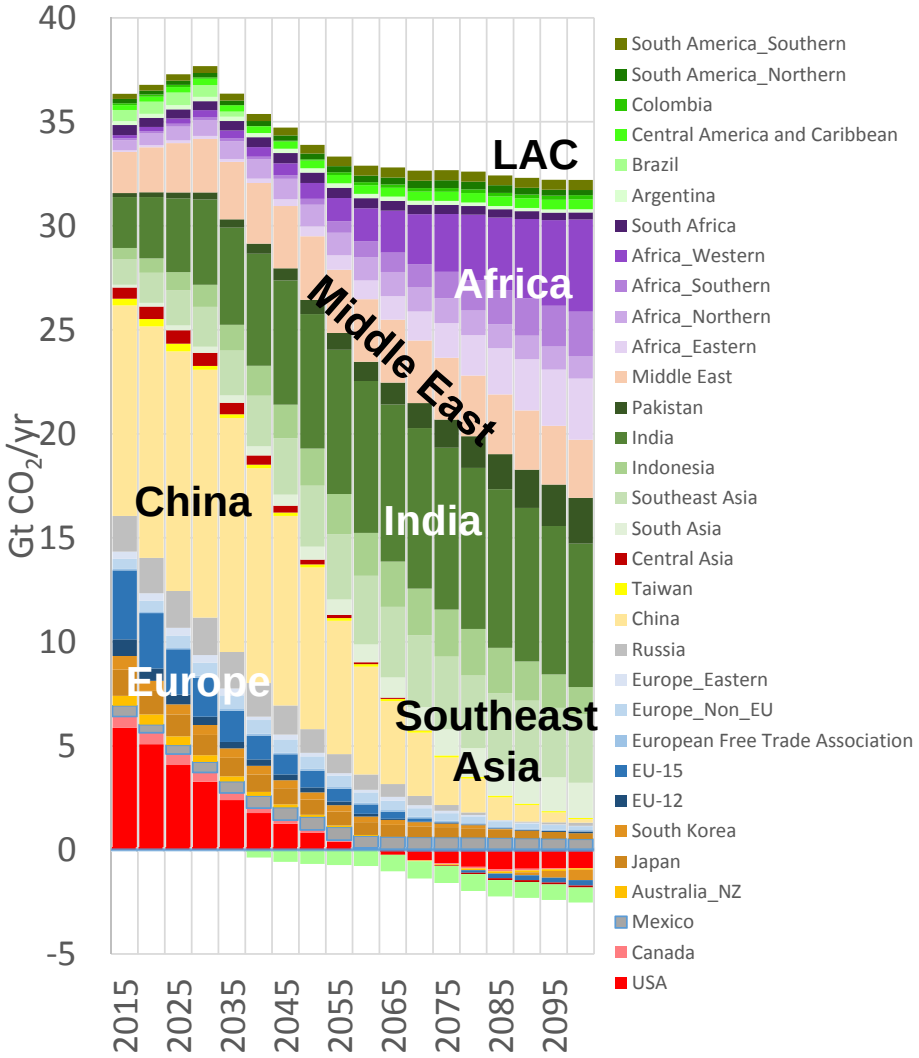
- Joint implementation **shadow price** lies between high and low prices of independent implementation

	2030	2050	2100
I-NDC Range	\$0 to \$152/tonCO_2	\$0 to \$144/tonCO_2	\$2 to \$314/tonCO_2
J-NDC	**\$46/tonCO_2**	**\$74/tonCO_2**	**\$120/tonCO_2**
	Fujimori, et al. 2016. \$9/ton CO_2		

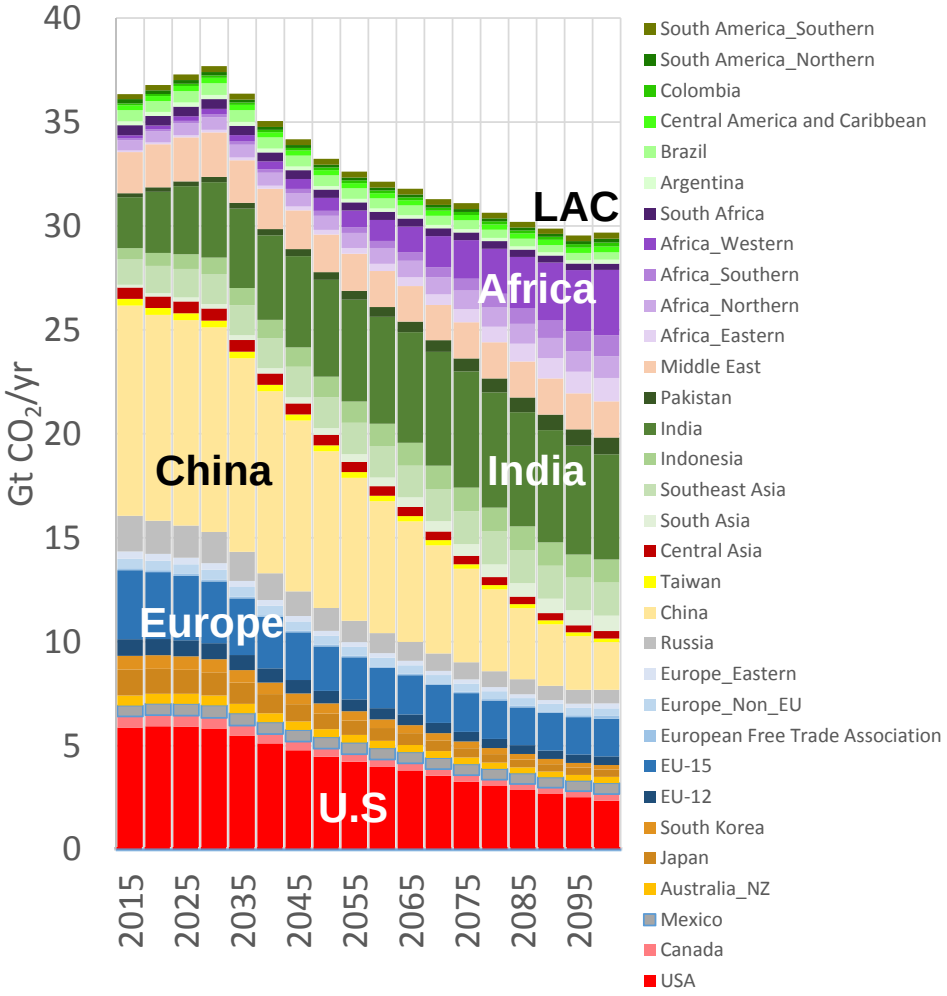


NDC Emissions: Independent vs. Joint Implementation

Global I-NDC Scenario CO_2 Emissions

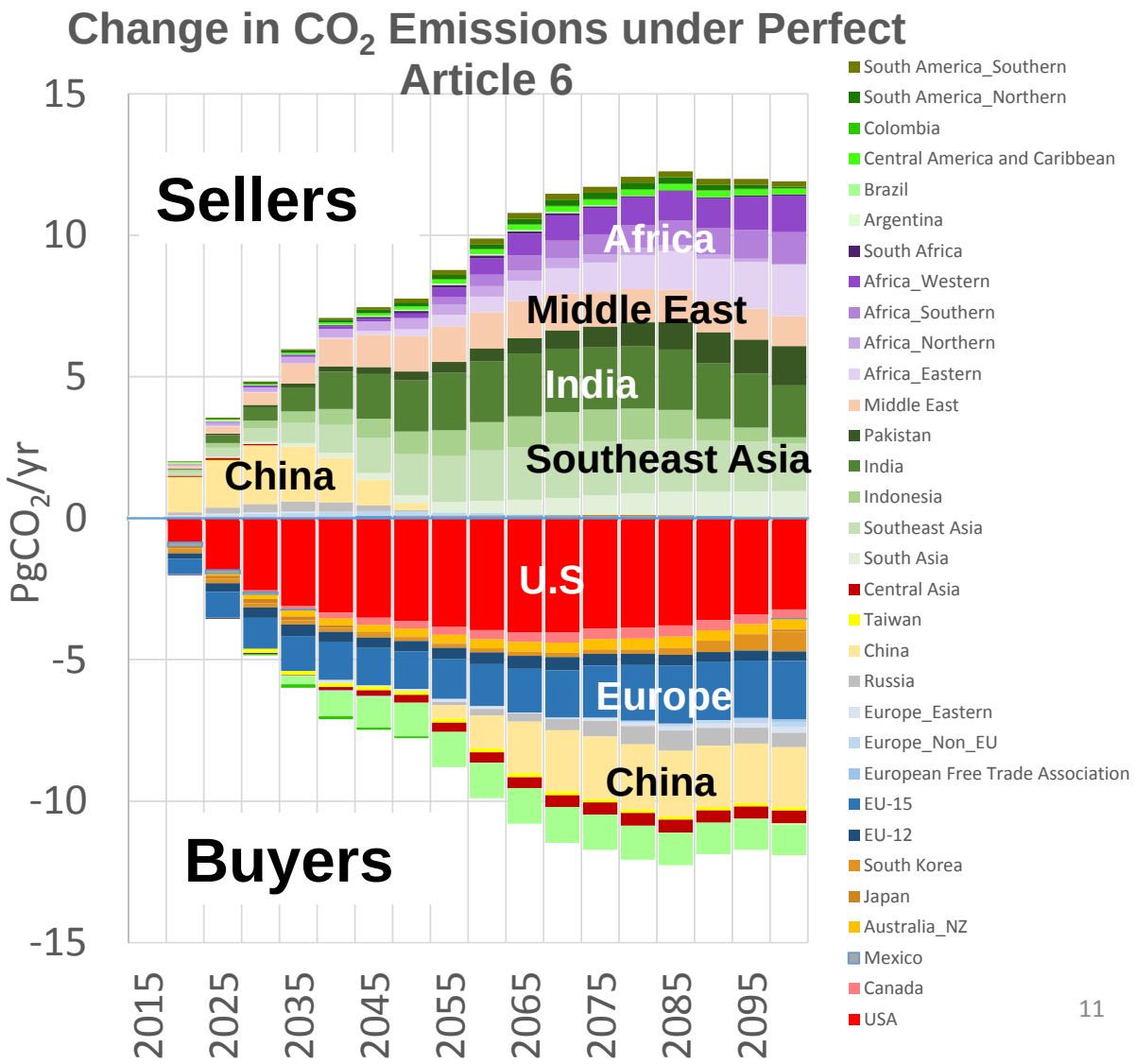


Global J-NDC Scenario CO_2 Emissions



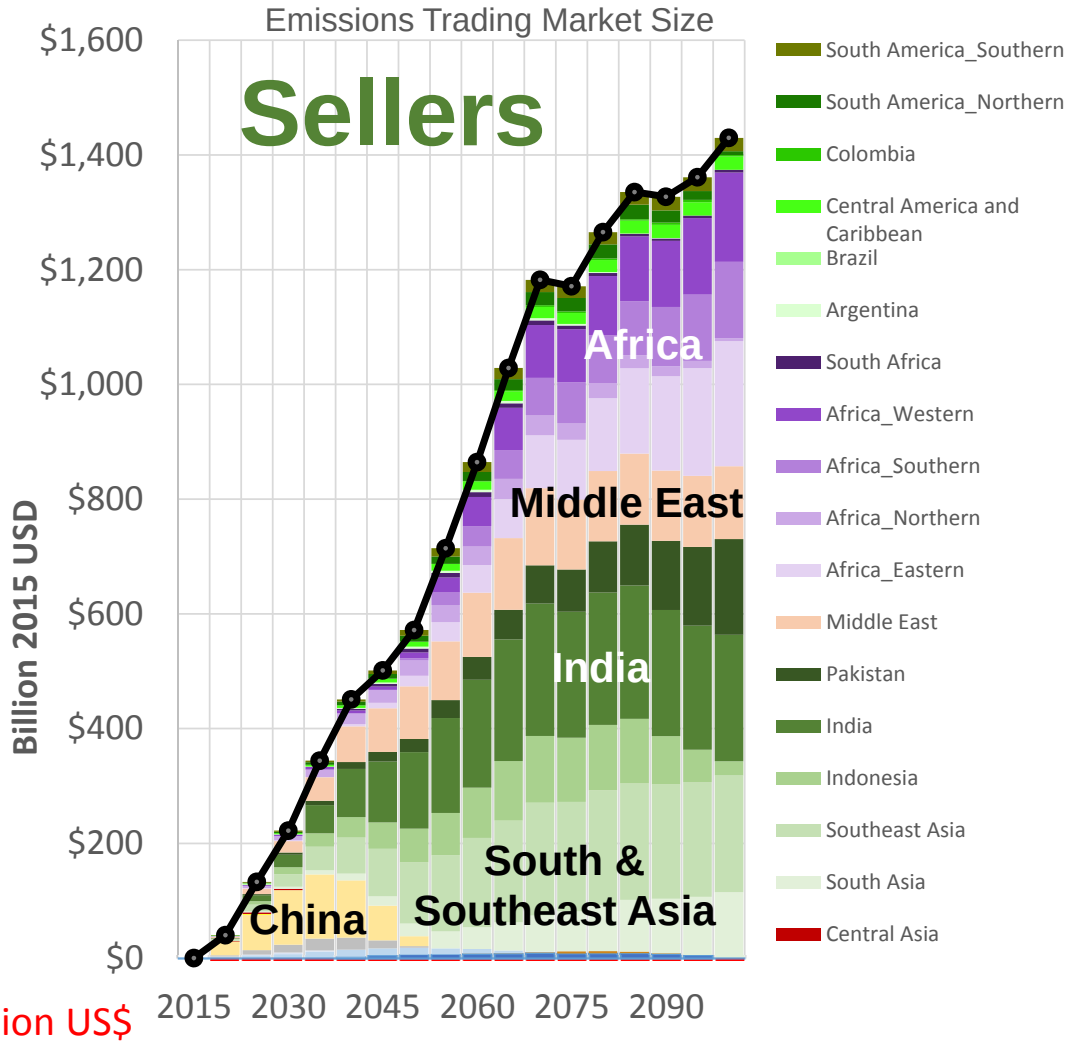
Potential changes in emissions—CO_2

- Seller (13 regions)
- Buyer (6 regions)
- Seller to buyer (10 regions)
- Buyer to seller (South Africa)
- Seller to buyer to seller (Colombia)
- Buyer to seller to buyer (European Free Trade)



Potential Market Size—Billion of 2015 US$

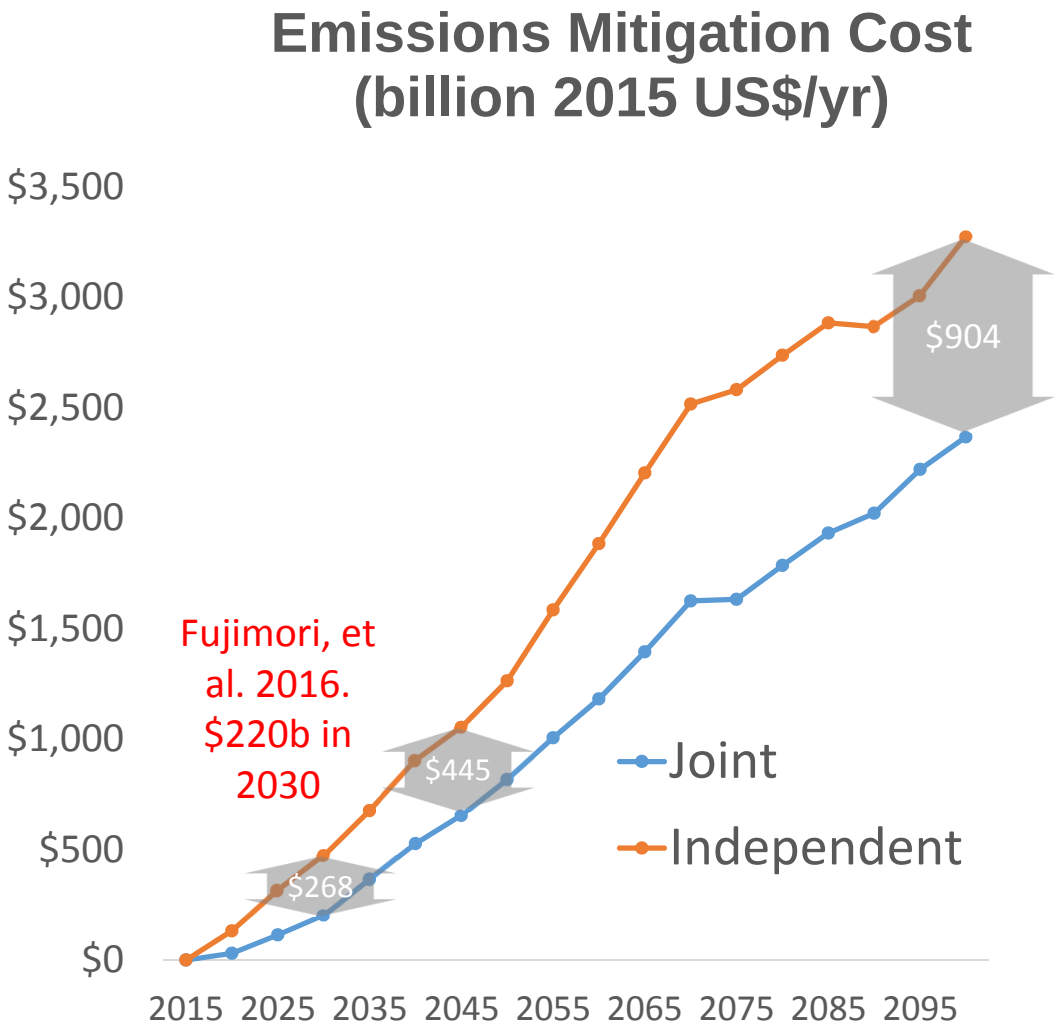
Year	Market Size (Billion 2015 US$)
2030	$222
2050	$572
2100	$1,430

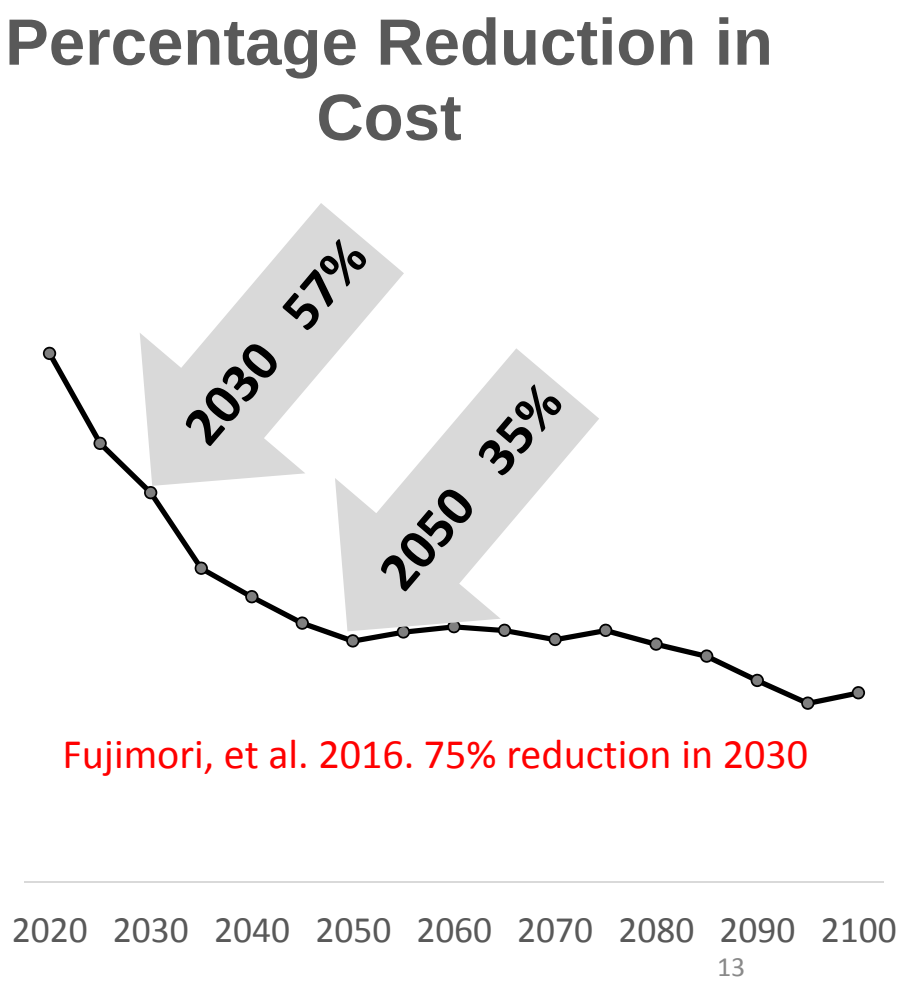


World Bank. 2017. Estimate 2030 market size at **$100-400** billion US$

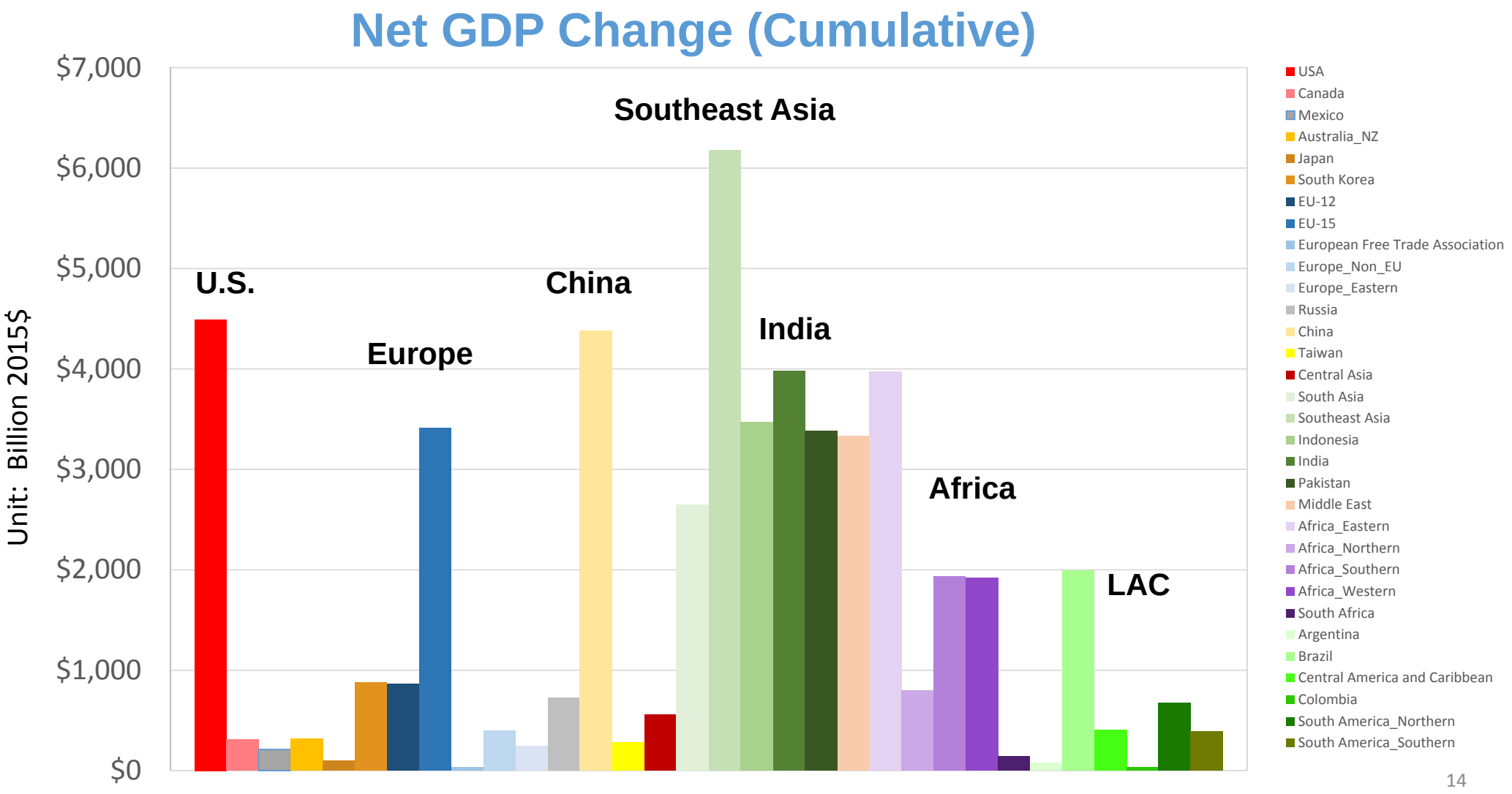
Fujimori, et al. 2016. Estimate 2030 market size of **$38 billion** 2005 US$

Emissions Mitigation Cost: Independent vs. Joint Implementation



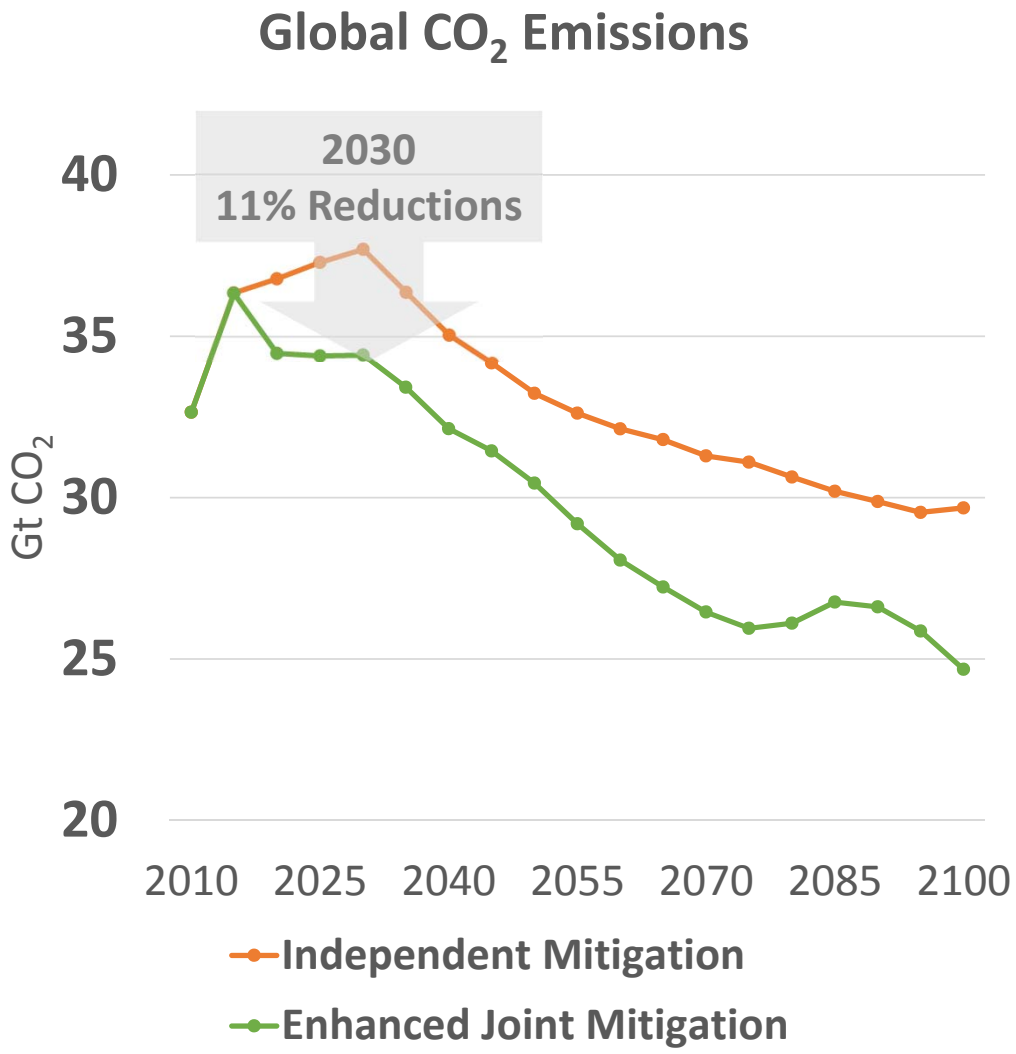


GDP Change by Region – Billion of 2015 US$



How much additional ambition could be enabled by cost reductions?

- We assume that the cost that each region is willing to contribute to emissions mitigation is reflected in their NDC,
- We sum the costs and then assume that in each period, the world limits emissions using Article 6 mechanisms.
- Each country increases its ambition so that its net cost, after trade, is identical to its net cost under the I-NDC scenario.
- Something more easily done in a model than the real world.



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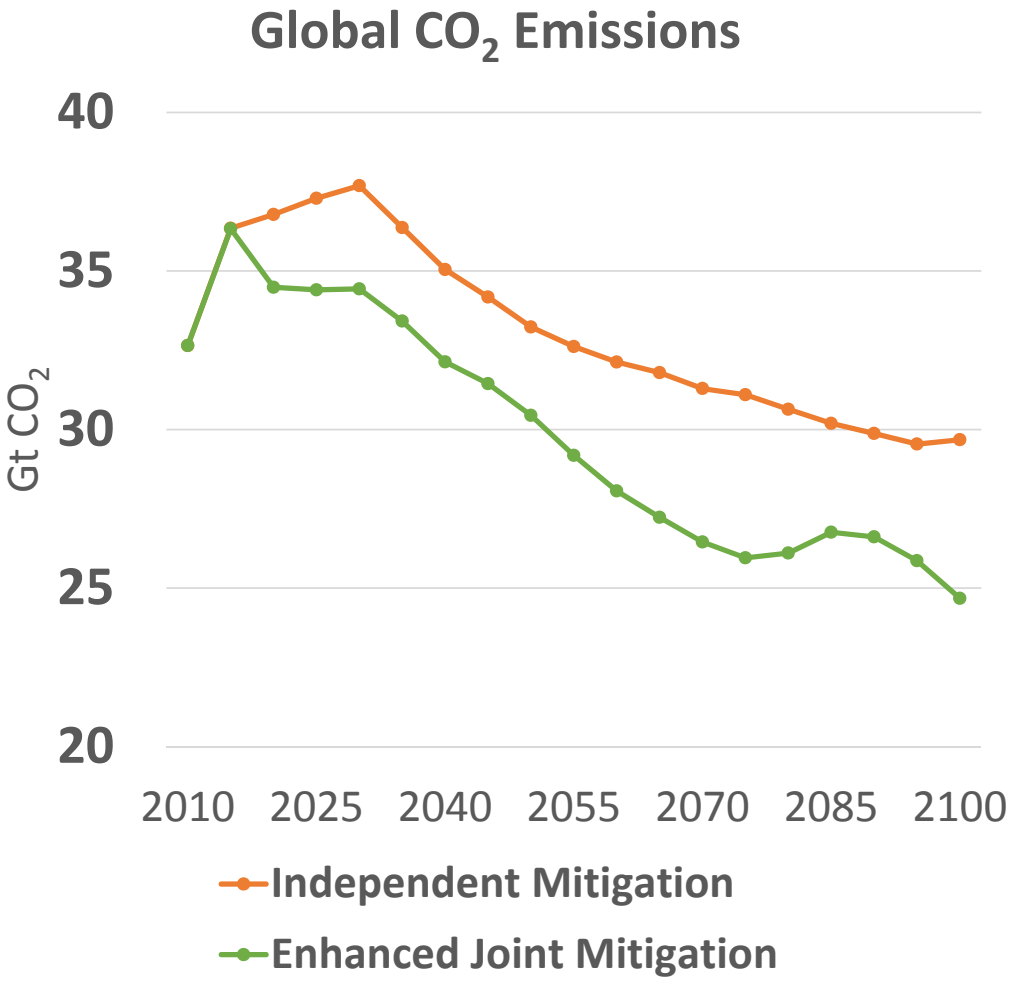


Cumulative Enhanced Mitigation (2020-2100)

310 Gt CO_2

How Valuable is Article 6?

- Article 6 holds significant potential to reduce cost and enhance ambition
  - Everyone could be better off through collaboration
  - **2030 global net benefit ~$270 billion**
- Realizing this potential is a real-world challenge
  - **Near-term**: Translating NDCs to Internationally Transferred Mitigation Outcomes (ITMOs)
  - **Long-term**: It could take any number of forms including NDC coalitions, ratchet mechanisms, or other novel approaches.

Source: https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf

45Q

45Q

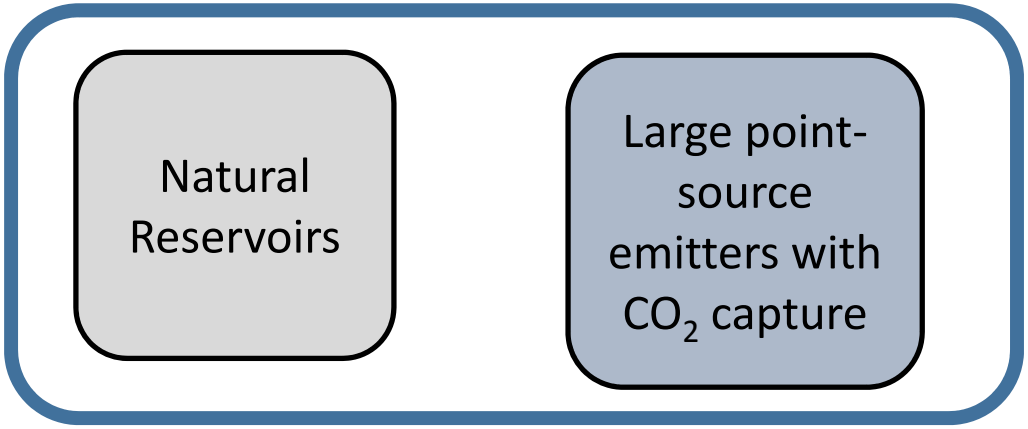
The Bipartisan Budget Act of 2018 included an amendment to the federal tax code section 45Q.

- The new 45Q provisions increase the value of the tax credit for capturing CO_2 in a qualifying facility and
  - **Selling for use in EOR to $35/ton**
  - **For deep saline storage to $50/ton.**
- EMF34 Study Group goal: Assess the effect of 45Q on CO_2 capture utilization and storage (CCUS)
- This implies developing a model of the CO_2 market including supplies and demands

Source: https://www.pnnl.gov/science/images/highlights/atmospheric/pipeline.jpg

45Q, CCUS, and CO2 Market

- **Potential sources of concentrated CO_2**
  - Natural reservoirs
  - Large point source emitters with CO_2 capture technology



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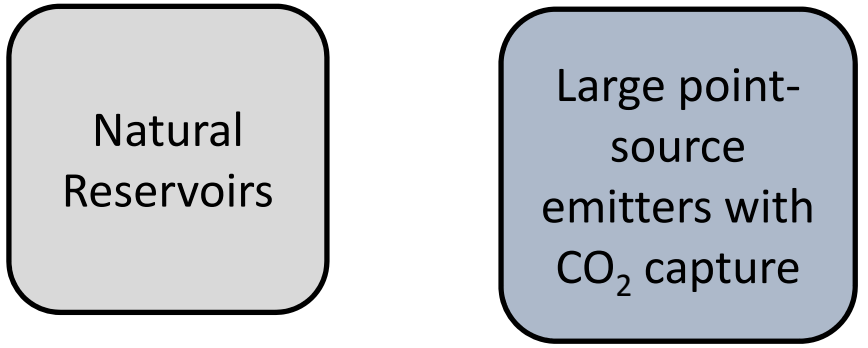
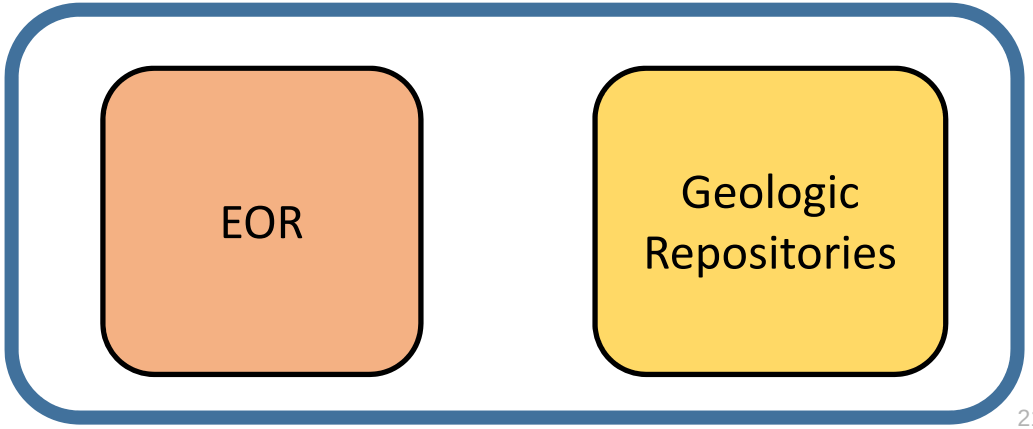


- **Potential disposition of concentrated CO_2**
  - EOR
  - Long-term storage (e.g., Deep saline reservoirs, onshore and offshore)



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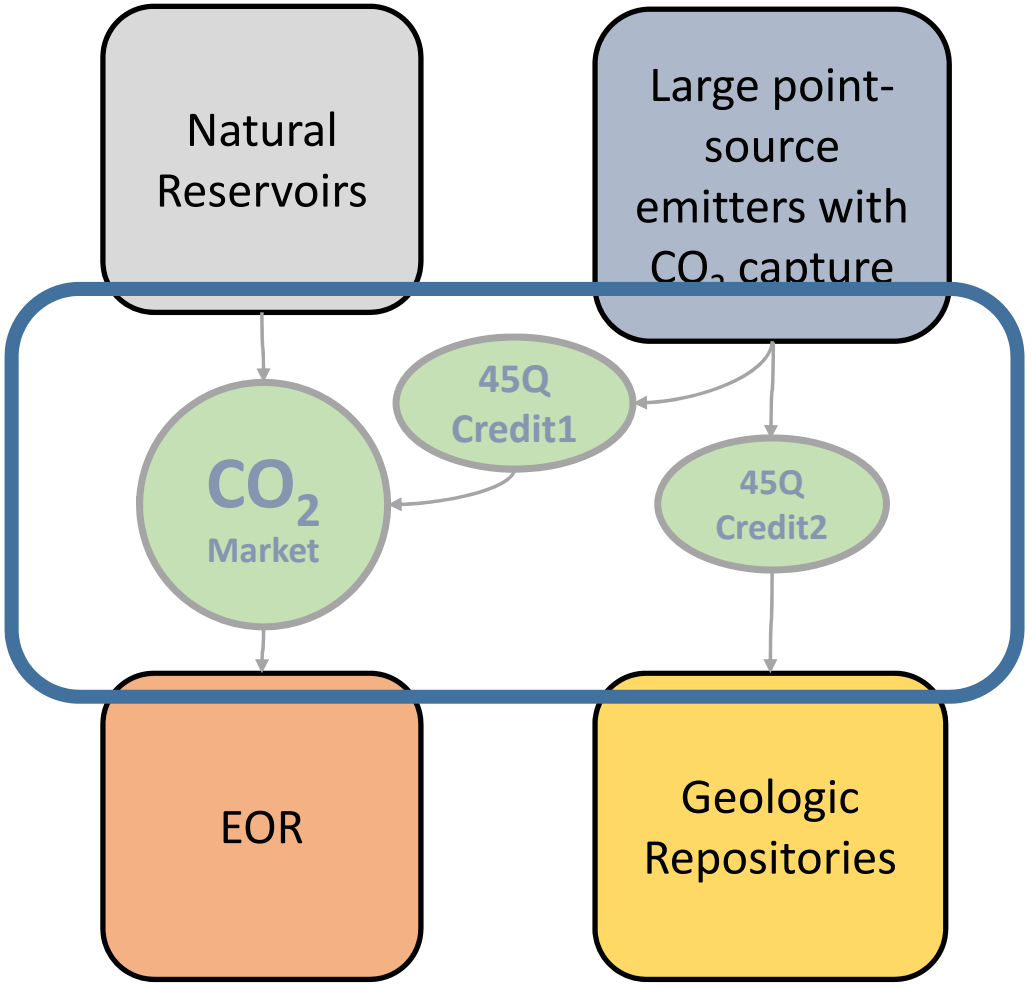
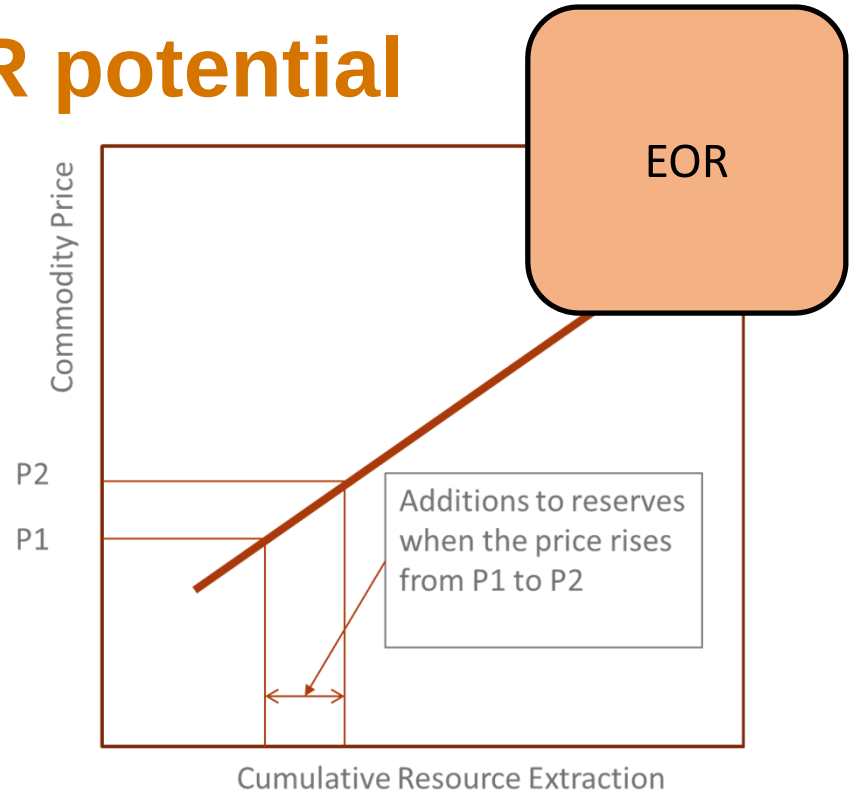
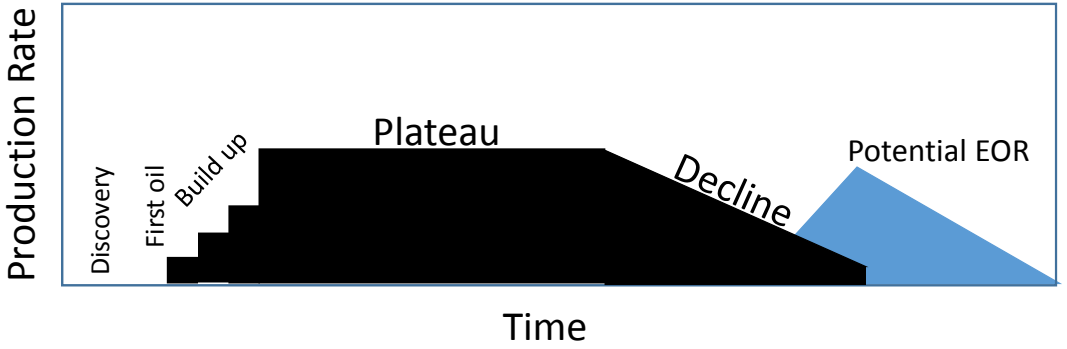
  - Large point source emitters with CO_2 capture technology
- **Potential disposition of concentrated CO_2**
  - EOR
  - Long-term storage (e.g., Deep saline reservoirs, onshore and offshore)
- **Markets that connect them**



Resources, reserves, and EOR potential

- **Production occurs out of reserves**
  - Reserves are constantly being depleted and enhanced
- **The amount of reserves added depends on the resource supply schedule, technology and policy**
  - Reserves are essentially vintage production entities
  - Reserves are produced over time (60 years in GCAM)
- **Each reserve vintage includes a potential EOR category**
  - Derived demand for CO_2 depends on EOR potential and cost





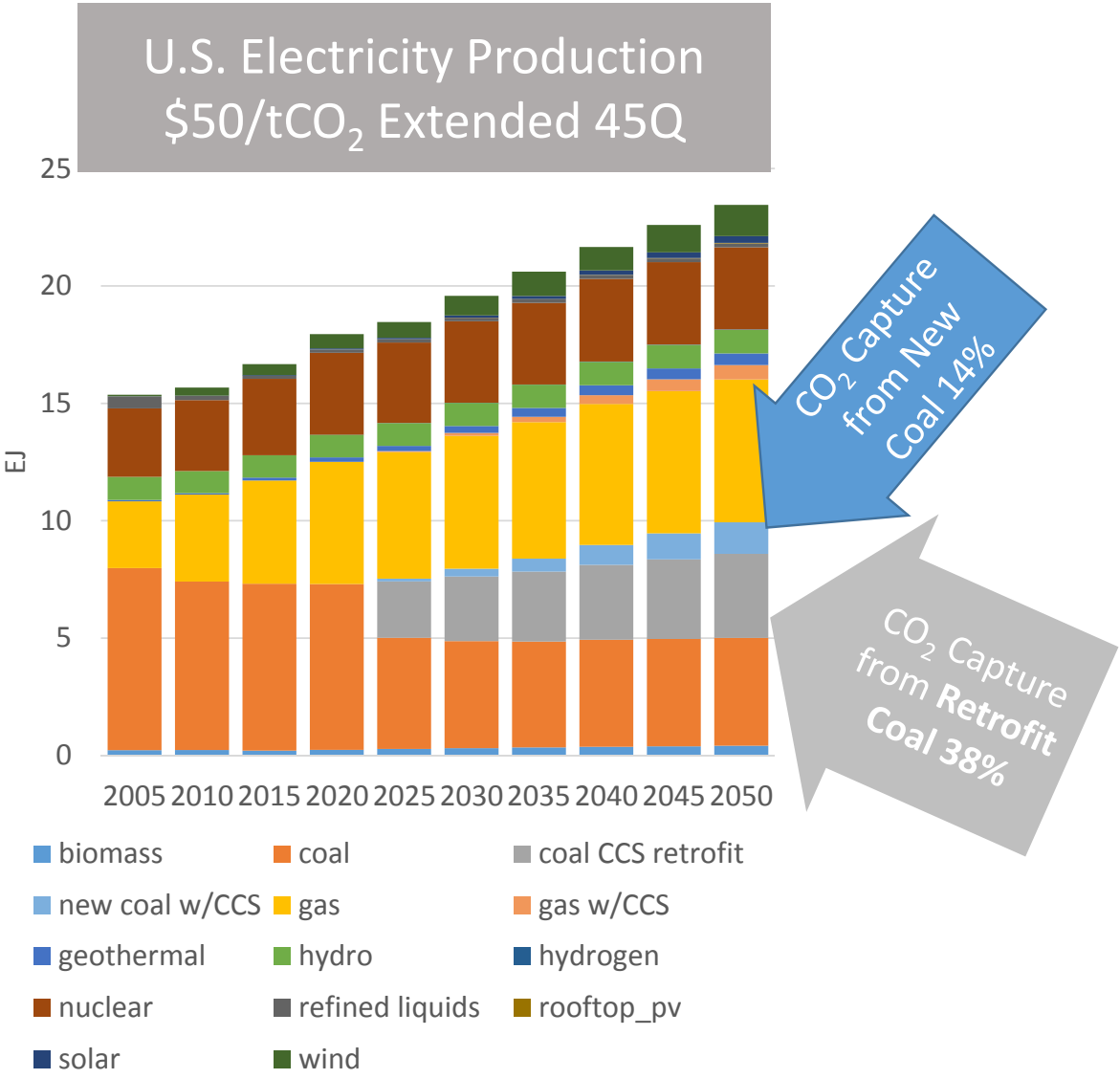
GCAM US Electric Production--$50/tCO$_2$

Ref 45Q scenario

- $50/tCO$_2$ for CCS
- $35/tCO$_2$ for long-term and EOR

Credits drive coal retrofits and some new coal with CCS

- 1/3 of coal retrofitted to CCS in 2025
- 2% coal with new CCS in 2025
- > half of all coal has CCS in 2050

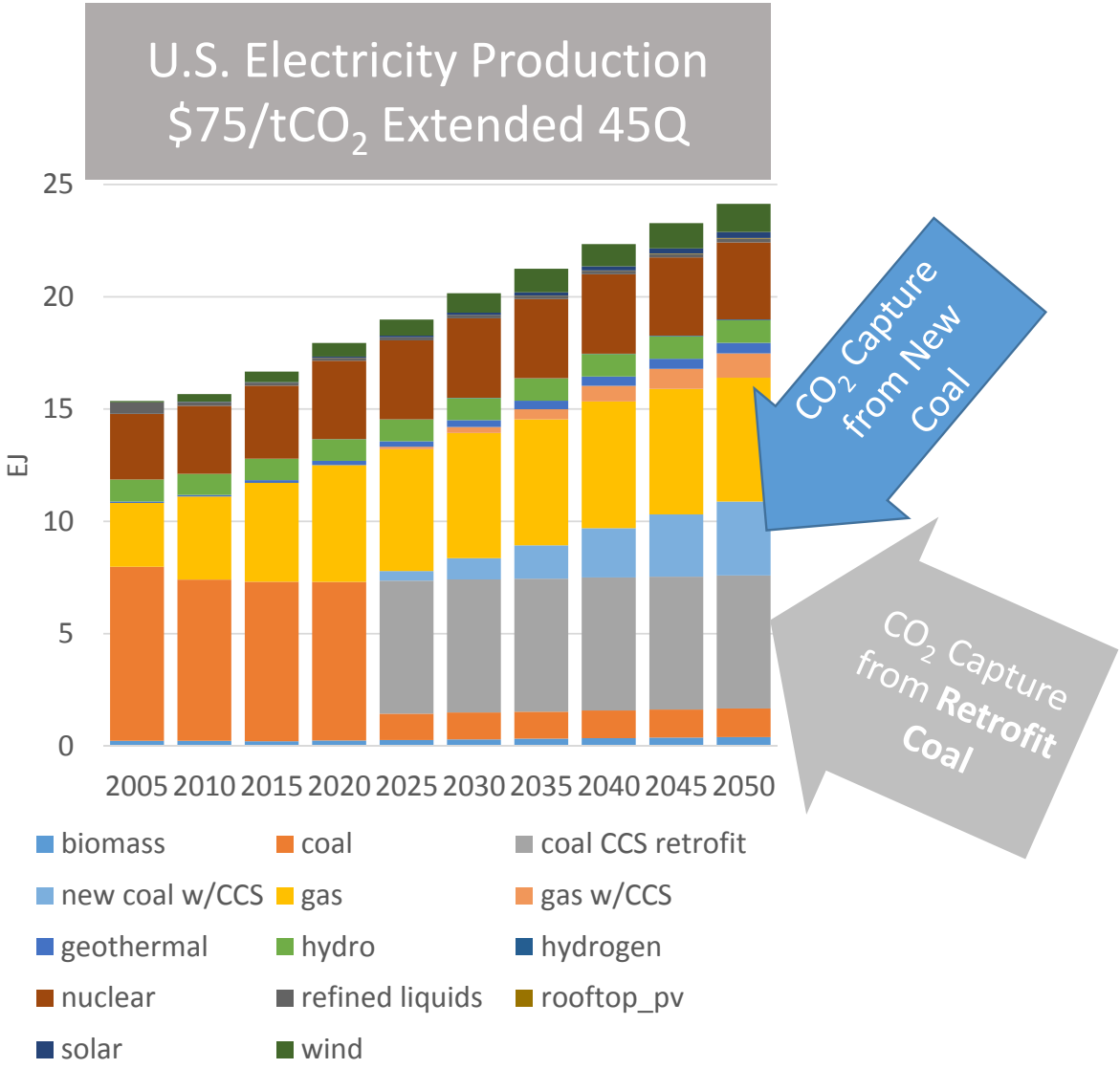


GCAM US Electric Production--$75/tCO$_2$

Ref 45Q scenario

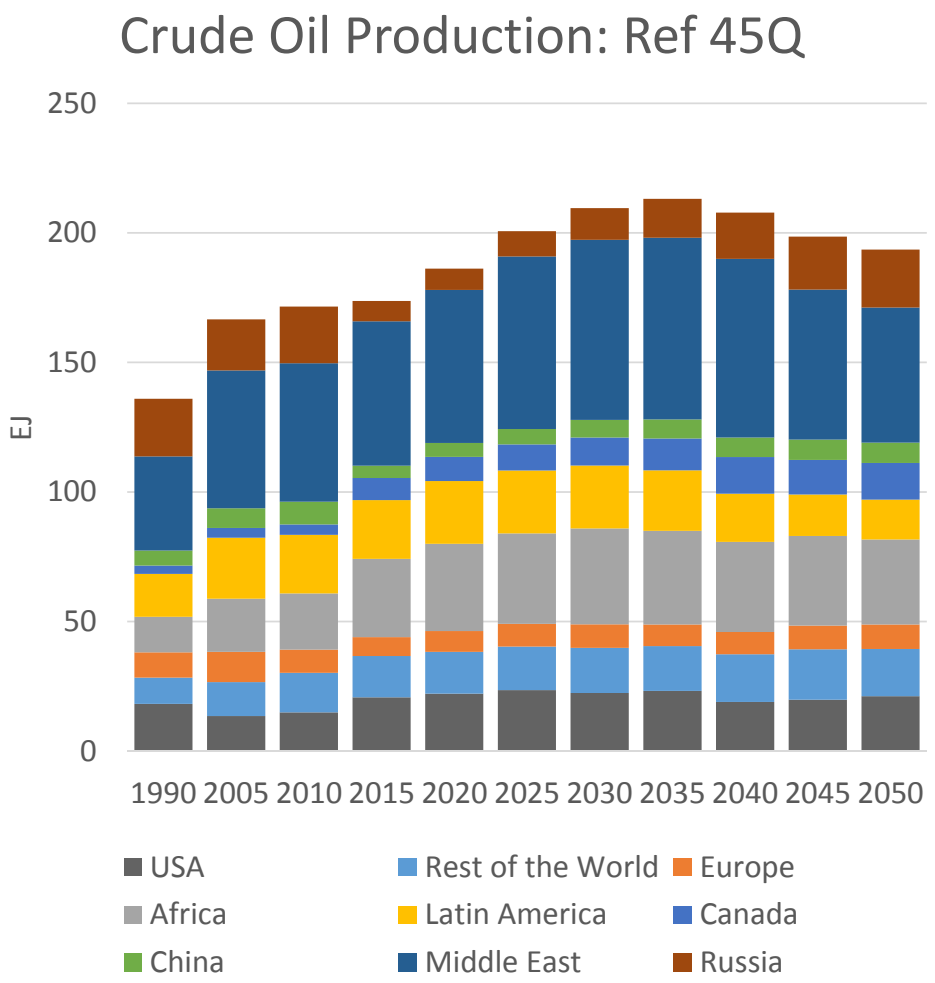
- $75/tCO$_2$ for CCS
- $50/tCO$_2$ for long-term and EOR

Credits drive coal retrofits with some new coal with CCS.



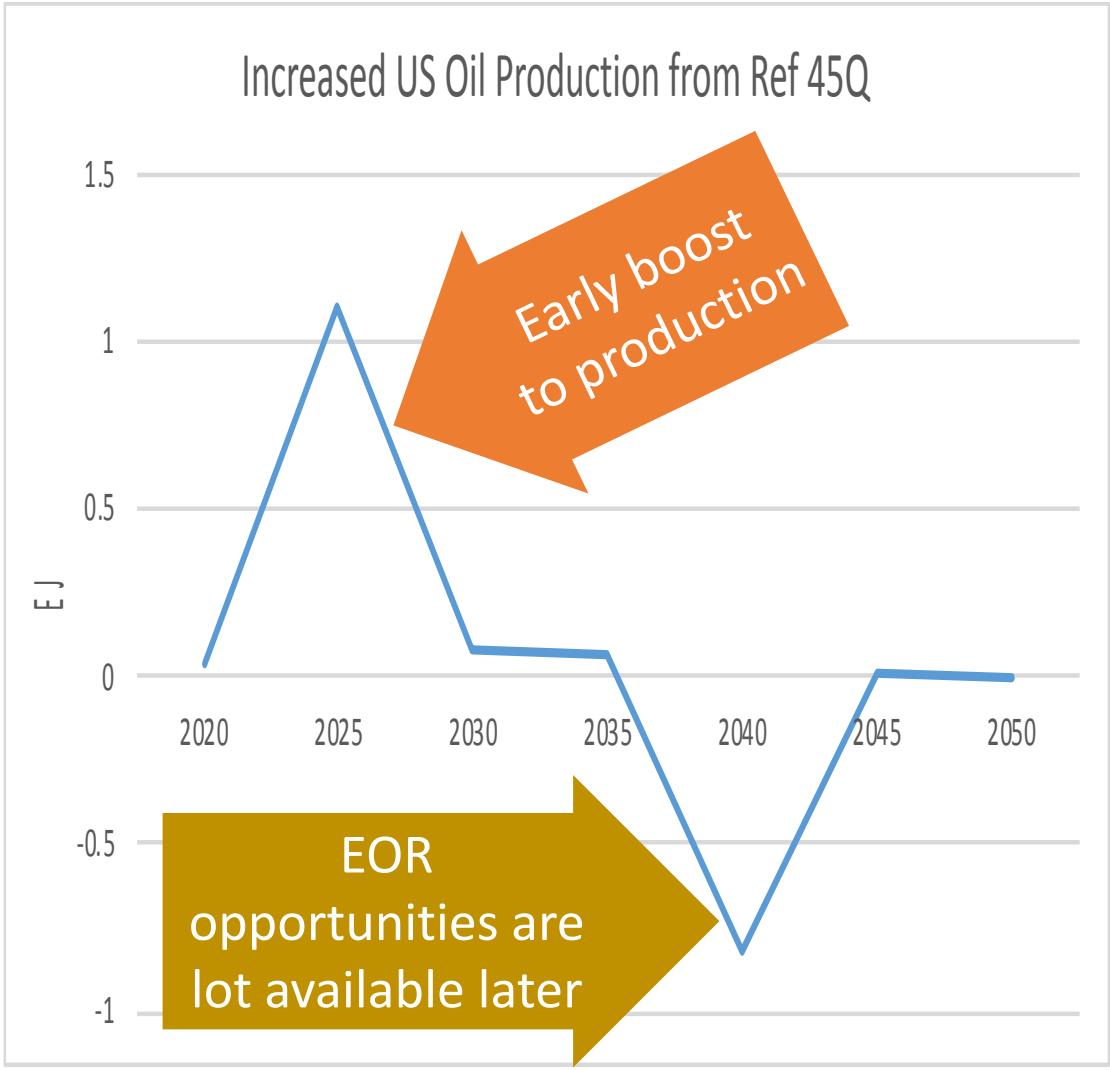
GCAM Regional Oil Production

- **Resource/Reserve model leads to stable regional production behavior**



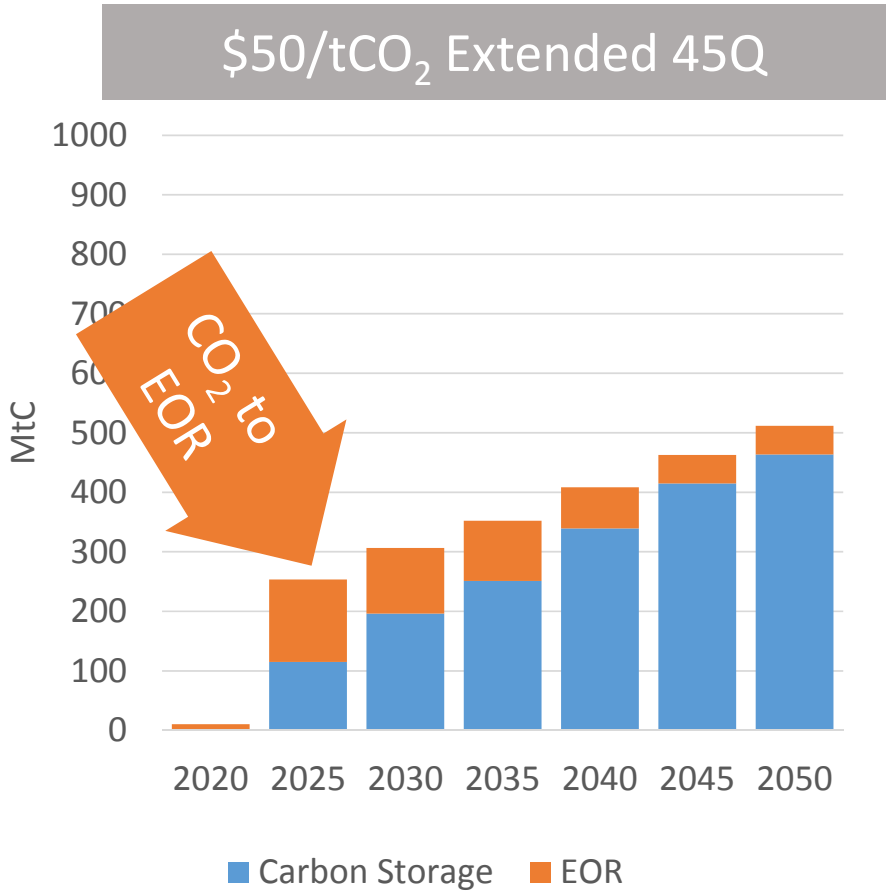
45Q Impact on US Oil Production

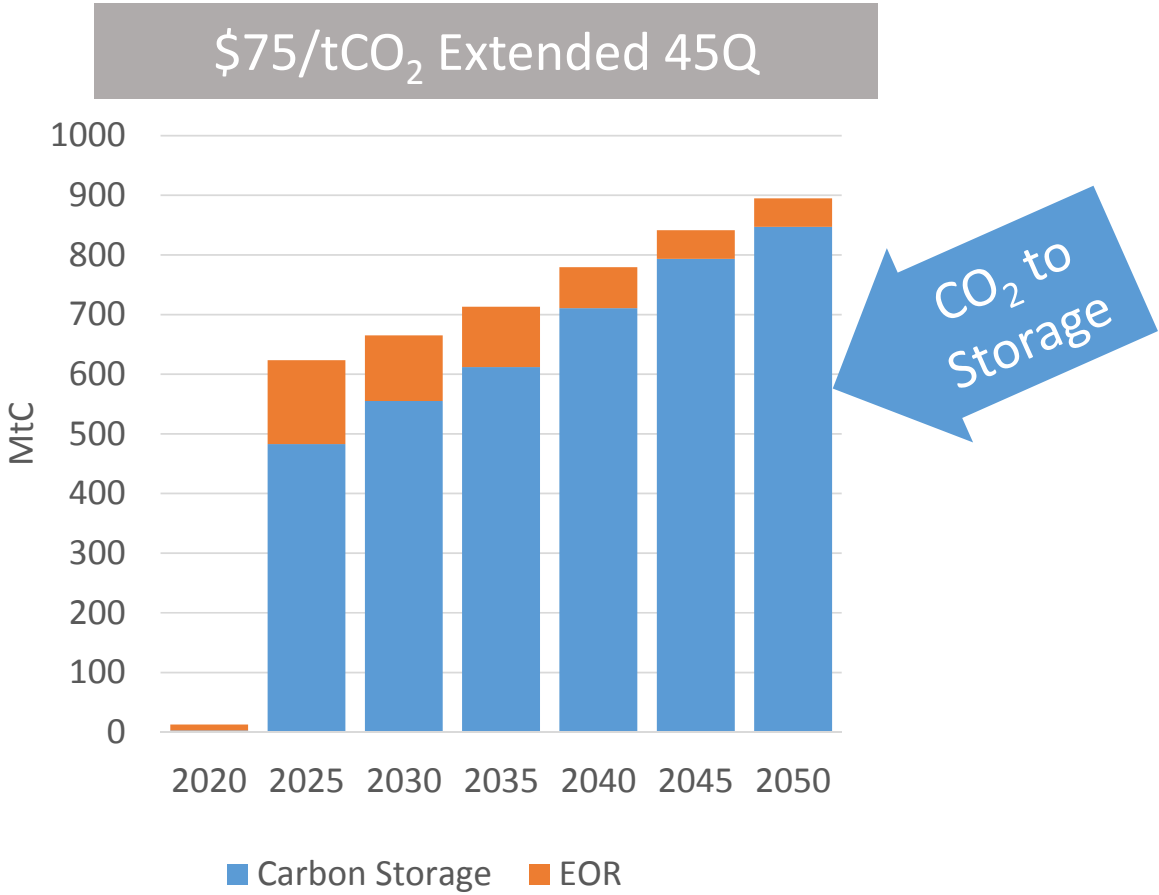
- Early results show small 45Q net upward impact.
- Interaction with Global Market needs to be considered. US increase near-term could save some cheaper oil elsewhere for medium term.



GCAM CCUS (MtC/year)

- EOR is used earlier under our modified, extended 45Q, but over time and at higher CCUS levels the growth is in long-term storage.





What's next?

- Policy questions continue to develop and need analysis to answer.
- The two questions emerging here are an initial contribution to a literature.
- But each answer in turn will stimulate new questions.

Source: https://matcha-jp.com/en/1432

DISCUSSION