

Carbon Capture Commercial Considerations

Development Issues in today's Carbon Capture System ("CCS") marketplace

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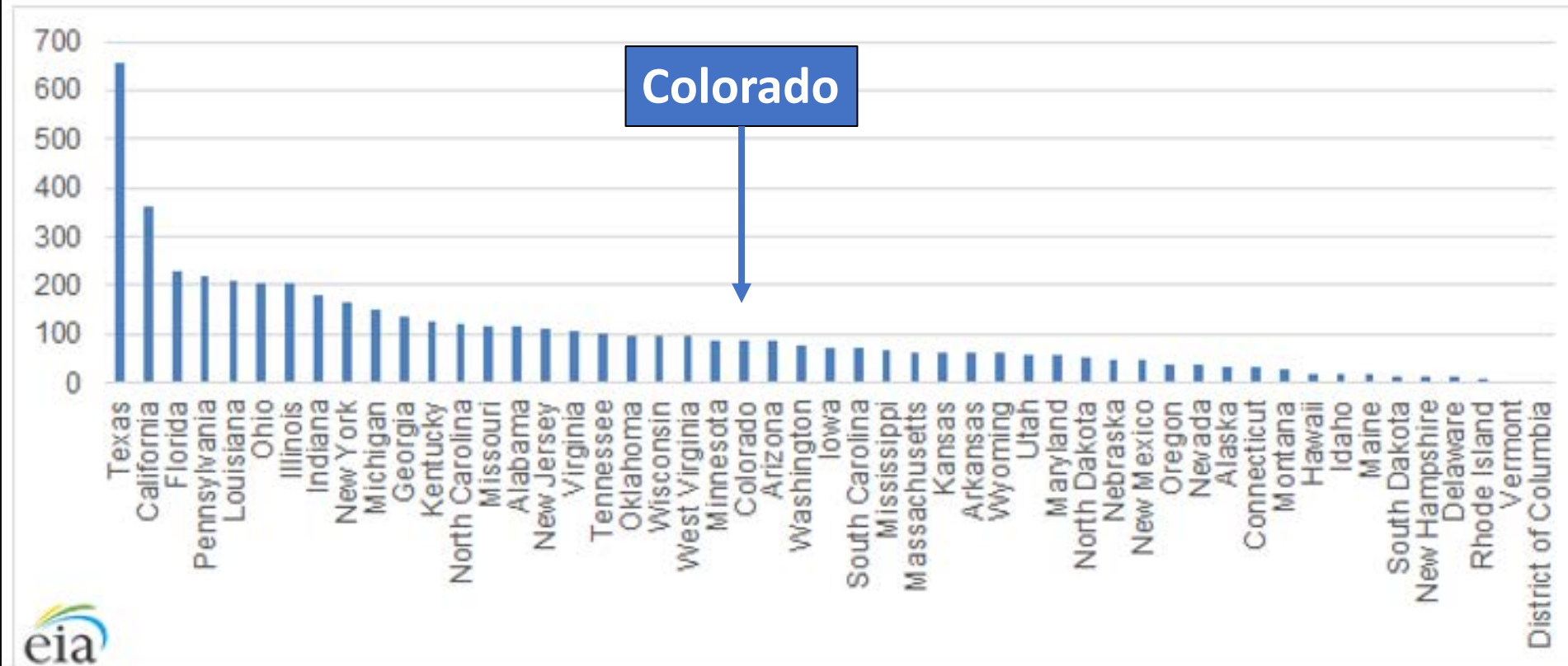
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Colorado CO₂ emissions

China emits 10 billion tonnes per year
100x Colorado

Figure 1. Energy-related carbon dioxide emissions by state, 2016

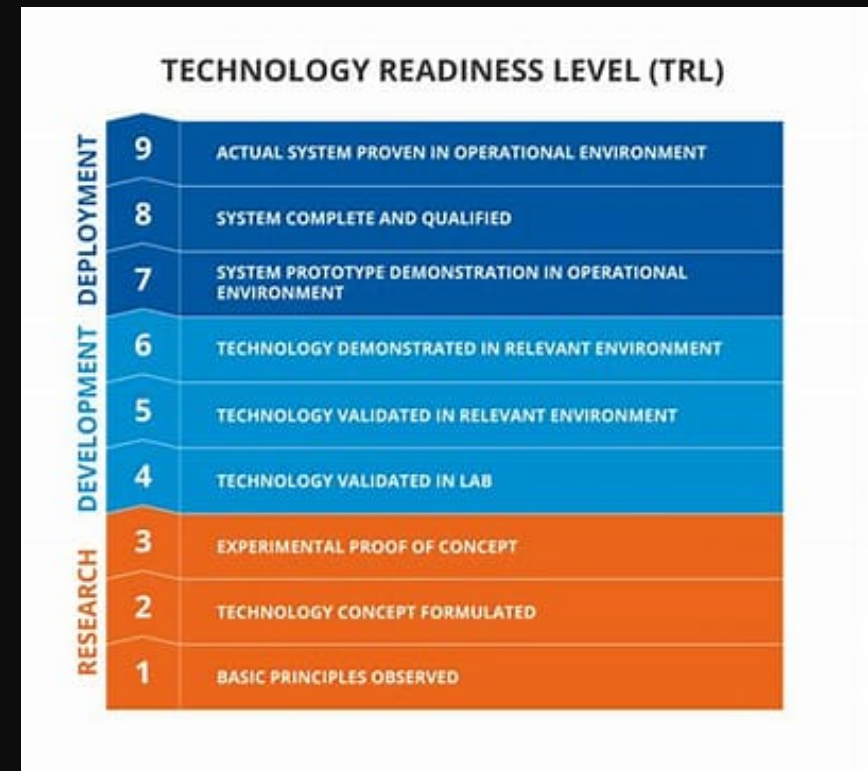
million metric tons of carbon dioxide



Source: EIA, State Energy Data System and EIA calculations made for this analysis.

Industrial carbon capture technologies

- Stages of technical readiness (Technology Readiness Level, AKA “TRL”)
- Many technologies – few are at TRL 9
- Caution when talking about “Carbon Utilization”
 - Volume is the challenge – “bailing with a thimble on the Titanic”
- Caution when relying on TRL
 - TRL makes no judgement on ability to actually reduce CO2 emissions
 - Life Cycle Analysis (“LCA”) perspective not considered



See also:
Technology Readiness and Costs of CCS by
Kearns, Liu, and Consoli

<https://www.globalccsinstitute.com/wp-content/uploads/2021/03/Technology-Readiness-and-Costs-for-CCS-2021-1.pdf>

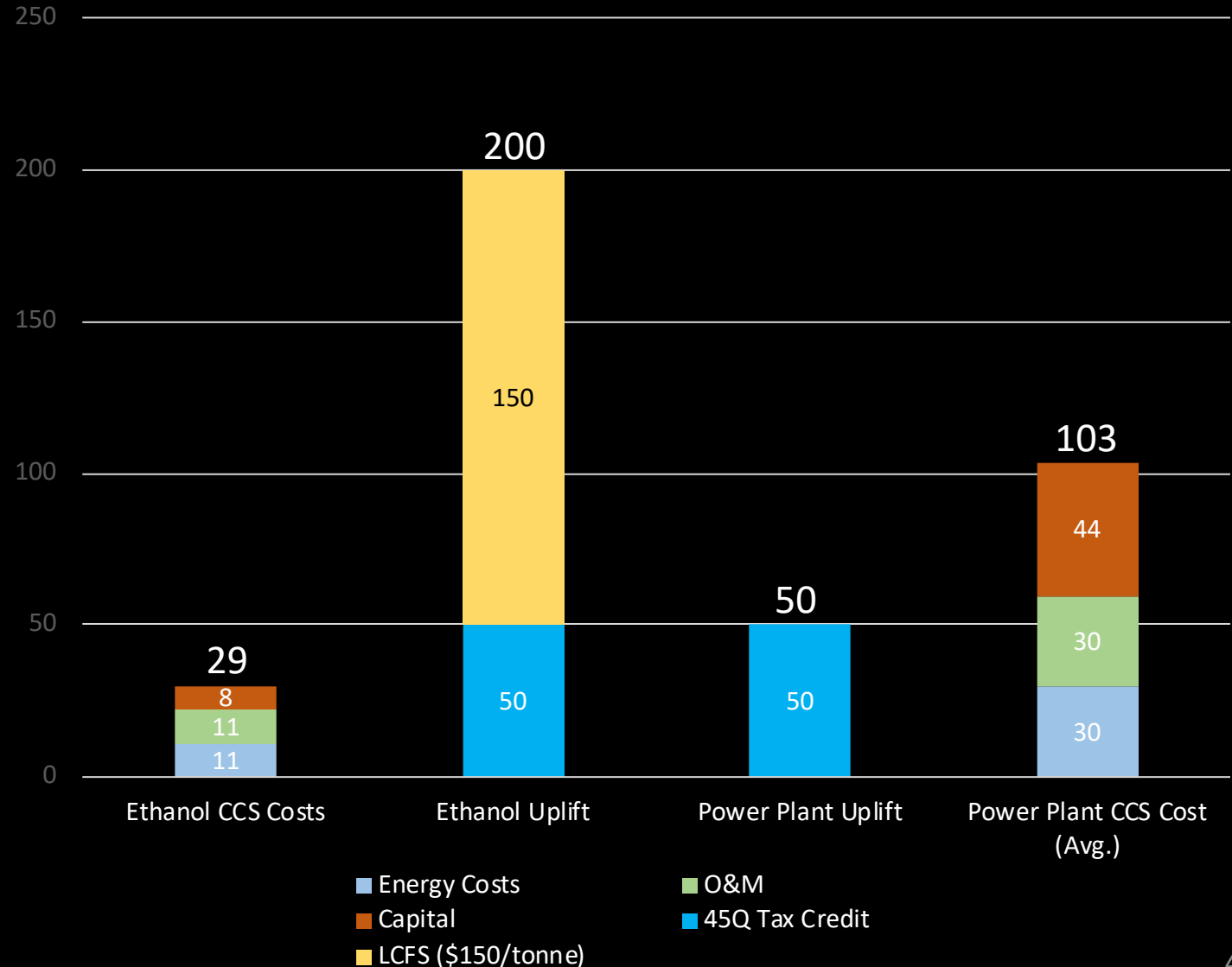
Geologic storage – large-scale, permanent

Storing CO₂ in
sandstone is like
injecting water
into a sponge

- Saline formation – at or near TRL-9
 - demonstrated secure
 - good candidates on all continents
 - massive volumes for significant impact
- Enhanced oil recovery (“EOR”) – TRL-9 for over 40 years
 - demonstrated secure
 - good candidates in many locations (on-shore oil fields)
 - massive volumes for significant impact
 - economic value and displaces oil produced without CO₂ storage

Large difference in economics

Relative Costs of Typical Carbon Capture System
Ethanol vs. Power
(\$/tonne)



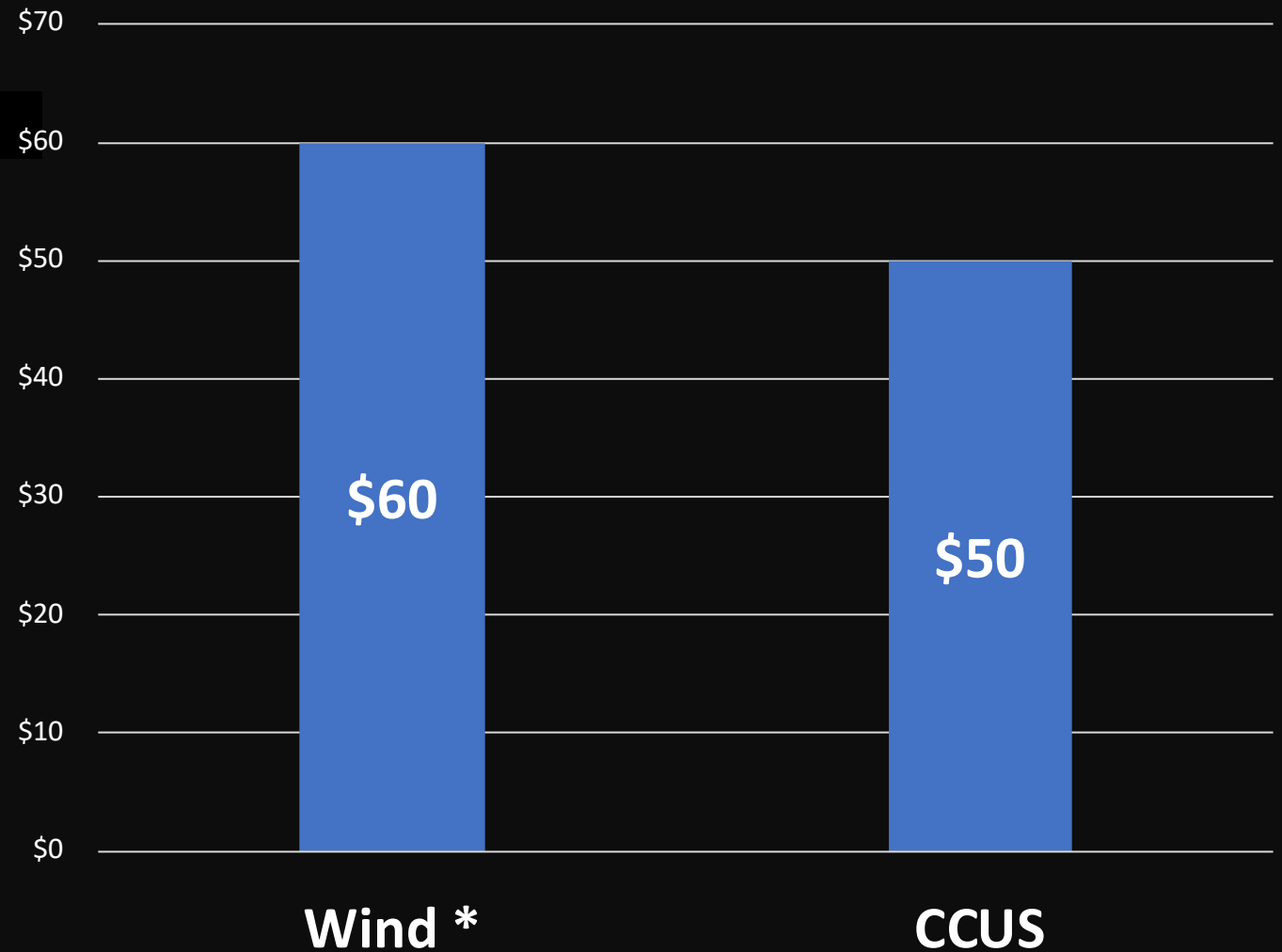
Sources:

1. Costs from National Petroleum Council report "Meeting the Dual Challenge" 2019
2. LCFS amount from California Air Resources Board Weekly LCFS Credit Transfer Activity Report 12th April 2021 – 18th April 2021

Are we sending the right signal?

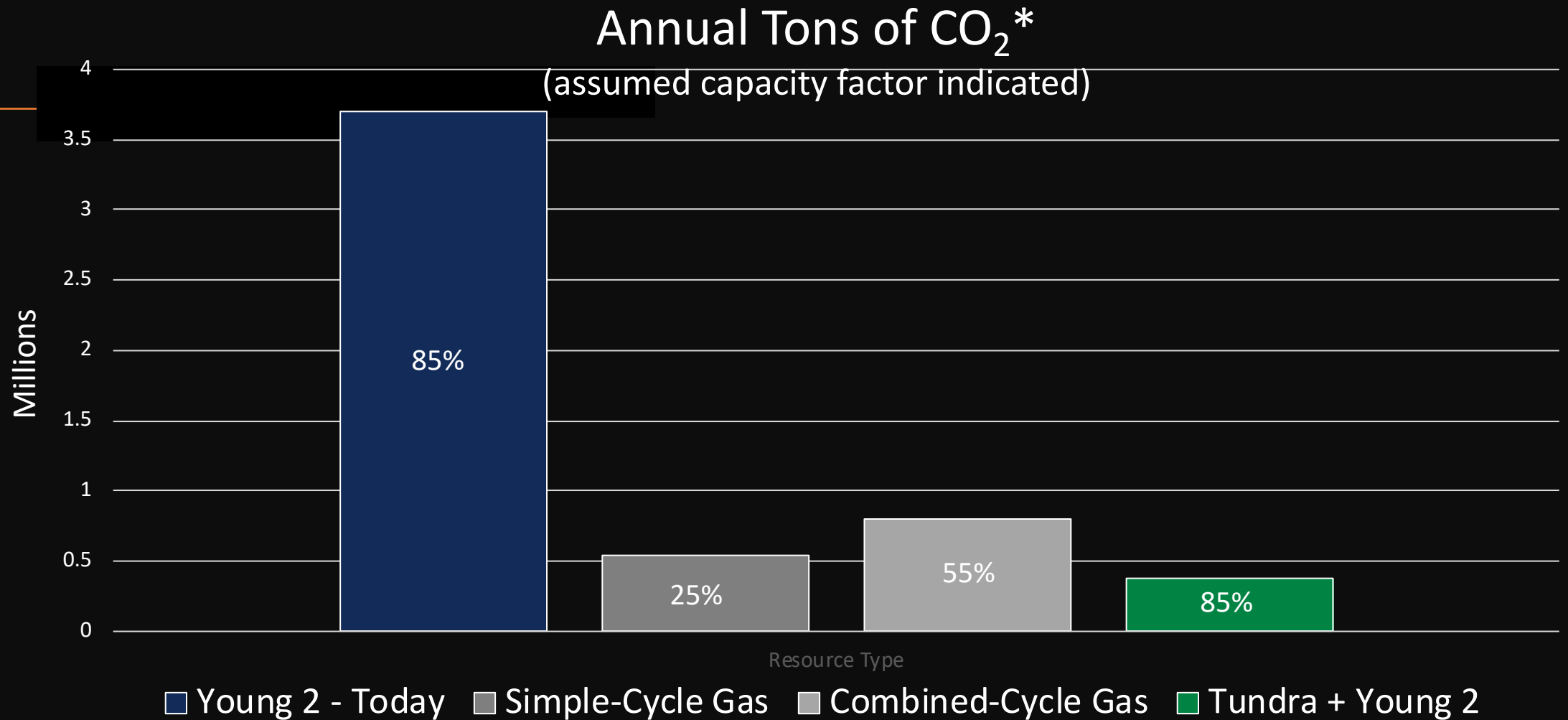
Federal tax credit policies, in partnership with State and ISO line extension and capacity reserve policies, are de-stabilizing our grid by incentivizing un-reliable generation.

Federal Tax Credits per ton of avoided CO₂ emissions



* Note: does not include CO₂ emissions from firm resources required to back up intermittent resource

Firm resource options



* Calculations based on CO₂ emissions at the plant