

The impact of CCUS infrastructure on the levelized cost of electricity (LCOE) at Cascade

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Abstract

Carbon capture, utilization, and storage (CCUS) is an important technology to reduce greenhouse gas (GHG) emission, specifically carbon dioxide (CO₂). This study evaluates the impact of theoretical CCUS implementation at Cascade and how that would impact the levelized cost of electricity (LCOE) at Cascade. The most significant barrier to CCUS implementation is the high cost associated with carbon capture technology (an addition of 2.5 to 3 cents per kWh). In this study, the levelized cost of electricity (LCOE) with and without carbon capture at Cascade, a NGCC facility, is shown to differ by 45%, or 3 cents per kWh.

As carbon pricing increases to \$75 to \$90/tonne or more, the LCOE model demonstrates that it is beneficial to implement CCUS/CCS at Cascade. Further modeling was conducted to illustrate the benefits of Cascade participating in TIER and how future reductions in TIER benchmarks would negatively impact NGCC facilities without carbon capture

Introduction

In Alberta, GHG emissions from electric power generation accounted for 44.3 MT CO₂e in 2017 (60% of total Canadian), mainly due to the largest coal fired electricity capacity in Canada [2]. Alberta plans to phase out coal-based facilities by replacement through natural gas (NG), (e.g., Cascade) and renewable energy facilities. However, NGCC facilities may require CCUS infrastructure to compete in Alberta's deregulated market. Cascade is a new, natural gas combined cycle (NGCC) power plant that is currently under construction near Edson and slated to be in operation by 2023.

NGCC facilities in Alberta will operate under Alberta's TIER system with the current benchmark at 0.37 tCO₂/MWh (370 kgCO₂/MWh). Reductions to this benchmark and an increasing carbon price will negatively affect NGCC facilities without CCUS which may motivate CCUS deployment in the coming years.

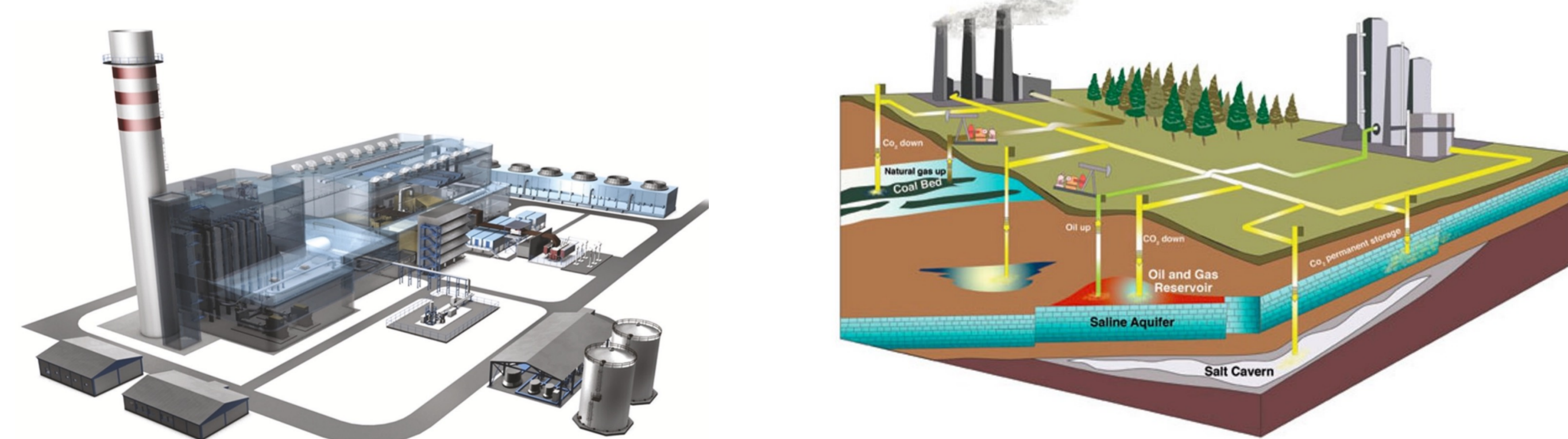


Figure 1: Left, artists rendering of Cascade Power Plant; Source Backwoods Energy Services from ESG-Indigenous Case Study. Right, Image illustrating different utilization or storage options for captured CO₂ from Cascade; Modified from Alberta Geological Survey.

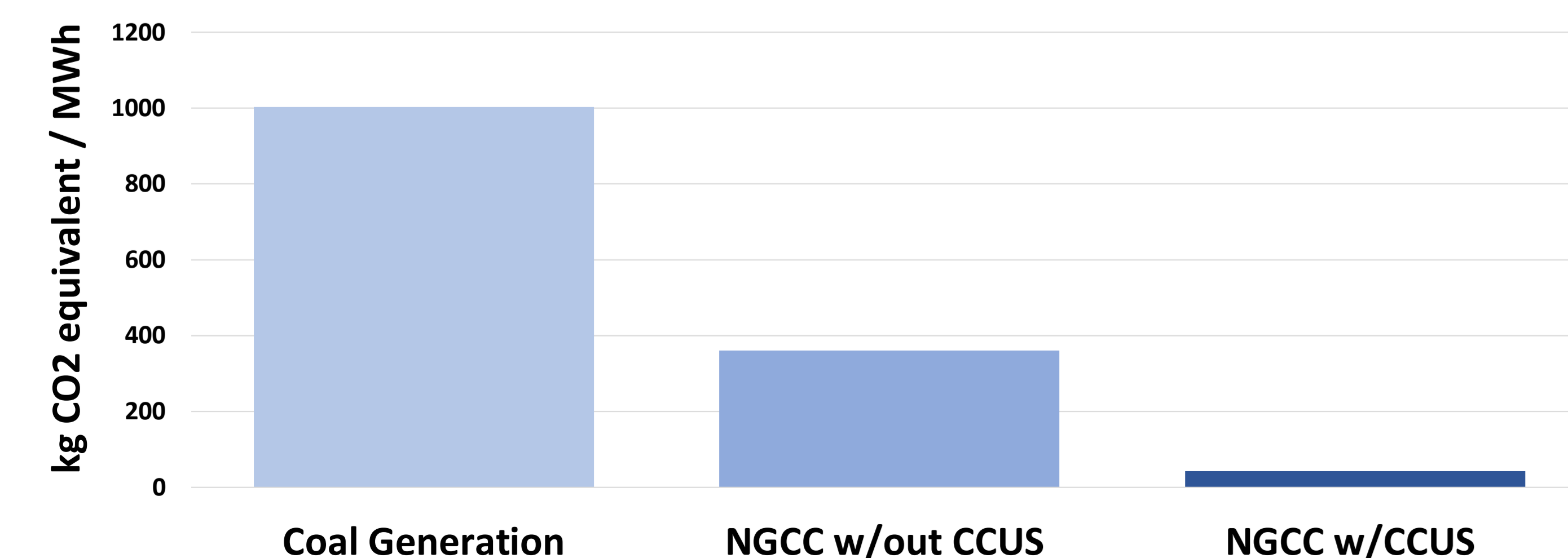


Figure 2: Potential CO₂ emissions from a NGCC facility, like Cascade, with/without CCUS, compared to coal-fired electricity. Data from 3, 5, 7.

LCOE Modeling and Assumptions*

LCOE (cents/kWh) is a metric that represents the cost of constructing and operating an electric power generation plant. The economic modeling assumption:

- Project lifespan: 25 years
- Net Capacity: 900 MW
- Capacity factor: 70%
- TIER Benchmark: 0.37 tCO₂/MWh
- Expected rate of return: 10%
- Nominal discount rate: 8%
- Oil Price: \$50/bbl
- Annual fuel cost, w/o CCS: 0.019 (\$/kWh), w/CCS: 0.023 (\$/kWh)
- Emissions reduction: from 353 kg of CO₂/MWh to 42 CO₂/MWh post CCS [7]
- CAPEX (w/o CC): \$1.5 B
- CAPEX (w/ CC): \$2.7 B
- O&M: 25 \$/kW
- Post combustion capture cost: 95 \$/tCO₂
- CO₂ transportation cost: 4\$/tCO₂
- CO₂ storage cost (saline aquifer): 8\$/tCO₂
- CO₂ storage cost (EOR): 6.5\$/tCO₂

* All costs reported in this poster are in Canadian dollar

Figure 3 illustrates the effect of carbon price on LCOE at NGCC plants with and without carbon capture (CC) and w/out participation in the Technology Innovation and Emissions Reduction (TIER) system. The breakeven Carbon price w/out TIER is ~\$105/tCO₂.

Figure 4 illustrates the effect on LCOE from a NGCC facility with CCS under TIER versus CCUS compared to a facility without CC with only the benefit of TIER. The breakeven Carbon price with CCS: \$90/tCO₂ and with CCUS: \$75/tCO₂

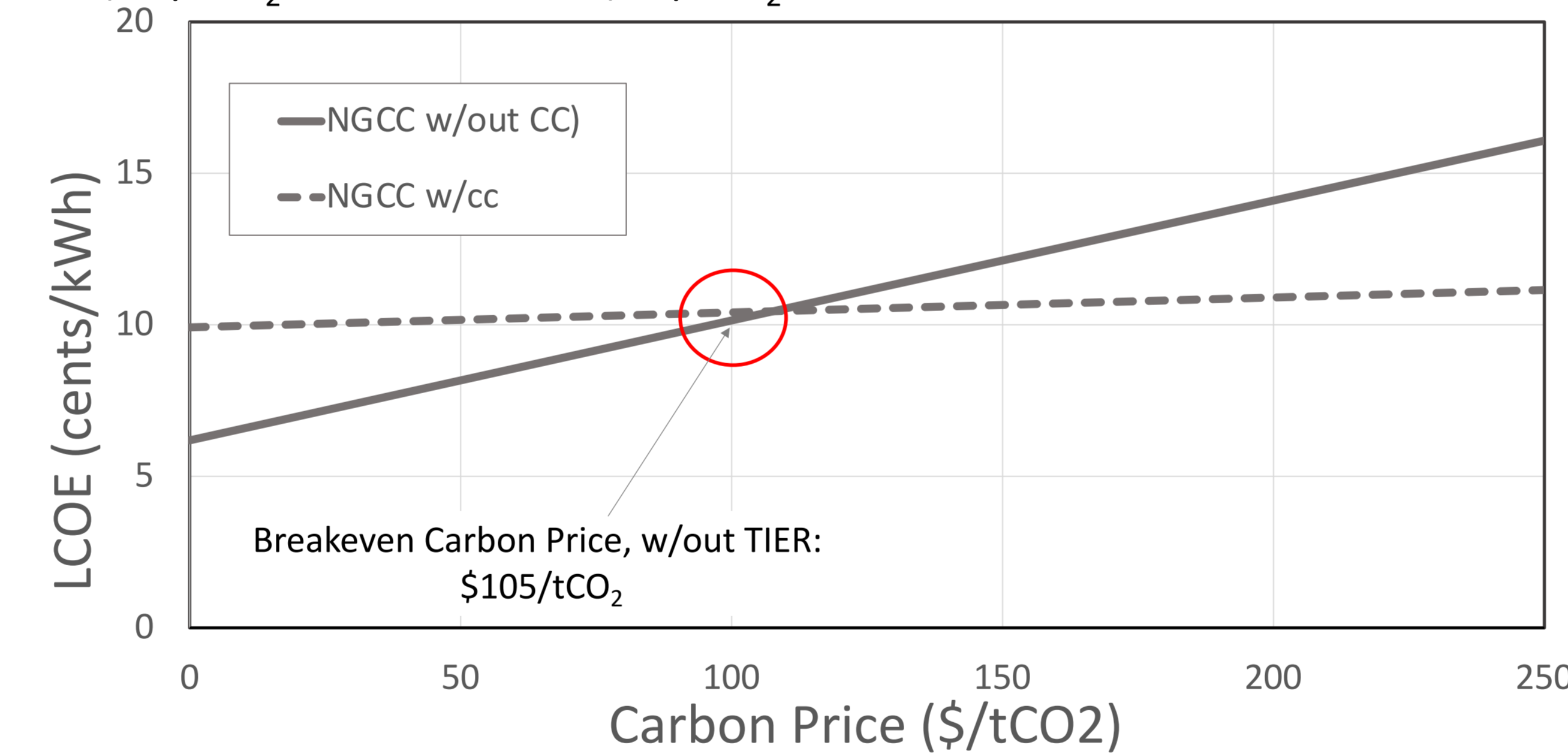


Figure 3: Natural Gas Combined Cycle LCOE with and w/out CCUS and TIER

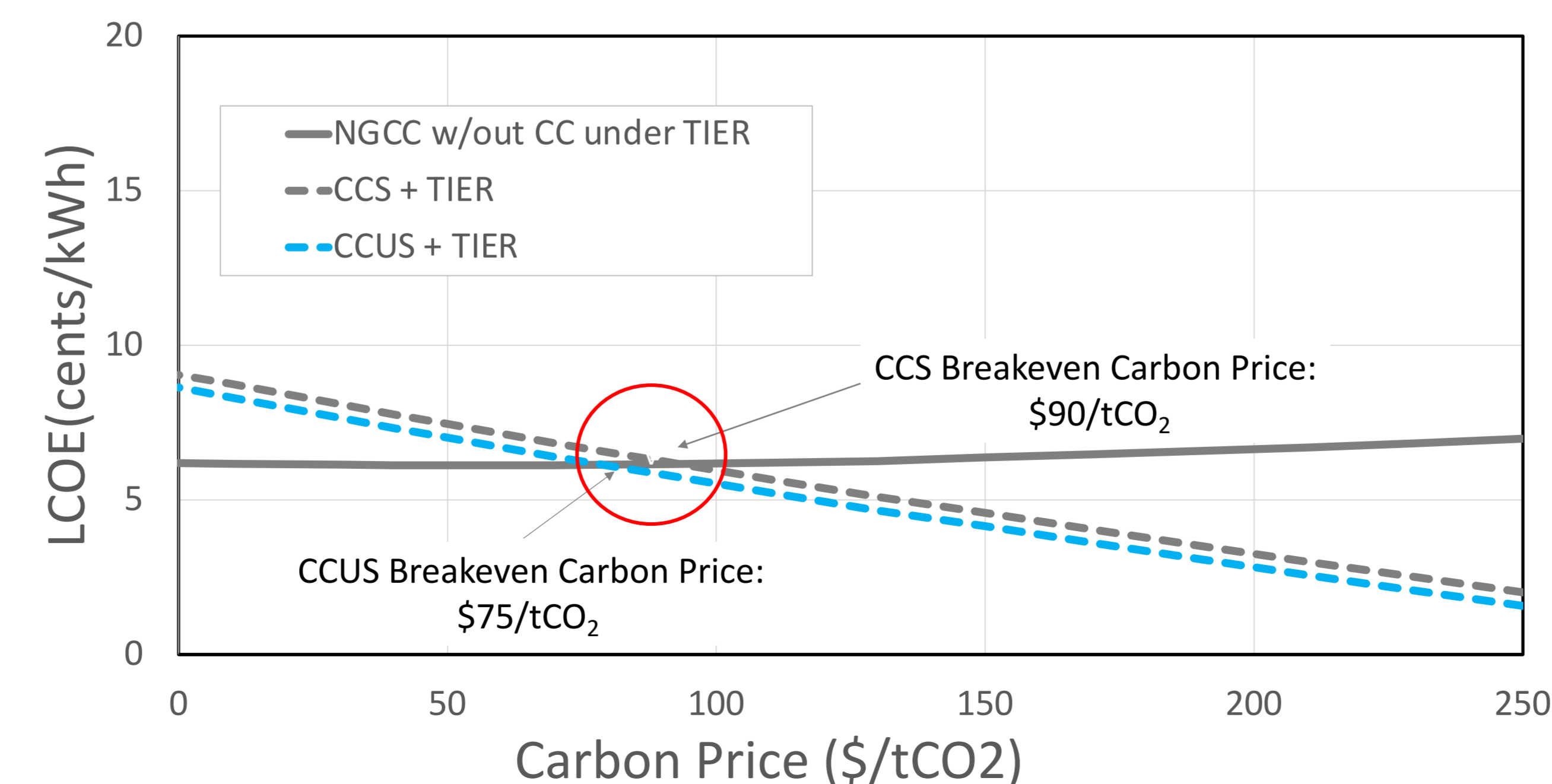


Figure 4: Natural Gas Combined Cycle LCOE with and w/out CCUS and TIER

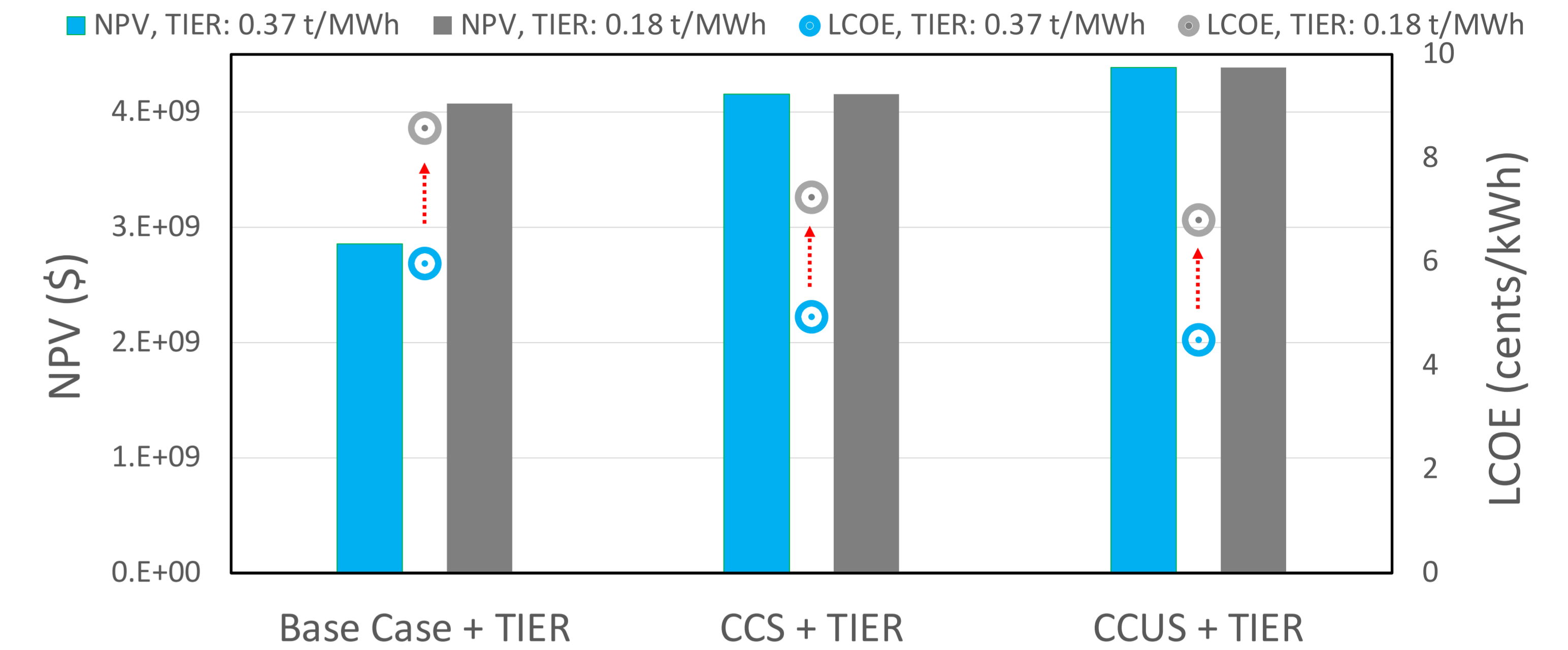


Figure 5: Impact of a more Stringent TIER Benchmark on NGCC Plants w & w/out CCS & CCUS

Observations

- Current carbon price of \$40/tonne favours facilities without CCUS
- If carbon price reaches or exceeds \$75/tonne, Cascade's LCOE will be lower with CCUS especially if the TIER benchmark is lowered below its current level.
- Sensitivities to modeling assumption uncertainties are expected to shift the LCOE graphs and change the breakeven price.
- Considering these uncertainties, a specific carbon price or tax to stimulate the use of CCS may or may not be adequate.

Conclusions and Future Work

- LCOE will be impacted if a facility implements CCUS due to cost of infrastructure.
- The current TIER benchmark (0.37 tCO₂/MWh) is sufficient to motivate CCUS if credits earned under TIER can be sold as a revenue source to other industrial emitters (Figure 5).
- Future reductions to the TIER benchmark and increases to the carbon price would negatively impact NGCC facilities LCOE without CCS/CCUS which jeopardizes competitiveness (Figure 5).
- Revenue for the facility and its investors will be negatively impacted due to the cost of CCS/CCUS, but if TIER is reduced and carbon price increases, a facility without CCS/CCUS may have reduced dispatch frequency which also negatively impacts Cascade and investors.

References

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