WSPA (Jessica Spiegel)

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September 3, 2025

Sent via email to: CCAEITEIndustries@ecy.wa.gov

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Re: Comments on Policy Design Considerations for EITEs under the Climate Commitment Act

Dear Adrian,

On behalf of the Western States Petroleum Association (WSPA), thank you for the opportunity to comment on the Department of Ecology's (Ecology) draft legislative report on methods for allowance allocation for emissions-intensive, trade-exposed (EITE) industries beginning in 2035 under the Climate Commitment Act (CCA). WSPA represents refineries and other covered fuel suppliers that are central to Washington's economy, energy security, and workforce; and which are directly impacted by the allowance allocation framework under development.

WSPA's recommends a framework that is durable, predictable, and helps prevent leakage by continuing an EITE compliance curve and no-cost allocations beyond 2034. WSPA also recommends that any framework offered by Ecology should avoid major declines in allowance distributions that would be antithetical to future growth and investment; should prioritize competitiveness and leakage prevention; and should ensure any modifications are grounded in realistic assessments of technical feasibility, economic impacts, and statutory obligations.

WSPA and our members have participated actively in the EITE advisory group process, including the Industries Advisory Group (IAG) and – when allowed – policy discussions via the Policy Advisory Group. We appreciate Ecology's effort to gather perspectives from stakeholders. However, we do have concern that the process did not initially focus on providing Ecology staff the interaction with industrial stakeholders needed to provide the depth of knowledge needed to assess the impacts some recommendations have on each sector. As a result, WSPA remains concerned that several of the draft recommendations and supporting analyses would not help prevent emissions leakage and economic harm, and therefore many not align with legislative intent in RCW 70A.65.110, which directs Ecology to evaluate allocation approaches by December 1, 2026 that "*prevent emissions leakage and economic harm to trade-exposed businesses"*.

WSPA believes this possible gap between the recommendations by Ecology and the legislative goals of the report may be remedied by further dialogue and additional stakeholder meetings with each industry sector, to allow Ecology staff a better understanding of the implications of recommendations on each sector. WSPA and our members welcome the opportunity to work with Ecology staff in developing deeper industry knowledge to better inform these work products as well as work products Ecology will need to prepare in the future.

This letter builds on our previous written comments submitted in April, June, and July 2025, which are incorporated here in full. We expand on those points with additional observations about

program design, compliance flexibility, environmental justice mapping, and leakage prevention. Finally, we provide narrow but important responses to the ERG and RMI consultant reports, highlighting technical flaws identified by our subject matter experts and independent reviewers.

Continued Provision of No-Cost Allowances Beyond 2034

WSPA strongly supports the continuation of no-cost allowance allocations to all existing and future EITE facilities in Washington beyond 2034. The Legislature was explicit in RCW 70A.65.110 when it directed Ecology to design an allocation framework that prevents leakage and protects the competitiveness of trade-exposed industries.

The dominant factors that compelled legislative direction in 2021 remain unchanged. Washington refineries remain among the most trade-exposed industries in the state. If Washington facilities are forced to absorb costs that competitors elsewhere do not bear, the result will likely be reduced production in the state of Washington, with supply made up through production from jurisdictions with weaker environmental standards. This dynamic—leakage—increases global emissions and undermines the state's climate objectives. California's recent experience provides a cautionary example: insufficient recognition of leakage risk has driven market volatility, discouraged investment, and left state regulators struggling to reconcile program costs with economic competitiveness.

Some stakeholders have suggested alternatives such as a carbon border adjustment mechanism (CBAM). While these approaches may appear attractive in theory, they are largely untested at a subnational level. WSPA does not oppose monitoring international developments in CBAM policy, but any suggestion that such mechanisms could substitute for robust no-cost allocations in Washington should be rejected.

For these reasons, we urge Ecology to clearly state in its report to the Legislature that the provision of allowances to protect EITEs should continue beyond 2034. This clarity is essential for long-term investment certainty.

Adjustment Factors and the Need to Avoid "Cliffs"

Any adjustments to EITE allocations beginning in 2035 must be undertaken with care to ensure that the legislative intent to protect trade-exposed industries is not compromised. WSPA has consistently cautioned against the use of a "cap adjustment factor" or other blunt instruments that would impose sudden reductions in allocations. Such approaches create "cliffs"—sharp declines in allowance distribution over an abbreviated period—that destabilize operations and investment planning for facilities with long capital cycles.

By 2035, Washington's cap will already have declined significantly relative to 2023 levels, meaning EITE facilities will be operating in an increasingly constrained environment if any new adjustment factors are applied. Introducing a cliff-like reduction in free allocations at that point would be destabilizing, and inconsistent with the Legislature's stated objective of preventing leakage. Instead, WSPA recommends that allowance allocations for EITEs remain on a smooth trajectory that avoids sudden discontinuities.

One option mentioned in draft materials—an annual allocation cap—may warrant further exploration, as it could provide flexibility to ensure adequate allowances for highly trade-exposed industries in cases where less competitive facilities exit the market. This approach could leverage use of allowances that become available to ensure that facilities which remain can stay

competitive in the global marketplace.

We also note with concern the concept of "net-zero industry prioritization" embedded in some discussions. This approach is inconsistent with the legislative intent of EITE allocation. It would pick winners and losers among facilities based not on trade exposure but on an arbitrary categorization. Such an approach should be rejected.

Finally, we urge Ecology to reject calls to adopt RMI's sector-specific benchmarking claims (such as its Exhibit 8 assumptions about refineries' ability to achieve deep emissions reductions by 2035). These assumptions are grossly overstated and technically infeasible, as explained further in our response to the RMI report later in this letter. They should not be used as justification for reducing allocations to EITEs.

Maintain Current Facility Baseline Allocation

Stability is essential for ensuring that Washington's Cap-and-Invest program achieves its objectives without creating unnecessary risk for EITE facilities and the state's economy. EITE industries make capital investments on long timelines and require predictability in order to plan effectively.

One of the most important elements of program stability is the treatment of baseline years. WSPA strongly recommends that Ecology retain the existing 2015–2019 facility baseline period for post-2034 allocation[1]. This period reflects representative operational levels for covered entities and provides a solid, known foundation for planning. Changing the baseline years at this stage would create perverse incentives: it could encourage facilities to delay or hold back emission reduction efforts in order to secure more favorable baselines, and it would penalize companies that have already invested in efficiency improvements or emissions reductions.

Consistency in baseline selection also promotes fairness. All covered entities have made business decisions with the current baseline years in mind. Altering those years midstream would unfairly disadvantage companies that acted early to reduce emissions or adjust operations. It would also create confusion in comparing Washington's program with linked or comparable programs in other jurisdictions.

Product Based Benchmark

Ecology has suggested sector-specific or product-based benchmarking as a method of allocating allowances. While this may appear aligned with some other jurisdictions practices, it could be especially problematic for Washington's EITE industries, and for refineries.

As an example, under federal antitrust law, the prior "safety zone" guidance regarding information exchanges (which allowed thresholds such as at least five participants and no single participant over 25% of market share) was rescinded by the FTC and DOJ in February 2023. It is our understanding that this change occurred due to concerns over maintaining competitiveness within the broader market. The advent of artificial intelligence models raised concerns that any data gathered could be disaggregated and un-anonymized, meaning that companies' competitively sensitive data could be made public. This concern would also be relevant for data collected by the State.

[1] WSPA does remain interested in Ecology considering an adjustment for the overall program baseline due to the differences of included products, but not at a facility level for allocations.

In addition, switching to this benchmark would force a baseline transition, which would add additional unnecessary complexity, expense, and time.

For these reasons, WSPA recommends that Ecology rejects product-based benchmarking as a default allocation method.

Best Available Technology (BAT) Benchmark

BAT is a term that identifies technologies that may reduce emissions in a greater quantity than some other similar technology, generally for a specific application within a production process. The designation of BAT is not intended as a framework for determining allowance distribution.

Requiring BAT as a condition for receiving allowances conflates two distinct policy objectives and undermines the predictability that EITE facilities need for long-term planning. While WSPA does not oppose making a BAT pathway available on a voluntary basis for facilities that wish to pursue it, any compulsory BAT allocation mechanism could be unworkable.

WSPA recommends that Ecology reserve BAT only as an optional pathway for interested facilities. The most effective approach remains the continuation of the current framework, which balances competitiveness with emissions accountability.

Leakage Risk Assessments

Ecology's draft report contemplates the use of leakage risk assessments as part of the framework for post-2034 allocation. WSPA strongly cautions against this approach. These assessments, while framed as technical exercises, are in practice highly subjective, resource-intensive, and prone to politicization. They introduce new layers of uncertainty without adding meaningful insight into the actual risk faced by EITE facilities in Washington.

The legislative intent in SB 5126 and RCW 70A.65.110 was clear: EITE facilities are recognized as highly vulnerable to leakage. That recognition drove the Legislature's directive to provide robust no-cost allowances. Attempting to "re-prove" leakage risk through new academic studies disregards that legislative determination and risks undermining the very protections the law was designed to secure.

Moreover, leakage risk assessments invite regulatory drift by shifting the burden onto industry to continually justify its vulnerability. This would create instability in allowance allocation and could discourage long-term investments in emissions reduction projects. Companies cannot responsibly commit capital if the level of allocation support is subject to recurring re-evaluation based on evolving academic methodologies.

Ecology's draft report also references the possibility of an "assistance factor." If this concept is pursued, WSPA recommends that it be set at least 1.0 (in consideration of the California methodology) or the highest leakage factor, to acknowledge the risk to EITE's. Any value lower than 1.0 would arbitrarily reduce the protection provided to trade-exposed industries and would directly contradict the policy rationale embedded in SB 5126. We note that AB 398 (2017) in California codified the assistance factor to 1.0. This change was in response to the California Air Resources Board adoption of a Cap-and-Trade regulation that included a lowered assistance factor. This affirms California's approach that the leakage risk for EITE remains high.

Finally, leakage cannot be reliably predicted or publicly signaled by the very companies at risk.

Under federal securities laws, publicly traded entities cannot disclose or forecast material adverse developments such as facility closures, reductions in output, or loss of competitiveness before such events are finalized and disclosed in accordance with SEC requirements. Asking facilities to anticipate or quantify leakage in advance would place them in direct conflict with securities law. And it is equally problematic for the state to attempt such forecasting itself — in essence speculating which plant might close first. Beyond the legal conflicts, this raises ethical concerns: government should not be in the position of predicting or effectively signaling the demise of specific employers, facilities, or local economies. Together, these issues underscore why leakage risk assessments are both impractical and inappropriate as a policy tool.

To reiterate, WSPA strongly cautions against this approach. These assessments, while framed as technical exercises, are in practice highly subjective, resource-intensive, and prone to politicization. They can introduce new layers of uncertainty without adding meaningful insight into the actual risk faced by EITE facilities in Washington.

Decarbonization Pathways and the Limits of Electrification

A recurring theme in stakeholder discussions has been the potential for deep decarbonization of industrial facilities through electrification. While WSPA supports efforts to pursue technically feasible emissions reductions, we caution against overreliance on electrification as a pathway for Washington's EITE industries. At present, commercially and technically feasible options to electrify refining and other high-temperature processes, at scale, do not exist. The infrastructure, permitting, and cost barriers remain significant, and until these are removed the commercial viability of any existing or new technology will remain challenging.

Real-world case studies confirm these challenges: even relatively low-temperature, seemingly straightforward equipment retrofits have proven and technically complex and prohibitively costly.

An illustrative example is provided in Appendix A.

Electricity Allocations and Consignment

Some stakeholders have raised the issue of providing no-cost allowances for purchased electricity used by EITE facilities. The need for this protection will diminish over time as Washington's grid becomes increasingly decarbonized under the Clean Energy Transformation Act (CETA). We encourage Ecology to weigh the potential benefits of electricity allocations against the administrative effort required to implement them, recognizing that the balance of costs and benefits may shift as grid emissions decline.

Ecology has also raised the possibility of requiring a portion of EITE allocations to be consigned to auction, with the proceeds reserved for projects intended to reduce emissions. WSPA does not oppose consignment in principle but emphasizes that flexibility and safeguards are essential to make this tool workable. At a minimum, these should include:

- Expedited permitting for funded projects, so that proceeds can be deployed in a timely manner.
- Flexibility to redirect proceeds if intended projects cannot be implemented.
- Protections for facilities that cannot reasonably access or deploy consignment proceeds.

Without these guardrails in place, any use of consignment would risk creating additional

compliance costs without achieving meaningful emissions reductions.

Response to ERG and RMI Supporting Reports

Several of Ecology's draft recommendations rely on consultant reports prepared by Eastern Research Group (ERG) and Rocky Mountain Institute (RMI). While these reports provide perspective, they contain significant methodological flaws that make them an unsound basis for long-term policy decisions.

ERG Report

Overburdened Community
Given the technical nature of the ERG analysis, WSPA hired Trinity Consultants to provide a third-party review of the Air Quality/Overburdened Community portion of the ERG analysis which is provided as Appendix B to this comment letter. As WSPA noted during the advisory committee meetings, the ERG materials are missing calculations and data that did impact the ability to complete a full review. However, Trinity's review of the ERG analysis used in Ecology's draft report found the following technical and methodological flaws. These errors consistently overstated both the environmental and economic benefits of reducing EITE allocations. The following highlights the most significant issues that call into question the validity of ERG's conclusions:

- **No Basis for CAP Reductions** – ERG assumed a one-to-one relationship between GHG allowance reductions and criteria air pollutant (CAP) reductions despite no technical or operational linkage. CAPs are already controlled by existing permit limits and NAAQS compliance, and EITEs contribute less than one percent of statewide CAPs in most categories.

- **Model Issues with use of EPA's COBRA Tool** – ERG used the COBRA screening model incorrectly, producing misleading health benefit estimates. For example, Trinity notes that

  "*the 2023 baseline emissions inventory in the COBRA model used to assess health impacts is fundamentally different than the 2023 Ecology baseline emissions inventory used by ERG to compute the assumed reductions in EITE CAP emissions …* [*the result of this for refining] of the ERG report's methodological error led it to model a 21 to 47% increase in refinery CAP emissions instead of 6%."*

  As another example, some of the modeled reductions were treated as increases, inflating the projected benefits from negligible changes.[2]

- **Inflated Social Cost of Carbon (SCC) Value** – ERG appears (the calculation method is obscure) to have significantly overstated climate benefits relative to the EPA social cost of carbon value, valuing reductions at $2.6 billion. To replicate the calculation, using EPA's SCC, the Trinity assumed a 6% reduction in 2034 and calculated a value closer to $213 million (in 2034).

- **Mapping Without Analysis** – ERG's maps of EITEs relative to overburdened communities and Tribal lands applied inconsistent radii (3 miles vs. 10 miles) with no justification, implying nearly half the state is impacted. These visuals are misleading and

[2] WSPA encourages Ecology staff to also confirm that the models are using a correct inventory database in the COBRA model that aligns with the current EITE facilities.

unsupported by emissions data. For the majority of the overburdened community areas, many point sources are just not a measurable source for criteria pollutants.

Economics

Separately WSPA hired Turner Mason to provide a third party review of the RMI report. Given that more in depth analysis, WSPA hired an affiliated consultant, DSC, to perform a quick third-party review of the economic section of the ERG analysis. ERG's draft report appears to mischaracterize Washington's refining industry and its ability to absorb or adapt to carbon costs. These errors consistently understate risks and overstate transition potential. The following highlights the most significant issues that lead to the understatement of risks:

Findings

- **Volatility Understated** ERG's analysis makes the refining business look more stable than it actually is. In reality, refining is highly cyclical — profits swing up and down much more sharply than ERG reported, closely tied to oil prices. When measured this way, volatility is over 60% higher than ERG showed. This means Washington refineries already operate on a financial rollercoaster, with very limited ability to absorb new costs.
- **Employment Undercounted** – ERG's "~2,000 workers" only focuses on direct employment[3]. Various studies show more indirect wages, contract wages, and that refinery roles are up to 60% higher than county averages, magnifying the economic and community importance of these jobs. These impacts are typically evaluated when assessing economic impacts to a regional area, especially more rural areas like Whatcom and Skagit Counties.
- **Transition Pathways Overstated** – ERG's suggestion that Washington refineries could shift rapidly to renewable diesel or SAF ignores market realities. Renewable diesel margins are compressed due to overcapacity, and SAF remains hampered by the lack of a coherent U.S. policy framework and thin state-level incentives. These constraints severely limit near-term viability.

RMI Report

As noted above, WSPA also contracted with Turner Mason & Company to conduct an independent technical review of the RMI pathways analysis included in Ecology's draft materials. This review is provided to Ecology in Appendix C. Their findings show that RMI's assumptions are unrealistic, economically damaging, and in some cases counterproductive from a climate perspective. The following highlights the most significant flaws:

- **Global Emissions May Increase** – RMI failed to account for the global emissions impact of continuing to need products, such as gasoline, if the local refineries are no longer producing those products and they need to be brought in from other jurisdictions.
- **Severe Margin Losses** – Turner Mason assessed the financial impact of closing or converting major refinery units, which they analyzed would reduce margins by $0.7 to $1.2 billion annually per facility, threatening the long-term viability of Washington refineries.

[3] Both the ERG and RMI reports consistently cite only ~2,000 direct refinery jobs, overlooking the additional ~2,000 contractors as well as broader indirect and induced employment. The repetition of this narrow figure across multiple analyses raises concerns about the separation and independence of these inputs. In economic analyses of this nature, indirect employment effects are typically included, and their exclusion significantly understates the workforce and community impacts of policy decisions affecting Washington's refining sector and the economies of the surrounding counties.

- **Workforce Impacts Understated** – RMI counted only direct unit operators, overlooking contractors and broader economic effects. In reality, closures would displace thousands of workers, with many facing wage losses of 40–50%.

- **Capital Projects Not Competitive** – Options such as FCC carbon capture, renewable diesel conversions, or low-carbon hydrogen require billions in capital and only break even at carbon prices between $100 and $600/ton, even after federal IRA incentives. These projects would not be prioritized in corporate portfolios under current market and policy conditions.

- **Timing Constraints Ignored** – Large-scale projects can only be scheduled during refinery turnaround cycles, typically every five years. With permitting and construction timelines added, most major decarbonization projects could not be realistically completed before the late 2030s or 2040s.

WSPA appreciates that Ecology took steps to clarify the relationship with the RMI submissions and recommends that it be clear that RMI's submissions represent external advocacy, not contracted technical analysis. Treating them otherwise risks embedding aspirational positions in place of sound policy grounded in feasibility, statutory intent, and data.

Conclusion

WSPA supports the objective of decarbonizing the industrial sector while maintaining economic competitiveness and legal defensibility. However, the draft recommendations in their current form do not necessarily reduce the likelihood of emissions leakage and economic harm. We urge Ecology to revisit its assumptions, take more time to get to know our industry and sector, and incorporate stakeholder feedback into a revised report that recognizes the real-world constraints and risks facing EITE facilities.

We welcome further dialogue and look forward to continued engagement on this important issue.

Sincerely,

Jessica Spiegel
Vice President, Northwest Region

WSPA

CC: Joel Creswell, Department of Ecology
CC Tamara Jones, Department of Ecology
CC Andy Hayes, Department of Ecology
Attachments:

- Appendix A: Refinery Electrification Example
- Appendix B: Trinity Review of WA ERG Report
- Appendix C: Turner Mason Memo EITE Decarbonization Pathways for Washington Refineries

Appendix A

Standalone Memo Refinery Electrification

Subject: Technical and Cost Barriers to Electrification – Illustrative Case Study

Overview

This memorandum provides an illustrative example of the complexity and cost associated with attempting to electrify even relatively low-temperature refinery equipment. The purpose is to demonstrate why electrification, while often discussed as a decarbonization pathway, presents significant technical and economic barriers that cannot be overlooked when evaluating policy options for emissions-intensive, trade-exposed industries (EITEs).

Case Study Example

Within the last few years, one facility conducted a screening exercise to identify potential "low-hanging fruit" opportunities to replace steam-based heating with electric heating. A heat exchanger was identified as a potential candidate for a straightforward conversion.

- The exchanger was a modest unit (~9 MMBtu/hr duty) with a relatively low steam requirement.
- Because it operated at lower temperatures and only performed sensible heat duty (no vaporization), it appeared to be a good test case for electrification.
- The initial concept was to remove the existing tube bundle and replace it with an approximately 2.7 MW electric heating element while retaining the existing shell, with the expectation that this would keep costs down.

In practice, the retrofit proved infeasible. The number and size of the required electric rods made the bundle unable to fit within the existing shell due to required rod spacing to address electrical impendence concerns. This requirement dictated an increase in the shell to effectively double its original size and weight then creating both structural concerns and significant piping rework to proceed.

The redesign dramatically increased the overall cost of conversion — more than 300 percent above the original estimate. This outcome occurred despite the fact that this was considered one of the "simpler" and lower-temperature electrification opportunities available. This project is estimated to deliver a value in the range of $400–$600 per metric ton of CO_2 reduced. However, it should be noted that the realized value depends on where within the steam system boiler network the project is implemented. In some cases, the benefits may be offset by how decarbonization and offsets are measured under the CCA framework, and at certain points in the system network no directly measurable reductions would occur for the refinery.

Implications

This example highlights the real-world engineering and cost challenges of electrification:

- Even relatively small, low-temperature units pose significant feasibility hurdles.
- Conversions often require major redesigns of equipment rather than simple component swaps.
- The associated costs can increase severalfold beyond initial estimates, undermining economic viability.
- Scaling such approaches to larger, higher-temperature refinery equipment would be even more complex and costly.

Conclusion

While electrification is frequently raised in policy discussions as a potential decarbonization strategy, this example demonstrates the need for caution. Technical feasibility and cost barriers remain substantial even for modest applications, and policymakers should avoid assuming rapid or low-cost electrification pathways in Washington's EITE sectors.

Technical Review of Eastern Research Group's (ERG) Report "Environmental Justice and Economic/Market Information on Emissions-Intensive, Trade-Exposed (EITEs) Facilities in Washington"

Prepared for Western States Petroleum Association

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TABLE OF CONTENTS

TABLE OF FIGURES

1. EXECUTIVE SUMMARY

The Washington Climate Commitment Act (CCA), enacted in 2021, established the Cap-and-Invest program to reduce greenhouse gas (GHG) emissions from large industrial facilities in the state, referred to as "covered facilities." To prevent GHG emissions leakage from Emissions-Intensive, Trade-Exposed (EITE) facilities, the CCA currently provides "no-cost" GHG allowances, covering 100% of reported facility emissions. These no-cost allocations are scheduled to decline to 97% from 2027 through 2030 and then to 94% from 2031 to at least 2034.

It has not yet been established if there will be changes in the manner in which no-cost allowances are allocated to EITE facilities during the period from 2035 to 2050. As a result, the Washington Department of Ecology (Ecology) has been directed to prepare a report for the Washington Legislature that assesses the issue and provides recommendations on the most appropriate approach to allocating no-cost allowances to EITE facilities beginning in 2035.

As part of this process, Ecology contracted Eastern Research Group (ERG) to assess the potential environmental and economic impacts of different no-cost allowance allocation approaches by analyzing the expected impacts of the 6% reduction scheduled for 2034 (from 100% to 94% no-cost allocation). The ERG report, *"Environmental Justice and Economic/Market Information on Emissions-Intensive, Trade-Exposed (EITEs) Facilities in Washington,"* was published on June 30, 2025, and is publicly available on the Washington State Department of Ecology's website[1]. The report focuses on the following environmental issues:

- The estimated contribution of EITEs to total emissions of criteria air pollutants (CAPs), hazardous air pollutants (HAPs), and GHGs
- The projected health benefits from reductions in EITE-related CAP emissions resulting from the 2034 reduction in no-cost allowance allocations to EITE facilities
- The estimated monetary value of GHG emission benefits resulting from the 2034 reduction in no-cost allowance allocations to EITE facilities

In addition, the ERG report presents three case studies intended to address air quality issues in select counties with higher numbers of EITE facilities.

At the request of the Western States Petroleum Association (WSPA), Trinity Consultants, Inc. (Trinity) has conducted a technical review of the ERG report's methodologies, assumptions, and findings related to the environmental issues listed above. In summary, Trinity identified the following major flaws and shortcomings and has determined that in addition to providing poorly documented analyses the ERG report:

- Improperly assumed that reductions in no-cost GHG allowance allocations to EITE facilities would lead to directly proportionate reductions in CAP emissions.
- Did not identify any meaningful air quality issues associated with CAP and HAP emissions from EITEs, or discuss any substantial air quality benefits that would be expected from the 6% reduction in no-cost

[1] Eastern Research Group. 2025, June 30. Environmental Justice and Economic/Market Information on Emissions-Intensive, Trade-Exposed (EITEs) Facilities in Washington (Publication No. 25-14-057). Washington State Department of Ecology. https://apps.ecology.wa.gov/publications/documents/2514057.pdf

GHG allowances to EITE facilities, whether considered statewide, in overburdened communities, or in counties with higher numbers of EITE facilities.

- Failed to properly conduct the analysis of potential health benefits from assumed CAP reductions resulting from the 6% reduction in no-cost GHG allowances to EITE facilities, rendering the results of that analysis meaningless.

- Failed to accurately compute the monetary value of GHG reductions expected to result from the 6% reduction in no-cost GHG allowances to EITE facilities, reducing the health benefits from the stated $2.6 billion to the Trinity-calculated $213 million.

2. INTRODUCTION

One element of the Washington Cap-and-Invest program, established under the Climate Commitment Act (CCA) in 2021 and implemented in 2023, is intended to reduce greenhouse gas (GHG) emissions from large industrial facilities in the state. The law sets a declining cap on emissions and requires major emitters to obtain tradable allowances, with targets of reducing GHG emissions to 45% below 1990 levels by 2030, 70% below 1990 levels by 2040, and 95% below 1990 levels by 2050, at which point "net-zero" carbon emissions are to be achieved. One concern addressed during the development of the Cap-and-Invest program[2] was to ensure that leakage of GHG emissions from Emissions-Intensive, Trade-Exposed (EITE) facilities did not occur and that the facilities were not adversely impacted by the CCA. Under the CCA, EITEs are facilities that are energy intensive and have significant exposure to trade and are defined as facilities in the following sectors, including but not limited to those specifically listed:

- Building Product, Electronics, and Aerospace Manufacturing
- Food Processing and Manufacturing
- Petroleum Refining and Chemical Manufacturing
- Primary Metals and Glass Manufacturing
- Pulp, Paper, and Cement Manufacturing

The issue of concern with EITEs is that CCA requirements mandating GHG emission reductions would economically disadvantage in-state facilities, likely leading to a decline in in-state manufacturing, which would be offset by increased production and emissions at out-of-state facilities to meet existing product demand, a dynamic commonly referred to as "leakage."

To address the risk of leakage, the Washington CCA's Cap-and-Invest program provides "no-cost" GHG allowances to EITE facilities, allowing them to comply with program requirements without experiencing significant adverse economic effects. Under the current requirements, no-cost allowances are allocated to EITEs based on a baseline for facility emissions established using actual emissions from 2015 to 2019, as follows:

- 100% no-cost allowances from 2023 through 2026
- 97% no-cost allowances from 2027 through 2030
- 94% no-cost allowances from 2031 through 2034

The legislation and current WAC rules do not specify the manner in which no-cost allowances will be allocated to EITE facilities during the period from 2035 to 2050. As a result, the Washington Department of Ecology (Ecology) has been directed to prepare a report for the Washington Legislature, providing an assessment of the issue and recommendations on how best to proceed with no-cost allowance allocation to EITEs beginning in 2035.

As part of its process to develop this report for the Legislature, Ecology contracted Eastern Research Group (ERG) to assess the potential environmental and economic impacts of no-cost allowance allocation choices by analyzing the expected impacts of the 6% reduction scheduled for 2034 (from 100% to 94% no-cost allocation). The ERG report documenting this work, titled "*Environmental Justice and Economic/Market Information on Emissions-Intensive, Trade-Exposed (EITEs) Facilities,*" presents the following findings:

[2] RCW 70A.65.005(6) states: "The legislature intends to create climate policy that recognizes the special nature of emissions-intensive, trade-exposed industries by minimizing leakage and increased life-cycle emissions associated with product imports."

- The estimated contribution of EITEs to total statewide emissions of criteria air pollutants (CAPs), hazardous air pollutants (HAPs), and GHGs is less than 1% for most CAPs, 9% for NO_x, and 21% for SO_2, less than 0.4% for HAPs, and 13.3% for GHGs.

- The projected health benefits from reductions in EITE-related CAP emissions as a result of the 2034 reduction in no-cost allowance allocations to EITE facilities are $30.4 to $50.2 million.

- The estimated monetary value of GHG emission benefits expected from the 2034 reduction in no-cost allowance allocations to EITE facilities is $2.6 billion.

In addition, the ERG report also addresses the locations of EITE facilities relative to overburdened communities and presents three case studies focused on air emissions issues in select counties with larger numbers of EITE facilities.

At the request of the Western States Petroleum Association (WSPA), Trinity Consultants, Inc. (Trinity) conducted a technical review of the ERG report's methodologies, assumptions, and findings related to the environmental issues listed above. The results of Trinity's review are presented in this report.

3. CRITERIA AIR POLLUTANT (CAP) EMISSIONS

The ERG report assumes that the 6% reduction in GHG emission allowances will directly result in proportional reductions of criteria air pollutants (CAPs). This assumption is flawed for multiple reasons as described in Section 4 of this report. CAPs are compounds for which health-protective National Ambient Air Quality Standards (NAAQS) have been established or are precursors to pollutants for which NAAQS exist.

The CAPs addressed in the ERG report that have established NAAQS are:

- Carbon monoxide (CO)
- Sulfur dioxide (SO_2)
- Particulate matter with diameters of 10 micrometers or less (PM_{10})
- Particulate matter with diameters of 2.5 micrometers or less ($PM_{2.5}$)
- Nitrogen dioxide (NO_2)

The CAPs addressed in the ERG report that are precursors to compounds with established NAAQS are:

- Volatile organic compounds (VOC) – precursors to ozone formation
- Oxides of nitrogen (NO_X – including NO_2) – precursors to both ozone formation and $PM_{2.5}$
- SO_2 and Ammonia (NH_3) – precursors to $PM_{2.5}$ formation

The NAAQS for ozone were established because ozone is an oxidant and the primary compound associated with smog. As noted, VOC and NO_X emissions are precursors to the formation of ozone in the atmosphere, which results from photochemical reactions. Similarly, substantial portions of $PM_{2.5}$, and to a lesser degree PM_{10}, can be formed as a result of various atmospheric processes involving NO_X, SO_2, and NH_3. Importantly, according to Ecology's attainment status data[3], and with the recent redesignation of Whatcom County to attainment for SO_2[4], all areas of Washington currently comply with all NAAQS.

CAP Selection

The ERG report focuses its environmental analysis on certain CAPs but provides no explanation as to why these CAPs were selected. The selection of CO is particularly surprising, as the last Washington area out of compliance with the CO NAAQS came into attainment in the early 2000s, and all subsequent monitoring across the state has shown levels well below the standard. Similarly, the selection of SO_2 does not appear justified, given that only one area near the aluminum smelter in Whatcom County was in non-attainment with the SO_2 NAAQS, but that area was redesignated as attainment in January 2025. Statewide monitoring data show that SO_2 concentrations are now consistently far below the NAAQS. Inclusion of NO_X is more reasonable, given the need to maintain compliance with the ozone and $PM_{2.5}$ NAAQS, which is generally a regional issue. However, NO_2 emissions are also well below NAAQS, as discussed in the next section.

[3] Washington State Department of Ecology. 2025. Areas Meeting and Not Meeting Air Standards. https://ecology.wa.gov/regulations-permits/plans-policies/areas-meeting-and-not-meeting-air-standards

[4] EPA. 2024. Designation of Areas for Air Quality Planning Purposes; Redesignation Request and Associated Maintenance Plan for Whatcom County, WA 2010 SO_2 Nonattainment Area. Federal Register, 89 (FR 101896), pp. 101896–101901. Environmental Protection Agency. https://www.federalregister.gov/d/2024-29575

CAPs and Air Quality

The ERG report presents ambient air quality data for the years 2020 through 2023 for NO_2, CO, SO_2, and ozone in Table 6 of their report, while providing minimal context. The reader is required to find "Comparison Values" (each pollutant's NAAQS) and compare those with "Design Values" (monitored concentrations in the form of each pollutant's respective NAAQS), some of which are presented in different units (e.g., CO values are presented in both ppm and ppb).

To assist in putting air quality data into perspective, Trinity prepared Figure 1 and Figure 2, which show that NO_2 and CO concentrations are far below the respective NAAQS values. Ozone concentrations are shown in Figure 3, and while they appear closer to NAAQS levels, it is important to note that the data used in the ERG report are not corrected for exceptional events (wildfire days). For ozone, Table 6 of the ERG report is also missing data for several sites that were reported by Ecology Network Plan; these missing 2023 design values are included in Figure 3 below based on Ecology's 2024 publication.[5] According to the Puget Sound Clean Air Agency[6], the 2023 ozone design value for the Enumclaw site, when wildfire smoke-impacted days are excluded, is 0.067 ppm, rather than the 73 ppb (0.073 ppm) reported by ERG. Since the current ozone NAAQS is 0.070 ppm (70 ppb), the difference between these values is critical for determining attainment status[7]. In addition, the Figure 3 chart appears to indicate there may be an increasing trend in ozone at the Enumclaw site; however, the 3-year design values are highest in 2022 and 2023 because they are most influenced by the wildfire years in 2021 and 2022 (2022 and 2023 are the two years that included both 2021 and 2022 in the 3-year average). The 4th highest 8-hour concentrations in 2023 and 2024 were lower than those measured in previous years at the site.[8]

Table 6 in the ERG report includes SO_2 design values for year 2020 and only from the Ferndale monitors, which were impacted by the now-closed aluminum smelter (which was not an EITE facility). The design value for those sites is now 3 ppb in contrast to the 68 and 89 ppb reported by ERG for the two Ferndale monitors. In addition, ERG did not report SO_2 data from ambient air quality monitoring conducted at three other Ecology monitoring sites (Anacortes, Cheeka Peak, and Seattle-Beacon Hill in Skagit, Clallam, and King counties, respectively) during all four years. The SO_2 design values ranged from only 1 to 3 ppb in 2023 compared to the NAAQS of 75 ppb, which is why Trinity did not prepare a figure presenting those data (i.e., the measured values are so far below the NAAQS that the bars would be indistinguishable from zero).

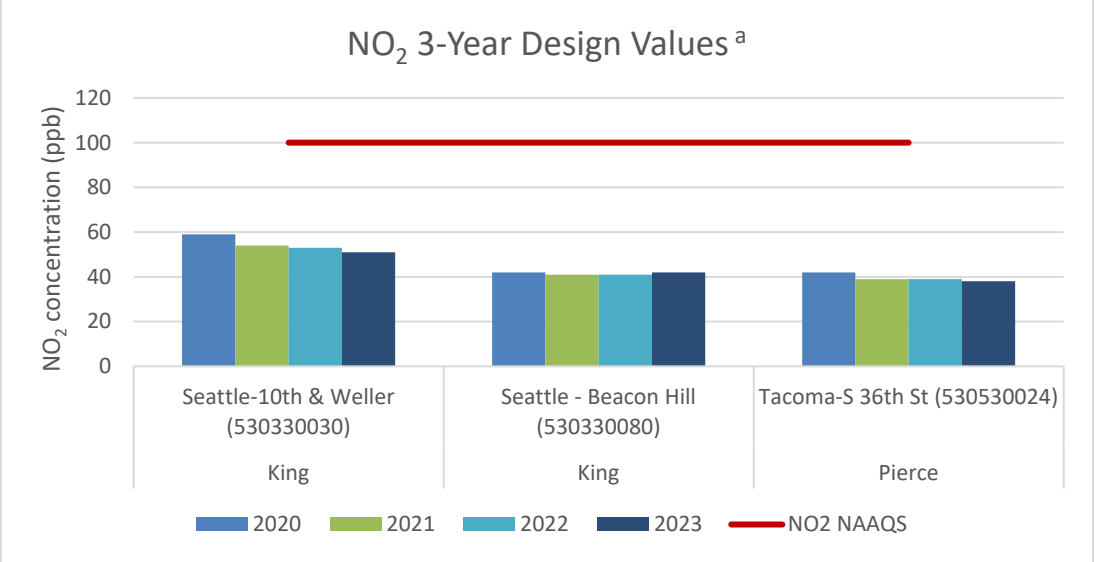
[5] Washington State Department of Ecology. 2024. Ambient Air Monitoring Network Plan 2024 (Publication No. 24-02-017). Washington State Department of Ecology. https://apps.ecology.wa.gov/publications/documents/2402017.pdf

[6] Puget Sound Clean Air Agency. 2024. 2023 Air Quality Data Summary (Air Quality Report). https://www.pscleanair.gov/DocumentCenter/View/5649/Air-Quality-Data-Summary-2023?bidId=

[7] U.S. Environmental Protection Agency. 2024. NAAQS table (Criteria Air Pollutants). https://www.epa.gov/criteria-air-pollutants/naaqs-table

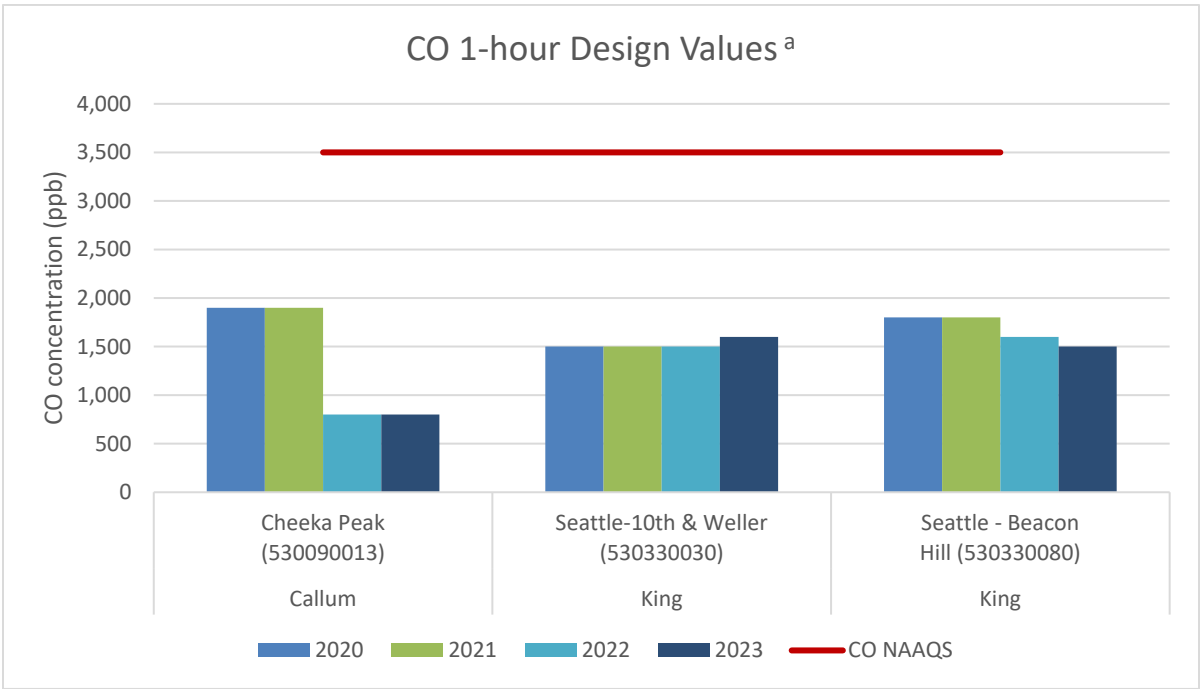
[8] Puget Sound Clean Air Agency. 2025. 2024 Air Quality Data Summary (Air Quality Report). https://pscleanair.gov/DocumentCenter/View/6035/2024-Data-Summary?bidId=

Figure 1. Comparison of NO_2 Design Value [a] Data Presented by ERG to the NAAQS Level.



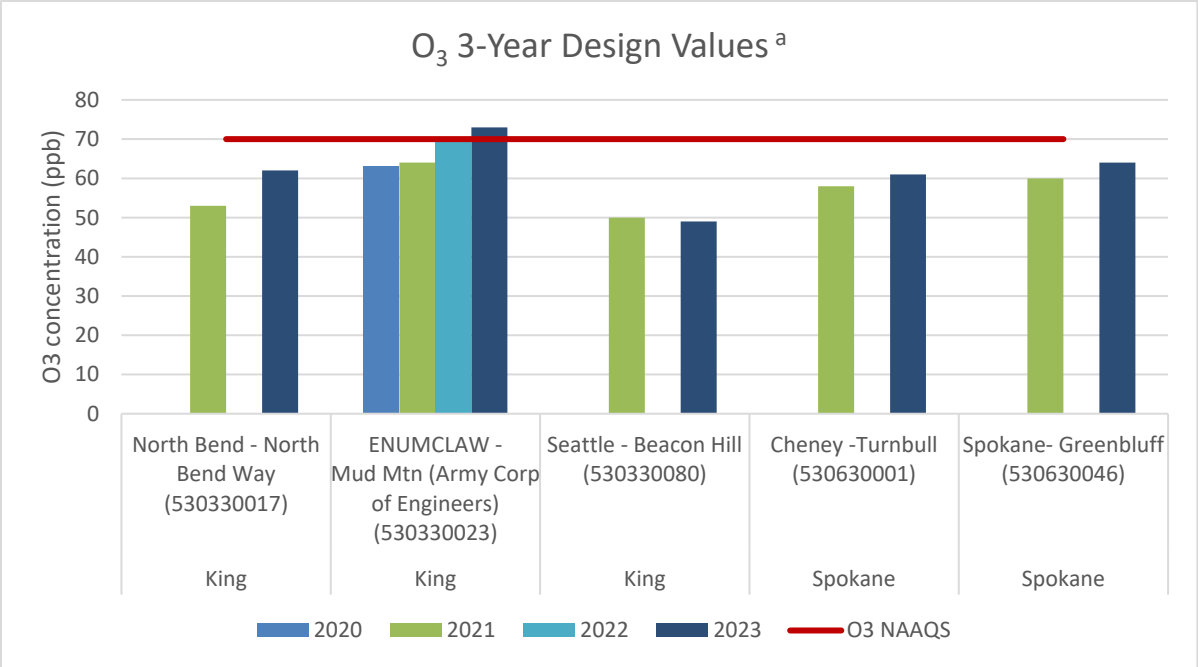
a. The NO_2 1-hour NAAQS design value is the 3-year average of 98th percentile of the yearly distribution of 1-hour daily maximum concentrations.

Figure 2. Comparison of CO Design Value [a] Data Presented by ERG to the NAAQS Level.



a. The CO 1-hour NAAQS design value is the 2nd highest 1-hour average value in each year (not averaged over 3 years).

Figure 3. Comparison of Ozone (O_3) Design Value [a] Data Presented by ERG to the NAAQS Level.



a. The ozone 8-hour NAAQS design value is the 3-year average of annual 4th highest daily maximum 8-hour concentrations.

EITEs and Statewide Inventory

The ERG report's assessment of CAPs relies on 2022 emissions inventory data in Table 2 (page 6 of the ERG report), which shows the total contribution of CAP emissions from EITEs to total statewide CAP emissions. According to the ERG report, EITEs contribute less than 1% of total statewide emissions of each CAP, with the exception of NO_X and SO_2. For NO_X, total EITE emissions are about 9% of total statewide emissions, and for SO_2, EITE emissions represent about 21% of total statewide emissions. Recall that the Design Values for SO_2 are orders of magnitude below the NAAQS, indicating minimal benefit of any subsequent reductions. Overall, the fact that air quality in the state of Washington complies with all federal NAAQS, and that EITEs contribute little to total statewide CAP emissions, except for SO_2, which is now significantly below NAAQS, suggests that there is not a pressing need for emissions reductions from EITEs beyond those already required under federal, state, and local regulations.

The ERG CAP assessment continues with reporting of total emissions inventory data for CO, NO_X, and SO_2 for 15 of Washington's 39 counties with EITEs in 2022, along with the percentage of county-level totals emitted by EITEs. As shown in Table 3 of the ERG report, in 9 of these 15 counties, EITE emissions accounted for 5% or less of total county-level emissions of each pollutant. The maximum contributions of EITEs to total emissions of CO, NO_X, and SO_2 were about 11%, 47%, and 96.4%, respectively.

Unfortunately, the ERG report does little to put these results into proper context, given that regardless of the contribution of EITEs to total emissions, pollutant concentrations do not violate the federal NAAQS.

In summary, nothing presented in the sections of the ERG report discussed above suggests that reductions in EITE emissions, resulting from reductions in no-cost GHG allowance allocations, would improve air quality in Washington.

4. HEALTH RISK ASSESSMENT

The ERG report does attempt to link reductions in CAP emissions from EITEs to health benefits. The report's analysis involves the use of U.S. EPA's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)[9]. The ERG report notes on page 22 that COBRA:

> *"...can be utilized to better understand how changes in air pollution from clean energy and fuel programs can impact human health."*

According to the ERG report, COBRA results indicated that a 6% reduction in CAP emissions from EITEs in 2034 would correspond to a total monetary health benefit of $5.5 to $8.5 million per year in the counties where EITE facilities are located, and a statewide benefit of $34 to $50 million. The ERG report also notes that about 95% of these monetary benefits are due to a reduction in mortality of 0.3 to 0.4 people in EITE counties and 1.6 to 2.4 people statewide. To put these mortality rates into perspective, the state of Washington reported[10] 66,062 deaths statewide in 2023, which means even the upper bound mortality reduction of 2.4 reported by the ERG report translates to an overall reduction of 0.004% in statewide deaths.

Additionally, Trinity's review shows that there are a number of flaws in the way the ERG report applied the COBRA model, and that these flaws caused the ERG report to overstate the health benefits associated with the assumed reduction in CAP emissions.

COBRA Model Use

The ERG report failed to appropriately characterize the COBRA model, which could lead the reader to inappropriately rely on the information presented as authoritative rather than recognize its modeling results as a preliminary screening, especially since dollar values are presented for the estimated health benefits.

The ERG report does not include or even mentions U.S. EPA's disclaimers,[11] which state:

> *"COBRA does not replace regulatory quality analyses. COBRA serves as a preliminary screening tool to identify those scenarios that might benefit from further evaluation with the more sophisticated air quality modeling approaches that are currently available."*

[9] U.S. Environmental Protection Agency. 2024. CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool. https://www.epa.gov/cobra

[10] Washington State Department of Health. (n.d.). All Deaths – County and State Dashboards [Data dashboard]. Washington State Department of Health. https://doh.wa.gov/data-and-statistical-reports/washington-tracking-network-wtn/death/county-all-deaths-dashboard

[11] U.S. Environmental Protection Agency. 2025. Why Use COBRA? https://www.epa.gov/cobra/why-use-cobra-0

CAP and GHG Correlation

Further, the ERG analysis inappropriately correlates the reduction in CAPs with GHG emission reductions. On page 2, the ERG report notes that COBRA was used to:

> *"…estimate the potential health benefits associated with EITE emission reductions in Washington. The analysis outlines the potential health benefits associated with a six percent reduction in criteria air pollutants (CAPs) from the 2023 baseline by 2034. This assumes the reduction in CAPs aligns with the GHG emission reductions."*

The ERG report assumes that the 6% reductions in EITE emissions of the CAPs VOC, NO_X, $PM_{2.5}$ and SO_2 would result from a 6% reduction in no-cost GHG allowance allocations – presumably because the report assumes EITE activity would decrease by 6%. There is clearly no technical basis for this assumption, given that GHG reductions needed for compliance with the CCA could be achieved by EITEs through specific GHG control strategies such as carbon capture and sequestration (CCS) or the use of renewable fuels for process energy, which may or may not result in proportional reductions in CAPs.

Interestingly, even the ERG report acknowledges that its assumption is invalid, as stated in footnote 17 (bottom of page 21 of the ERG report):

> *"The correlations between EITE facility GHG emissions and CAP emissions between 2012 and 2023 are 0.698 for SO2, 0.868 for NO_X and 0.588 for CO. However, for the purpose of this analysis, we assume a 1 to 1 relationship between reductions in GHG emissions and reductions in CAP emissions."*

This acknowledgement, which makes sense given the regulatory requirements and emissions control systems already in place to reduce CAP emissions, means that the ERG report overstated the reduction in CAPs, given that the 6% reduction applies specifically to GHG emissions. This also means that the health benefits are also overstated. Further, the relatively poor correlation values between CAPs and GHGs reported by ERG demonstrate that any meaningful effort to estimate CAP reductions from EITE facilities due to reductions in no-cost allowances should be performed on a facility specific basis using detailed information about how facility operations would be changed.

Modeling Methodology

In addition to the above, there are other serious flaws with ERG report's overall modeling methodology to assess health benefits associated with presumed reductions in CAPs. Although ERG states (pages 21 to 26 of the report) that its results represent the benefits that would result from the assumed reductions in CAP emissions from EITEs, the description provided in Appendix A for Table A.12 states:

> *"Table A. 12 outlines each EITE's county, sector, and changes in emissions that ERG input into COBRA. In COBRA, the selected county and sector dictate the emissions baseline. Given that some baseline emissions were less than the reduction amount, ERG input the change in emissions as an increase and then used the absolute value of the results. When emissions were not provided by Ecology, "N/A" is presented."*

In other words, the ERG report treated the health impacts of increased CAP emissions as equal in magnitude to the health benefits of decreased CAP emissions. This approach assumes a strictly linear relationship between emission changes and health outcomes in the COBRA model. The ERG report did not provide support for this assumption, even though it is well known that many atmospheric processes modeled by COBRA are non-linear — for example, the effects of changes in VOC and NO_X emissions on ozone levels.

As stated in the ERG report, the reason why the health impacts of assumed reductions in EITE CAP emissions were modeled as increases instead of reductions is that total EITE emissions (in tons per year) in that sector and for a given county were smaller than the assumed ton-per-year reductions in CAP emissions. As a result, applying those assumed reductions in EITE CAP emissions would have eliminated all EITE CAP emissions in that sector for that county from the COBRA modeling. However, the ERG report's choice to model emission reductions as emissions increases is, quite simply, incorrect.

The root of the problem is that the 2023 baseline emissions inventory in the COBRA model used to assess health impacts is fundamentally different than the 2023 Ecology baseline emissions inventory used by ERG to compute the assumed reductions in EITE CAP emissions. This mismatch creates a complete inconsistency between the 2023 baseline inventory and the modeled EITE CAP emissions reductions.

This issue can be easily illustrated through examination of the 2023 baseline emissions inventory for the Petroleum and Related Industries sector, which is split into three subsectors in the COBRA model: Asphalt Manufacturing, Oil and Gas Production, and Petroleum Refineries and Related Industries. COBRA contains emissions only for the Petroleum Refineries and Related Industries subsector, which is essentially the five petroleum refineries located in Washington[12] and all of which are EITEs. The ERG report also provides total 2023 CAP baseline emission estimates for all five of these petroleum refineries, as well as the assumed 2034 CAP reductions due to the 6% reduction in no-cost GHG allowance allocations to the refinery facilities. The baseline 2023 COBRA and ERG report inventory values are presented in Table 1.

As shown, the ERG report's baseline inventory ton-per-year values are about 3.5 to 8 times higher than the COBRA baseline inventory ton-per-year values, depending on the pollutant. As a result, when the ERG report assumed in its baseline inventory that a 6% reduction in no-cost GHG allowances would result in a 6% reduction in CAP emissions, the outcome was a much larger percentage of the COBRA baseline inventory. This is also shown in Table 1, where the results of the ERG report's methodological error led it to model a 21 to 47% increase in refinery CAP emissions instead of 6%. Clearly, this error dramatically inflated the magnitude of the apparent changes in EITE emissions and also resulted in a dramatic overstatement of the magnitude of the health impacts.

[12] BP Cherry Point Refinery, HF Sinclair Puget Sound Refinery, Marathon Anacortes Refinery, Phillips 66 Ferndale Refinery and U.S. Oil and Refining Co.

Table 1. COBRA and ERG 2023 Washington Petroleum Sector Emissions (tons per year)

	VOC	NO_X	$PM_{2.5}$	SO_2
COBRA Baseline	618	707	141	286
ERG Baseline	2485	5491	483	998
ERG 6% Reduction	149	329	29	60
Ratio ERG Baseline to COBRA Baseline	4.0	7.8	3.4	3.5
Ratio ERG 6% Reduction to COBRA Baseline	0.24	0.47	0.21	0.21
Effective Change in Sector Emissions Used by ERG in COBRA Modeling	+24%	+47%	+21%	+21%

While Trinity has not investigated every sector in the ERG report's assessment, it is highly likely that similar problems with inventory discrepancies exist in those sectors as well. This is evidenced by the ERG report's own statement that emission increases had to be used instead of decreases because the magnitude of the 6% reductions calculated in the ERG report was greater than the COBRA baseline emissions. It should also be noted that, as indicated in the COBRA user's manual, the ERG report could have input a custom emissions inventory baseline, just as it did for the human population estimates by county.

In summary, notwithstanding its modeling limitations, the ERG report had two options to properly exercise the COBRA model. The first was to use the COBRA baseline inventory and implement appropriate assumptions for emission reductions in each sector on a percentage basis rather than the ton-per-year basis. The second was to input the ERG baseline inventory as a custom emissions inventory. The ERG report did neither. Instead, it computed emission changes in tons per year using its own baseline and then applied those to the COBRA tons per year baseline, thereby inflating the actual magnitude of the emissions change.

The fact that CAP emission reductions were modeled as increases, coupled with the failure to recognize the fundamental inconsistencies between the COBRA baseline inventory and the ERG report baseline inventory, renders the ERG report's health impact assessment and associated cost benefit results meaningless. Again, it should be stressed that proper analysis will likely result in dramatically lower health impact values, even when using the COBRA model.

5. GHG EMISSIONS AND SOCIAL COST OF CARBON

The ERG report presents very little information related to overall GHG emissions in Washington or those specifically associated with EITEs. In the Executive Summary and the GHG Emissions section of the report (pages 4 and 5), ERG states that in 2023, based on data collected by Ecology, there was a total of 90.8 million metric tons of CO_2-equivalent emissions reported under Washington's GHG Reporting Program. It also states that, in 2023, the 39 identified EITEs accounted for 13.3% of the total reported emissions. Table A1 in Appendix A of the report presents annual GHG emissions in terms of CO_2 equivalents for each of the 39 EITEs over the period from 2012 through 2023.

The ERG report then discusses the benefits of GHG reductions that would result from the 6% reduction in no-cost allowance allocation to EITEs in 2034, expressed in terms of the social cost of carbon (pages 26 and 27). The extremely brief description of the methodology mentions that a social cost of carbon value for 2034 was interpolated from data presented in U.S. EPA's 2023 Report on the *Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances*.[13] However, the actual value used for the social cost of carbon is not provided by ERG.

Next, the ERG report indicates that it determined the GHG reductions as follows:

> *"Using the 2023 covered emissions as a baseline, we assumed a six percent reduction in covered greenhouse gas emissions by 2034, in line with the no-cost allocation for EITEs in 2034."*

While not specifically discussed, it appears that ERG then multiplied the social cost of carbon in 2034 by 6% and, after accounting for inflation, arrived at an estimate of $2.6 billion as the total benefit of the GHG emission reductions resulting from the 6% decrease in no-cost allowance allocation to EITEs. Results for specific EITE sectors are presented in Table 13 of the ERG report. It is important to note that the report contains no details of how this value was calculated, as it does not provide the value of the 2034 social cost of carbon used, the 2034 GHG emission reductions assumed to result from EITEs, or the value of the adjustment to convert from 2020 dollars to 2024 dollars.

Given the lack of detail provided in the ERG report regarding its social cost of carbon calculation, Trinity attempted to replicate it. Trinity first estimated the GHG emission contribution of EITEs in the state of Washington by multiplying the total 2023 covered emissions of 90.8 million metric tons of CO_2-equivalent emissions by 13.3% as follows:

Total GHG emissions from EITEs = 0.133 x 90,800,000 metric tons of CO_2-equivalent emissions

The result is 12.1 million metric tons of CO_2-equivalent emissions. Next, the emission reductions from the 6% reduction in no-cost allowance allocations in 2034 are estimated as follows:

2034 GHG reductions from EITEs = 0.06 x 12,100,000 metric tons of CO_2-equivalent emissions

[13] U.S. Environmental Protection Agency. 2023. EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances (Supplementary Material for Regulatory Impact Analysis). https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf

The result is 0.73 million metric tons of CO_2-equivalent emissions. It should be noted that this reduction represents less than 1% of the assumed 90.8 million metric tons of covered GHG emissions.

Next, Trinity obtained the 2034 social cost of carbon value of $245 per metric ton of CO_2 emissions[14] from Table A.5.1 of the 2023 EPA report referenced above, using the 2% discount rate in line with the ERG report. Trinity then adjusted the cost from 2020 dollars for inflation, applying a CPI index of 1.19, and arrived at $292 per metric ton of CO_2 emissions in 2024 dollars. Finally, Trinity calculated the value of the 2034 GHG reductions from EITEs as follows:

Value of 2034 GHG reductions from EITEs = $292 per metric ton x 730,000 metric tons

The result was $213,160,000 or about 8% of the $2.6 billion value from the ERG report. To put this in perspective, the social cost of carbon used in the ERG report would have to be about $3,600 per metric ton of CO_2, which is completely inconsistent with the values presented in the EPA report. Unfortunately, given the lack of information provided in the ERG report, the source of the discrepancy between the ERG report's calculations and Trinity's calculations cannot be identified.

It is also important to note that the estimated monetary value of GHG reductions obtained using the social cost of carbon values from the referenced U.S. EPA report represents global impacts, not impacts in the geographic region where the GHG reductions occur. This means that only a very small fraction of the $213 million in benefits would actually be realized in the state of Washington, in contrast to the full economic impacts, which would directly affect the state.

[14] The EPA report presents social cost values for methane and nitrous oxide. However, because the ERG report expresses GHG emissions in CO_2 equivalents, the differing global warming potentials of these gases have already been accounted for, and the use of the social cost of CO_2 is appropriate.

6. HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS ASSESSMENT

The ERG report also presents an assessment of hazardous air pollutant (HAP) emissions from EITEs relative to HAP emissions from other sources. As noted by ERG in Table 1 (page 4), HAPs are: "p*ollutants that are known or suspected to cause cancer or other serious health effects."* and that *"Washington state regulates over 430 toxic air pollutants from industrial and commercial sources."* The ERG report also notes on page 15 that there are 188 HAPs and indicates in Table A.9 that emission inventory values contained in the report were developed by U.S. EPA as part of the National Emissions Inventory.[15]

HAPs and Air Quality

The ERG report presents an analysis of total HAP concentration data based on ambient air quality monitoring. These results, which do not differentiate between HAPs emitted by EITE facilities and all other sources of HAPs, are presented in terms of monitor locations where the cancer risk posed by all HAPs exceeds 1 in a million (see Table 7 of the ERG report). In addition, specific compounds are identified where monitoring data shows a Noncancer Hazard Quotient equal to or greater than 1 (Table 8), or where monitored concentrations exceed Acceptable Source Impact Level (Table 9). However, no differentiation is made between emissions of HAPs from EITEs and emissions from other sources, so reported data reflect contributions from all HAP sources and do not represent potential impacts from EITEs.

In contrast, a technically sound assessment of potential HAP impacts from EITEs would need to apportion the sources of HAPs observed at each monitor and determine the fraction of the measured concentration attributable to EITE facilities in the area. Similarly, to assess the impacts of a reduction in EITE HAP emissions resulting from reductions in no-cost GHG allocations, one would need to evaluate whether any reductions in HAPs would occur, model those reductions on a facility-specific basis, and then apply pollutant-specific toxicity data to assess health benefits.

HAPs and Statewide Inventory

In addition to the above, the large number of HAPs (and TAPs) regulated by the state of Washington have a wide range of potential health effects and potencies. However, in the ERG report, HAPs are summed together and reported in terms of their total mass. Tables 4 and 5 (pages 7 and 8 of the ERG report) indicate that total HAP emissions from all EITEs represented only 0.4% of the total statewide HAP inventory in 2022. Total HAP emissions in the 15 counties where EITEs are located accounted for as little as 0.005% and up to 8.3% of total HAP emissions, depending on the region analyzed. Although the ERG report performs no analysis of the impact of reductions in no-cost GHG emission allowances on EITE HAP emissions, if the same (unsupported) correlation approach is applied to HAP emissions as the ERG report implemented during the CAP-based health benefits assessment, the reductions would amount to only a 0.024% reduction in total statewide HAP emissions and about a 0.5% reduction in HAP emissions in those counties where EITEs make the greatest contributions.

In summary, given the lack of a technically sound analysis, the ERG report does not provide meaningful insight into HAP or TAP impacts from EITE facilities or from possible reductions in emissions of those compounds. Based on the information presented, the ERG report should have concluded that the HAP

[15] U.S. Environmental Protection Agency. 2025. 2022v1 Emissions Modeling Platform. https://www.epa.gov/air-emissions-modeling/2022v1-emissions-modeling-platform

emissions from EITEs are too small to warrant a detailed analysis, or that HAP concentrations are already below levels of concern.

7. REVIEW OF ERG'S CASE STUDIES

The ERG report also presents what are described as "Case Studies" of Cowlitz, King, and Skagit counties (see pages 57-89), which were selected because *"…they host a large number of EITEs and have high levels of GHG emissions from EITEs."* The report indicates that the number of EITE facilities is seven in Cowlitz county, four in King county, and four in Skagit county. No explanation is provided for how these case studies are relevant to the report's findings.

In each case study, the amount of GHG emissions from EITEs is presented along with comparisons to total county GHG emissions from all facilities covered by the CCA. The report then notes that EITEs account for a substantial portion of each county's covered GHG emissions. However, there is no discussion on what conclusions, if any, should be drawn from these findings. Their inclusion may imply that reductions in GHG emissions from EITE facilities would produce some sort of localized air quality benefits. If so, it should be noted that there is no technical basis for this conclusion, since GHG emissions are global in scale and do not provide localized benefits in and of themselves except through unproportional "co-benefits" such as potential reductions in CAPs and HAPs.

Similar discussions are presented for EITE contributions to CAP and HAP emissions in each county, using data generally already included in the broader CAP and HAP sections of the ERG report. Again, the ERG report is silent on how these county-level results are relevant to the report's overall conclusions.

Nothing in the ERG report's case studies suggests that, even in counties with higher numbers of EITE facilities, EITE emissions contribute substantially to an identified air quality issue, or that potential reductions in EITE emissions resulting from reduced no-cost GHG allowance allocations would provide a meaningful air quality benefit.

8. OVERBURDENED COMMUNITIES

The ERG report also discusses EITEs in relation to their proximity to Overburdened Communities (OBCs) and OBCs "Highly Impacted by Air Pollution." In its Executive Summary, the ERG report states:

> ***"Twenty EITEs are located within overburdened communities in Washington State and 10 EITEs are located within overburdened communities highly impacted by air pollution, as defined by the Department of Ecology. Seven EITEs are located in or near Tribal Lands."***

However, the ERG report does not provide any assessment of the actual impacts of EITEs on OBCs, nor does it evaluate the impacts that reductions in GHGs, CAPs, or HAPs from decreased no-cost allocations of GHG allowances to EITE facilities would have on these communities. Instead, the report only notes the geographic proximity of some EITEs to OBCs.

Presumably, the ERG report's consideration of OBCs is related to the Revised Code of Washington (RCW) Section 70A.65.020, which requires that the CCA achieve reductions in criteria pollutants as well as greenhouse gas emissions in overburdened communities highly impacted by air pollution. A map showing the location of OBCs with the highest cumulative air pollution levels, developed by Ecology,[16] is presented in Figure 4 below, along with Figure 5, which shows the locations of EITEs in relation to OBCs highly impacted by air pollution and is from the ERG report (reference Figure 33). As shown, the communities shown in Figure 4 developed by Ecology generally align with the OBCs highly impacted by air pollution identified in the ERG report in Figure 5, and it does appear, based on Figure 5, that ten EITEs are located in OBCs highly impacted by air pollution. This means that the other twenty-nine of the total of 39 EITEs (or roughly 75%) in Washington are located outside of OBCs that are highly impacted by air pollution. Figure 5 also shows that OBCs highly impacted by air pollution cover only a relatively limited portion of the state.

[16] Washington State Department of Ecology. (n.d.). Improving Air Quality in Overburdened Communities. https://ecology.wa.gov/air-climate/climate-commitment-act/overburdened-communities

Figure 4. Washington communities with the highest cumulative air pollution levels.

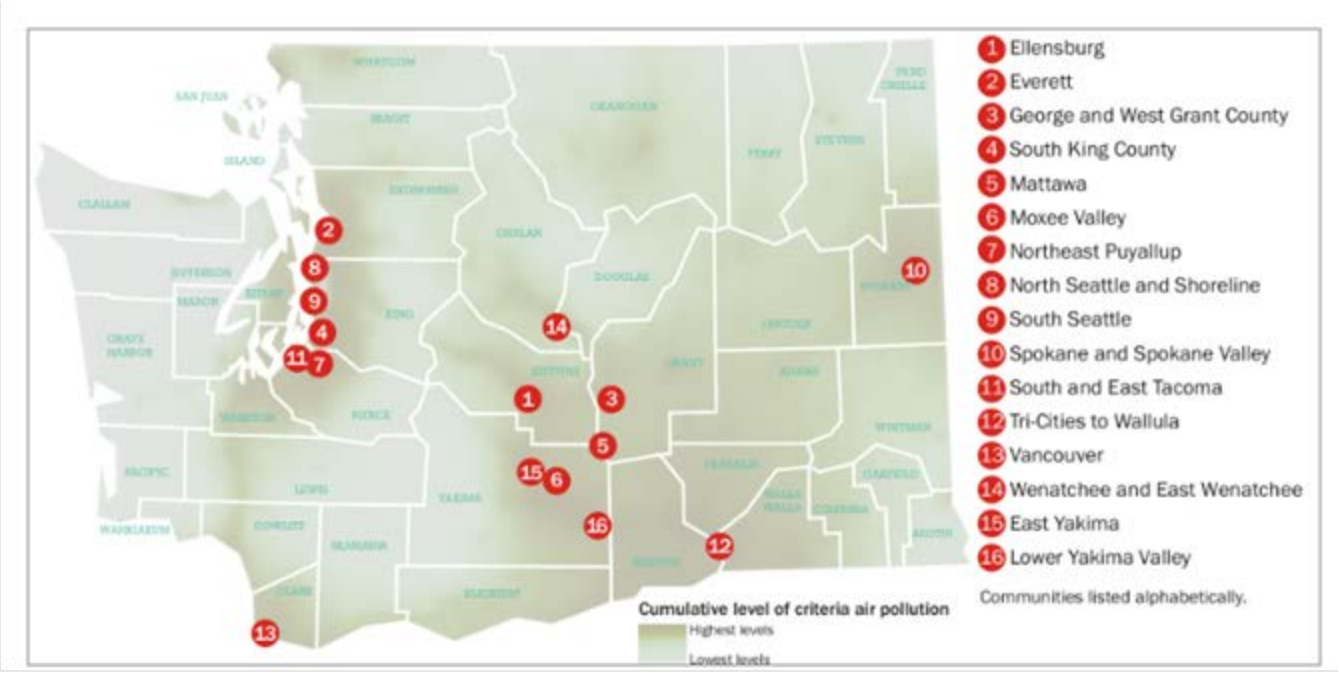


Figure 5 (ERG Figure 33). Map of EITEs and OBCs highly impacted by air pollution.

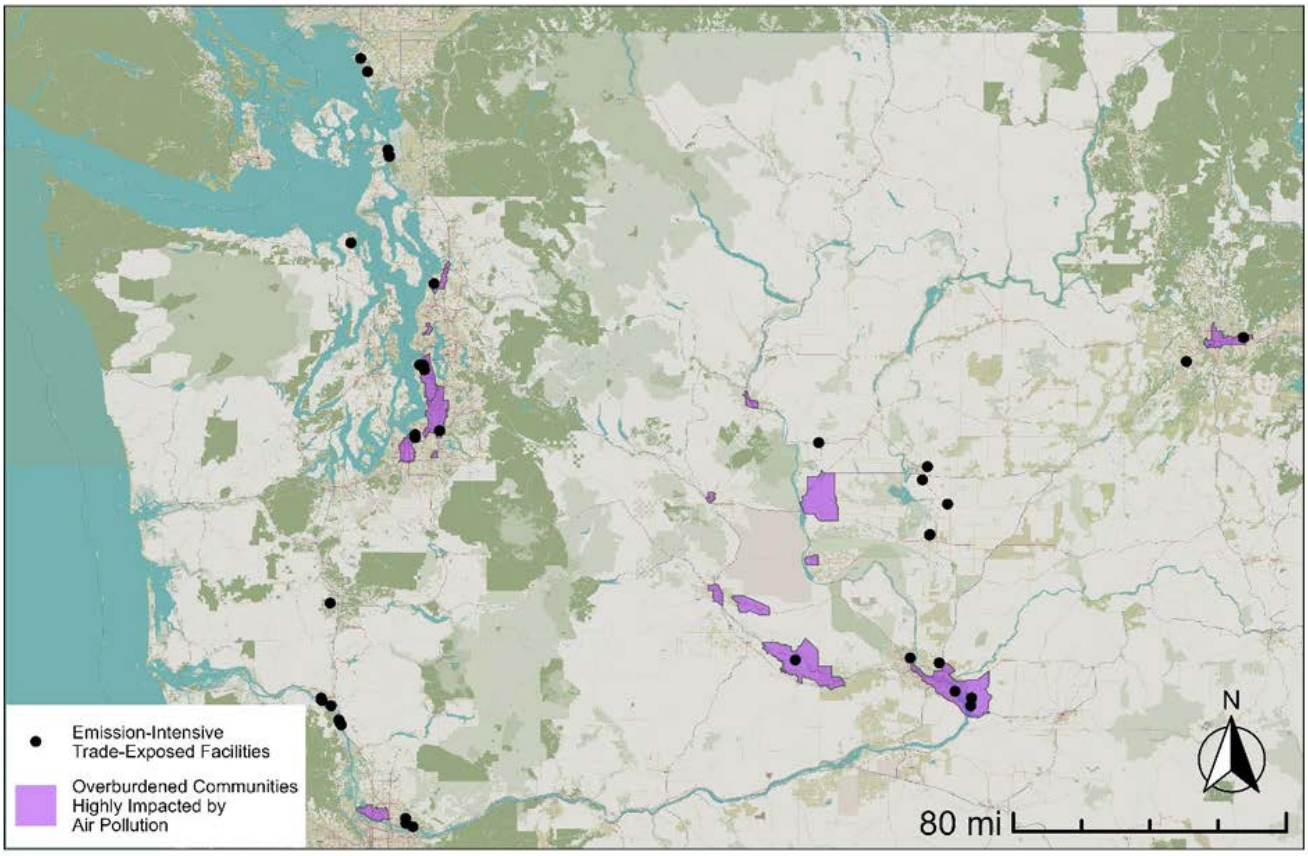


Figure 33. Map of EITEs and OBCs highly impacted by air pollution.

A similar map is presented in Figure 6 (Figure 34 of the ERG report), showing the location of EITEs relative to Tribal Reservations. This figure again is consistent with the ERG finding that seven EITEs are located on or near tribal lands. However, ERG fails to make it clear which EITEs are both located in OBCs highly impacted by air pollution and also located on or near tribal lands. Again, the ERG report provides no analysis or data on the impact of total EITE emissions, or reductions in EITE emissions, on Tribal Reservations due to reductions in no-cost GHG allowances to EITE facilities.

Figure 6 (ERG Figure 34). Map of EITE locations and Tribal Reservations.

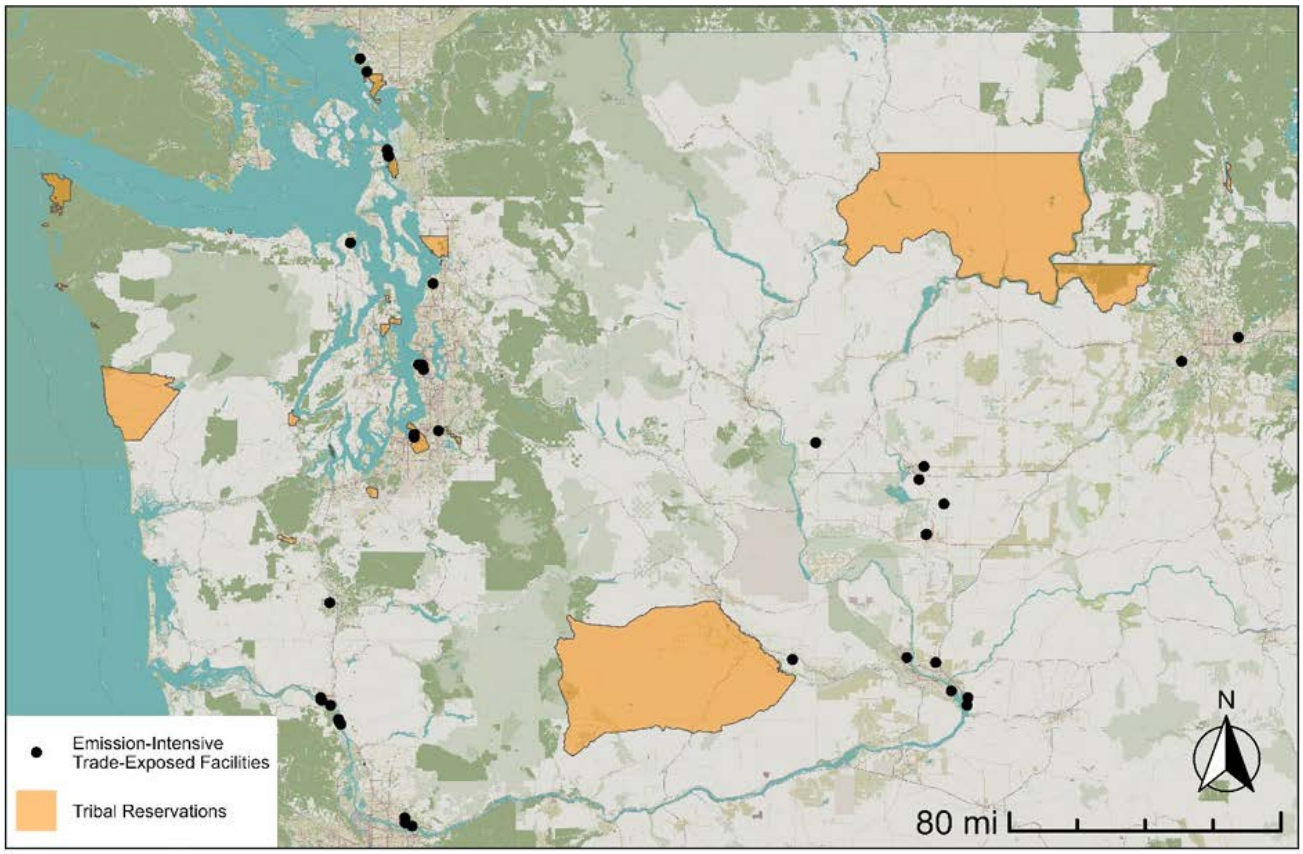


Figure 34. Map of EITE locations and Tribal Reservations

Interestingly, the ERG report also includes another map in Figure 32 (referenced as **Figure 7** in this report), which shows EITE locations and apparently the locations of all overburdened communities in Washington, from which ERG reaches the conclusion listed below:

> ***"There are 20 EITEs located within overburdened communities in Washington State, and an additional 15 EITE facilities located nearby (within three miles) of overburdened communities (see Figure 32)."***

There are a number of issues raised by ERG's Figure 32. First, ERG provides no explanation of why the location of EITEs in or near OBCs that ***are not*** highly impacted by air pollution is relevant. Second, ERG again provides no analysis or data that addresses either the direct impact of EITEs on these OBCs or how a reduction in the no-cost allocation of GHG allowances would affect any of these communities. Finally, although unstated by ERG, the point of Figure 32 seems to be to show that 35 of 39 EITEs in Washington are in or near OBCs (which are shown to cover roughly half of Washington's geographic area) and to imply a linkage between EITEs and OBCs, even if the OBCs are not highly impacted by air pollution.

Figure 7 (ERG Figure 32). Map of overburdened communities and EITE facilities.

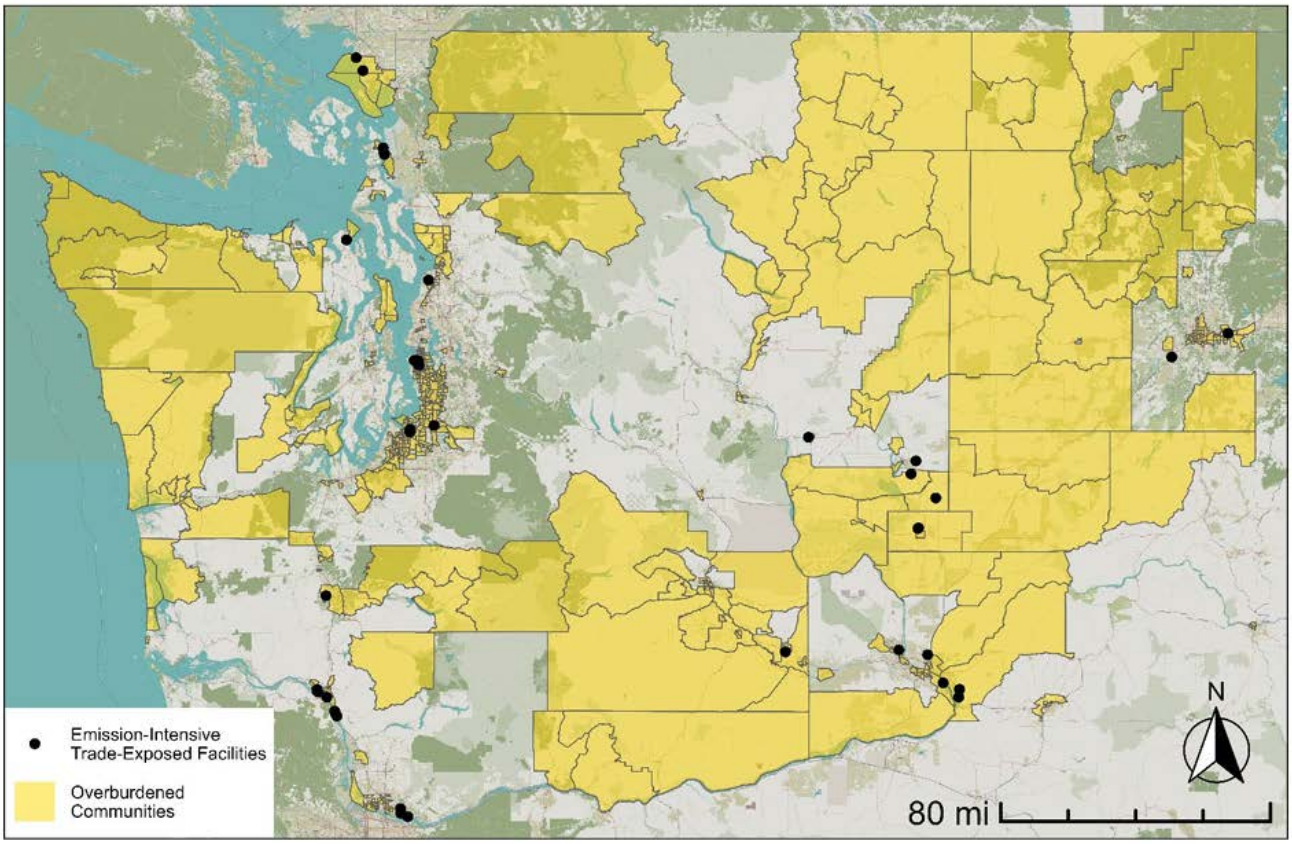


Figure 32. Map of overburdened communities and EITE facilities.

Turner, Mason & Company
energy consulting & advisory

Memorandum

To: Western States Petroleum Association

From: Turner, Mason & Company

Date: August 28, 2025

Subject: Analysis of Decarbonization Pathways for Washington Refineries

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Executive Summary

Implementing the decarbonization pathways analyzed in this memo have the potential to reduce CO2e emissions ~5 MMTPA (Million Tons per Annum), a 78% reduction from current levels. Fully implementing these projects across all Washington refineries could take until the mid-2040s, with total required investment ranging from $12 to $22 billion (in $2025).

We note the following significant findings:

1) Reduction in CO2e emissions in Washington would be offset by higher emissions elsewhere in the world as products needed to balance the market in Washington would be refined and imported. Net emissions could be higher depending on the trade-off of reduced emissions from shutting down a processing unit in Washington and increased emissions from importing finished products to and exporting unfinished products from the Washington market.
2) Shutting down units, such as a naphtha reformer or delayed coker would have material negative commercial implications, with annual margin losses in the range of $0.7 to $1.2 billion depending on the unit closed. Shutting down these units could require major changes in operations and logistics, which could increase operational risks and threaten the economic viability of the refinery.
3) While workforce reductions appear somewhat small (25 to 45 FTE or “full-time equivalent” workers for each unit closed), displaced operators could face 40 – 50% reductions in compensation relative to comparable jobs in Washington.
4) Most capital projects to reduce CO2e emissions have negative economic value and are unlikely to be competitive for capital in a refining company’s capital budget.
5) Planning for maintenance turnarounds before 2030 are underway already. Unless turnarounds in the next five years already includes a decarbonization capital project, such CO2e reductions could not be implemented until well into the latter

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half of the 2030s. Quite likely only one such project could be implemented per turnaround given their complexity and other required work.

Background

Turner, Mason & Company (TM&C)[1] was commissioned by WSPA (Western States Petroleum Association) to evaluate decarbonization pathways for Washington refineries as presented by RMI (Rocky Mountain Institute) at the EITE (Emissions Intensive Trade Exposed) Industries Advisory Group meeting on November 14, 2024. This memo summarizes the project scope, economic implications, timelines, and key findings related to CO2e emissions reductions, with a focus on operational changes and major capital investments.

The primary differences between the analysis by RMI and TM&C are twofold. First, RMI does a top-down analysis based on theoretical estimates using information gathered from the U.S. Department of Energy, as well as a variety of other public sources. By contrast, TM&C analysis is a bottom-up analysis using operating parameters and capital cost estimates from a number of actual projects we have worked on with clients or vetted for potential financial investors. We apply these real project examples to a typical petroleum fuels refinery in the Pacific Northwest to consider potential changes in refinery configurations, operations, and capital costs. The second difference is we consider changes in global greenhouse gas emissions net of material movements required to keep the refineries and broader Pacific Northwest petroleum fuels markets in balance.

A key assumption in this analysis is that petroleum fuel demand is independent of any change of configuration or operations of a refinery. Thus any reduction in petroleum fuels production in Washington refineries would need to be imported to meet local demand.

Shutting down key processing units, such as a naphtha reformer and/or a delayed coker would increase vessel traffic to handle exports of intermediates to keep the refineries balanced and imports of finished products to keep local petroleum product markets balanced.[2] We assume there is sufficient dock and harbor capacity to handle this increase

[1] Turner, Mason & Company (TM&C) provides research and consulting services utilizing reasonable care and employing methodologies consistent with industry practice and applicable professional standards. Our assessments are based on our experience in the petroleum, renewable and biofuels markets and are consistent with practices commonly used in these sectors but ultimately represent our professional judgements and, in some cases, opinions. Unless explicitly stated, forward looking data and other information herein, do not include, nor should they be construed as including advice, guidance, or recommendations from TM&C to take, or not to take, any actions or decisions in relation to any matter, including without limitation, relating to investments, or the purchase or sale of any securities, shares or other assets of any kind. Should you take any such action, or decision based on information contained herein, you do so entirely at your own risk. TM&C does not guarantee the accuracy or completeness of the data or our assessments and shall have no liability whatsoever for any loss, damage, costs, or expenses incurred or suffered by you as a result of your reliance on them.

[2] Unlike the US Gulf Coast, refineries in the Pacific Northwest are not surrounded by petrochemical plants that have the potential to absorb intermediate products as feedstocks. California refineries also tend (cont'd on page 3)

in vessel traffic. Any capital investments required for additional logistics capacity or debottlenecking are not included in our estimates. We also have not factored in any potential operational risks from these material changes in logistics and supply chains.

We calculate CO2e emissions related to the imports of refined products to meet local demand, as well as the export of unfinished or intermediate products that could no longer be processed to meet local Pacific Northwest product specifications.

Decarbonization from Changing Operations

Shutting Down a Naphtha Reformer

A naphtha reformer converts low-octane straight-run naphtha from the CDU (crude distillation unit) into high-octane reformate, which is a key component of gasoline. The primary purpose of the reformer is to improve the octane rating of gasoline and to produce hydrogen, as a byproduct, which is used in other refinery processes, such as hydrotreating (reducing sulfur in a product) and hydrocracking (a process designed to crack heavier molecules into distillates).

Shutting down a naphtha reformer actually has the potential to *increase* global CO2e emissions. Shutting down a naphtha reformer would reduce unit-specific CO2e emissions 6%. However, in our representative refinery, a SMR (steam methane reformer), which is used to make hydrogen, must be run at a higher utilization to make up for the loss of hydrogen supply when the naphtha reformer is closed. In our representative refinery, CO2e emissions increase ~10% because of greater natural gas usage in the SMR.

The straight-run naphtha from the CDU (that no longer goes to the naphtha reformer) would not meet gasoline blending specifications (especially octane). We assume those naphtha volumes are exported to Asia.[3] Shipping to the U.S. Gulf Coast requires the use of scarce and expensive Jones Act tankers in addition to the logistical complexity of transiting the Panama Canal. Shipping to Europe is generally more expensive than Asia because in addition to the Panama Canal fees there are longer voyage distances and EU carbon pricing fees for marine transport.

By losing the naphtha reforming, gasoline production decreases ~20% and we assume that volume needs to be replaced by imports from Asia to keep the Pacific Northwest gasoline market balanced. This assumption is consistent with the latest forecast from the Washington Transportation Economic and Revenue Forecast Council that projects gasoline sales in the state to be essentially flat for the next 10 years[4].

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to be internally balanced so Washington refineries would need to export intermediate materials that could no longer be processed in a now closed processing unit.

[3] The US Gulf Coast or Europe could be alternative markets for sources of gasoline imports or destinations for naphtha exports. We exclude them from this analysis because each market likely has structurally higher transportation costs than sailing to/from Asia.

[4] See slide 12 (on page 16 of pdf) at: https://erfc.wa.gov/sites/default/files/2025-06/trans20250625_0.pdf

The higher utilization of the SMR to make up the hydrogen lost when the reformer is closed, as well as the CO2e emissions associated with importing gasoline and exporting naphtha, would result in a net increase in CO2e emissions of ~45% (+0.5 MMTPA).

The loss in gasoline production also compresses refinery margins about 80%, which for our representative model would be a loss of almost $700 MM per year, based on 2024 prices. Given that carbon emissions increase while the refinery loses money, calculating an implied cost of carbon is not meaningful.

Shutting Down a Coker

A coker is an oil refinery unit that processes very heavy residues from the CDU and VDU (vacuum distillation unit) and cracks them into lighter gas oils, which can be fed to conversions units, *e.g.*, such as the FCC (Fluid Catalytic Cracker) or hydrocracker to make higher value products, such as gasoline and diesel. One of the by-products from the coking process is solid petroleum coke, which can be used as a fuel, anode material for aluminum smelting, or other industrial applications.

A coker is valuable to a refinery because it can increase liquid yield from heavy crude residues, which supports processing of heavier, cheaper crude slates. The coker also helps to reduce low-value residual fuel oil production, whose use is often is limited by environmental regulations.

Shutting down a coker reduces CO2e emissions but has significant economic and operational drawbacks. In our representative refinery, shutting down the coker reduces the feed to the FCC, which reduces the production of gasoline (-15%) and jet fuel or diesel (-35%). Jet/diesel production has a larger volume loss because low-value marine (bunker) fuel oil production increases tenfold. Meeting marine fuel specifications requires blending volumes of distillates (*e.g.*, jet, diesel) with the atmospheric and vacuum residue that would no longer be used as feedstock to the coker. We assume the marine fuel oil is exported to Asia because it is the most liquid market for fuel oil bunker sales.

CO2e emissions from coker operations would decrease by 0.2 MMTPA, or 15%, due to reduced natural gas consumption. Similar to shutting down a naphtha reformer, the loss in finished product volumes compresses refinery margins. For our representative refinery this loss would be over $1.2 billon per year, assuming the refinery does not change its operations, such as its crude slate.[5] Looking at just the reduced margin associated with reducing CO2e emissions from the coker implies a carbon cost of over $7,200 per ton of CO2e reduced.

The refinery could lighten its crude slate by running less heavy crude oil, such as Western Canadian Select (diluted bitumen) and more North American light-sweet crude oils, such as those streams found in the Bakken of North Dakota. Lightening the crude slate would reduce the amount of marine fuel oil, which tends to sell at a discount to crude oil. The

[5] Losses could be potentially higher if the coker produces anode-grade coke, which is used for steel/aluminum manufacturing. Anode coke can sell for sizable premiums to typical petroleum cokes, which tend to be used as substitutes for coal. There are several cokers in Washington with the potential to make anode coke.

lighter crude slate would be more expensive but reduces the need to export large volumes of marine fuel (that sell at a discount to crude oil). This reduces the margin loss from shutting down the coker and the implicit carbon cost to about $4,200 per ton of CO2e.

However, when looking at the change in total carbon emissions including those associated with importing and exporting product volumes to keep the Washington petroleum market in balance, shutting down the coker results in a net increase in CO2e emissions. Thus, on a total carbon emissions basis the implied cost of carbon is not meaningful because the refinery loses money, but total CO2e emissions increase.

Logistical Challenges

Shutting down processing units within an integrated refinery design could require major changes in operations and logistics, such as, increased vessel traffic to handle imports. We assume sufficient dock and harbor capacity exist so no material infrastructure investments are required to close either type of unit.[6] Such changes could increase risks around the operations of the refinery and required supply chains. These risks have the potential to threaten the economic viability of the refinery and have not been incorporated in this analysis.

Workforce Implications

According to a study by Western Washington University, Washington's refineries employ approximately 2,200 permanent employees and an additional 2,000 contract workers.[7] The number of employees necessary to operate each individual process unit depends on the unit's size, technology level of automation, and site practices. Staffing levels are usually measured in FTEs (full-time equivalent) required for each shift, combining field and process control roles for continuous operation (typically several crews rotating shifts). In addition, there are additional FTEs to support equipment reliability, maintenance, and process operations. These support FTEs can be embedded on-site or on-call depending on the plant's size and automation level.

For a typical naphtha reformer FTE staffing levels are in the range of 2 – 4 FTEs per shift (across 5 rotating shifts) for a total of 10 – 20 personnel to support operations on a 24/7

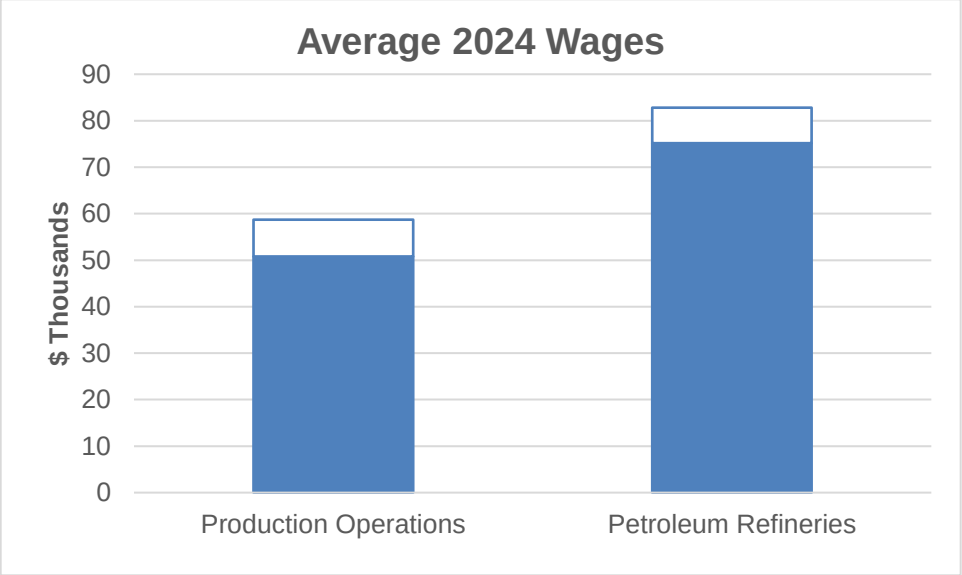
However, the import of gasoline, jet, and diesel to keep Washington petroleum product market demand satisfied, combined with the export of marine fuel oil to Asia results in a net *increase* in CO2e emissions for the Washington refining system of 0.5 MMTPA.

basis. For a delayed coker operational FTEs can range 15 – 25 for the unit. Additional FTEs for technical support and maintenance can double the FTEs for each unit.

[6] If marine logistics investments were required, there is no guarantee such projects could be permitted. Examples of denied vessel traffic permits in Washington include the Gateway Pacific Terminal (2016) and Millennium Bulk Terminals (2017) coal export terminals. These permits were denied over environmental and vessel traffic concerns.
[7] *Washington State Refinery Economic Impact Study*, Center for Business and Economic Research, Western Washington University, February 2025.

These refineries are not only significant local employers, but also provide high wages relative to other industries in the communities where they are located. Based on State of Washington data for 2024, refinery plant workers earn wages that are 40-50% higher than comparable process operation jobs (see Figure 1).

Figure 1: Comparing Refining Wages to Other Industries



Source: TM&C analysis; *Occupational employment and wage statistics,* State of Washington, Employment Security Department, 2024

Thus, while workforce reductions appear somewhat small (25 to 45 FTE for each closed unit), displaced operators could face 40 – 50% reductions in compensation relative to comparable jobs in Washington. Many of these workers could face the dilemma of accepting a job less than half of what they currently earn (assuming they can find a job) or be compelled to leave their current location (or the state) in search of opportunities elsewhere.

Decarbonization from Capital Projects

Competing against other projects for limited capital

Many capital projects for decarbonization, such as RD (renewable diesel) or SAF (Sustainable Aviation Fuel) conversion, FCC carbon capture, and green hydrogen production have negative economic value. Even if projects could have positive value, they may not be competitive with other projects in the company's project portfolio. Therefore, without significant incentives, low-carbon projects tend to not be competitive for capital in refining companies' budgets.

Timelines are another reason low-carbon projects can be unattractive to investors. Regulatory compliance and permitting can heavily impact project timing. For example, typical permitting timing can range between 6 to 72 months depending on the jurisdiction.[8] For this analysis we assume three years and a construction window of two years (with a range of 18 to 48 months). Longer permit processes tend to erode the economics of a project for two reasons: (1) project costs tend to rise over time and typically escalate faster than the assumed price path of revenue streams in petroleum markets and (2) project NPV (Net Present Value) tends to consider a project begins with the first activity specific to the project (*e.g.*, permit applications, ordering long-lead items) rather than when construction begins. The longer the permit process, the farther in the future is the beginning of receiving benefits from the project. The benefits are discounted at a corporate hurdle rate that usually is greater than the company's cost of capital. The more distant the benefits are and/or the higher the discount rate, the less valuable those future benefits are, relative to the costs, when discounted back to the beginning of the project (*e.g.*, permit applications).

Another key aspect to the start-up timing of a new project is minimizing how much its commissioning impacts other refinery operations. Planning for a start-up window (and backtracking to when construction commences) is a function of other operations, maintenance, and turnaround activities. A delay in permitting can materially disrupt when the project can be commissioned and, by extension, when construction should begin. In the worst case, a project can be delayed by an entire turnaround cycle which could be as much as 5 years in duration.

Converting units to renewable diesel or Sustainable Aviation Fuel

Converting existing petroleum refining units to renewable diesel production is a strategic pathway for energy companies seeking to reduce carbon intensity while leveraging existing infrastructure. Refiners can retrofit hydrotreaters or hydrocrackers to process renewable feedstocks, such as used cooking oil, animal fats, and vegetable oils, into renewable diesel, a drop-in fuel chemically similar to conventional diesel but with significantly lower lifecycle greenhouse gas emissions. This approach not only extends the value of existing assets but also minimizes capital expenditures, shortens project timelines, and enables refiners to respond quickly to growing policy incentives and market demand for low-carbon fuels. Renewable diesel can be converted into SAF with additional processing steps to meet jet fuel specifications for viscosity, freezing point, and flash point.

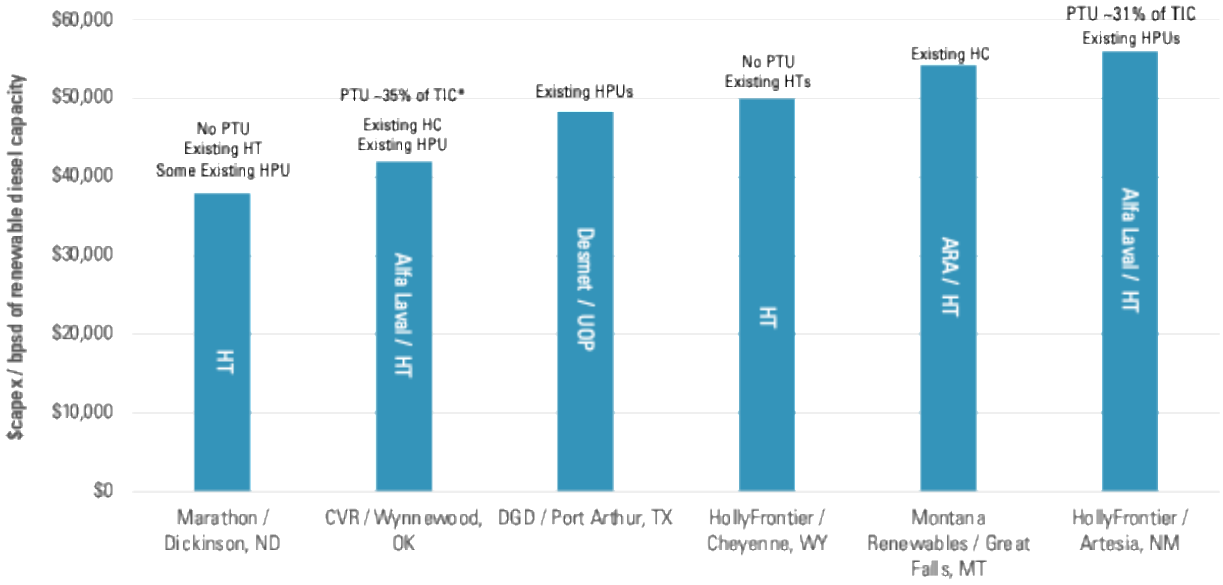
Conversion to RD/SAF production could have positive value under certain conditions, particularly with incentives like the 45Z Clean Fuel Production tax credit. The original IRA (Inflation Reduction Act) limited the credit to clean transportation fuels produced and sold between January 1, 2025 and December 31, 2027. The OBBBA (One Big Beautiful Bill

[8] Chevron's refinery in Richmond, California had a modernization project in which some of the permits took over nine years to approve. The initial permit applications were submitted to the City of Richmond during 2006, with final approval received in April 2015.

Act) extends the claim period by two years, now allowing credits for fuel produced and sold through the end of 2029. However, the OBBBA imposes new constraints on renewable fuels projects, such as feedstock origin, so combined with the difficulty to commission a major project before 2030 likely reduces the value of extending the credit period.

The following chart provides estimated capital investment for RD conversions based on our analysis of actual renewable diesel projects. Brownfield capital costs depend on what units are available for re-purposing.

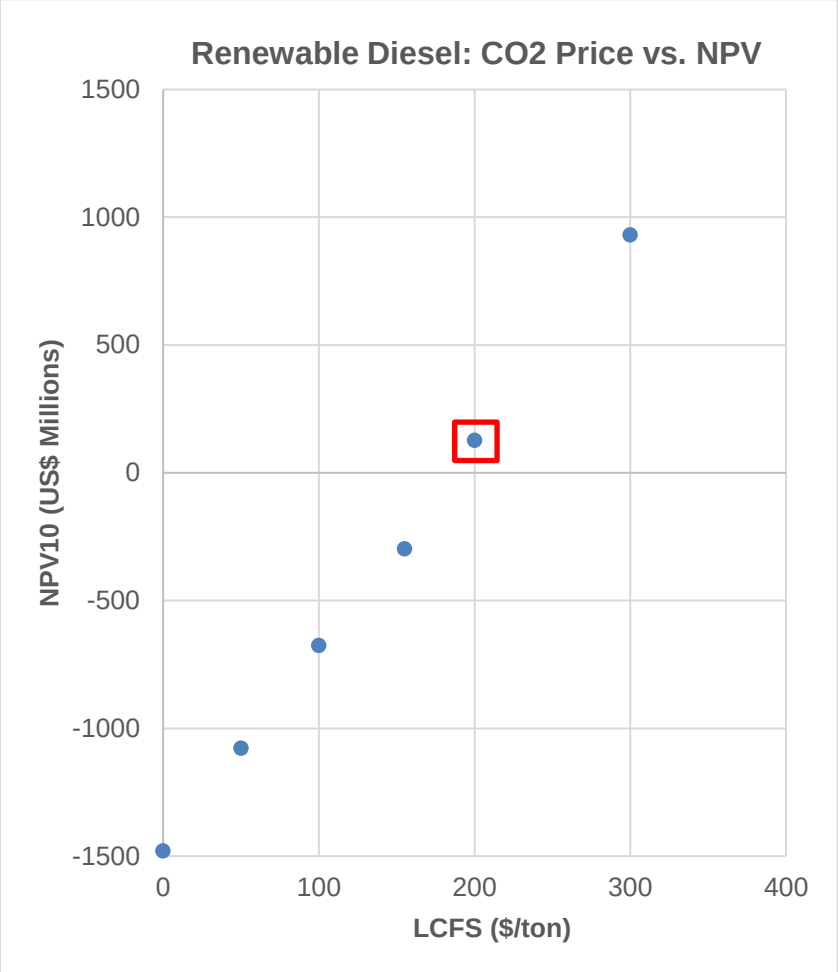
Figure 2: Renewable Diesel Capital Costs



Source: TM&C Regulatory & Renewable Fuels Outlook.

A hydrocracker is ideal, but there is only one in Washington at BP-Cherry Point. We focus on revamps of distillate or naphtha hydrotreaters. Naphtha hydrotreaters have an average capacity of 22 TBD (thousand barrels per day), while diesel hydrotreaters tend to be larger, with average capacity of 40 TBD. To help minimize capital costs, we model a hydrotreater with a capacity of 25 TBD. We assume a conversion cost of ~$46,000/bpd, which is 30% higher than a similar project in the U.S. Gulf Coast to account for less fabrication economies of scale and availability of skilled labor in the Pacific Northwest.

Figure 3: Renewable Diesel/SAF Project Economics



Source: TM&C analysis

The reduction in CO2e is about 0.2 MMTPA, which is 16% of the refinery's CO2e emission profile. The implied carbon cost that makes the project break-even on an NPV basis is just under $200/ton (net of tax credits).

FCC carbon capture

The FCC is a key processing unit designed to convert heavy fractions, such as gas oil into a blendstock for gasoline, a more valuable product. It achieves this through a process called catalytic cracking, where a catalyst and heat are used to break down longer hydrocarbon molecule chains into smaller ones.

This unit is a candidate for CCS (Carbon Capture and Storage) primarily because it is one of the largest single-point sources of CO2e in a petroleum oil refinery; about 25–35% of total refinery CO2e emissions, mainly from the regenerator during coke combustion.

The regenerator process in FCC units, which combusts coke at high temperatures, naturally concentrates emissions and makes the logistics of carbon capture more straightforward. The flue gas stream from FCC regenerators is continuous and accessible, which makes it viable for post-combustion capture technologies or alternative capture approaches.

We considered three technologies to test the potential project economics of effective carbon capture from FCC operations:

1) **Post-Combustion** - CO2 is captured from the flue gas after combustion. The most common approach uses amine-based solvents to absorb and strip CO2, which can capture 85 - 90% of CO2 emissions. It has advantages of minimizing required unit modifications and is widely proven in power and industrial sectors. Its challenges include high energy consumption and relatively high operating costs.
2) **Oxyfuel (Oxy-Firing) Combustion** - uses pure oxygen mixed with recycled CO2 instead of air. This leads to a flue gas with a much higher CO2 concentration, simplifying downstream capture, which can lead to 90 – 100% capture efficiency and flue gas with 93 – 95% CO2 concentration. This can result in lower operating costs than post-combustion, but higher capital costs due to required air separation units and modifications to the FCC regenerator. Thermal management and potential corrosion also must be addressed.
3) **Chemical Looping Combustion (CLC)** - uses oxygen carriers (typically transition metals) to combust coke in the regenerator. Its main advantages include lower energy intensity and a high purity CO2 stream (90 – 96% capture). Key challenges include significant catalyst redesign, integration of air reactor, and the technology is still largely at laboratory/pilot scale.

Table 1: Comparing Carbon Capture Technologies for FCC Emissions

Technology	Capture Rate	Capex ($/TBD)	Key Modifications	Status
Post-Combustion	85 – 95%	$3,200	Minimal	Commercial/pilot
Oxyfuel	90 – 100%	$4,700	Air separation, regenerator	Pilot/commercial
CLC	90 – 96%	$4,900	Catalyst, air reactor	Lab/pilot

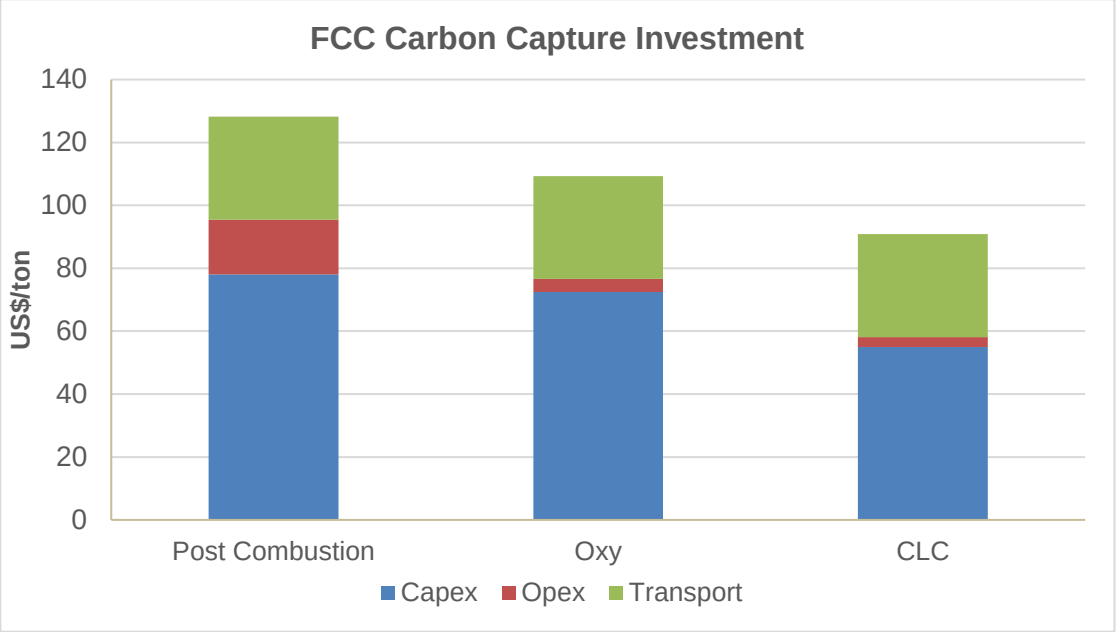
Source: TM&C analysis, industry research, “Progress in the CO2 Capture Technologies for Fluid Catalytic Cracking (FCC) Units—A Review”, *Frontier Energy Research*, vol 8, 2020;

Our modeled FCC has a capacity of 60 TBD, with CO2e emissions of about 400 ktpa (thousand tons per annum) and an assumed capture rate of 90%.[9] The capital cost runs from $350MM to $530MM depending on which technology is chosen. Operating costs

[9] It is important to distinguish between design capacity and actual operational rates. In real-world practice, actual rates may be somewhat lower due to factors such as maintenance, equipment downtime, variable loads, and off-design performance. A typical capture rate over a three-year period tends to be around 75%, but improving with experience and scale.

include transportation to the nearest proposed sequestration facility (*i.e.*, Big Sky Carbon Sequestration Project) and range $93/ton to $140/ton. We assume each project qualifies for 45Q tax credit ($85/ton) and will begin construction before the tax credit is scheduled to sunset on January 1, 2033.

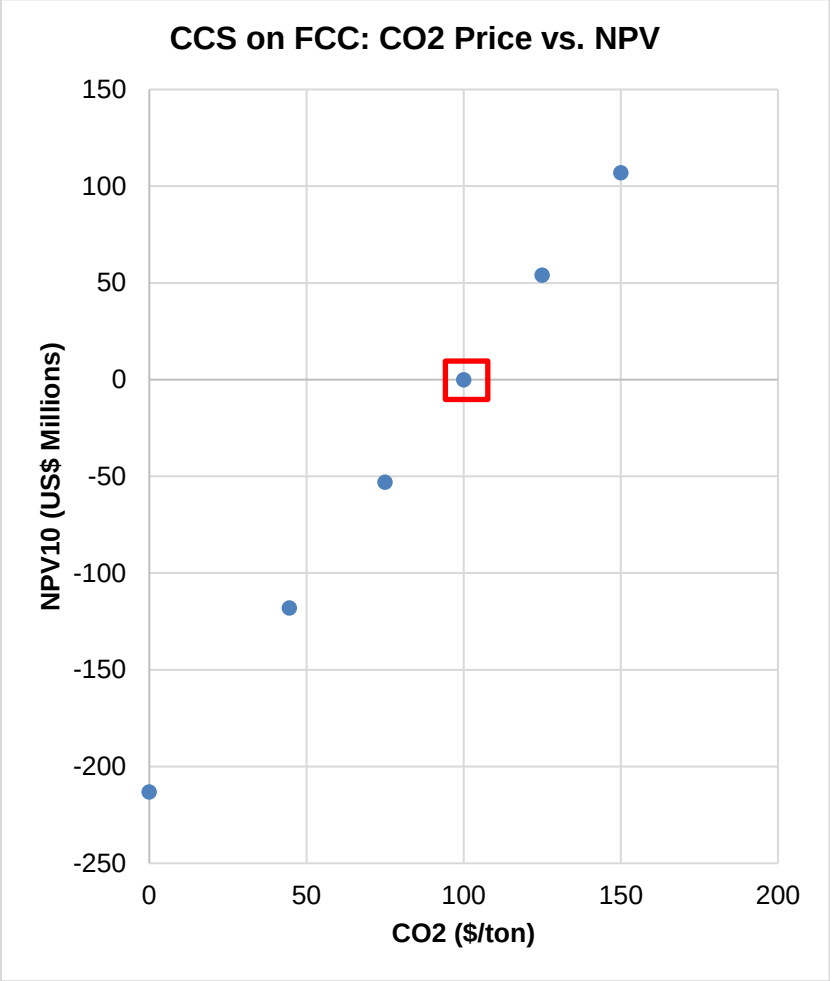
Figure 4: Comparing Technology Capital Cost for FCC Carbon Capture



Source: TM&C analysis, , industry research

The implied carbon cost that makes the project break-even on an NPV basis is about $100/ton (net of the 45Q tax credit). The CO2e reduction is 0.36 MMTPA (about 32% of the refinery's CO2e emissions).

Figure 5: CO2 Price Drives FCC Carbon Capture Project Economics



Source: TM&C analysis

Across all cases, the 45Q tax credit has a project value of about US$180 million.

Low-carbon hydrogen

Hydrogen is essential to multiple refinery processes to upgrade heavier, higher-sulfur crude fractions into lighter, cleaner transportation fuels. The major uses are: hydrotreating (removing sulfur, nitrogen, metals, and olefins/aromatics saturation to meet fuel specifications and protect downstream catalysts), hydrocracking (converting heavy gas oils to lighter, high-value products, *e.g.*, jet, diesel, naphtha, while simultaneously removing sulfur and nitrogen), isomerization (rearranging the molecular structure of light hydrocarbons to improve the octane number of gasoline components), and lubricants (improving the quality of lubricants, waxes, and other specialty products by removing impurities and saturating aromatic compounds).

The economic feasibility of a low-carbon hydrogen depends on very high carbon prices because it is typically more expensive to produce than conventional hydrogen from unmitigated steam methane reforming using natural gas (*i.e.*, "grey hydrogen"). A sufficiently high and predictable carbon price helps close that cost gap and creates bankable offtake. This is a key enabler for projects to secure financing and reach FID (Final Investment Decision).

Green hydrogen through electrolysis has a number of project challenges, such as capital cost of electrolyzers, low thermal efficiency of the process chain, difficulty to scale the project, and the uncertain availability of green electricity (unless building that generation and transmission is included in the project).

The 45V tax credit under the IRA is intended as a mechanism to address some of these challenges. To receive the full 45V tax credit of $3/kg a green hydrogen project must meet specific conditions related to lifecycle greenhouse gas emissions, production methods, and other requirements.[10] For example, under U.S. Treasury's final rules (released December 2024), electricity used for hydrogen production must meet three pillars to ensure low-carbon intensity:

- **Additionality** - generation must be new (constructed within 36 months before the hydrogen facility is placed in service) or from a source with increased capacity to ensure it contributes to grid decarbonization;
- **Temporal Matching** - electricity must be generated at the same time as hydrogen production (annual matching is allowed until 2028 when hourly matching is required);
- **Geographic Matching** - electricity must come from the same grid region as the hydrogen production facility to ensure it reflects local grid emissions characteristics.

These additional requirements can increase significantly the cost of a low-carbon hydrogen project as the table below shows:

Table 2: Capital Costs of Low-Carbon Hydrogen Plant (US$MM)

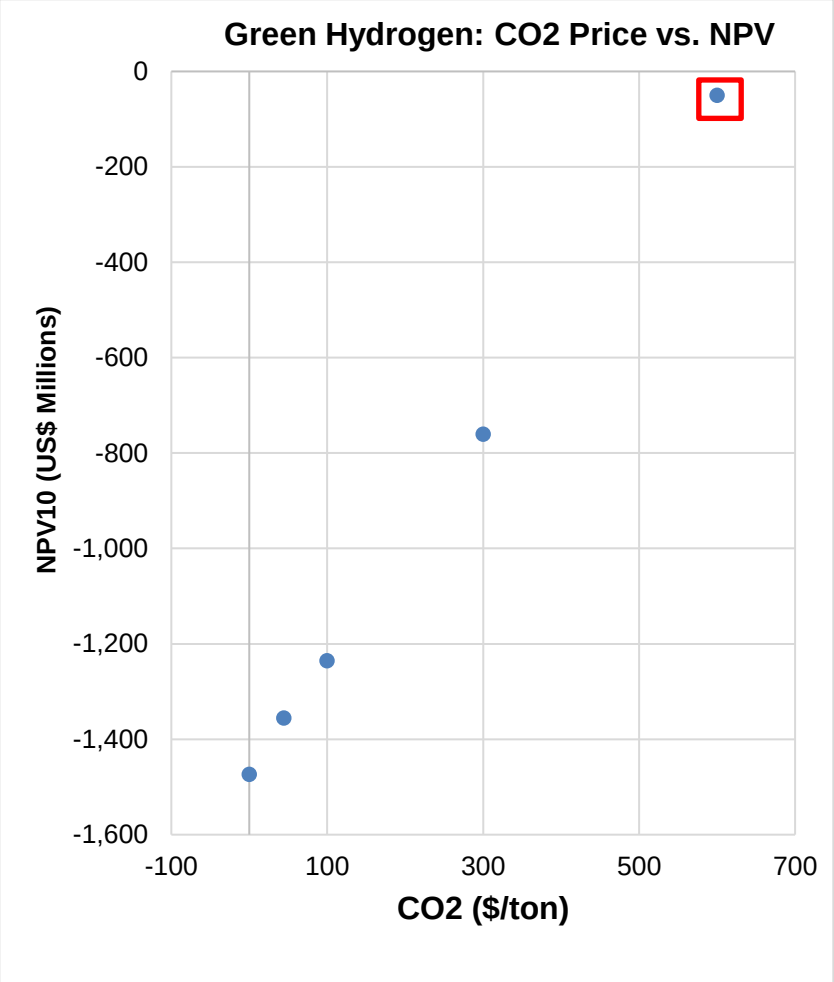
	Low	High
H2 Plant	635	1,325
Green Electricity	660	1,580
Transmission	270	750
Total	1,565	3,655

Source: TM&C analysis

[10] The OBBBA accelerates the phase-out of the 45V credit for facilities starting construction after December 31, 2027.

We model a low-carbon hydrogen project that produces enough volume to support the 25 TBD renewable diesel project described above, which is about 70 MMCFD (million cubic feet per day) or about quadruple the hydrogen required to desulfurize a similar volume of petroleum diesel.

Figure 6: Low-carbon Hydrogen Project Economics



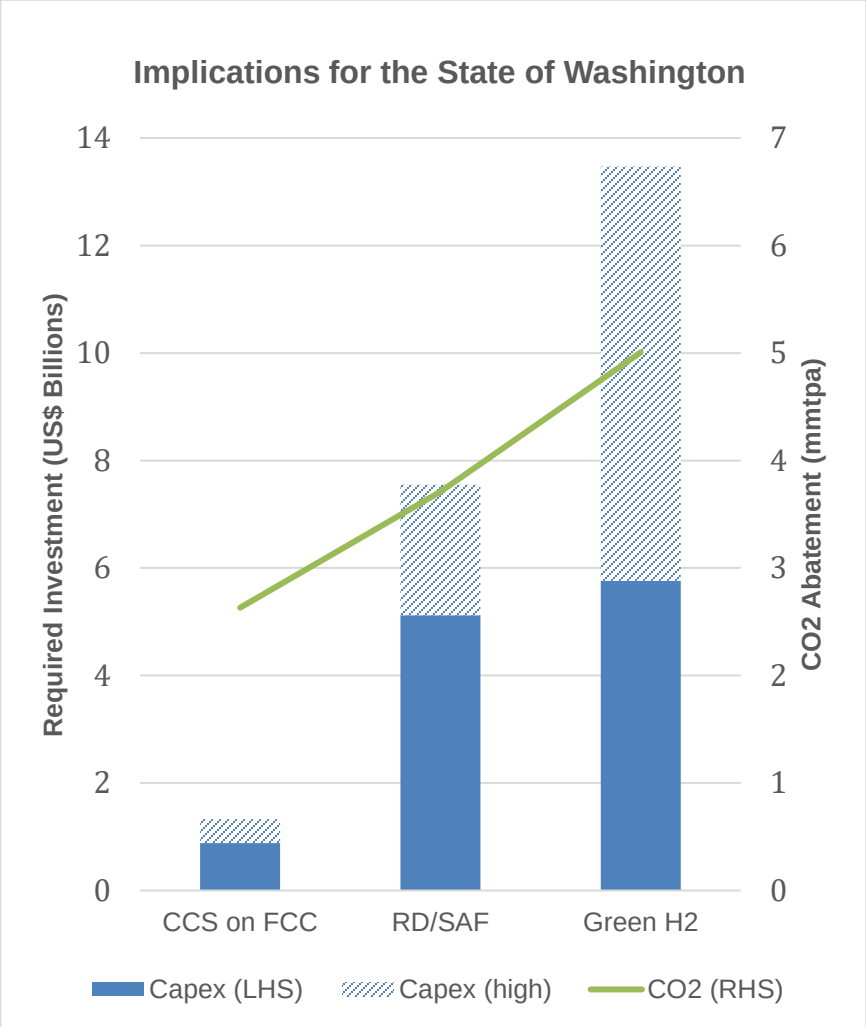
Source: TM&C analysis

The implied carbon cost that makes the project break-even on an NPV basis is about $600/ton (net of the 45V tax credit). The CO2e reduction is 0.36 MMTPA (about 32% of the refinery's CO2e emissions). Configurations becomes more attractive as qualification for tax credit incentives improve.

Global CO2e Emissions Implications

Fully implementing these projects across all Washington refineries could take until the mid-2040s. We assume each refinery would be able to implement no more than one capital project per turnaround cycle given their complexity and other work required around integrating the project with the rest of the refinery. Total required investment could range $12 to $22 billion (in $2025) based on economics of actual projects TM&C has examined across the U.S. If all suggested pathways were implemented, CO2e emissions could be reduced ~5 MMTPA, a 78% reduction from current levels.

Figure 7: Summary of Project Costs and Impact



Source: TM&C analysis

Reducing emissions in Washington by shutting down units like cokers or naphtha reformers does not yield a net reduction in global CO2e emissions. The shortfall in local

production would require importing refined products from Asia or the Middle East, which increases global emissions due to shipping and potentially less efficient foreign refineries. When processing units in Washington are shut, exporting unfinished intermediates from Washington to other regions could further increase net emissions. It is ironic that shutting down a naphtha reformer or coker could result in intermediate products being exported to a foreign refinery, processed into finished products, and then imported back to meet local Washington demand. The CO2e emissions savings from shutting the unit would be swamped by the increase in emissions from shipping unfinished volumes to a foreign refinery and then returning finished product to Washington.

Recommendations

- **Re-evaluate Operational Changes** - shutting down cokers or naphtha reformers is not a cost-effective decarbonization strategy due to high margin losses ($0.8–$1.4 billion annually) and workforce impacts;
- **Prioritize Incentives** - projects, such as FCC carbon capture and RD/SAF conversion, may become economically viable with enhanced incentives. Policymakers could consider continuing, restoring, or expanding these incentives to improve project economics;
- **Global Perspective** - address the lack of net global CO2e reductions by exploring local renewable fuel production or carbon capture technologies that minimize reliance on imported products;
- **Further Analysis** - conduct detailed studies on RD/SAF conversion costs and green hydrogen economics to better assess their feasibility with current incentives.

Conclusions

Decarbonizing Washington refineries presents significant economic and operational challenges. While operational changes, such as shutting down a coker might reduce local CO2e emissions, they incur substantial margin losses and potentially increase global emissions due to the need to increase product imports to keep the Pacific Northwest market in balance.

Capital projects, such as converting to RD/SAF or FCC carbon capture achieve greater reductions than shutting down the units studied, but require significant investment and incentives to be viable.

TM&C recommends a balanced approach that leverages incentives and prioritizes projects with the greatest ***net*** CO2e reduction potential and economic feasibility.

Methodology

Our analysis focuses on refinery CO2e emissions, plant economics, and the timing of decarbonization pathways. Pathways are divided into operational changes (*e.g.*, shutting down units such as naphtha reformers or delayed cokers) and capital-intensive projects

(*e.g.*, RD/SAF conversion, green hydrogen production, and carbon emissions capture on units, such as the FCC).

We used TM&C's proprietary refinery modeling system to create a complex refinery representative of a typical Washington refinery. To design the configuration of the refinery, we used EIA (Energy Information Agency of the U.S. Department of Energy) unit capacity data of the five petroleum fuel refineries in Washington. Capacities of key processing units include:

- Crude Distillation Unit: 150 TBD
- Naphtha Reformer: 25 TBD
- Naphtha Hydrotreater: 22 TBD
- Distillate Hydrotreater: 40 TBD
- Fluid Catalytic Cracker: 60 TBD
- Coker: 30 TBD
- Other units sized as needed to balance the refinery

We modeled a simplified refinery crude slate based on EIA foreign imports, inter-PADD transfers, and State of Washington data.

We use 2024 average prices in our analysis. Results are based on our knowledge of industry practices and assumptions based on our collective years of experiences. We also compare our results to a representative USGC Coking Refinery.