Washington State Department of Commerce

Washington State Refinery Economic Impact Study

CENTER FOR ECONOMIC AND BUSINESS RESEARCH | WESTERN WASHINGTON UNIVERSITY

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Report to the Legislature

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Executive summary

Purpose and legislative requirements

Chapter 475, Laws of 2023, Sec. 132 (19) requires the Washington State Department of Commerce (Commerce) to contract with a third-party entity to conduct a study that analyzes the economic impact of oil refining in Washington. Commerce must submit the report to the Legislature by December 31, 2024.

This report provides a broad assessment of the economic impacts of the current operations of Washington's five refineries and evaluates scenarios that describe how the operations and economic impacts may change in the future. The purpose of the study is to provide data and analysis that helps our state to understand how anticipated changes in the oil market may impact refineries, refinery workers, communities and tribes near refineries. This study is not a policy report and does not make policy recommendations. However, the data provided in this study can be used by stakeholders to help understand potential changes and may be used to inform additional planning and policy processes in the future. We intend this study to serve refineries, refinery communities, and policy makers and their future needs.

In order to complete this work, Commerce contracted with Western Washington University's Center for Economic and Business Research. The study team evaluated existing research and the best available public data, engaged with tribal staff and leadership, convened an Advisory Committee, and utilized modeling tools and specialized databases including IMPLAN Economic Impacts Model, JobsEQ Real-Time Intelligence Job Postings Database, and the EPA Co-Benefits Risk Assessment Health Impacts (COBRA) tool among other resources. This report is informed by the Washington 2021 State Energy Strategy and state greenhouse gas (GHG) reduction requirements.

Key Findings

The study has identified ten key findings. The findings, associated sub-points, and additional context are presented in brief below. Each chapter in this study begins with a presentation of the relevant finding or findings based on the data and analysis included in the chapter from which the findings are derived.

As a note on terminology used in this report, in the context of economic impact analysis, "significant" means that the impacts in the economic are noticeable and substantial. Use of this term in this context does not apply a value judgement about these impacts beyond categorizing their scope as substantial.

1. Washington's refineries are significant local employers that provide high wages compared to other industries in the communities where they are located.

- 1.1 Refineries employ a large number of workers – approximately 2,200 permanent employees and 2,000 contract workers. Many of these workers are represented by unions.

The five Washington refineries employ more than 2,200 permanent employees and approximately 2,000 contract workers per year. Additionally, refineries pay substantially higher salaries, on average, than the per capita averages in these counties, making a significant contribution to each county's economic activity. Refinery worker salaries vary significantly based on role, seniority and other factors. However, when looking at the state petroleum refining industry, average wages range from $97,000 to $191,800, which is greater than the county averages across all industries ($61,000 to $66,000). Average annual wages for occupations in the petroleum refining industry range from $2,000 to $35,000 higher than statewide occupational wages. It is

important to note that refinery jobs are economically valuable in these counties and that employees might struggle to attain comparable wages in other jobs in these counties.

2. Washington's refineries pay significant levels of state and local taxes, which fund public services, pollution prevention, and environmental remediation, among other things.

Refineries pay numerous types of state and local taxes directly, and taxes are paid based on the wages paid to workers. Refineries may also receive some tax breaks, particularly related to federal research and development incentives. Even with these tax breaks taken into consideration, the estimated tax contributions at the state and local levels from refineries amounts to over $292 million per year. Some of this funding is used to pay for public services, while about 47% (approximately $137 million per year) is supplied through the Hazardous Substance Tax. The Hazardous Substance tax is designed to help address environmental harms that result from hazardous substances such as petroleum products. This includes funding the Model Toxics Control Act (MTCA) pay for cleanups and oversight. Local property tax revenue contributes to local school districts, emergency services and other local government operations. Refinery workers also contribute to tax revenues when they use their income to purchase goods and services.

3. Tribes with and without treaty rights, and tribal citizens, have crucial perspectives on the impacts of refining in Washington, and their input must be a central component of discussions and evaluations regarding current and future refinery operations.

- 3.1 Washington's refineries are located on or near tribal lands, including usual and accustomed territories.
- 3.2 Refinery operations have infringed on tribal treaty rights including harvesting rights, land rights, and cultural practices.
- 3.3 Refineries have damaged tribes' environmental health by tainting traditional food sources and causing dangerous spills and flares.

The Legislature provided important direction to Commerce in relation to the completion of this study: "The department must offer early, meaningful, and individual consultation with any affected Indian tribe for the purpose of understanding potential impacts to tribal rights and resources including cultural resources, archaeological sites, sacred sites, fisheries, and human health."

This approach is critical, as refinery operations impact tribal nations and citizens in many ways. In particular, impacts on treaty rights must be considered. It has been a central focus of the work of this study to make every effort and respond to every opportunity to consult with tribes and ensure that the array of diverse perspectives and unique input we've received through that consultation is infused into this work. This study does so in multiple ways, including information shared in chapters one and five, as well as in an articulation of the engagement with tribes as well as public engagement that was conducted as part of this work (see Appendix A). While it is not possible to summarize all of the perspectives of tribal leaders and tribal citizens in relation to the topics in this study, the document includes reference to the history, includes public data on impacts and interactions between tribes and refineries and, where appropriate, includes more direct input from conversations and interviews conducted as part of this project. Tribal perspectives are and must remain central to understanding current or future refinery operations or future uses of these sites.

Chapter 1 provides data and analysis related to Key Findings 1-3.

4. Greenhouse gas emission limits and other climate and clean energy policies in Washington and across the broader regional market will contribute to changes in Washington's refinery industry.

- 4.1 Under the Climate Commitment Act, Washington refineries are "emissions-intensive, trade exposed industries" or EITEs, and currently receive no-cost allowances for their emissions.
- 4.2 The Climate Commitment Act, statutory greenhouse gas limits, the state Clean Fuel Standard and other policies will impact refinery operations as emissions caps decrease and demand for zero-emission vehicles increases.

The policy and regulatory context related to greenhouse gas emissions, clean fuels, and related policies is critical as these policies will shape the market for current and future petroleum products and alternative fuels, as well as regulating the refineries themselves.

Chapter 2 provides context and analysis related to Key Finding 4.

5. As petroleum demand declines, refinery operations will change, and economic impacts will vary depending on type and degree of decline.

- 5.1 Most of the petroleum products refined in Washington are sold to markets with greenhouse gas emission limits that will contribute to reduced demand for petroleum-based fuels.
- 5.2 Production and employment declines will lead to declines in labor income and value added, output, and tax revenues.
- 5.3 Reductions in petroleum demand and use will likely contribute to savings associated with health care and environmental costs.

This study reflects the likelihood, based on multiple public forecasts, strategies, and public policy, that demand for refined petroleum products will decline over the next 25 years. While modeling scenarios and resulting projections change depending on the assumptions and methodology, it was common across all data resources that conventional petroleum demand will decline in the coming decades. Scenarios evaluate reductions ranging from 6% to 95%. The 95% reduction scenarios are developed on a scenario of economy-wide greenhouse gas reductions to reach net-zero limits, and reflect that similar laws and policies are in place in the common markets for Washington's petroleum products.

The changes in demand and the resulting decisions that refineries may make to adjust to reduced demand vary, though all reviewed scenarios project economic losses for refineries and refinery communities, including loss of direct and indirect jobs and reductions in most types of taxes that refineries pay today. The scale of these impacts was estimated utilizing IMPLAN, an economic modeling software for several scenarios.[1] The functions available in the current version of IMPLAN does not include projections related to job growth in other sectors related to clean energy that may accompany reductions in petroleum production.

While the full range of projected changes are discussed in detail in this document, there are important ranges of total economic impacts that may occur depending on scale of demand decline. These include the following:

- Low end 6% decline: 1,838 jobs lost, and state and local tax payments reduced by over $38 million

[1] IMPLAN (Impact Analysis for Planning) is economic impacts analysis software that combines data and analytics to evaluate economic impacts and effects using an input-output (I-O) model.

- High end net zero: Over 25,000 jobs lost, and state and local tax payments reduced by over $112 million.

In addition to reduced economic impacts described above, reduced petroleum demand and use would likely also have positive economic outcomes for Washingtonians and the local environment. These could include savings associated with reduced costs that are often associated with refinery operations and petroleum use, such as health care costs or reduced costs associated with environmental remediation. While the primary IMPLAN modeling software used to calculate the direct and indirect economic impacts of changes to petroleum demand and use do not account for these health and environmental costs and co-benefits, additional tools were used to assess these topics. The US EPA Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) was used to assess the co-benefits of study scenarios based on reduced petroleum refinery emissions. A summary of anticipated impacts include:

- Low end 6% decline: $1 million to $1.6 million benefit in improved health effects due to reductions in $PM_{2.5}$ and O_3 in Washington.
- High end net zero: $16 million to $26 million benefit in improved health effects due to reductions in $PM_{2.5}$ and O_3 in Washington.

6. All five of Washington's refineries are likely to change their product mix or function as part of achieving net zero emission limits by 2050.

- 6.1 Several scenarios of change in refinery product mix or function are possible and may occur in succession.
- 6.2 Washington refineries may remain viable in the future, but are expected to change their core products or overall function. Refinery closure is possible, but more likely in the long term.

This study evaluates eight scenarios that Washington's refineries may choose in the coming years, including smaller changes to products produced, more significant changes in production (i.e., full conversion to alternative fuel production) or change in function (conversion to a transfer station or closure with or without site redevelopment). The strong climate and clean energy laws in Washington require reductions in GHG emissions from Washington's largest sources of emissions (through the Climate Commitment Act) and statutory requirements to reach net-zero emissions across the economy by 2050.

While significant levels of Washington's refined fuels are exported out of the state (approximately 40% are sold for end use outside Washington on average), at present many of the markets for these products are in states or regions that have their own regulations that will involve a transition to net-zero on a similar timeframe. As such, this study anticipates that net-zero limits may be associated with approximately 95% reduced demand for conventional petroleum products, with only a small proportion finding a market in regions without similar GHG reduction requirements. As described below, many alternative fuel products may be produced instead of conventional petroleum, including renewable diesel, alternative jet fuel and others. However, anticipated feedstock and energy limitations make it unlikely that all five refineries will fully replace their current production capacity by 2050. As such, a change in either product or function, including the possibility of closure, is plausible at Washington's refineries in the longer term.

7. Washington's refineries are moderately well-positioned to produce alternative fuels, though likely at levels lower than would fully replace the current refinery capacity.

This study assesses the competitive position of Washington's refineries to produce alternative fuels as "moderate." Review of relevant data indicates that significant levels of alternative fuel may be produced in Washington in the medium and longer terms, with ranges between 1.7 billion gallons a year and 6.5 billion gallons a year (though these production levels may occur at refineries or other sites[2]). The potential for these fuels to be produced at refineries is significant: research indicates it can be cost-effective to produce alternative fuels at an existing refinery site compared to another type of existing facility or building an entirely new facility. The capital equipment, workforce skills and other aspects of the operations of refineries makes them well positioned to produce some levels of alternative fuels, such as alternative diesel or alternative jet fuel, in co-production or conversion to alternative fuel production. Washington's refineries are already taking steps toward the production of alternative fuels. One example is the production of renewable diesel at BP's Cherry Point refinery since 2018 and the expansion of production in 2022. Additionally, the recent grant of almost $27 million to support production of sustainable aviation fuel at BP's Cherry Point refinery via a grant through the Federal Aviation Administration's (FAA) Fueling Aviation's Sustainable Transition via Sustainable Aviation Fuel (FAST-SAF) sends a positive signal about the future of alternative fuels. At the date of publication of this report, the grant agreement between BP and the FAA has not been finalized.[3]

There are, however, limitations to this potential, because Washington may not have sufficient access to either the feedstocks or the clean electricity needed to produce alternative fuels. It may be more cost-effective for businesses in Washington to import alternative fuels from regions with more access to those feedstocks and electricity. Commerce's Green Hydrogen and Renewable Fuels legislative report indicate that 2.5GW of renewable electricity capacity may be needed to produce renewable liquid fuels by 2035 (for aviation as well as on-road and maritime fuels). Both this study and RMI's recent Maritime Decarbonization report indicate that Washington may import more of these fuels than it is able to produce, due to constraints related to clean, low-carbon electricity and transmission capacity. In addition, significant costs will be required to add co-processing or convert fully to refining alternative fuels.

Chapter 3 presents data and analysis which contribute to Key Findings 5-7.

8. Alternative industries for impacted workers exist in Pierce, Skagit and Whatcom counties, though at present these opportunities are not sufficient for scenarios where refinery workforce declines significantly.

- 8.1 Apprenticeships and on-the-job training (OJT) are commonly used at refineries, but many workers lack formal credentials and certifications. This could make transferring to alternative industries difficult.
- 8.2 Refinery workers have hard and soft skills which could be valuable in other professions.
- 8.3 There are industries in nearby counties which could be suitable for displaced refinery workers, though there are not currently a sufficient number of such opportunities to make up for a significant employment decline at refineries.
- 8.4 Displaced employees are likely to experience lower levels of pay upon transitioning to careers outside of the refinery industry.

The 2,200 permanent workers in Washington's five refineries may be impacted by declining production or changes in product or function at refineries and face the possibility of job loss in future years. Additionally,

[2] Companies including Twelve plan to produce SAF as an e-fuel at a new facility in Moses Lake.
[3] Press Releases | News | U.S. Senator Maria Cantwell of Washington (senate.gov)

contract workers who regularly work significant hours at the refineries would also be impacted. Opportunities to employ these workers in similar skill-level jobs, ideally with commensurate levels of pay, benefits and safe working conditions will be important to support the livelihoods of these workers and sustain economic activity in Pierce, Skagit, and Whatcom Counties. At present, alternative industries exist in these counties that provide a relatively good match with many core refinery worker skillsets. Some examples include the utilities and food manufacturing sectors. However, these jobs exist at lower levels than the total refinery workforce, and several sectors such as pulp and paper mills are demonstrating decline rather than growth. As such, in the case of significant workforce declines such as those modeled for 95% reduction of refinery activity, there are not currently sufficient opportunities in the counties where the refineries are located. This may create significant challenges for workers and their families who would otherwise not seek to relocate to another county. This challenge is particularly acute for tribal citizens strongly connected to their specific tribal lands and the practices and culture connecting them to these particular lands, and are therefore not likely to move to a new region. This disparity highlights the need for a plan to transition workers.

Chapter 4 provides data and analysis contributing to Key Finding 8.

9. Alternative uses for refinery sites exist, with industrial uses likely to be more feasible than non-industrial.

- 9.1 Depending on the type and extent of contamination, remediation may be very expensive, time-intensive and require a variety of remediation methods.
- 9.2 The Department of Ecology oversees remediation efforts, and legal and financial obligations usually fall on current or previous site owners. The Model Toxics Control Act (MTCA) can also help determine liable parties or fund cleanup processes.
- 9.3 There are several potential future uses for refinery sites which present varying levels of economic, health, and environmental benefits and burdens.
- 9.4 Some scenarios are more feasible than others, depending on contamination levels and other factors.

This study evaluates potential alternative future uses for refinery sites in the event of closure. These include energy industrial, non-energy industrial, industrial symbiosis, heavy manufacturing and return to tribal ownership (including return to non-industrial state). Each of these potential uses could bring economic benefits by providing new operations at these sites and would need to be developed in ways that comply with state climate and clean energy laws, and as such, may have potential as longer-term opportunities beyond 2050. However, it is important to recognize that alternative uses will still have environmental impacts that must be considered. A full cost-benefit analysis of the GHG and other impacts of alternative uses is outside the scope of this report and would need to be assessed on a case-by-case basis and consider the specific details of any proposed project

The energy industrial category in particular aligns well with many aspects of existing refinery capital equipment and workforce skillsets and competencies. However, there are significant challenges that would need to be overcome for refinery sites to be cleaned up and developed for these alternative uses, including remediation costs (which vary depending on classification of use, such as industrial or residential) and lengthy timelines for siting and permitting of new operations which, in some circumstances, can last a decade or more.

10. Refinery operations contribute to human health and environmental harms, with associated economic costs, impacting their local

economies, environments, neighboring tribal nations, and surrounding communities.

- 10.1 Proximity to refineries (as with most heavy industrial facilities) is linked to higher risks of cancer, respiratory issues, cardiovascular diseases, neurological damage, and reproductive health problems.
- 10.2 Pollutants emitted at these sites include benzene, sulfur dioxides, formaldehyde, and particulate matter, contributing to smog, ozone formation, and other environmental hazards.
- 10.3 Many overburdened populations are located near refineries and face disproportionate pollutant exposure. The Environmental Health Disparities map highlights the increased risk to vulnerable communities in these areas.

Refineries impact the local environment and communities in a wide variety of ways. While this document is primarily an economic impacts study, legislative direction included requirements to consider health and environmental impacts, tribal rights and resources and more. When considering health impacts, this study assesses air quality impacts of refinery operations, as well as issues including water pollution and its impact on local marine life and communities which depend on marine life in their diets. Tribal communities with traditional practices of catching and consuming fish and seafood can be among those most directly impacted by water pollution, which limits the safe consumption of seafood.

Chapter 5 presents data, case studies, and additional information informing Key Findings 9-10.

Full proviso text

The text of the proviso states that the study must include:
(i) An overview of Washington's five oil refineries including: Location, age, workforce demographics, direct and indirect jobs connected with the industry, health and environmental impacts, local tax revenues paid by refineries, and primary and secondary products and markets;
(ii) A summary of projected scenarios for Washington refineries' primary markets, taking into account realistic, real world outcomes, given existing mandated decarbonization targets, feedstock availability, and statutes that impact Washington refinery products;
(iii) A summary of anticipated short-term, medium-term, and long-term economic viability of the five Washington oil refineries based on refinery product demand forecasts as outlined in (b)(ii) of this subsection;
(iv) A forecast of direct and indirect effects of the projected petroleum decline, including indirect employment impacts, the geography of those impacts, and impacts to local jurisdictions, utilities, ports, and special purpose districts from reduction in tax revenues, and impacts to local nonprofits and community programs from the refining industry;
(v) An assessment of potential future uses of refinery sites that include energy industrial, nonenergy industrial, heavy manufacturing, and industrial symbiosis, including an assessment of previously closed refinery sites throughout the United States and current use of those sites. Each potential future use shall be assessed and include data regarding: Greenhouse gas emissions, local pollution and environmental health, direct and indirect employment benefits, estimated tax impacts, potential costs to Washington residents, and feasibility based on relevant market trends; and an assessment of previously closed refinery sites throughout the United States and current use of those sites;
(vi) The competitive position of Washington refineries to produce alternative fuels consistent with Washington's emissions reductions defined in RCW 70A.45.020, the anticipated regional, national, and global demand for these fuels between 2023 and 2050; and the likely employment, tax, environmental, cultural, and treaty impacts of refinery conversion to these alternative fuels;
(vii) An identification of refinery workers' skillsets, potential alternative sectors and industries of employment, an assessment and comparison of total compensation and benefit packages including retirement and health care programs of current and alternative jobs, impacts to apprenticeship utilization, and the current and expected availability of those jobs in Pierce, Skagit, and Whatcom counties;
(viii) A land and water remediation analysis; including cost estimates, current terrestrial and aquatic pollution mapping, an overview of existing policies and regulations that determine accountability for cleanup and identifies

gaps that may leave local and state taxpayers financially liable, and an assessment of the workforce and skills required for potential cleanup;
(ix) A summary of existing petroleum refining capacity and trends in Washington, the United States, and internationally; and
(x) An assessment of decline or loss of tax revenues supporting state environmental programs including the model toxics control act, the pollution liability insurance agency, and other programs, as well as the decline or loss of transportation gas tax revenues.

A statement on the use of public data

It is important to note that the data used in this study is all publicly available. The act of collecting or sharing refinery-specific business information is restricted by laws designed to protect confidential business information and prevent anti-competitive behavior. As such, the study relies exclusively on the best available public data.

The refineries operating in Washington are independent businesses each with their own operational requirements, including required returns on investment or assets or overall corporate strategies to respond to a changing global market for refined products. The analyses conducted here do not rely on any private company data and assumptions made may not align with corporate strategies or interests.

Introduction

There are five oil refineries located in Washington:

1. Par Pacific/U.S Oil in Tacoma,
2. Marathon Anacortes,
3. HF Sinclair Anacortes,
4. Phillips 66 Ferndale and
5. BP Cherry Point.

These refineries are located across Pierce, Skagit and Whatcom Counties.

Washington's refineries make significant contributions to the state and regional economy. In total, the refineries have the capacity to produce approximately 665,000 barrels of oil per day (for reference, one barrel is approximately 42 gallons). The refineries support approximately 2,200 permanent jobs and 2,000 contracted jobs per year. The largest by volume products Washington's refineries manufacture and sell include gasoline, diesel, jet fuel, renewable diesel and asphalt.

The current economic impacts of the refineries occur in ways that generate both benefits and costs to Washington, its residents, and the environment. Economic benefits include the wages, purchases from local businesses, and tax revenues paid by the refineries. Economic costs include health costs from air and water pollution of refineries.

Projected scenarios

This study develops and evaluates eight potential future scenarios that Washington's refineries may pursue in the short term (2026), medium term (2035) and long term (2050). These scenarios are more likely to occur one after another rather than in isolation. The earlier scenarios are more likely in the short term, whereas the later

ones are more likely in the long term. Scenarios are described as they may pertain to an individual refinery. It is not assumed that a single scenario would apply to all five refineries concurrently; the five refineries could be involved in different scenarios during the same timeframe.

The scenarios evaluated in this study are:

Scenario	Most likely timeframe(s)
1. Minor demand changes; shift in product mix	Short to medium term
2. Minor demand changes; increase in exports	Short to medium term
3. Change in products: Joint venture/Co-Location	Most likely in medium or long term
4. Change in products: Fully alternative fuel production	Most likely in medium or long term
5. Change in function: Tank farm or storage facility	Most likely in medium or long term
6. Change in function and products: Combination of Scenarios 3 and 5	Most likely in medium or long term
7. Change in function: Closure and redevelopment	Most likely in medium or long term
8. Change in function: Closure and no redevelopment	Most likely in medium or long term

Chapter 1: Refineries in Washington

Key Finding 1. Washington's refineries are significant local employers that provide high wages compared to other industries in the communities where they are located.

- 1.1 Refineries employ a large number of workers – approximately 2,200 permanent employees and 2,000 contract workers. Many of these workers are represented by unions.

Key Finding 2. Washington's refineries pay significant levels of state and local taxes, which fund public services, pollution prevention, and environmental remediation, among other things.

Key Finding 3. Tribes with and without treaty rights and tribal citizens have crucial perspectives on the impacts of refining in Washington, and their input must be a central component of discussions and evaluations regarding current and future refinery operations.

- 3.1 Washington's refineries are located on or near tribal lands, including usual and accustomed territories.
- 3.2 Refinery operations have infringed on tribal treaty rights including harvesting rights, land rights, and cultural practices.
- 3.3 Refineries have damaged tribes' environmental health by tainting traditional food sources and causing dangerous spills and flares.

Refinery History in the State

Background

Washington's oil refining industry dates back to the late 19th century. Due largely to the abundant crude oil resources found in Canada and Alaska, Northwest Washington's access to strategic marine shipping networks and supportive land-based transportation infrastructure, Washington quickly became a pivotal hub for refining operations on the West Coast of the United States. Discoveries of oil in Alberta, Canada in 1947 then spurred the construction of pipeline networks across Canada and the Pacific Northwest to deliver crude oil from the source fields to the refineries in the 1950s. Further oil extraction on Alaska's North Slope prompted the building of the BP Cherry Point refinery in the 1970s, one of the nation's newest refineries.[4]

Overview

The roots of Washington's petroleum refining industry can be traced back to the 1850s, when the first American oil refinery was built in Pittsburgh.[5] As population and economic development grew westward during the 19th and 20th centuries and new discoveries of crude oil resources were made, refining operations spread across the inland and coastal Western U.S. Also during this time, the federal government facilitated a robust treaty campaign to seize lands inhabited by native and indigenous peoples across the west, including in Washington. In Washington, the 1854 Treaty of Medicine Creek[6] and the 1855 Treaty of Point Elliott[7] ceded lands that would later become the sites of refinery operations to the United States government. The refineries

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[4] Washington Research Council Economic Profile, "The Economic Contribution of Washington State's Petroleum Refining Industry in 2019", June 2021

[5] Sulman, Michael A, "The Short Happy Life of Petroleum in Pittsburgh: A Paradox in Industrial History", Pennsylvania History: A Journal of Mid-Atlantic Studies, Pennsylvania State University, January 1966.

[6] "Treaty of Medicine Creek, 1854", from Washington Governor's Office of Indian Affairs, Resources, accessed September 16, 2024.

[7] "Treaty of Point Elliot, 1855", from Washington Governor's Office of Indian Affairs, Resources, , accessed September 16, 2024.

built on March Point in Anacortes are situated on Swinomish land. The refineries built in Ferndale and Blaine are situated on Lummi land, with the Tacoma refinery located on Puyallup land.

With the discovery of oil fields in California and Alberta, the demand for regional refining capacity grew. Between 1954 and 1957, a total of four refineries were created in Washington,[8] with an initial capacity of 104,000 barrels per day by 1958.[9]The fifth and final refinery opened in 1971, adding an additional capacity of 100,000 barrels per day.[10]

The establishment of refineries in Washington was driven by both economic development efforts and geographic strategy, as well as growing demand for petroleum. In the early 20th century, Washington's economy was heavily reliant on industries like fishing and logging. However, by the 1950s, these industries were in decline.[11] Local communities sought out new sources of economic growth, including the development of petroleum refineries.[12] The construction of Shell's refinery at March Point in 1953 provided an economic boost in Anacortes, followed by General Petroleum's refinery in Ferndale in 1954.

The choice of locations for these refineries was influenced by the discovery of oil in Alberta and the completion of the Trans Mountain Pipeline in 1953.[13] The Trans Mountain Pipeline enabled the direct transport of crude oil from Edmonton to Washington. The Puget Sound area's proximity to these new oil sources made it a well-suited location for refining operations from a business perspective. Additionally, these refineries allowed Washington to become less dependent on oil shipments from California, which was struggling to meet demand at the time.

However, these decisions were not just logistical in nature, but also a result of environmental racism. Environmental racism describes the systematic and intentional placement of environmental hazards in native communities and communities of color.[14] Alongside redlining, intentional policies, regulations, and laws have placed additional burdens of industrial pollution on these communities. These policies create greater health inequities, while affected communities have been historically excluded from decision making processes about these environmental hazards, or less enforcement of environmental regulations. As a result, native communities and communities of color experience a variety of side effects. This includes higher rates of asthma, disproportionate exposure to pollution from all sources and other strains. Vulnerable communities, such as native communities, were seen as a "path of least resistance"[15] over communities with more power and influence to defer locally unwanted land uses.[16] While these facilities were sited decades ago, their placement has continuing negative impacts on adjacent communities. Living within 10 miles of a petroleum

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[8] Gustafson, Zane and Eric de Place. "The History of Northwest Refineries", Sightline Institute, September 22, 2021.
[9] Hennig, C.E., "Petroleum Refineries, Including Cracking Plants in the United States, January 1, 1958." U.S. Bureau of Mines, Page 10.
[10] BP, "bp in Washington Fact Sheet" Updated September 2024.
[11] Center for the Study of the Pacific Northwest, "II. Seeing the Forest for the Trees: Placing Washington's Forests in Historical Context"; Northwest Power and Conservation Council, "Commercial Fishing"
[12] Lunsford, Bret, "Intro to Anacortes History", City of Anacortes, Accessed June 28, 2024.
[13] TransMountain, "Our History", Accessed July 12, 2024; The Canadian Press, "Timeline: Key dates in the history of the Trans Mountain pipeline", Published October 3, 2018, updated June 18, 2019.
[14] Augusta University Online, "Environmental Racism: Definition, Examples, and Prevention" Environmental Racism: Definition, Examples and Prevention – Campus Insider
[15] Mohai P, Pellow D, Roberts JT. Environmental justice. Annual Review of Environment and Resources. 2009;1(2009):405–430.
[16] Vickery, J., & Hunter, L. M. (2016). Native Americans: Where in Environmental Justice Research?. Society & natural resources, 29(1), 36–52. https://doi.org/10.1080/08941920.2015.1045644

refinery has been linked to increased risks of cancer,[17]asthma, birth defects, neurological damage, cardiovascular damage and blood disorders.[18]

The refining industry continued to expand in Washington in the 1960s, as refineries benefitted from access to Canadian and Alaskan crude oil supplies. In particular, the discovery of oil at Prudhoe Bay in 1968 helped drive the expansion of refinery operations in Washington. The ARCO Cherry Point Refinery was built in response to the discovery and developed primarily to process Alaskan North Slope crude oil.[19] The now-BP Cherry Point facility has since diversified its capabilities, utilizing crude oil from around the world. The facility became the largest in the state and cemented Washington's role as a key refining hub on the West Coast. By 1982, the refining capacity at the five major refineries had increased to more than double 1958 levels, at nearly 408,000 barrels per stream day.[20] Since then, it has climbed to 674,500 barrels per stream day in 2024.[21]

Washington has the fifth highest oil refining capacity of any U.S. state, with a current total refining capacity of approximately 665,000 barrels per day (bpd). States with a larger refining capacity, in ascending order, include Illinois, California, Louisiana and Texas. Washington has a location quotient of 1.54 for the Petroleum Refineries industry. Location quotient is a measurement of concentration in comparison to the nation. This means that the Washington region has 54% more than expected employment in petroleum refineries, compared to the nation. In order of greatest capacity to least, the refineries in Washington include:

1. BP Cherry Point Refinery situated near Blaine,
2. HF Sinclair Anacortes Refinery,
3. Marathon Anacortes Refinery,
4. Phillips 66 Ferndale Refinery, and
5. Par Pacific - U.S. Oil Tacoma Refinery.

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[17] Stephen B Williams, Yong Shan, Usama Jazzar, Preston S Kerr, Ikenna Okereke, V Suzanne Klimberg, Douglas S Tyler, Nagireddy Putluri, David S Lopez, John D Prochaska, Cornelis Elferink, Jacques G Baillargeon, Yong-Fang Kuo, Hemalkumar B Mehta, Proximity to Oil Refineries and Risk of Cancer: A Population-Based Analysis, JNCI Cancer Spectrum, Volume 4, Issue 6, December 2020, pkaa088,
[18] California Government- Proposition 65 Fact Sheets, "Petroleum Products- Environmental Exposure from Refineries".
[19] Office of Management, "March 13, 1968: Oil discovered on Alaska's North Slope.", U.S. Department of Energy; Alaska Business Magazine, "Where Does All That Oil Go?", October 2, 2018.
[20] Stream day refers to the maximum number of barrels of input that a distillation facility can process with a 24-hour period when running at full capacity under optimal crude and product slate conditions with no allowance for downtime. This number is often higher than barrels per calendar day, which factors in limitations like input quality, environmental constraints, downtime for maintenance or repairs. Stream day capacity is typically about 6% higher than calendar day capacity.
[21] U.S. Energy Information Administration, "Washington Refinery Operating Atmospheric Crude Oil Distillation Capacity as of January 1", Released June 14, 2024.

Figure 1: Map of Washington oil refineries

All five refineries produce gasoline, diesel oil and jet fuel as major products. Figure 2 shows the overall trajectory of crude oil distillation capacity in Washington since 1990. The gap results from the Energy Information Administration-820 Refinery Capacity Survey not being completed in 1996 and 1998.

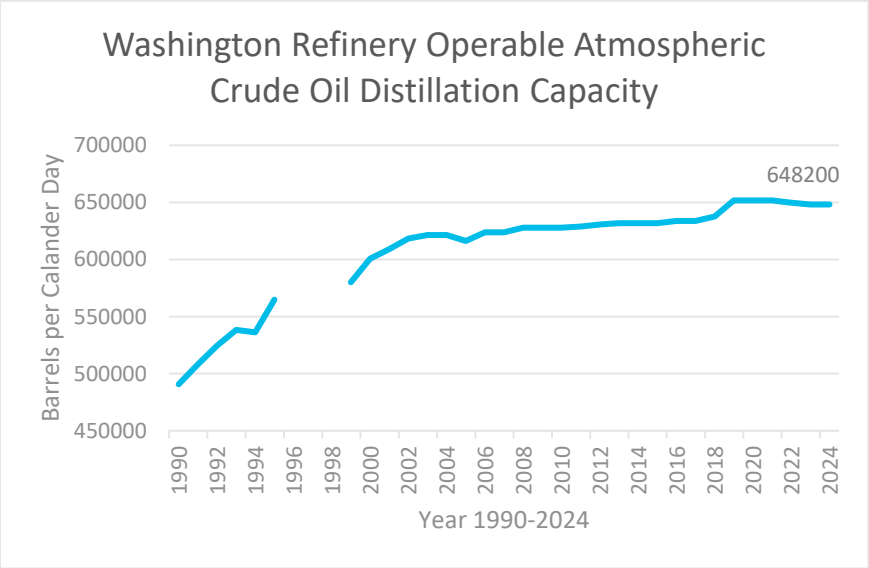

Figure 2: EIA, Washington refinery annual operable atmospheric crude oil distillation capacity as of January 1 (barrels per calendar day), 1990 to 2024. Data updated June 2024.[22]

Table 1 contains the barrel per day crude oil capacity, approximate full time employees and 2022 greenhouse gas (GHG) emissions for each refineries. These numbers are provided to help demonstrate the differences in operation capacity and workforce at each refinery. Within this report, all modeling is done at a statewide level, with all five refineries homogenized. This is due to the need to assess and report only public data for this study, as well as the focus on reporting high level economic analysis rather than specific findings at the refinery level. Crude oil capacity ranges from 42,000 to 250,000 barrels per day, with full time employees ranging from approximately 190 employees to 800 employees. Table 1 also contains the direct facility emissions and supplied fuel emissions of each refinery in metric million tons of carbon dioxide equivalent. Petroleum refining, along with other fuel suppliers and power plants, are some of the top emitters in Washington.[23]

Table 1: Overview of refinery capacity, employment and greenhouse gas emissions.

Refinery	Barrel per Calendar Day Crude Oil Capacity	Approximate Full Time Employees *	2022 total facility Greenhouse Gas Emissions in million metric tons CO_2e **	Supplied Fuel Emissions in million metric tons CO_2e ** Total Emissions	Biogenic Carbon Dioxide
Phillips 66, Ferndale	105,000[24]	240	0.718	8.264	.329
Marathon (Tesoro), Anacortes	119,000[25]	400	1.37	7.609	.325

[22] Washington Refinery Operable Atmospheric Crude Oil Distillation Capacity as of January 1 (Barrels per Calendar Day)
[23] Data.wa.gov, GHG Reporting Program Publication.
[24] Sourced via Washington State Department of Ecology, Phillips 66 Refinery - Washington State Department of Ecology
[25] Sourced via Marathon website, Anacortes Refinery | Marathon Petroleum Refineries

Refinery	Barrel per Calendar Day Crude Oil Capacity	Approximate Full Time Employees *	2022 total facility Greenhouse Gas Emissions in million metric tons CO_2e **	Supplied Fuel Emissions in million metric tons CO_2e ** Total Emissions	Biogenic Carbon Dioxide
HF Sinclair, Anacortes	149,000[26]	470	1.9	2.522	.094
Par Pacific- U.S. Oil, Tacoma	42,000[27]	190	0.128	2.442	.139
BP, Cherry Point, Blaine	250,000[28]	800	2.12	5.65	.183
Total	665,000	2,100	6.2	26.49	1.072

***Approximate Full Time Employees sourced from Washington State Department of Ecology Industrial facilities permits profiles.[29]**
**** Carbon dioxide equivalent emissions, both direct facility emissions and supplied fuel emissions sourced via the Washington Greenhouse Gas Reporting Program[30]**

As of the 2021 report by the Washington Research Council[31], using 2019 numbers, 53.2% of petroleum products refined in Washington were sold in the state, 39.5% of products were sold domestically, with the remaining 7.3% exported to foreign markets. The primary export markets in 2019 were Mexico (39.9%), Canada (30.3%) and Peru (3.8%).

Similarly, this report has aggregated available emitted pollutants data on each refinery. Four of the refineries report emitted pollutants to the Northwest Clean Air Agency, which makes this information publicly available. However, the Par Pacific- U.S. Oil refinery reports to the Puget Sound Clean Air Agency, which does not publicly report this data. As a result, we sourced comparable values where possible. This report does not include information about the permitted emissions of each refinery.

Table 2: Comparison of emitted pollutants from each refinery.

Pollutant (Tons per year)	Phillips 66	Marathon	HF Sinclair	Par Pacific- U.S. Oil*	BP Cherry Point	Health and Environmental Impacts of Pollutants
PM_{10}	31	146	210	NA	138	PM_{10} is airborne particulate matter with a diameter of 10 microns or less and are small enough to pass through the throat and nose, entering the lungs. Exposure can lead to reduced lung function, worsening of respiratory diseases, faster disease progression, reduced life expectancy, and increased hospitalization and emergency department visits. Children, asthmatics, and older adults are particularly susceptible.[32]

[26] Sourced via HF Sinclair website, HF Sinclair Corporation | Operations - Facilities - U.S. - Anacortes, WA
[27] Sourced via Par Pacific- U.S. Oil website, Washington | Par Pacific
[28] Sourced via bp website, Refineries | What we do | bp America
[29] Industrial facilities permits - Washington State Department of Ecology
[30] Data.wa.gov, GHG Reporting Program Publication
[31] Washington Research Council Economic Profile, "The Economic Contribution of Washington State's Petroleum Refining Industry in 2019", June 2021
[32] California Air Resources Board, "Particulate Matter and Health Fact Sheet", March 20, 2023.

Pollutant (Tons per year)	Phillips 66	Marathon	HF Sinclair	Par Pacific-U.S. Oil*	BP Cherry Point	Health and Environmental Impacts of Pollutants
SO_2	28	81	213	NA	854	Sulfur oxides can harm the human respiratory system, and contribute to particulate matter pollution. At high concentrations, sulfur oxides can harm trees and plants by damaging foliage and decreasing growth, and contribute to acid rain. Additionally, it can contribute to reduced visibility or haze. [33]
NO_x	681	1873	1316	430**	1935	Nitrogen oxides are a mixture of gases composed of nitrogen and oxygen. Exposure to high levels can damage respiratory airways, and contact with skin or eyes can cause burns. They can contribute to acid rain and reduced visibility. [34]
VOC	603	804	492	NA	419	Volatile organic compounds (VOCs) are a group of chemicals that can vaporize into air. They can cause eye, nose, and throat irritation, headaches and loss of coordination, nausea, and damage to the liver, kidneys, or central nervous system. Some VOCs are suspected or proven carcinogens. [35]Benzene, a VOC, is a known carcinogen resulting from petroleum refining. [36]
CO	162	464	604	NA	456	Carbon monoxide is a pollutant that reduces the ability of blood to carry oxygen. Exposure can result in fatigue, headaches, confusion and dizziness. People with cardiovascular disease with short term exposure may experience chest pain and further decreased exercise tolerance. It can also participate in chemical reactions that produce ozone, and is classified as a short-lived climate forcing agent. [37]
CO_2	718,028	1,370,882	1,907,858	127,073**	2,123,675	Depending on the concentration of carbon dioxide and length of exposure, possible symptoms include headache, drowsiness, confusion, increased cardiac output, elevated blood pressure, and increased arrhythmias. [38] Carbon dioxide in the atmosphere acts as a greenhouse gas and helps accelerate climate change. It also contributes to ocean acidification. [39]
Methane	2,004**	2,455**	6,435**	817**	6,448**	Methane can contribute to poor air quality by contributing to the formation of ground level ozone and particulate pollution, which can damage airways, aggravate lung disease, increase rates of preterm birth, heighten stroke risk, and increase cardiovascular morbidity and mortality. [40] Methane has a shorter atmospheric lifetime than carbon dioxide, but absorbs more energy while it exists in the atmosphere, making it a potent greenhouse gas.[41]

[33] Environmental protection Agency, "Sulfur Dioxide Basics", January 31, 2024.
[34] Agency for Toxic Substances and Disease Registry (ATSDR). 2002. Managing Hazardous Materials Incidents. Volume III - Medical Management Guidelines for Acute Chemical Exposures: Nitrogen Oxides. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.
[35] Minnesota Pollution Control Agency, "Air Pollutant- Volatile organic compounds (VOCs)"
[36] Edokpolo, B., Yu, Q. J., & Connell, D. (2015). Health risk assessment for exposure to benzene in petroleum refinery environments. International journal of environmental research and public health, 12(1), 595–610.
[37] California Air Resources Board, "Carbon Monoxide and Health".
[38] FSIS Environmental, Safety and Health Group, "Carbon dioxide Health Hazard Information Sheet".
[39] Lindsey, Rebecca, "Climate Change: Atmospheric Carbon Dioxide", NOAA Climate.gov, April 9, 2024.
[40] Environmental Defense Fund, "how Methane Impacts Health".
[41] International Energy Agency, "Global Methane Tracker 2022- Methane and climate change"

Pollutant (Tons per year)	Phillips 66	Marathon	HF Sinclair	Par Pacific-U.S. Oil*	BP Cherry Point	Health and Environmental Impacts of Pollutants

***Par Pacific numbers are from data.wa.gov. This data is limited but provides the most applicable source for emissions of the U.S. Oil Tacoma refinery.[42] For consistency, we pulled methane emissions from this same portal for other refineries as well.**
****Numbers are in metric tons of carbon dioxide equivalent ($MTCO_2e$)**

An Overview of Petroleum Refining

Petroleum refining is the process of turning crude oil into usable products. According to the Energy Information Administration (EIA) oil refining includes three basic steps: Separation, Conversion and Treatment.[43] In the separation stage, oil is pumped through hot furnaces where the resulting liquids and vapors get discharged into distillation units. The distillation units' purpose is to separate the crude oil into broad categories or "fractions"[44] based off the product's boiling point. As the crude separates, different products boil off at different temperatures, refiners then recover these products 'Lighter' products, with lower boiling points, are recovered at lower temperatures. 'Heavier' products, with higher boiling points are recovered at higher temperatures. Lighter products separate to the top of the distillation unit, and heavier products settle at the bottom.

After the products have been separated by the distillation process, they enter their next basic step, the conversion stage. Heavy, less valuable product can be converted into lighter, more valuable products through a process called "Cracking." Cracking uses heat, pressure, catalysts and sometimes hydrogen to crack heavy hydrocarbon molecules into lighter ones.[45] This helps refineries to maximize the value of the crude oil that is processed.

Finally, the products are put through the treatment stage where the finishing touches are applied. For gasoline, different streams of products are mixed to form the end product. Once each product is treated differently, they are stored on-site before being transported via pipeline, rail, truck or ship to off-site storage or their destination.

Washington is part of Petroleum Administration for Defense District (PADD) 5. PADDs are geographic groups of the 50 states and the District of Columbia divided into five districts to help coordinate the production and use of petroleum across the country. PADDs were intended to help ration gasoline during World War II. Currently, PADDs help users of EIA petroleum data assess regional petroleum product supplies.[46] PADD 5 includes Washington, Oregon, California, Nevada, Arizona and Alaska.

Jobs in the Refining Industry

The refineries in Washington serve as major sources of employment in the regional economy, providing employment opportunities and producing products to support various sectors such as transportation,

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[42] Data.wa.gov, GHG Reporting Program Publication.
[43] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." Refining crude oil - the refining process - U.S. Energy Information Administration (EIA). Accessed September 10, 2024.
[44] Crude oil distillation and the definition of refinery capacity - U.S. Energy Information Administration (EIA). Accessed September 10, 2024.
[45] U.S. Energy Information Administration (EIA). "Glossary- Catalytic Cracking", Accessed September 10, 2024.
[46] "Padd Regions Enable Regional Analysis of Petroleum Product Supply and Movements." U.S. Energy Information Administration (EIA), February 2012.

manufacturing and agriculture. Refineries play a crucial role in meeting demand for petroleum products in Washington and beyond, including gasoline, diesel, jet fuel and heating oil.

Washington employs approximately 2,200 petroleum refinery[47] workers of the 62,135 employed across the US. Within the past decade, employment Washington's refineries increased by 290 jobs. This is a 1.4% annual increase in the last 10 years, compared to a 1.4% decrease nationally. The average annual wage per refinery worker in Washington is $185,973, which is greater than the national average wage of $169,167 for the same industry position. This wage represents a 2.8% average annual increase from the last 10 years.[48] This is the average pay across all refinery occupations, and therefore may be skewed upward by high wages for administration.

We identify key occupations within the refining industry in **Error! Reference source not found.**, ranked by e stimated proportion of total workforce, along with select demographics. We used the Bureau of Labor Statistics' six-digit 2018 Standard Occupational Classification (SOC) code system. SOC codes group occupations by similar job duties, and in some cases skills, education or training. For many of these occupations, a majority of workers are between 35-64 years old. Petroleum refinery workers frequently work for their entire career in a single facility or company. Many of these positions require a high school diploma or GED for entry-level work and have significant on-the-job training (OJT). Four of Washington's five refineries employ union workers. Unionized facilities across all industries generally have higher pay rates[49] and safer conditions at work sites[50] compared to non-union facilities. All refineries employ union contractors. Workers in petroleum refining have higher earnings than other industries,[51] in part due to the dangerous nature of petroleum refining and specialized skillset required.[52] **Error! Reference source not found.** also provides the a verage annual wages for the occupations within the petroleum refining industry in Washington. These occupational wages were between 0.5% and 51% higher than occupational wages for all industries in Washington, with the exception of construction laborers.

Table 3: Occupations in the petroleum refining industry. Data from BLS and Chmura, Q4 2023.

Occupation	SOC Code	Employment in Washington	Average Annual Wages for Industry in Washington	Percentage of Washington Occupation that is Male	Leading Age Range of Occupation in Washington (in years old)	Percentage of Occupation in Washington Identified as White
Petroleum Pump System Operators, Refinery Operators and Gaugers	51-8093	309	$97,100	70%	45 to 54	80%
Mixing and Blending Machine	51-9023	144	$62,600	83%	45 to 54	64%

[47] Petroleum refining falls under the North American Industry Classification System (NAICS) code 32411, which is used to compare industry and occupational data.
[48] JobsEQ Industry Spotlight Report, Petroleum Refining as of Q4 2023.
[49] Bureau of Labor Statistics, "News Release: Union Members 2023", January 23, 2024.
[50] Frank Manzo IV, Michael Jekot, and Robert Bruno, "ilepi-pmcr-unions-and-construction-health-and-safety-final.pdf", November 30, 2021
[51] Bureau of Labor Statistics, "Occupational Employment and Wages, May 2023 51-8093 Petroleum Pump System Operators, Refiner Operators, and Gaugers".
[52] Union of Concerned Scientists, "Oil Refineries: A Deadly Industry", September 26, 2024.

Occupation	SOC Code	Employment in Washington	Average Annual Wages for Industry in Washington	Percentage of Washington Occupation that is Male	Leading Age Range of Occupation in Washington (in years old)	Percentage of Occupation in Washington Identified as White
Setters, Operators and Tenders						
First-Line Supervisors of Production and Operating Workers	51-1011	117	$122,100	77%	45 to 54	77%
Industrial Machinery Mechanics	49-9041	94	$110,200	96%	55 to 64	81%
Heavy and Tractor-Trailer Truck Drivers	53-3032	63	$66,300	93%	45 to 54	76%
Laborers and Freight, Stock and Material Movers, Hand	53-7062	50	$57,500	76%	25 to 34	71%
Inspectors, Testers, Sorters, Samplers and Weighers	51-9061	42	$88,900	62%	45 to 54	70%
Construction Laborers	47-2061	38	$57,700	96%	35 to 44	79%
Industrial Production Managers	11-3051	36	$155,400	82%	35 to 44	79%
Chemical Plant and System Operators	51-8091	36	$82,100	70%	35 to 44	80%
Remaining Component Occupations[53]		1,259	$112,300	--	--	--
Total		**2,187**				

We completed further analysis to analyze the top two occupations' employment figures and participating industries. This was to identify potential job loss and growth as refineries transition to alternative operations, which we elaborate on in Chapter 4 of this report.

The highest employed category is Petroleum Pump System Operator, Refinery Operator and Gauger. Within this occupation, 411 employees (69.3%) are in the industry of Petroleum and Coal Products Manufacturing, followed by Management of Companies and Enterprises (39 employees, 6.6%) and Other Pipeline Transportation (34 employees, 5.8%).

[53] We condensed occupations with fewer than 36 workers into a remaining component occupations line for clarity and brevity.

Table 4: Employment of petroleum pump system operators, refinery operators and gaugers by industry in Washington.

Industry	Percentage of Occupation Employed	Employment	10-Year Projected Employment Growth
Petroleum and Coal Products Manufacturing	69.3	411	-19
Management of Companies and Enterprises	6.6	39	4
Other Pipeline Transportation	5.8	34	1
Miscellaneous Nondurable Goods Merchant Wholesalers	4.7	28	0
Pipeline Transportation of Crude Oil	2.3	13	1
All Others	11.2	66	4

The second largest employed occupation is that of Mixing and Blending Machine Setter, Operator and Tender. This occupation also has its greatest employment in the Petroleum and Coal Products Manufacturing industry. However, this occupation is significantly more dispersed between industries than Petroleum Pump System Operators. There are 192 employees in the leading industry of Petroleum and Coal Products Manufacturing, with the Cement and Concrete Product Manufacturing, Other Food Manufacturing, Animal Food Manufacturing and Pulp, Paper and Paperboard Mills industries following. This occupation is expected to grow by approximately 60 employees in Washington in the next decade. Table 5 shows the proportions and count of employment of this occupation per industry for the top five industries and the 10-year projected employment change. This table demonstrates that other manufacturing industries are the most immediately transferable places for many refinery workers skillsets, although some industries are expected to grow while others decline.

Table 5: Employment of mixing and blending machine setters, operators and Tenders by Industry in Washington.

Industry	Percentage of Occupation Employed	Employment	10-Year Projected Change in Employment
Petroleum and Coal Products Manufacturing	8.4%	192	1
Cement and Concrete Product Manufacturing	7.7%	176	0
Other Food Manufacturing	7.5%	171	16
Animal Food Manufacturing	6.9%	156	10
Pulp, Paper and Paperboard Mills	4.9%	111	-23
All Others	64.6%	1473	60

Refinery Profiles

This section contains brief overviews of each refinery, including information about their workforce, products and local tax information.

Phillips 66

The Phillips 66 refinery is located near Ferndale, Washington. The refinery was established in 1954 and has a maximum crude oil capacity of 105,000 barrels per day. The workforce at the refinery varies by season and based on operational cycles. Workers on-site are a mix of company employees, contractors and sub-contractors. The refinery has approximately 240 full time employees, alongside 200 contractors.[54] Full time jobs at the refinery are widely related to chemical processes, gas processes, pipeline work and oversight, safety and management of the facility. Contracted jobs are largely related to the cleaning and servicing of different parts of the facility, as well as implementing upgrades and major repairs onsite.

The refinery produces large quantities of transportation fuels such as gasoline and diesel. They also produce residual fuel oil, which is supplied to the northwest marine bunker fuel market. These products are moved throughout the northwest United States by pipelines, barge ships and railcars.

The facility treats wastewater from operations before discharging to the Strait of Georgia. Non-contaminated wastewater is sent to either Lummi Bay, the Strait of Georgia or a wooded area that feeds a wetland before going to the Slater Road Ditch. Air quality activities for this refinery are regulated by the Northwest Clean Air Agency. All water, hazardous waste and cleanup related activities are monitored by the Washington State Department of Ecology.

The refinery is subject to the same taxes as all other refineries in Washington. The largest collected tax is the Hazardous Substance Tax (HST). Other taxes include the Business and Occupation (B&O) tax, property tax, Oil Spill tax, the Petroleum Products tax and the usual sales and use taxes.[55] Total property taxes paid for Phillips 66 in 2023 was $3,835,461 for their six company parcels owned and $474,883 in one partner holding parcel.[56]

Table 6: Phillips 66 Refinery emissions[57]

Pollutant	Pollution (tons per year)
PM_{10}	31
SO_2	28
NO_x	681
VOC	603
CO	162
CO_2	718,028

[54] Washington Department of Ecology, "Industrial Facilities Permits: Phillips 66 Refinery", Phillips 66 Refinery - Washington State Department of Ecology
[55] Washington Research Council, "The Economic Contribution of Washington State's Petroleum Refining Industry in 2019" Accessed September 16th, 2024
[56] Whatcom County Assessor's Office Property Data, https://www.whatcomcounty.us/3869/Property-Data-Downloads
[57] NWCAA, Major Businesses. https://nwcleanairwa.gov/permits-and-services/major-sources-of-air-pollution/

Marathon

The Marathon refinery, which does business under the name Tesoro, is located in Anacortes, Washington. Marathon acquired Andeavor in 2018, which included the acquisition of the Tesoro refinery in Anacortes.[58] It began operation in 1995 and has a crude oil capacity of 119,000 barrels per calendar day. The workforce at the refinery site varies by season and based on operational cycles. Workers on-site are a mix of company employees, contractors and sub-contractors. The refinery has approximately 400 full time employees, alongside 200 contractors.[59] Full time jobs at the refinery are widely related to chemical processes, gas processes, pipeline work and oversight, safety and management of the facility. Contracted jobs are largely related to the cleaning and servicing of different parts of the facility, as well as implementing upgrades and major repairs onsite.

The refinery produces large quantities of transportation fuels such as gasoline, diesel and jet fuel. They also produce residual fuel oil, heavy fuel oil and liquid petroleum gas. These products are moved throughout the northwest United States by pipelines and marine terminals owned by Marathon. This refinery primarily supplies products to the Washington and Oregon markets.

The facility treats wastewater from operations before discharging to Fidalgo Bay. Air quality activities for this refinery are regulated by the Northwest Clean Air Agency. Table utilizes the Northwest Clean Air Agency air quality emissions report for Tesoro (Marathon) Anacortes Refinery. All water, hazardous waste, and cleanup related activities are monitored by the Washington State Department of Ecology.

The refinery is subject to the same taxes as all other refineries in Washington. The largest collected tax is the Hazardous Substance Tax (HST). Other taxes include the Business and Occupation (B&O) tax, Property tax, Oil Spill tax, the Petroleum Products tax and the usual sales and use taxes. Total property taxes paid by Marathon in 2023 was $907,151,421 for the 85 parcels owned by the company.[60]

Table 7: Marathon Refinery emissions[61]

Pollutant	Pollution (tons per year)
PM_{10}	146
SO_2	81
NO_x	1873
VOC	804
CO	464
CO_2	1,370,882

Holly Frontier Sinclair

The Holly Frontier (HF) Sinclair refinery is located in Anacortes, Washington. The refinery became operational in 1957 and has a crude oil capacity of 149,000 barrels per day. Workers on-site are a mix of company

[58] Marathon Petroleum, "History", Our History | Marathon Petroleum Corporation
[59] Marathon Refinery Anacortes Branch Website, "Anacortes Refinery Home", Anacortes Refinery | Marathon Petroleum Refineries; Washington Department of Ecology, "Industrial Facilities Permits: Tesoro Refinery", Tesoro Refinery - Washington State Department of Ecology
[60] Skagit County Geographic Information Services, https://skagitcountywa.gov/Departments/GIS/Digital/parcels.htm
[61] NWCAA, Major Businesses. https://nwcleanairwa.gov/permits-and-services/major-sources-of-air-pollution/

employees, contractors and sub-contractors. The refinery has approximately 532 full time employees, alongside 400 contractors.[62] Full time jobs at the refinery are widely related to chemical processes, gas processes, pipeline work and oversight, safety and management of the facility. Contracted jobs are largely related to the cleaning and servicing of different parts of the facility, as well as implementing upgrades and major repairs onsite.

Major products produced at the refinery include transportation fuels such as gasoline, diesel, jet fuel and renewable diesel. Their primary markets are the Pacific Northwest and British Colombia, including major international air and seaports in the region. The facility treats wastewater from operations before discharging to Fidalgo Bay. Air quality activities for this refinery are regulated by the Northwest Clean Air Agency. Table utilizes the Northwest Clean Air Agency air quality emissions report for HF Sinclair Puget Sound Refining in Anacortes. All water, hazardous waste and cleanup related activities are monitored by the Washington State Department of Ecology.

The refinery is subject to the same taxes as all other refineries in Washington. The largest collected tax is the Hazardous Substance Tax (HST). Other taxes include the Business and Occupation (B&O) tax, Property tax, Oil Spill tax, the Petroleum Products tax and the usual sales and use taxes. Total property taxes paid by HF Sinclair in 2023 was $3,000,000 for their 38 company parcels.[63]

Table 8: HF Sinclair emissions[64]

Pollutant	Pollution (tons per year)
PM_{10}	210
SO_2	213
NO_x	1316
VOC	492
CO	604
CO_2	1,907,858

Par Pacific- U.S. Oil & Refining Co.

The U.S. Oil and Refining Co. (U.S. Oil) was acquired by Par Pacific in 2019. The refinery has a total crude oil capacity of 42,000 barrels per calendar day and is located in Tacoma, Washington. The refinery became operational in 1952. Workers on-site are a mix of company employees, contractors and sub-contractors. The refinery has approximately 190 full time employees.[65] Full time jobs at the refinery are widely related to chemical processes, gas processes, pipeline work and oversight, safety and management of the facility. Contracted jobs are largely related to the cleaning and servicing of different parts of the facility, as well as implementing upgrades and major repairs onsite.

This refinery's major products include motor, aviation and marine fuels. They are also the leading in-state provider of asphalt. This refinery sends products through the Pacific and West coast markets, using a marine

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[62] Washington Department of Ecology, "Industrial Facilities Permits: HF Sinclair Puget Sound Refinery", https://ecology.wa.gov/regulations-permits/permits-certifications/industrial-facilities-permits/hf-sinclair-puget-sound-refinery
[63] Skagit County Geographic Information Services, https://skagitcountywa.gov/Departments/GIS/Digital/parcels.htm
[64] NWCAA, Major Businesses. https://nwcleanairwa.gov/permits-and-services/major-sources-of-air-pollution/
[65] Washington Department of Ecology, "Industrial Facilities Permits: US Oil & Refining", US Oil & Refining - Washington State Department of Ecology

terminal and rail terminal. They also provide jet fuel to Joint Base Lewis-McChord (JBLM) via the McChord Pipeline, acquired in 1996. Using the McChord Pipeline, U.S. Oil serves as a primary supplier of JBLM.

Wastewater from all operations is treated and sent to Blair Waterway, which empties into Commencement Bay. Stormwater is sent to the Lincoln Avenue Ditch, the Erdahl Ditch and the City of Tacoma's stormwater pipe on the Port of Tacoma Road. Air quality activities at this refinery are regulated by the Puget Sound Clean Air Agency. This agency did not publicly provide the same pollution data available as the Northwest Clean Air Agency, resulting in a different table (see Table 9). Slightly different publicly available data was found via Washington's greenhouse gas reporting program publication to address pollution from this refinery.

The refinery is subject to the same taxes as all other refineries in Washington. The largest collected tax is the Hazardous Substance Tax (HST). Other taxes include the Business and Occupation (B&O) tax, Property tax, Oil Spill tax, the Petroleum Products tax and the usual sales and use taxes. The refinery paid $2,630,001 in property taxes for six parcels and paid $451,011 for two waterfront parcels. Total property taxes paid by Par Pacific in 2023 was $3,081,012 for their eight company parcels owned.[66] Per Par Pacific's website, they paid $9.9 million in city taxes and fees to Tacoma and $17.7 million in state taxes in 2019.

Table 9: Par Pacific- U.S. Oil Refinery emissions [67]

Pollutant	Pollution (tons per year)
C02	127,073
NO_x	430

BP Cherry Point

The BP Cherry Point refinery is located in the Cherry Point Industrial Zone in Blaine, Washington. The refinery became operational in 1971 and has a total crude oil capacity of 250,000 barrels per calendar day. The refinery is also capable of co-processing approximately 7,000 barrels per day of renewable diesel. The refinery has approximately 920 full time employees, around 500 part time employees and 500 contractors on any given day. During turnarounds, there can be several thousand additional contracted workers on site. Approximately 840 of BP's total full time employees work on refinery related activities. The remaining 80 are enablers of other BP businesses that work at the Cherry Point office. Full time jobs at the refinery are widely related to chemical processes, gas processes, pipeline work and oversight, safety and management of the facility. Contracted jobs are largely related to the cleaning and servicing of different parts of the facility.

This refinery's major products include gasoline, diesel, jet fuel and renewable diesel. This refinery provides jet fuel to both commercial and military customers, including airports in Seattle, Portland and Vancouver. The refinery moves products through the Pacific and West coast markets, using trucks, ships and barges and railcars. The refinery also produces secondary products such as calcined petroleum coke (CPC), natural gas liquids, elemental sulfur and carbon dioxide. CPC is used for fabrication of anodes in the aluminum electrolysis process. Natural gas liquids are commonly used for consumer heating and as feedstock for petrochemical products. Elemental sulfur is used in a broad range of industries, but the single largest end use is in

[66] Pierce County Assessor's Office Property Data, https://www.piercecountywa.gov/736/Data-Downloads
[67] Data.wa.gov, GHG Reporting Program Publication, https://data.wa.gov/Natural-Resources-Environment/GHG-Reporting-Program-Publication/idhm-59de/data

manufacturing phosphate fertilizers. Carbon dioxide is commonly used for beverage carbonation, refrigeration/condition for food products and as a working material in fire extinguishing systems.

This facility treats wastewater from operations before discharging to the Strait of Georgia. Stormwater runoff is treated and sent to Terrell Creek, ultimately ending up in Birch Bay. Air quality activities for this refinery are regulated by the Northwest Clean Air Agency. Table utilizes the Northwest Clean Air Agency air quality emissions report for BP Cherry Point. All water, hazardous waste and cleanup related activities are monitored by the Washington State Department of Ecology.

The refinery is subject to the same taxes as all other refineries in Washington. The largest collected tax is the Hazardous Substance Tax (HST). Other taxes include the Business and Occupation (B&O) tax, Property tax, Oil Spill tax, the Petroleum Products tax and the usual sales and use taxes. BP paid $10,321 on 45 parcels owned by BP Pipelines, $9,274,596 on 51 parcels owned for production and an additional $27,642 for 10 parcels owned by BP West coast Products LLC. Total property taxes paid by BP in 2023 was $9,312,559 for their 106 company parcels owned.[68]

Table 10: BP Cherry Point Refinery emissions[69]

Pollutant	Pollution (tons per year)
PM_{10}	138
SO_2	854
NO_x	1935
VOC	419
CO	456
CO_2	2,123,675

Refineries and Tribal Nations

This section provides a brief overview of the relationship between some of Washington's tribal nations and the five refineries. As noted earlier, four of the five refineries are on or in close proximity to reservation land of tribal nations, particularly the Swinomish Indian Tribal Community, Lummi Nation Nooksack Indian Tribe, and Puyallup Tribe. The refineries operate on lands including unceded tribal lands and known sacred and culturally significant sites. The proximity of Washington refineries to tribal nations substantively impacts tribal communities.

March Point, which houses the Marathon Anacortes and HF Sinclair Anacortes refineries, was part of the Treaty Reservation established by the Treaty of Point Elliot. A subsequent Executive Order in 1855 purported to exclude lands, including March Point from the Treaty Reservation, but was legally ineffective since only Congress has the authority to diminish a reservation.[70] While the refineries didn't begin operating until nearly 100 years later, these facilities --along with other nearby industrial operations--have significantly impacted treaty rights, tribal health, property and self-determination. Industrial operations can particularly impact cultural and subsistence food harvesting practices for tribal nations due to toxic pollution emissions. Treaty tribes in

[68] Whatcom County Assessor's Office Property Data, https://www.whatcomcounty.us/3869/Property-Data-Downloads
[69] NWCAA, Major Businesses. https://nwcleanairwa.gov/permits-and-services/major-sources-of-air-pollution/
[70] Judge Joseph J. Wiseman, "Judicial Toolkit on Indian Law", An Overview of Key Federal Indian Law Cases

Puget Sound have reserved the right to take fish, hunt and gather off their reservations, as described in relevant treaties.[7172] This includes marine and freshwater areas in and around Puget Sound. However, this right has been impacted by the accumulation of biotoxins in many key species, including but not limited to littleneck clams, Dungeness crabs and butter clams as a result of industrial pollution. [73]

Treaty rights, cultural practices, and tribal member health have also been impacted by direct refinery operations such as managing shipments by pipeline, rail and vessel. In March 2023, a BNSF Railway train derailed on the Swinomish Reservation and spilled thousands of gallons of diesel fuel on tribal land. Separate and apart from this spill, BNSF Railway was found to have breached the existing easement agreement with the Swinomish Indian Tribal Community from 2012 to 2021. The existing easement, established in 1991, allowed for BNSF to operate one train with up to 25 cars a day in either direction. However, BNSF Railway greatly exceeded this usage agreement, resulting in nearly $400 million of BNSF profits being awarded by a Federal Court to Swinomish as restitution.[74] Unplanned flaring at the Shell Anacortes refinery in 2015 resulted in the release of approximately 700 pounds of un-combusted air pollutants including hydrogen sulfide, dimethyl sulfide, mercaptans, pyrophoric iron and benzene.[75] The Swinomish Tribe reported over 550 affected people who live and work on the reservation, including 12 who sought medical treatment and five who visited an emergency room or hospital due to symptoms.[76]

The presence of the refineries also contributes to heightened air pollution in the area, in addition to pollution from wood smoke, car and boat exhaust, and production from a nearby logging yard.[77] As a result, the Swinomish Air Quality Program began monitoring pollution from industrial sources, urban areas, and natural sources, with over two decades of data.[78] The refineries on March Point, which is within the Swinomish Treaty Reservation, may contribute to local polycyclic aromatic hydrocarbon (PAH) pollution, along with pollution dispersing from the Seattle/Tacoma area. Due to colonization and relocation by the US Federal government, Native American reservations comprise a fraction of the lands tribes previously inhabited. These constraints contribute to the disproportionate susceptibility and adverse health outcomes from atmospheric fine particulate matter exposure in indigenous communities. Weather events such as inversions, common in the winter months, significantly increase the excess lifetime cancer risk on the Swinomish reservation.[79] The air quality concerns illustrated above negatively impact the ability to spend time doing activities outdoors and traditional activities. The presence of the refineries, alongside other industrial development on March Point, has affected how the Swinomish Tribe developed both their community and economy.

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[71] Gustafson, Zane and Eric de Place. "The History of Northwest Refineries", Sightline Institute, September 22, 2021. The History of Northwest Refineries - Sightline Institute
[72] Pacific Fishery Management Council, "Tribes", Tribes - Pacific Fishery Management Council (pcouncil.org)
[73] Swinomish Water Resources Program, December 1, 2006, Bioaccumulative Toxics in Subsistence-Harvested Shellfish – Contaminant Results and Risk Assessment, Swinomish Indian Tribal Community, La Conner, WA. Bioaccumulative Toxics in Subsistence-Harvested Shellfish - Risk Results (swinomish-nsn.gov)
[74] Tribal Business News, "Swinomish Tribe awarded nearly $400 million after BNSF Railway trespassed on reservation land." June 18, 2024. Swinomish Tribe awarded nearly $400 million after BNSF Railway trespassed on reservation land
[75] Environmental Protection Agency, "EPA penalizes Shell for Anacortes refinery release", February 10, 2021. EPA penalizes Shell for Anacortes refinery release | US EPA
[76] Preston, Seth. "Shell's Puget Sound Refinery penalized for chemical release | Northwest Clean Air Agency (nwcleanairwa.gov)", Northwest Clean Air Agency, November 16. 2016. ; Environmental Protection Agency, "Tesoro and Par Clean Air Act Settlement | US EPA", July 18, 2016.
[77]Northwest Indian Fisheries Commission, "Swinomish- Air Quality", Swinomish – Air quality | Northwest Indian Fisheries Commission
[78] Swinomish Indian Tribal Community- Natural Resources, "Air Quality", Air Quality | Swinomish Indian Tribal Community, WA
[79] Kramer, A. L., Campbell, L., Donatuto, J., Heidt, M., Kile, M., & Massey Simonich, S. L. (2020). Impact of local and regional sources of PAHs on tribal reservation air quality in the U.S. Pacific Northwest. The Science of the total environment, 710, 136412. https://doi.org/10.1016/j.scitotenv.2019.136412

The Swinomish Indian Tribal Community states that Fidalgo Bay is an important historic harvest site that has been impacted by contamination and has therefore had limited harvest in recent years. A Washington Department of Health study [80] concluded that the usage of Fidalgo Bay for harvesting and eating seafood would represent a public health hazard at rates considered normal for tribal harvests.[81] Impacts are ongoing and strongly felt by local tribal nations, although some cleanup efforts are planned in the area.[82] Similarly, industrial development and related activities, among other factors, at Cherry Point has contributed strongly to the decline of Cherry Point Herring stock. While Cherry Point Herring once had the highest spawning biomass in the state[83], their population has been in decline for decades. By 2001, the species, which was once most prolific stock in Puget Sound, had declined by 94%.[84] In 2023, no spawning was observed for the Cherry Point Herring stock for the first time since formal monitoring began.[85] Cherry Point herring are an important food source for a variety of species significant to tribal communities, including Chinook and Coho salmon. Additionally, the increased risk of oil spills due to increased vessel movements of crude oil presents significant risks to Pacific herring stock.[86] Populations already in decline, such as the Cherry Point stock, are considered less able to withstand the short-term impacts of an oil spill.[87]

In addition to the cultural significance of traditional fishing and harvesting areas located near refineries, each refinery is located on a site of known cultural significance. Cherry Point, also known as Xwe'chi'eXen, is a historic village and final resting place of Lummi Nation ancestors. Xwe'chi'eXen has supported ceremony and social gatherings for thousands of years, and Lummi has advocated for its protection, including blocking the development of a coal terminal at Cherry Point.[88] The terminal was blocked by the Army Corps of Engineers because it would have interfered with the Lummi Nation's treaty-protected fishing rights.[89] Since then, Whatcom County unanimously passed permanent land-use policies prohibiting new fossil fuel refineries, coal plants, transshipment facilities, piers and wharfs in the Cherry Point industrial zone.[90]

Native population density, assessed within 30 miles of the refineries, is highest within a 10-mile range around Washington's refineries.[91] Studies have found that a populations living within 10 miles of a refinery experience a variety of negative health impacts, including respiratory issues,[92] increased cancer risks[93] and cardiovascular

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[80] Washington State Department of Health, “Health Consultation; Fidalgo Bay, Anacortes, Skagit County, Washington”, February 25, 2010. Fidalgo Bay, Anacortes, Health Consultation, 2010 (wa.gov)
[81] "Rates considered normal for tribal harvests" or "Tribal scenario rates" refers to the developed consumption pattern used to assess risk within the study. Tribal members consume an estimated six to 11 times more fish than non-tribal members according to the EPA Columbia River Fish Contaminant Survey 1996-1998.
[82] Washington Department of Ecology, "Fidalgo & Padilla baywide cleanups, Anacortes".
[83] Northwest Ecosystem Alliance, "Petition to list the Cherry Point population of Pacific herring, Clupea pallasi, as 'threatened' or 'endangered' under the Endangered Species Act, 16 U.S.C. § 1531 et seq. (1973 as amended).", January 21, 2004.
[84] Washington Department of Fish & Wildlife, "News release: State scientists seek answers on Cherry Point herring decline", July 10, 2001.
[85] Puget Sound Vital Signs, "Biomass of Spawning Pacific Herring", March 13, 2024.
[86] Scruggs, Gregory, "Oil tanker traffic surges in WA waters with Trans Mountain Pipeline expansion", October 20, 2024.
[87] Spromberg, Julann A., Sarah E. Allan, and Nathaniel L. Scholz. 2024. “Potential Population-Level Impacts of Future Oil Spills on Pacific Herring Stocks in Puget Sound.” Human and Ecological Risk Assessment: An International Journal 30 (1–2): 138–63. doi:10.1080/10807039.2023.2301529.
[88] Mapes, Lynda V., "Tribes prevail, kill proposed coal terminal at Cherry Point", Seattle Times, May 9, 2016.
[89] U.S. Army Corp of Engineers: Seattle District, "News Releases: Army Crops halts Gateway Pacific Terminal permitting process", May 9, 2016.
[90] RE Sources, "In historic vote, Whatcom County approves landmark policy to regulate fossil fuel industry, protect Salish Sea", July 27, 2021.
[91] Calculated using U.S. Census Tract Demographic data.
[92] Fleischman, L., Kingland, D., Maxwell, C., & Rios, E. (n.d.). Clean Air Task Force (CATF)• League of United Latin American Citizens (LULAC) National Hispanic Medical Association (NHMA).
[93] Cordiano, R., Papa, V., Cicero, N., Spatari, G., Allegra, A., & Gangemi, S. (2022). Effects of Benzene: Hematological and Hypersensitivity Manifestations in Resident Living in Oil Refinery Areas. Toxics, 10(11), 678.

issues.[94] In 2016, an unplanned flare at the then Shell Anacortes refinery reportedly prompted 67 complaints. This incident impacted more than 550 people who live and work on the Swinomish Reservation, with reported symptoms including headaches, nausea, fatigue and irritation of eyes, throat and lungs.[95] The placement of refineries next to tribal reservations and/or Usual and Accustomed territories is particularly problematic for a range of reasons. Native Americans have specific relationships with the lands and waters they have stewarded from time immemorial. Their place is embedded in their identity. Economic constraints can also prevent or complicate moving off reservation lands. Additionally, with varying impacts from nation to nation, some tribal citizens have access to some of their nation's rights and resources only when they reside on reservation land - further complicating the capacity of some tribal citizens to move away from polluting refineries. Economically stable, non-tribal residents of the state have more mobility to move away from pollution sources to limit exposures.

[94] Oberschelp, C., Pfister, S., & Hellweg, S. (2023). Global site-specific health impacts of fossil energy, steel mills, oil refineries and cement plants. Scientific Reports, 13, 13708..
[95] Preston, Sean. "Shell's Puget Sound Refinery penalized for chemical release | Northwest Clean Air Agency (nwcleanairwa.gov)", Northwest Clean Air Agency, November 16. 2016. ; Environmental Protection Agency, "Tesoro and Par Clean Air Act Settlement | US EPA", July 18, 2016.

Chapter 2: Achieving Washington Decarbonization Mandates

Key Finding 4. Greenhouse gas emission limits and other climate and clean energy policies in Washington state and across the broader regional market will contribute to changes in Washington's refinery industry.

- 4.1 Under the Climate Commitment Act, Washington refineries are "emissions-intensive, trade exposed industries" or EITEs, and currently receive no-cost allowances for their emissions.
- 4.2 The Climate Commitment Act, statutory greenhouse gas limits, the state Clean Fuel Standard and other policies will impact refinery operations as emissions caps decrease and demand for zero-emission vehicles increases.

Washington State Law

Background

Washington passed a suite of laws and policies related to clean electricity, clean fuels and limiting emissions of greenhouse gases (GHGs) in recent years, as part of state action to address climate change. This chapter provides information on key policies related to Washington's climate mitigation and resilience strategy and the ways in which they may interact with or impact the operations and economics of Washington's petroleum refining industry.

Statutory Greenhouse Gas Emission Limits

In 2020, the Washington Legislature set new greenhouse gas emission limits in order to combat climate change. Under the law, the state is required to reduce emissions levels:

- 2020 – reduce to 1990 levels
- 2030 – 45% below 1990 levels
- 2040 – 70% below 1990 levels
- 2050 – 95% below 1990 levels and achieve net zero emissions

Achieving net zero emissions by 2050 will require that, on average, sectors across the state reduce their GHG emissions by approximately 95%, with additional reductions coming from carbon removal or sequestration projects and processes. Because these limits are established in law, it will be critical for industries across the state to make reductions.

Climate Commitment Act

The Climate Commitment Act (CCA) establishes a market-based program, which caps GHG emissions from Washington's largest emitting sources and establishes an investment program to fund climate mitigation and resilience, clean transportation and related programs. It came into effect in January 2023. The CCA works by capping total state emissions and incentivizing Washington's largest emitting sources and industries to reduce their emissions[96]. This program works alongside other critical climate policies to help Washington achieve its

[96] Washington Department of Ecology, Greenhouse gasses

commitment to reducing greenhouse gas emissions by 95% by 2050. The program covers approximately 75% of statewide emissions, applying to businesses that emit more than 25,000 metric tons of CO_2 equivalent per year.[97] The program leverages the existing GHG reporting program, with additional reporting requirements unique to the Cap-and-Invest program. An emissions cap or program baseline was established by the Department of Ecology, which is then used to establish the number of emissions allowances that can be sold each year. Each allowance is equal to one metric ton of CO_2 equivalent, and businesses can buy allowances at auction. Businesses are required to obtain allowances equal to their covered GHG emissions. Covered businesses that are noncompliant face fines of up to $50,000 per violation per day.

Ecology determines a set number of emissions allowances each year and must be set to achieve the share of reductions by covered entities to achieve statewide limits established in RCW 70A.45.020 in 2030, 2040 and 2050. This program is intended to incentivize businesses and consumers to find the most efficient path to lower carbon emissions. As allowances are reduced, the cost of allowances is expected to become more expensive. The level of available allowances is set to decline in alignment with targets to reduce statewide emissions by 45% by 2030, 70% by 2040 and 95% by 2050, relative to 1990 levels. Allowances can be purchased at quarterly sealed-bid auctions, or they can be bought on a secondary market. These allowances can be used for compliance, saved for use in the future or traded between market participants. Businesses that have more allowances than needed for compliance can sell some of their allowances to other businesses and individuals on the secondary market. Covered businesses may also earn offset credits. Offset credits[98] can be earned by participating in programs that help reduce, avoid or remove GHG emissions.

There are some businesses that receive no-cost allowances as required by legislature, including emissions-intensive, trade exposed industries (EITEs), natural gas utilities and electric utilities. The following information addresses EITEs only. Similar to the progressively fewer allowances offered on the cap-and-invest market, EITEs receive a declining number of no-cost allowances over time. Between 2023 to 2026, EITEs receive allowances equal to 100% of their baseline emissions, then receiving 97% for the 2027 to 2030 window, and ending with 94% from 2031 to 2034. Future legislative sessions will decide how many allowances EITEs receive from 2035 to 2050. These industries face unique challenges because they use high levels of energy and have high GHG emissions, but also have significant national or global competition for their products. Sudden or large changes to operational costs for these facilities could result in the business limiting in state operation or even relocating outside of the state. If these EITEs were to limit operations or relocate, it may reduce opportunities to reduce emissions and result in local job loss. Washington residents may still purchase these goods from out-of-state companies that are not subject to the carbon pricing policies, resulting in "leakage". Leakage refers to circumstances where Washington's overall emissions in state are reduced, but only because facilities have moved their operations and emissions to another location. Temporarily providing no-cost allowances for EITEs allows them to adjust and invest toward the net-zero and 95% reduction goals but accommodates the time it may take these facilities to implement changes and for other jurisdictions to consider carbon pricing policies. Similarly, the evolution of low carbon standards attempts to combat this outsourcing, including policy like Washington's Buy Clean and Buy Fair law.[99]

EITEs receive allowances based on their baseline emissions, based on an average emissions per unit of production during 2015-2019, known as their "carbon intensity baseline". A small number of facilities have a "mass-based baseline" that is based on their average emissions during 2015-2019. These allowances are updated each year by the Department of Ecology to be aligned with actual production at each facility. If output

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[97] Washington Department of Ecology, "Cap-and-Invest 101".
[98] Washington State Department of Ecology, "Offsets - Washington State Department of Ecology", Accessed August 6, 2024.
[99] Huang, M., Lewis, M., Escarcega, P., Escarcega, E., Torres, M., Waterstrat, H., Kinder-Pyle, I., Simonen, K. (2022). Buy Clean Buy Fair Washington Project: Final Report. Carbon Leadership Forum and Washington State Department of Commerce.

decreases at a facility, the number of allowances they receive proportionally decreases. Similarly, if they increase output, they receive a proportional increase in allowances. To receive no-cost allowances, facilities must be compliant with GHG reporting standards. The total number of allowances will continue to decrease based on a set reduction schedule through 2034. EITEs are incentivized to reduce emissions, because they can sell their unused allowances or save them for future use. Currently, the approach for allocating allowances to EITEs after 2034 is unclear. The Department of Ecology is preparing a report to the Legislature that offers information and recommendations on how best to proceed after 2034, which is due by the end of 2026.

There are approximately 41 facilities in Washington designated as EITEs and receiving no cost allowances. All five petroleum refineries are classified as EITEs and receive no-cost allowances. In 2023, about 9,330,137 no-cost allowances were given to EITEs. The refineries are contained in a subsector of Petroleum Refining and Chemical Manufacturing, which contains 10 total facilities. 6,731,041 allowances were provided for the 10 facilities in this subsector, accounting for approximately 72% of total EITE allowances. The five non-petroleum refining facilities listed in the subsector reported 379,905 metric tons of CO_2 equivalent in 2022. The petroleum refineries' total CO_2 equivalent emissions was equivalent to approximately 93% of the total allowances for the Petroleum Refining and Chemical Manufacturing subsector and approximately 66% of total no-cost allowances.[100] [101] [102] [103]

Revenue from the auctioning of allowances is then sent into critical climate projects. Investment of CCA revenue focuses primarily on improving clean transportation options, increasing climate resiliency, and addressing issues of environmental justice and health inequity. A minimum of 35% of the funds must be invested in projects that benefit overburdened communities and a minimum of 10% to projects supported by tribal resolution.[104]

Additionally, the CCA is working to reduce criteria air pollutants such as ozone and particulate matter, in overburdened communities. Sixteen overburdened communities have been designated by Ecology to date based on the criteria specified in the CCA. These overburdened communities are areas that are historically overburdened with health, social and environmental inequities and are highly impacted by criteria air pollution. These communities comprise about 15.5% of Washington's population, or more than 1.2 million people. [105]

Washington's Cap-and-Invest program is only the second of its kind in the U.S. The first and second Cap-and-Invest programs were launched by California in 2012 and in Québec, Canada; the programs linked in 2014. This linkage allows for joint allowance auctions, a common allowance price and the trading of allowances across jurisdictions. In March 2024, the Washington, California, and Québec jurisdictions expressed interest in linkage. While this is a long process with many considerations to implementation, linkage could offer Washington businesses access to a higher volume of emission allowances being traded. The larger market could contribute to a reduction in price swings and more consistent prices. This could stabilize allowance prices and improve the market's sustainability and durability in the long term. However, the earliest possible signing of a

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[100] Washington State Department of Ecology, "GHG Reporting Program Publication", Natural Resources & Environment, Updated January 12, 2024, Accessed July 17, 2024.
[101] Washington State Department of Ecology, "Allowance Allocation to Emissions-Intensive, Trade-Exposed Industries for the First Compliance Period: 2024 vintage allocation", October 2023.
[102] Washington State Department of Ecology, "Emissions Intensive Trade Exposed industries - Washington State Department of Ecology", Accessed August 5, 2024.
[103] Washington State Department of Ecology, "No Cost Allowances".
[104] Washington State Office of Financial Management, "2023-25 Biennium Climate Commitment Act investments to benefit overburdened communities and Tribes"
[105] Washington Department of Ecology, "Overburdened Communities", Overburdened communities - Washington State Department of Ecology

linkage agreement is in 2025, as the Department of Ecology must complete several steps first. These steps include developing a proposed linkage agreement, completing an environmental justice assessment and establishing findings based on linkage criteria.[106]

CCA implementation, and in particular the decisions made by the Legislature regarding EITE allowances and reductions required after 2034, will impact the opportunities available to Washington's refineries as they identify ways to meet required reductions.

Clean Fuel Standard

The Washington State Clean Fuel Standard (CFS) is intended to help limit carbon pollution from transportation. Transportation is currently the largest source of GHG emissions in Washington. In 2019, 39% of Washington's 102.1 million metric tons CO_2e emissions came from transportation. This policy aims to cut statewide GHG emissions by 4.3 million metric tons a year by 2038. [107] The CFS aims to reduce the emissions from the production and supply of transportation fuels by providing an increasing range of low carbon and renewable alternatives. These alternatives will serve to reduce dependency on petroleum and improve air quality. The CFS is a market-based policy designed to provide incentives for low carbon fuel production.

The CFS works by requiring fuel suppliers to reduce the carbon intensity of transportation fuels. Carbon intensity (CI) is the total amount of carbon dioxide released during a fuel's lifecycle per unit of transportation fuel energy that is released into the air. This includes the time the raw materials are produced, to the time the fuel is used. Fuel suppliers must gradually reduce the CI of transportation fuels to 20% below 2017 levels by 2034. This can be done by improving the efficiency of fuel production processes, producing or blending low carbon biofuels into fuel they sell and purchasing credits generated by low carbon fuel providers.

Fuels below the standard generate credits that can be kept or sold to producers of high-carbon fuels. Fuels above the standard generate deficits, for which credits must be bought to meet the required CI reduction that year. The CI requirement gradually increases over time, increasing the available amount of low carbon transportation fuels in the state. The reduced CI means reduced GHG emissions over time, aimed at helping address impacts of climate change. It is also possible to earn capacity credits. Capacity credits serve to incentivize low carbon fueling infrastructure, such as DC fast charging and hydrogen refueling infrastructure. These credits are available for fueling stations installed after January 1, 2023. DC Fast charging stations allow for short recharge stops when traveling extended distances, helping to expand supportive infrastructure for electric vehicles.

This policy is aimed at helping improve air quality, particularly for communities in high traffic areas. Transportation fuels emit harmful air pollution that has negative health impacts, some of which can be reduced using lower-carbon fuels. An estimated $1.8 to $3.8 billion in economic benefit could be generated by implementing the CFS due to reduced healthcare costs and improved health outcomes. [108]The CFS contributes to economic development as well. Currently, the majority of low carbon fuels produced in Washington are sold out of state. By expanding the requirements for in state clean fuel production, the CFS helps expand the supply of clean fuels in state and supports their production. The CFS has provisions that tie stricter CI standards to the production of biofuels in Washington. Specifically, the statute requires that the carbon intensity reductions may not exceed 10% until two standards are met: the production and completion of a new or expanded biofuel

[106] Washington Department of Ecology, "Focus on: Cap-and-Invest Program Linkage", Publication 23-14-004, July 2024; Washington Department of Ecology, "Cap-and-Invest Linkage".
[107] Washington Department of Ecology, "Clean Fuel Standard".
[108] Washington State Department of Ecology, "Clean Fuel Standard Cost Benefit Analysis Report", Berkeley Research Group, Energy & Climate, May 12, 2022.

production facility with capacity to produce 60 million gallons of biofuel per year with at least 10 million gallons of annual capacity located in a new (rather than expanded) facility, and at least a 15% increase in the volume of in-state liquid biofuel production and the use of feedstocks grown or produced within the state relative to the start of the program.

Motor Vehicles Emissions Standards- Zero-Emission Vehicles

As part of Washington's Clean Vehicles program, new zero-emission and low-emission vehicle standards were adopted in 2021. These requirements take effect in 2024 with the release of model year 2025 vehicles. Zero-emission vehicles (ZEVs) include battery powered electric vehicles, plug-in hybrid electric vehicles and fuel cell electric vehicles. These vehicles must have at least 50 miles of electric-only range. An increasing percentage of ZEV sales is required each year, ranging from 6% to 9% of sales.[109] By 2035, 100% of vehicles sold in Washington must be ZEVs.[110]

New vehicles that do not meet Washington's vehicle emission standards cannot be registered, licensed, rented or sold in the state. Oregon, California and Washington share the same vehicles emissions standards. Used cars purchased with more than 7,500 miles may be registered in Washington, regardless of whether it meets California vehicle emission standards. Used cars with less than 7,500 miles must meet these standards. A 2009 or newer model car bought in California or Oregon will meet Washington standards, and cars purchased in states that without these vehicle emissions standards cannot be registered in Washington. [111]

An important note is that the law does not ban any gas or diesel vehicle currently on the road. Rather, it steadily replaces fossil-fuel powered vehicles with cleaner models for new vehicle sales. This standard is helping to drive an expected decline in conventional fuel consumption in Washington. However, fleet turnover of existing vehicles introduces difficulty in modeling fleet levels. 18.8% of Washington's new vehicle sales in 2023 were electric and plug-in hybrid vehicles. Additionally, there was a 43% increase in registered electric vehicles and plug-in hybrid vehicles in 2023, jumping from 118,050 registered vehicles to 168,850.[112] This gathering momentum of electric vehicles can be attributed to federal and state incentives for their purchase, increasing options for consumers and declining production costs contributing to price cuts. The increased adoption rates of ZEVs are expected to exert a downwards pressure on fuel prices as fewer drivers in state are reliant on internal combustion engine vehicles.

Relevance of Washington State Climate and Clean Transportation Policies for this Study

This study evaluates the economic impacts of current and potential future operations of Washington's refineries, with statutory language requiring that possible future outcomes consider "realistic, real-world outcomes, given existing mandated decarbonization targets, feedstock availability and statutes that impact Washington refinery products." In addition to short- and medium-term reductions that are expected to occur in the early years of program implementation, this study assumes that by 2050, refineries will also have made significant changes to products and function that align with net-zero economy-wide reductions. These potential changes are described within the scenario analysis in Chapter 3.

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[109] Washington Department of Ecology, "Zero-emission vehicles (ZEV)".
[110] Washington Department of Ecology, "Washington Clean Cars"
[111] Washington Department of Ecology, "Washington Clean Cars"
[112] Halter, Caroline, "A record year for electric and plug-in hybrid vehicles in Washington", Washington Department of Ecology, April 9, 2024.

Decarbonization in Washington Refineries' Typical Export Markets

Significant amounts of the fuels and products produced in Washington's refineries are sold to states and regions in the Northwest. For example, Washington supplies fuel to Oregon, which has no refineries and is served by the Olympic pipeline. The Olympic Pipeline connects four of Washington's refineries to Portland, Oregon. Washington also exports products to California and British Columbia. These states and the province of BC have emission reduction and climate policies that are relatively aligned with Washington's policies. Examples include the proposed linkage of California, Quebec and Washington's carbon allowance auctions, as well as the adoption of low carbon fuel standards in California, Oregon and Washington.

Washington refineries also export their products internationally. Some primary international export markets for products refined in Washington include Canada, Mexico and several countries in Central and South Americas. In 2022, Mexico submitted an updated Nationally Determined Contribution (NDC) to the Paris agreement, which included plans to reduce GHG emissions by 35% by 2030. [113]Efforts are particularly focused on improving building energy efficiency and improving clean transportation access. Expected results include GHG emissions reduced or avoided equivalent to over 3.3 million gasoline powered passenger vehicles driven for one year.

In June 2021, the Canadian Net-Zero Emissions Accountability Act became law. This legislation ensures transparency and accountability as Canada works to achieve net-zero emissions by 2050. [114]Current emissions projects, with continued efforts toward emissions reductions, have Canada on track to meet or even exceed a target reduction of 30% below 2005 levels by 2030. Canada has also introduced an Electric Vehicle Availability Standard, [115] similar to Washington's ZEV standards.

Chile, which receives exports of distillate fuel oil and residual fuel oil from PADD 5, enshrined net-zero targets in their Climate Change Framework Law in 2022. The plan creates new governance structures across national and local levels to help accelerate net-zero implementation. [116] Chile has also adopted electric vehicle initiatives, with a goal of 40% electric vehicles on the road by 2050. Electric vehicle sales gained significant momentum in 2022, which is expected to continue. [117]

While it is not clear the extent to which climate and clean energy laws will be established and implemented in other states and countries in the future, global efforts are developing to reduce the impacts of climate change, which is expected to continue to reduce demand for conventional petroleum and fossil fuel products over time.

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[113] United States Agency International Development, "Mexico: Climate Change Country Profile", 2023.
[114] Government of Canada, "Net-zero emissions by 2050", Environmental and Natural Resources.
[115] Government of Canada, "Canada's Electric Vehicle Availability Standard (regulated targets for zero-emission vehicles)".
[116] Cynthia Elliott, Clea Schumer, Rebecca Gasper, Katie Ross and Neelam Singh, "Chile's New governance Structures Are Streamlining Net-zero Implementation", World Resources Institute, March 6, 2024.
[117] Mobility Portal Europe, "Chile, the market everyone is watching to sell electric vehicles and install chargers", May 9, 2024.

Chapter 3: Forecasting the Future

Key Finding 5. As petroleum demand declines, refinery operations will change, and economic impacts will vary depending on the type and degree of decline.

- 5.1 Most of the petroleum products refined in Washington are sold to markets with greenhouse gas emission limits that will contribute to reduced demand for petroleum-based fuels.
- 5.2 Production and employment declines will lead to declines in labor income and value added, output, and tax revenues.
- 5.3 Reductions in petroleum demand and use will likely contribute to savings associated with health care and environmental costs.

Key Finding 6. All five of Washington's refineries are likely to change their product mix or function as part of achieving net zero emission limits by 2050.

- 6.1 Several scenarios of change in refinery product mix or function are possible and may occur in succession.
- 6.2 Washington refineries may remain viable in the future, but are expected to change their core products or overall function. Refinery closure is possible, but more likely in the long term.

Key Finding 7. Washington's refineries are moderately well-positioned to produce alternative fuels, though likely at levels lower than would fully replace the current refinery capacity.

Forecasted Fuel Demand

Introduction

This section compiles information on petroleum and renewable fuel demands through 2050 for four geographic scopes: U.S., Pacific coast, Washington and global markets.

Renewable fuels are included as potential products that can be produced at Washington refineries; in particular, the products that are focused on in this study are renewable diesel and alternative[118] jet fuel (AJF)[119]. AJF is a broad term for jet fuels with non-crude oil feedstock. This term has been largely replaced by sustainable aviation fuel as this term encompasses desired sustainability attributes. However, for consistency with Washington state law, we use the term AJF in this report with the assumption that the alternative fuels will also be sustainable. While other technology/product options exist for refineries, these fuels are the most compatible with existing refineries. This section also evaluates the possibility of adding (stacking) federal and state/province policies that impact the decision to produce renewable fuel as well as sales location. The trends presented within this section will need to be evaluated with refinery specific details to determine the optimal product slate at each refinery.

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[118] Alternative jet fuel is a defined term in Washington state law, meaning "a fuel that can be blended and used with conventional petroleum jet fuels without the need to modify aircraft engines and existing fuel distribution infrastructure, and that have a lower carbon intensity than the applicable annual carbon intensity standard in Table 2 of WAC 173-424-900, as it existed on the effective date of this section. Alternative jet fuel includes jet fuels derived from coprocessed feedstocks at a conventional petroleum refinery."

[119] Chapter 232, Laws of 2023

Four geographic scopes were compiled on petroleum and renewable fuel demands through 2050: U.S., Pacific coast, Washington state, and global. On a global scale, petroleum fuels are expected to grow by 2050. However, a dip, especially evident in gasoline, is expected in the mid-term (2035). All other geographic scales have a slight decline over the timeline, with reductions in gasoline consumption from electrification being a key driver. Renewable fuels are included as potential products for Washington refineries; thus, the focus centers on producing renewable diesel and AJF. While other technology/product options exist for refineries, these fuels are the most compatible with existing refineries. Demand for renewable diesel and AJF are projected to increase over all geographic scopes and the timeline. The possibility of adding (stacking) federal and state/province policies impact the decision to produce renewable fuel as well as the sales location. Increased demand, policy support in the Pacific coast region, and compatibility with technology support adding renewable fuels to Washington refinery's product slates either through co-processing or conversion of refineries to biorefineries. However, feedstock and specific refinery infrastructure can limit this option. The trends presented will need to be evaluated with refinery-specific details to determine the optimal product slate at each refinery. Much of the detailed prediction data is from the U.S. EIA and it should be noted that the GHG emission limits in the state of Washington are much lower, making substantial potential declines in petroleum fuel demand more likely. This is discussed as one of the potential cases.

Petroleum Fuel Demand

The demand for petroleum fuels in the near-term (2025), mid-term (2035) and long-term (2050) will influence the production choices of Washington refineries. Demand for petroleum fuels over these time horizons are discussed for four geographic areas: (1) U.S., (2) Washington, (3) Pacific coast region and (4) global. The Pacific coast region is defined as Washington, California, Oregon and Canadian British Columbia.

Each refinery is unique and produces specific slates of fuel distillates and non-fuel products using different crude oils. This report focuses on the demand for gasoline, jet/kerosene and diesel/residual fuel distillates and uses generalized refinery operating assumptions rather than data from specific Washington refineries. These trends and options will need to be evaluated for each unique refinery scenario in order to make specific projections about demand changes at the individual refinery level.

1. U.S.

The reference case in the 2023 U.S. Annual Energy Outlook (AEO), issued by the U.S. Energy Information Agency (EIA), was chosen as the source of petroleum consumption projections. Gasoline, jet/kerosene and diesel/residual fuel use in the U.S. is predicted to drop by an average of 9% by 2050 (**Error! Reference source not found.**)**Error! Bookmark not defined.**[120].

Table 11: Reference case 2023 AEO U.S. petroleum fuel consumption values (billion gallons/year).

Fuel type	2022	2025	2030	2035	2040	2045	2050	2022-2050 % change
Gasoline	135	133	124	116	112	110	113	-16%
Jet/Kerosene	24	26	27	28	30	32	34	42%
Diesel/Residual	65	62	59	57	56	56	56	-14%
Total	**224**	**221**	**210**	**201**	**198**	**198**	**203**	**-9%**

[120] EIA, "Annual Energy Outlook 2023" (2023).

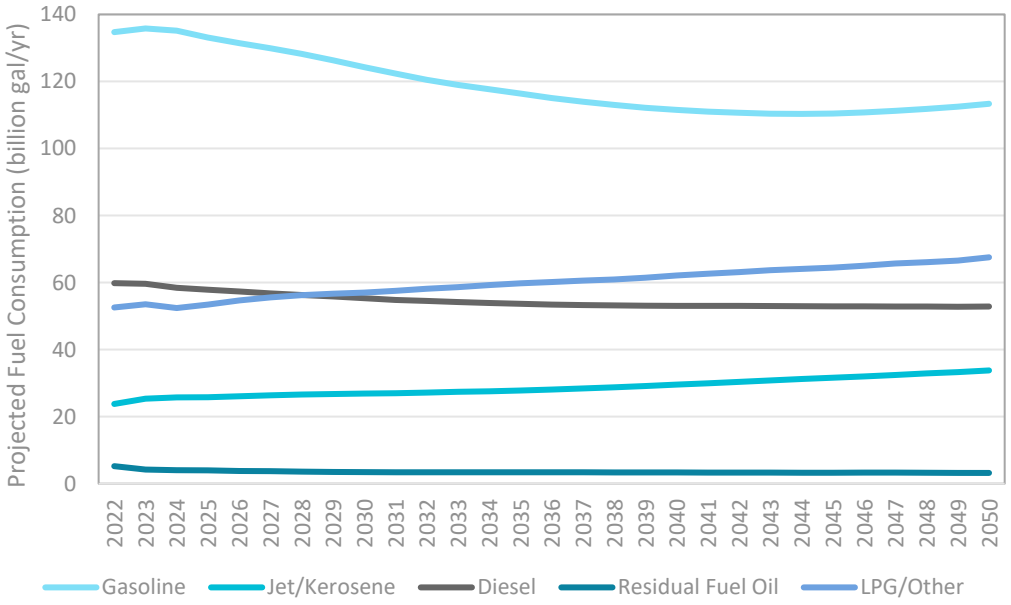

Figure 3: Change in fuel distillate demand for the AEO 2023 reference case from 2022 to 2050.

Gasoline has the largest projected consumption drop at 14% from 2022 to 2050 (Figure 4). A sensitivity analysis was completed to determine the impact of the oil price. The reference case gasoline consumption was compared to high and low oil price cases. As expected, more gasoline is consumed in a scenario that anticipates low oil prices and less is consumed in a scenario with high oil prices, with the differences most apparent in the long-term. The data shows only minor changes to gasoline consumption between the selected cases by 2030.[120]

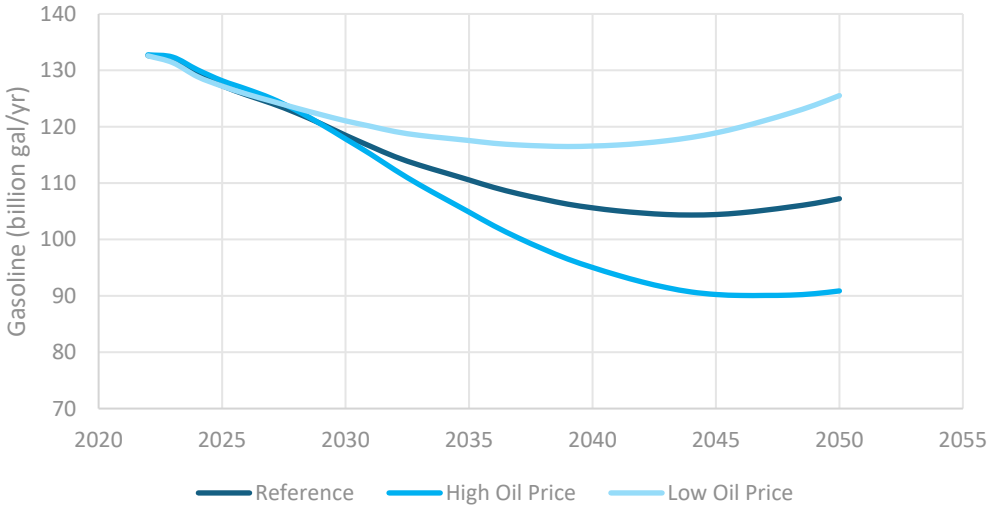

Figure 4: AEO 2023 gasoline consumption for the reference, high oil price and low oil price cases.

2. Washington

Washington consumed a total of 4.6 billion gallons of petroleum distillate fuel oil, jet fuel, gasoline and residual fuel oil in 2021, corresponding to 1% of the total U.S. consumption.[121] This is roughly half of the 8.9-billion-gallon capacity of the Washington refineries, which includes distillates and products not listed above.

The U.S. EIA data does not include state-level fuel projections. Thus, to develop a reference case describing business as usual for Washington's fuel consumption through 2050, it is assumed that the consumption rate from 2021 will stay consistent through 2050. This rate was applied to the U.S. AEO data (Figure 5, Table).

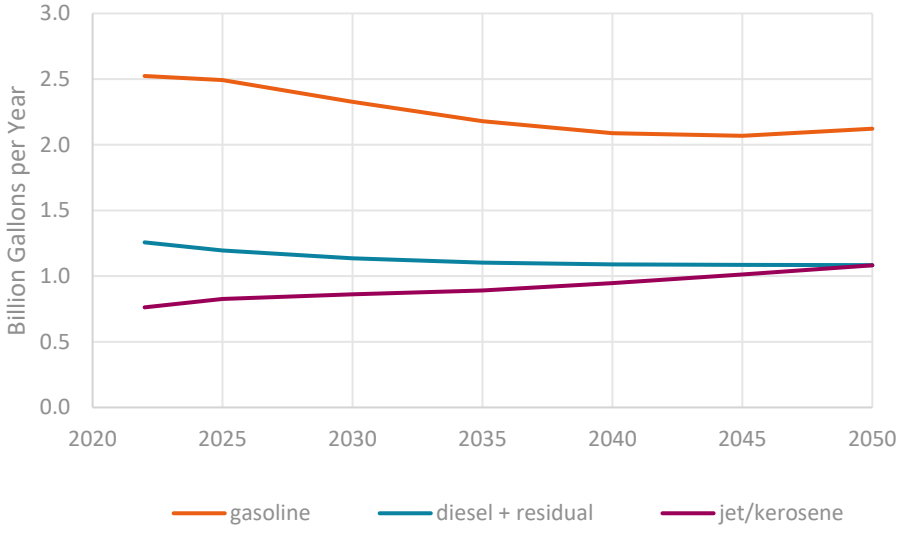

Figure 5: Washington petroleum fuel consumption values based on AEO reference case through 2050.

Washington has the newly implemented Clean Fuel Standard (CFS), the Climate Commitment Act and net zero GHG-emission limits law passed in 2020.[122] [123] [124] These Washington-specific policies demonstrate Washington's legal commitments to significantly reduce GHG emissions. Gasoline is the largest volume fuel used in Washington and reductions in carbon intensity of transportation fuels will likely require product use changes including additional ethanol consumption, although additional options will be needed in addition to ethanol use to reach these targets. In 2022 the Washington and California ethanol blend rates in gasoline were 7.1% and 7.3%, respectively.[125] The values are nearly identical, and California implemented the Low Carbon Fuel Standard (LCFS) over a decade ago in 2013. The zero-emission law is expected to impact the amount of gasoline required for new cars purchased in the state but could face litigation delays and does not impact

[121] EIA, "State Energy Consumption Estimates 1960 Through 2022" (2022).
[122] Washington Department of Ecology, "Washington Clean Fuel Standard Data & Reports," (2024).
[123] Washington State Legislature, RCW 70A.30.010 (United States, 2020).
[124] State of Washington Department of Ecology, "Climate Commitment Act," Climate Commitment Act, (2024).
[125] California Air Resources Board, "LCFS Data Dashboard," (2024).

used car sales. The Climate Commitment Act states that emissions from the combustion of fuels used in aviation, agriculture, marine fuels used outside of Washington, any fuel exported from Washington and biofuels are exempt from the statewide 95% GHG reduction target.[126] This program is market-based, and as such, the potential future cost to a refinery is unknown. However, it is expected that this legislation will promote the reduction in Washington petroleum fuel consumption.

A sensitivity analysis was completed as part of this study to address the uncertainty surrounding CFS, electrifying road transport and the impact of the Climate Commitment Act. Figure 6 illustrates gasoline projections, including the AEO reference, low oil price and high oil price cases. The legislation enacted in Washington could lead to petroleum fuel consumption dropping below the national average. To quantify a more rapid possible reduction, a scenario based on the assumption that gasoline consumption in Washington declines at the same rate as was included in a 2024 California Air Resources Board (CARB) report. The selected comparative scenario is labeled as “fast” in that report, which is based on full, successful implementation of a similar zero emission vehicle legislation. However, it does not account for the California-specific details used in the modeling effort.[127] It should be noted that because a Washington-specific analysis was not completed, outcomes will vary from the California values. In addition, the California predictions only extend to 2045. Neither the AEO nor the CARB scenarios meet the statutory 95% CO_2e reduction by 2050. However, an assumed scenario with a 95% reduction in demand was included in Figure 6 to illustrate compliance with the state's GHG emission limits.[128]

For all gasoline scenarios, small differences are predicted through 2030, and we anticipate petroleum demand levels that are much higher than the corresponding Washington emissions limits. With the longer projections, uncertainty increases, as does the spread in the scenarios. In the reference case, consumption of petroleum fuels drops 6% by 2050; this drop increases to 50% for the California “fast” scenario in 2045.The low and high oil price scenarios have Washington petroleum consumption declining by 1% or 14% by 2050, respectively. The AEO reference case for diesel and distillate fuel consumption predicts a 14% drop; for aviation fuel a 42% growth is expected. The U.S. Sustainable Aviation Fuel Grand Challenge set a target replacement rate of petroleum fuel of 100% by 2050.[129] If we assume the complete replacement of aviation fuel, the AEO reference case and the California “fast” scenarios have total petroleum fuel decreases of 33% by 2050 and 77% by 2045, respectively. The final scenario assumes that emissions reductions follow the Washington regulations with a 95% reduction in 2050 being the result of a 95% reduction in petroleum fuel use. The methods to attain these reductions were not modeled.

[126] State of Washington Department of Ecology, "Focus on: Washington’s Climate Policies and Fuel Prices" (2023).
[127] Q. Gee, A. Berliner, and A. Wong, "2024 Transportation Fuels Assessment" (2024).
[128] Washington Department of Ecology, “Washington’s Cap-and-Invest Program,” Washington Department of Ecology, (2024).
[129] U.S. Department of Energy, U.S. Department of Transportation, U.S. Department of Agriculture, and U.S. Environmental Protection Agency, "SAF Grand Challenge Roadmap Flight Plan for Sustainable".

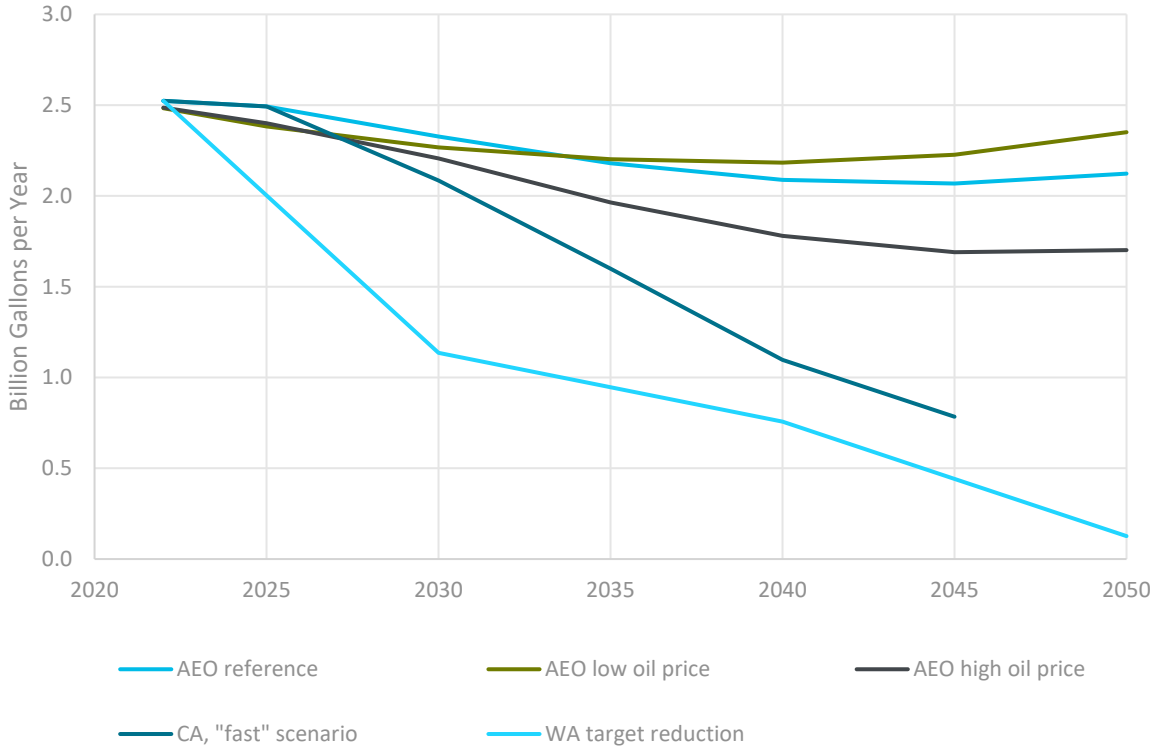

Figure 6: Gasoline projections for Washington

3. Pacific Coast Region

The EIA uses Petroleum Administration for Defense Districts (PADD) to define and track petroleum product movement within the U.S. via pipelines. Washington is part of PADD 5, which also includes California, Oregon, Nevada and Arizona. For nearly 40 years, PADD 5 has imported between 1.3 and 2.2 billion gallons annually from other U.S. PADDs. Very little exportation from PADD 5 has occurred, with 2001 being the last year with recorded exports to other U.S. PADD regions. This data, while incomplete without non-pipeline transported fuel or imports/exports outside of the U.S., demonstrates a strong historical demand for petroleum fuels on the West Coast that consistently surpasses production.

In 2022, California dominated regional energy consumption from petroleum fuels, with nearly five times the consumption of the next largest Pacific coast state, Washington.[130] California consumed 4% of the U.S. total energy from distillate fuel oil, jet fuel, gasoline and residual fuel oil petroleum fuels; Oregon and Washington consumed significantly less, using 0.5% and 1%, respectively.[130] Table presents the projections of petroleum fuel for the Pacific coast states, calculated following the method described for the state of Washington, which applies the state percentage to the AEO reference case data.

In 2019, British Columbia used 10% of the total petroleum products in Canada (3.7 billion gallons).[131] [132] This portion is assumed to remain constant through 2050 and applied to national projections (Table).[132] The proximity of the Washington refineries makes British Columbia an ideal trade partner, however there are two

[130] Washington Department of Ecology, "Washington Clean Fuel Standard Data & Reports," (2024).
[131] Canada Energy Regulator, "Access and Explore Energy Futures Data," Canada Energy Regulator, (2023).
[132] Canada Energy Regulator, "Provincial and Territorial Energy Profiles - British Columbia," Canada Energy Regulator, (2024).

refineries in British Columbia with a combined capacity of 1 billion gallons annually.[132] While U.S. fuel products are currently sold into British Columbia, Canada as a whole exports 75% of its total production into the U.S.[133]

Table 12: Projected state, province and regional fuel consumption data (billion gallons/year).

	2022	2025	2030	2035	2040	2045	2050
Washington	4.5	4.5	4.3	4.2	4.1	4.2	4.3
California	22	22	21	20	20	20	21
Oregon	2.5	2.4	2.3	2.2	2.2	2.2	2.2
U.S. Region Total	29	29	28	26	26	26	27
British Columbia	3.4*	3.3	3.0	2.6	2.2	1.8	1.6
Region Total	32	32	30	29	28	28	29
*** value for 2019**							

4. Global

The International Energy Outlook (IEO) 2023 projects petroleum demand will grow globally for all distillates by 2050 compared to 2022. However, gasoline consumption has a mid-term dip (Table).[134] Despite the expectation of rising demand for renewable fuel, the reference case for petroleum fuel demand grows due to population growth and the impact of price premiums for renewable fuel. Global demand growth supports continued petroleum fuel production. However, the economics of transporting fuel to global demand centers is not included in this scenario and may limit the economic feasibility of products from Washington refineries being sold internationally.

Table 13: Reference case 2023 IEO global petroleum fuel consumption values. (billion gallons/year).

	2022	2025	2030	2035	2040	2045	2050
Gasoline	400	400	393	389	392	404	422
Jet/Kerosene	399	414	424	437	451	468	486
Diesel/Residual	80	102	114	126	138	151	163
Total	**879**	**917**	**932**	**951**	**980**	**1023**	**1072**

Renewable Fuel Demand

The demand for renewable fuels is expected to grow across the timeline assessed for this project. Greenhouse gas (GHG) reduction targets, goals, incentives and mandates enacted at state, provincial, national and global levels facilitate the transition to renewable fuels, but the combined effectiveness of the various policies is uncertain.

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[133] Canada Energy Regulator, "Provincial and Territorial Energy Profiles - Canada," Canada Energy Regulator, (2024).
[134] EIA, International Energy Outlook 2023 (2023).

The largest volume of renewable fuel production in the U.S. is ethanol, at nearly 85% in 2022.[135] However, ethanol is not a likely choice for Washington petroleum refineries to produce. The volume was included in this section as a point of reference. Renewable diesel and AJF produced using the hydroprocessed esters and fatty acids (HEFA) process are the simplest products for a petroleum refinery to manufacture as the process technology is similar to current refining processes. Renewable diesel and AJF are similar products, with renewable diesel having a wider hydrocarbon chain length range. The hydrocarbon chain lengths for AJF overlap with a portion of the renewable diesel specification, which means that each fuel producer will determine if they want to produce renewable diesel or combination of renewable diesel and AJF. Biodiesel is not an optimum choice due to the process technology differences but is a direct competitor for renewable diesel in both feedstock and market, so it is included.

U.S.

AEO 2023, used for the petroleum projections, was selected as the source of renewable fuel production predictions for the U.S. (Table). As with the petroleum analysis, the reference case is the focus; however, the sensitivity analysis includes cases for low and high oil prices. Figure 7 illustrates that high oil prices increase renewable diesel production more than low oil prices hinder volumes compared to the reference case.**Error! B ookmark not defined.** It is important to note that projection values vary with assumptions. The U.S. Department of Agriculture reported that the 2022 U.S. renewable diesel production capacity was 3 billion gallons, with 2.9 billion gallons consumed, compared to the AEO consumption value of 2.1 billion gallons. [136] The U.S., through the U.S. AJF Grand Challenge, stated a goal of 10% AJF usage by 2030 (3 billion gallons) and 100% replacement (35 billion gallons) in 2050, with the caveat that the fuel must have a life-cycle GHG reduction of at least 50%.[137] The AJF production projection for 2050 assumes that the current AJF blend limits will be removed by 2050, allowing 100% AJF to be utilized.

Table 14: Reference case 2023 AEO U.S. renewable fuel production volumes (billion gallons/year).

	2022	2025	2030	2035	2040	2045	2050
Ethanol	15.0	15.7	15.5	15.5	15.6	16.2	17.2
Biodiesel	1.6	1.6	1.2	1.2	1.1	0.9	0.7
Renewable diesel	2.1	2.4	2.1	2.3	2.5	2.5	3.2
AJF			3.0				35.0

[135] EIA, "Annual Energy Outlook 2023" (2023).
[136] USDA, “U.S. Bioenergy Statistics,” Economic Research Service U.S. Department of Agriculture, (2024).
[137] Canada Energy Regulator, “Access and Explore Energy Futures Data,” Canada Energy Regulator, (2023).

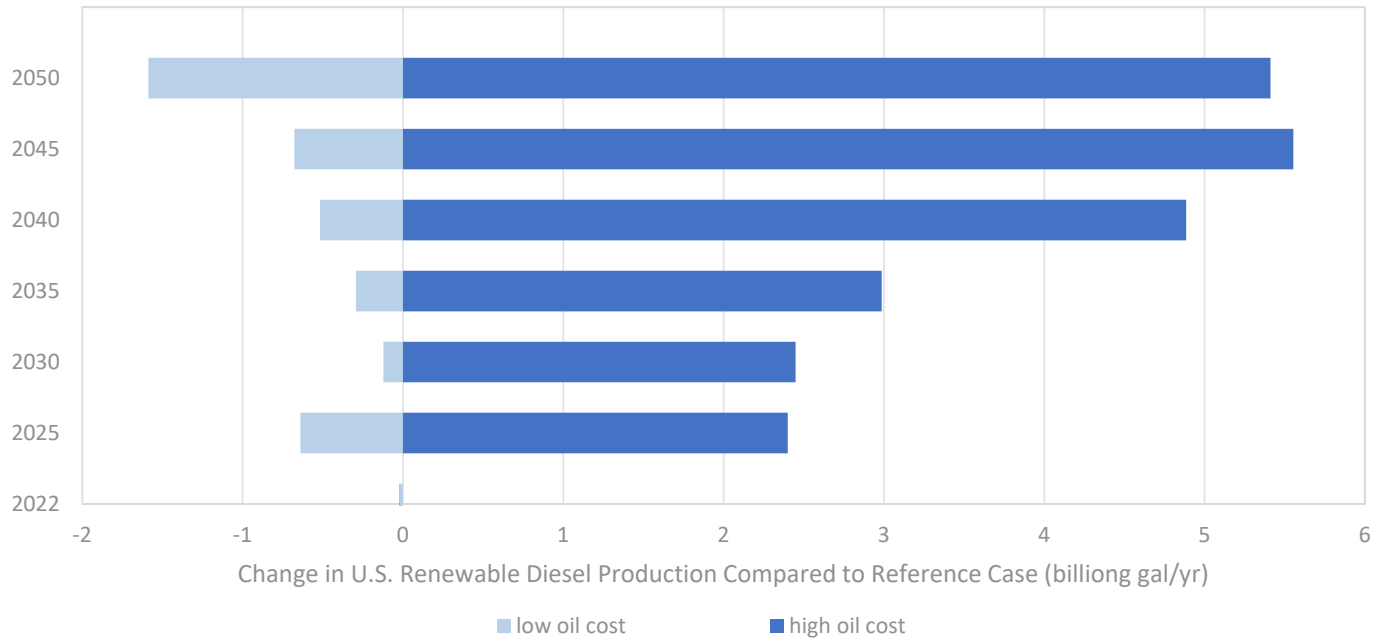

Figure 7: Change in projected U.S. renewable diesel production volume compared to the AEO reference case for the low and high oil price cases.

Washington

The Washington CFS has defined GHG annual reduction targets through 2028, which will be met through various measures, including renewable fuels. Overall, the CFS requires fuel suppliers to reduce the carbon intensity of transportation fuels by 20% by 2034, compared to a 2017 baseline. Feedstock and conversion technology provide renewable fuels with a unique carbon intensity (CI). The breadth of reduction measures will allow for many solutions to reach the target.[138]

Washington has met the ethanol blend wall of 10%; thus, unless a higher maximum blend level is approved, additional GHG reductions from fuels will be from other sources.[139] Although in 2022 the renewable diesel blend rate was negligible, for 2024 Berkley Research Group predicts 5.5% renewable diesel in Washington. California has a significant demand for renewable diesel, reaching a blend rate of 46% in 2022, a decade after the introduction of LCFS.[140] [141]The estimation of the renewable diesel demand for Washington assumes similar growth to California, with a 50% blend ratio starting in 2035 with a linear increase from 2024. The estimated demand for renewable diesel in Washington could reach over 0.5 billion gallons by 2050.[142] Reduction in emissions from aviation is currently not a requirement in Washington, as the CFS does not cover aviation fuels. However, Seattle-Tacoma International Airport (SEA), the largest airport in Washington, has set AJF use goals.[142] [143] The total demand for renewable diesel and AJF in Washington for 2035 and 2050 is estimated to be 0.5 and 1.3 billion gallons, respectively (Table).

[138] Washington State Legislature, RCW 70A.30.010 (United States, 2020).
[139] BRG, "Washington Department of Commerce Clean Fuel Supply Forecast Report" (2022).
[140] California Air Resources Board, “LCFS Data Dashboard,” (2024).
[141] G. Yowell, "What Is Displacing Fossil Diesel in California?" (2024).
[142] Washington Department of Ecology, “Washington Clean Fuel Standard Data & Reports,” (2024).
[143] EIA, "State Energy Consumption Estimates 1960 Through 2022" (2022).

Table 15: Washington renewable diesel and AJF replacement estimates

	2024	2025	2030	2035	2040	2045	2050
Renewable Diesel (% of total diesel consumption)	5.5%	7%	16%	24%	33%	41%	50%
Renewable Diesel (billion gallons/year)	0.07	0.09	0.2	0.3	0.4	0.4	0.5
AJF (SEA) (% of total jet fuel consumption)			10%*	25%			100%
AJF (SEA) (billion gallons/year)			0.1*	0.2			0.7-0.8
***goal is for 2028**							

Pacific Coast Region

Renewable fuel consumption in the Pacific coast region will be dominated by California. In 2021, California consumed 99% of the renewable diesel in the U.S., with Oregon taking nearly all the rest.[144] These states are leading U.S. consumption, likely because of the long-standing state policy support and aggressive target GHG reductions. In 2023, California alone consumed 2 billion gallons of renewable diesel. The state of California also has a 20% target for AJF use by 2030, equivalent to 0.8 billion gallons.[145] [146] California GHG targets currently level off in 2030; however, new lower targets are in. Oregon used 0.08 billion gallons of renewable diesel in 2023, a replacement rate of only 6%, leaving a nearly untapped market.[147] British Columbia has mandates to meet that are more aggressive than the national Canadian targets. The required blend ratio for diesel is 4%, and for aviation fuel, it is 1% in 2028, 2% in 2029, and 3% in 2030 and beyond.[148] The Pacific coast regional demand will depend on GHG targets and the different policies to meet the targets. A reasonable regional estimate is 3 billion gallons per year of combined renewable diesel and AJF use in the Pacific coast region in 2030, which could increase to 4 billion gallons in annual consumption by 2050.

Global

The Organisation for Economic Co-operation and Development (OECD) and the Food and Agricultural Organization (FAO) have published renewable fuel consumption projection values out to 2032 for ethanol and biodiesel (Table).[149] The term “biodiesel” for this reference is the sum of biodiesel and renewable diesel.

Table includes the F1-low scenario for AJF production computed by the International Civil Aviation Organization (ICAO) based on public production announcements.[150] This scenario assumes that AJF and all renewable fuels have the same level of policy support and that electrification of ground transport will allow a higher fraction of AJF to be separated from renewable diesel. This assumption is also included in the 2022 value, which is why the value is above the actual production. Long-term projections out to 2050 are challenging for a specific location and only become more difficult for larger geographic areas. In 2030, the global demand for renewable diesel and AJF could reach nearly 20 billion gallons. Using ICAO AJF projections to 2050 and holding the renewable diesel value steady, 60 billion gallons of middle distillates could be produced by 2050. The IEA World Energy Outlook projects a combined liquid biofuel volume in 2030 and 2050, ranging from 46-86 and 69-83 billion gallons, respectively.[151]

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[144] EIA, "State Energy Consumption Estimates 1960 Through 2022" (2022).
[145] Washington Department of Ecology, “Washington Clean Fuel Standard Data & Reports,” (2024).
[146] R. Rivas, and Muratsuchi, AB 1322. "California Global Warming Solutions Act of 2006: Aviation Greenhouse Gas Emissions Reduction Plan." (California Legislative Information, USA, 2022).
[147] Oregon Office of Economic Analysis, "2023 Clean Fuels Forecast" (2023).
[148] British Columbia, “LCFS Requirements,” British Columbia, (2024).
[149] OECD-FAO, "OCED-FAO Agricultural Outlook 2023-2032" (2023).
[150] ICAO, LTAG Data Spreadsheet (2022).
[151] IEA, World Energy Outlook 2023 (2023).

Table 16: OCED-FAO renewable fuel consumption and ICAO AJF production projections in (billion gallons/year).

	Average 2020-2022	2025	2030	2032	2035	2040	2045	2050
Ethanol (OCED-FAO)	32.9	36.6	39.0	39.9				
Biodiesel (OCED-FAO)	14.4	16.2	17.3	17.7				
AJF* (ICAO)	0.4**	0.6	1.5		3.6	8.6	19.4	39.6
***F1-low scenario **2022 value**								

Washington Refinery Renewable Fuel Scenarios

This section of the study will discuss possible production scenarios available to Washington refineries. These paths could include continuing production of petroleum distillates or adapting their process to include renewable fuels. Context is provided about incorporating renewable fuel production as part of current operations or as a comprehensive change of business model. All of the content of this section is based on public information and does not include the details needed to make refinery-specific decisions. In addition, specific refinery names and locations are not included in this analysis.

Co-processing Biogenic Carbon

Co-processing occurs when biogenic carbon sources and crude oil are processed together in an existing petroleum refinery with the resulting fuel typically having a lower CI. Depending on refinery specifics, co-processing can be implemented quickly with relatively low capital investment.[152] [153] [154] Refineries can select multiple insertion points, including before the fluid catalytic cracker or in either the hydrotreating or hydrocracking operations. Co-processing also allows a refinery to continuously modify the feedstock based on market conditions, increasing the co-processing rate or returning to 100% crude oil. Each refinery will have to evaluate the ability to co-process as adding biogenic feedstock creates a more acidic and exothermic refining environment, both of which can limit addition rates depending on process variables such as refinery metallurgy.[153]

As with crude oil, not all the feedstock ends up as fuels. This analysis assumes that 80% of the biogenic carbon becomes part of the fuel products.[155] Currently, ASTM D1655, the standard specification for aviation fuels limits co-processing to 5% of the feedstock if aviation fuel is part of the product slate.[156] An ASTM working group is assessing increasing the biogenic feedstock limit to 30%. The co-processing scenarios selected for the Washington refineries are 5%, 10% and 30% replacement of crude with biogenic carbon. These

[152] Shell, “Co-processing,” Shell Website, (2024).
[153] BP, “The role of co-processing in aviation’s transition to a lower-carbon future,” Air Bp, (2022).
[154] ExxonMobil, “Co-processing: Working towards a sustainable energy solution at scale,” ExxonMobil, (2024).
[155] Z. Li, and S.B. Lehmann, "Biogenic Carbon Tracking and Measurement in Co-Processing of Biogenic Feeds in Petroleum Refineries" (2023).
[156] ASTM International, “Revision of D1655-23a Standard Specification for Aviation Turbine Fuels,” ASTM, (2023).

scenarios could theoretically result in 0.3, 0.7, and 2.0 billion gallons of renewable fuels respectively. Each refinery will have to evaluate their own ability to co-process and the rate at which this is possible.

Biorefinery Co-Location

Co-locating a biorefinery at an existing petroleum refinery is another option refineries may consider. Co-location involves adding infrastructure to an existing site that allows for the sharing of assets. There is no defined methodology to determine the ideal size of a co-located facility, as this depends on the specifics of each site. The volume of renewable fuel produced through co-location would likely be between the value estimated for co-processing at 5% feedstock replacement and the volume for a full refinery conversion.

Refinery Conversion

Conversion of petroleum refineries into biorefineries is the final option discussed and is a less expensive option than building a greenfield biorefinery.[157] Four U.S. refineries have publicly announced complete conversions with project costs. This report used the public data to calculate the mean cost of converting a refinery, normalized to dollars per gallon of renewable fuel. The $2 per gallon calculated value should only be used for scoping-level analyses as each refinery will have site-specific costs that will change this value significantly. A survey of the same facilities revealed that the announced renewable fuel scale was consistently lower than the amount of crude a refinery could process. A mean production ratio was calculated to be 0.5 (volume/volume). The low and high scenarios analyzed are based on the minimum and maximum production ratios of 0.2 and 0.7, respectively. No trend was discernable from the public data used to calculate production ratios; each refinery will have a unique possible biorefinery capacity based on details not available for use in this study. Table 17 presents the theoretical production volume and conversion costs, respectively, for three levels of renewable fuel production for the combination of all Washington refineries. Although beyond the scope of this report, it is also possible for a refinery to complete a partial conversion, which allows a refinery to refine both crude oil and biogenic carbon in parallel processes.

Table 17: Calculated potential renewable fuel production (billion gal/yr) and estimated conversion costs at converted Washington refineries for three theoretical production ratios. These values assume that all refineries convert at each level without assessing the viability of this choice.

Scenario	Low	Mean	High
Potential fuel production (billion gallons/year)	1.7	4.2	6.5
Estimated conversion costs (billion $)	$3.4	$8.5	$13.1

Lipid Feedstocks

Although demand for renewable fuels is expected to grow and stay high through 2050, the current primary feedstock for petroleum refineries choosing conversion or co-processing is lipids. Other possible feedstocks are pyrolysis oil and Fischer-Tröpsch crude, but availability, cost, catalysts and additional process complications limits them. Pyrolysis oil is not currently ASTM-approved for jet fuel; however, it could become a more prevalent feedstock in the long term. Lipids, especially those with low CI, like used cooking oil (UCO) and

[157] de Jong S, Faaij A, Slade R, Mawhood R, and Junginger M, (2015). The feasibility of short-term production strategies for renewable jet fuels – a comprehensive techno-economic comparison. Biofuels, Bioprod. Bioref. DOI: 10.1002/bbb.1613 (2015).

animal tallow, are in high demand and have limited availability. Using vegetable oils, such as soybean or canola oil, is a higher cost and CI option. The higher CI fuel from vegetable oils often translates into less financial policy support than lower CI fuels from waste fats. The use of vegetable oil is further limited as some countries do not count these fuels toward goals or mandates.

On a global scale, inedible tallow production is 23 million tons per year,[158] and 13 million tons per year of UCO are available.[159] These are the primary waste feedstocks that will provide considerable GHG reductions. Eighteen percent of global production of conventional vegetable oils is used for renewable fuels, which is 27 million tons per year, excluding palm oil.[160] [161] Second-crop oilseeds and oilseed trees planted on marginal lands could be 90 million tons per year if implemented globally. This sums to a global lipid value of 60 to 150 million tons per year. However, much of this material already has markets, including human and animal feed. Converting all the lipids to renewable fuels could produce approximately 10 to 30 billion gallons a year of renewable fuels. Increasing global demand for lipids, the price response to this demand, existing announcements for additional fuel production, as well as competing uses will need to be included in the decision-making process at each refinery when considering biofuel production.

Additional Long-Term Options

Although the simplest biofuel production technology to integrate into an existing petroleum refinery is HEFA, other options are possible in the long-term. These include, but are not limited to, alcohol to jet, pyrolysis, gasification Fischer-Tröpsch, catalytic hydrothermolysis and power-to-liquids (also known as electro fuels or e-fuels). Hydrogen is a key input for AJF, renewable diesel, as well as other renewable distillates and each of the conversion technologies could create demand for green hydrogen. Therefore, the Pacific Northwest Hydrogen Hub could support creating a green hydrogen industry in the state that could be used in fuel production.

Policy Support

If Washington refineries decide to pursue the production of renewable fuels, a significant source of revenue will be from policy support. The values of market-based policies vary significantly; the numbers used in this report represent historical values that may vary in the future. For the policies that require CI scores to estimate values, CORSIA core LCA and ILUC values were used in the calculations.[162] The ability for a specific fuel to qualify for policy support requires detailed analyses; the generalized values in this report should not be used to make financial decisions.

U.S. Pacific Coast State Policy

California, Oregon and Washington all have state policies that financially support the use of biofuels and other low carbon or sustainable fuels. California's LCFS was the first state policy implemented, and with the large California fuel demand, it dominates renewable fuel volumes compared to Oregon and Washington.[163] LCFS issues credits to fuel producers with a fuel CI lower than the annual target, and the credit is traded at market value. Oregon's Clean Fuel Program (CFP) and Washington's CFS function similar to LCFS.[164] [163] The value of these market-based policies changes with demand, significantly impacting renewable fuel producer revenue. Although California does not always have the highest credit price, the fuel demand, existing supply chains and

[158] ICAO, LTAG Data Spreadsheet (2022).
[159] WEF, and McKinsey & Company, "Clean Skies for Tomorrow Sustainable Aviation Fuels as a Pathway to Net-Zero Aviation" (2020).
[160] OCED-FAO, OECD-FAO Agricultural Outlook 2024-2033 (2024).
[161] USDA, Oilseeds: World Market and Trade (2024).
[162] ICAO, CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels (2022).
[163] Oregon Department of Environmental Quality, "Oregon Clean Fuels Program Overview," (2024).
[164] Washington State Legislature, RCW 70A.30.010 (United States, 2020).

approved producers translate into renewable fuel volumes that do not quickly switch to other locations. However, over time it is expected that the credit values and fuel volumes will meet the volumes needed to meet each state's GHG reduction laws. Washington has also established production and use tax credits for AJF under SB 5447 (Chapter 232, Laws of 2023), which provides support for production and use of AJF. However, the practical value of this policy is small as its value is capped at the B&O tax paid, which is a very small portion of overall costs for businesses and therefore is not a controlling economic driver.[165]

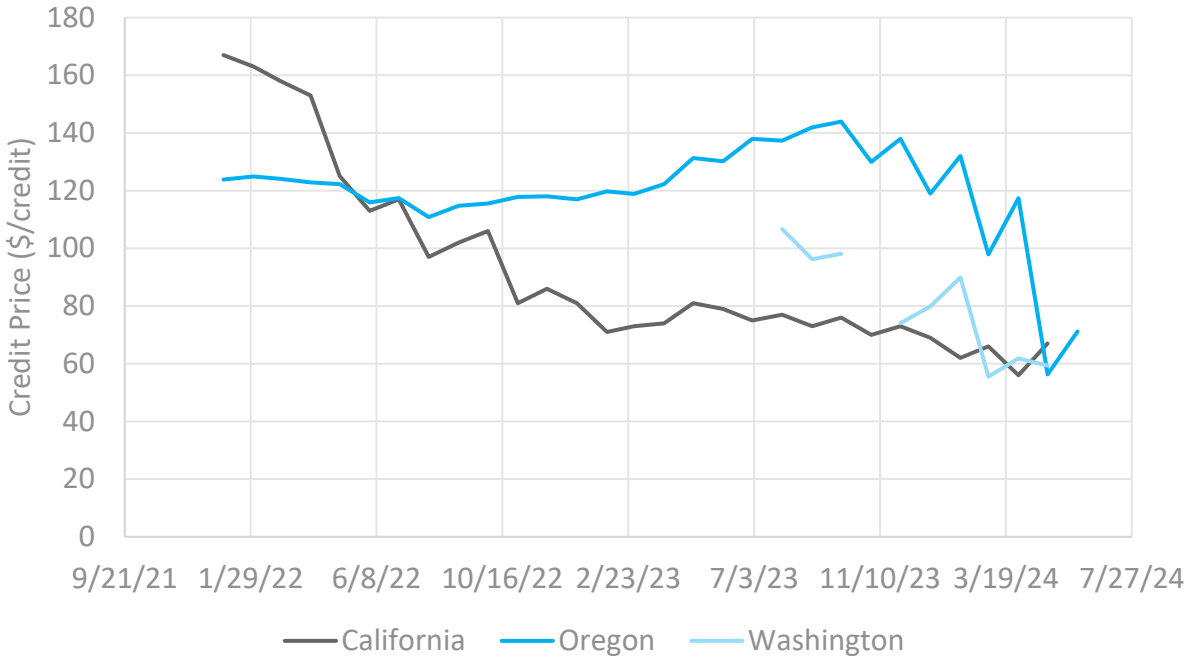

Figure 8: Credit value for LCFS, CFP and CFS from 2022.

U.S. Federal Policy

Two federal policies are likely to influence future biofuel project economics. The first is the renewable fuel standard (RFS). The RFS pays market-value prices for renewable identification numbers (RINs) issued for each gallon of fuel produced. The number of RINs issued per gallon varies with the energy density of the fuel. The value of each RIN is based on the current market and the RIN designation, determined by the fuel production technology, feedstock and a threshold GHG reduction requirement. RIN designations are D3 (cellulosic), D4 (biomass diesel), D5 (advanced) and D6 (conventional) and the RIN designation assigned to a fuel is tied to conversion technology, feedstock and fuel CI.[166]

[165] Washington State Committee on Finance, SB 5447 - 2023-24 (2023).
[166] EPA, "Approved Pathways for Renewable Fuel," U.S. Environmental Protection Agency Renewable Fuel Standard Program, (2024).

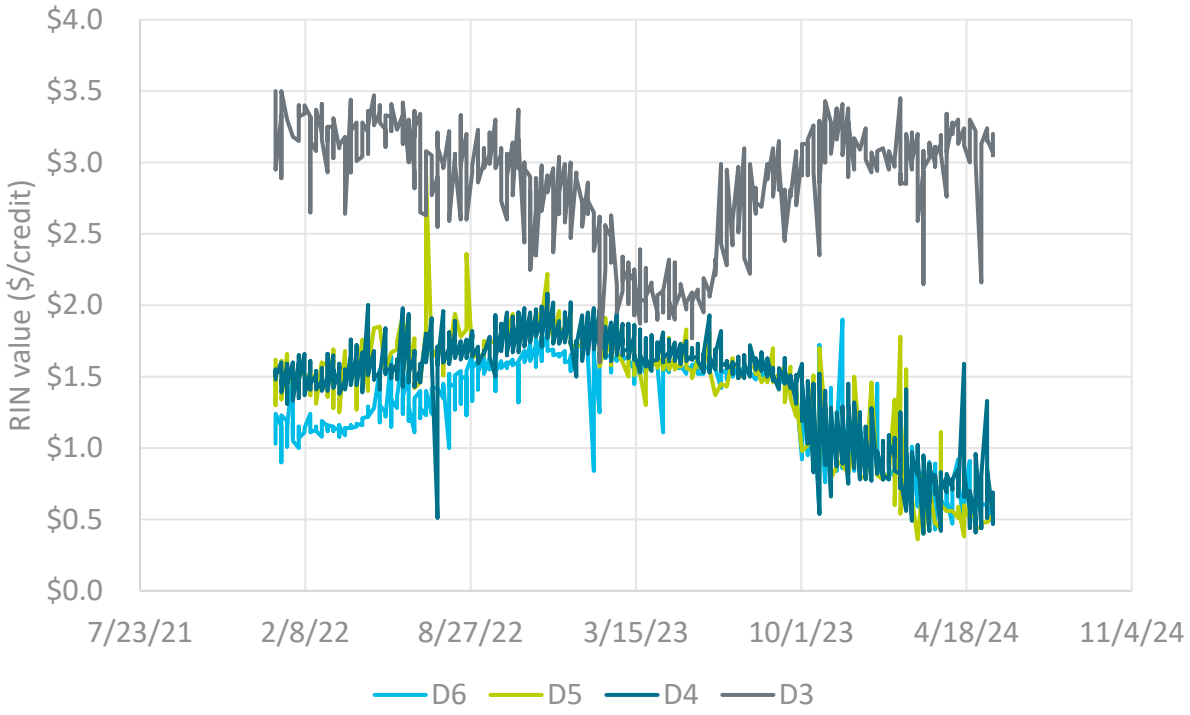

Figure 9: RIN value from 2022 for RIN designations D3, D4, D5 and D6.[167]

The Inflation Reduction Act (IRA) passed in 2022 includes the Clean Fuel Production Credit, commonly known as 45Z.[162] [168] [169] This credit is available from 2025 through 2027 for renewable fuels produced in the U.S. with a CI of less than 50 kg CO_2e/MMBtu, if all applicable criteria are met. The value of this credit increases linearly from $0/gallon for a fuel with a CI of 50 kg CO_2e/MMBtu to $1.75/gallon for AJF and $1/gallon for other transportation fuels if the fuel CI is 0 CO_2e/MMBtu. Per the legislation, this credit it is available for co-processing of Fischer-Tröpsch crude, but not for lipid feedstock. The limited 3-year duration of 45Z is short relative to the typical timeline required to implement new biorefining capacity.

Stacked U.S. Policies

Producers add the value they receive from all applicable incentives, commonly called stacking. This analysis assumes that the fuel will stay in Washington, so the state policy used is CFS; nevertheless, producers can send the fuel to Oregon or California and get similar support. Diesel and AJF are used as examples to demonstrate the impact of stacking policies, as well as feedstock and process technology choices (Table). It is likely that if a refinery is still weighing their options, 45Z will have expired before a refinery conversion could be completed. Without the impact of 45Z for three years, the small differences in policy value between co-processing and refinery conversion will have to be compared to required capital costs and operational risks.

[167] EPA, "RIN Trades and Price Information," EPA, (2024).
[168] OCED-FAO, OECD-FAO Agricultural Outlook 2024-2033 (2024).
[169] USDA, Oilseeds: World Market and Trade (2024).

Table 18: Estimated policy support for RFS, WA CFS and 45Z. 45Z is only applicable from 2025 through 2027. Biorefinery values apply to purpose-built biorefineries or converted petroleum refineries.

Technology	Feedstock	Fuel	WA CFS ($/gal)	RIN ($/gal)	45Z ($/gal
Co-processing	UCO	Diesel	0.9	2.1	-
Co-processing	UCO	SAF	0.9	2.0	-
Co-processing	soybean oil	Diesel	0.4	2.1	-
Co-processing	soybean oil	SAF	0.4	2.0	-
Conversion to Biorefinery	UCO	Diesel	0.9	2.3	0.7
Conversion to Biorefinery	UCO	SAF	0.9	2.1	1.2
Conversion to Biorefinery	soybean oil	Diesel	0.4	2.3	0.1
Conversion to Biorefinery	soybean oil	SAF	0.4	2.1	0.2

Canada and British Columbia Policies

Renewable fuels sold in British Columbia earn both federal and provincial support, which is relevant for potentially exporting fuels from Washington refineries. The Canadian Clean Fuel Regulations (CFR) is a federal program supporting GHG reductions in Canada. This program supports fuel based on tCO_2e of emissions avoided. The average price between 2022 and 2023 was $99 (133 CAD)/t CO_2e. However, price change is expected in this relatively new program as the policy matures.

British Columbia has a renewable fuels mandate with a $445 (600 CAD)/$tCO_2e$ penalty in 2023, up from the $148 (200 CAD)/$tCO_2e$ previously set for not meeting the mandate. This mandate is paired with a low carbon fuel standard. This program works similarly to the California, Oregon and Washington programs, with each credit issued representing one tCO_2e emissions reduction. The mean value of the BC low carbon fuel standard for 2022 through 2024 year to date is $346 (467 CAD)/$tCO_2e$, which is 3-4 times the values of the U.S. Pacific coast states.

Policy Summary

Stacking the federal with state or provincial policies influences a refinery's decision to produce and sell renewable fuels in a specific location. The values of policies vary based on the details of the policy. If the policy is tied directly to CI, waste feedstocks will create more revenue than purpose-grown crops. In the U.S., renewable fuels are sold to states where policies are stacked with federal programs. The same is true in Canada, where a high credit price makes for an attractive market. However, this is also balanced with the fact that British Columbia is a smaller overall fuel market compared to places like California. A fuel producer will need to decide the best location for selling fuels based on existing sales contracts and supply chains, policy details, CI calculations, duration of policies providing incentives or regulations, local demand and fuel approval status among other items.

Projected Scenarios

This section of the report details eight projected scenarios, based on engagement with Washington's refineries. Draft scenarios were initially constructed to describe possible projected scenarios for the primary markets of Washington refineries. These were then discussed and improved based on input from refineries and other members of the project Advisory Committee as described in Appendix A. These scenarios take into account realistic, real-world outcomes, given existing decarbonization targets, feedstock availability and statutes that impact Washington refineries. These scenarios are not exclusive, and may happen sequentially. Scenarios 1 and 2 are unlikely to be sustained across all refineries through 2050 in accordance with decarbonization targets. Other scenarios may be consistent with state GHG limits at single refineries, depending on other circumstances across the refinery sector and Washington economy.

All scenarios are based on changes of demand, and differentiate auto, aviation and diesel fuel types. The scenarios are also based on a decrease in auto fuel, an increase in aviation fuel demand, an increase in alternative fuel and moderate amounts of diesel use change. These assumptions consider real world outcomes influenced by decarbonization and regulatory statues affecting the state's refinery products. However, these scenarios consider the potential evolutions of an individual refinery, rather than all five in Washington. Each scenario could happen within the same timeframe as another scenario at different refineries. Alternatively, multiple scenarios could happen sequentially at one refinery.

In addition to the predications, the following are core assumptions that inform all eight scenarios:

- Refineries can adjust product mix without large capital changes.[170] They can swing the product mix produced based on the incoming crude oil composition and with some process adjustments.
- Exports are outside of Washington (scenarios will specify whether domestic or abroad).
- The geography for distribution of refined petroleum products affects cost effectiveness, and therefore where refineries sell their product. The Puget Sound region is open to international markets for some products. Final goods have limited destinations based on market availability and distribution infrastructure. Every state's decarbonization path is different.
- Aviation fuel production is central to the market changes, but there are tolerance limits for these alterations. Barrels of oil have limits on ratio productions for auto, aviation and diesel fuel. The amount this can change varies from refinery to refinery, based on their crude oil inputs and technological process. Additionally, refineries are limited by their ability to store and distribute product. Storage capacity may be a limiting factor for adjusting product mix.
- Changes to the market take substantial time, and market uncertainty will hinder rates of change and investments.
- Changes to the market will reduce supply resiliency, and there is risk for disruptions in market price.
- The demand of chemical feedstock will impact pricing and product distribution paths. The overall demand for chemical feedstocks in Washington is lower than other states with higher concentrations of manufacturing. Profitable production in Washington relies on competitive pricing with international shipping costs included.
- Consolidation of refinery companies is unlikely due to regulations. Scenarios outline ownership changes when relevant.
- All refineries are homogenized in the scenarios.
- Marine fuel is not considered within this analysis (or assumed to be held constant) for simplicity.

[170] Capital changes refers to investments in infrastructure, such as would be required to convert to alternative fuel production.

For each scenario, this study projects changes in employment, wages or personal income, refinery profits, job roles, Gross Domestic Product (GDP), tax revenue and effects on other entities or community development programs. For the most part, the impacts of the scenarios on the variables could be positive, negative or unchanged within the time frame under consideration (2024-2050). As is the case in assessing potential future economic impacts, the longer the timeline assessed, the more uncertainty is introduced. This study assumes existing laws and policies will remain in force, while recognizing that policies in place at the time of writing may shift in future years, affecting the projected outcomes. Additionally, the time required for refineries to adjust operations based on permitting, construction timelines, staff training and other factors can slow responses to policy and impact compliance with decarbonization goals.

These projections are based on a thorough literature review of studies on the economic impacts of refineries in the U.S. and our understanding of the relationship between refineries' operations and key economic variables. As with any economic projections, the potential economic outcomes may vary over time due to some fundamental economic changes beyond our model. However, using short-term, medium-term and long-term frameworks allows this study to capture the effects of scenarios on the economic outcomes at different time periods.

Although the economic factors considered may not be exhaustive, this list captures the key outcomes the scenarios may have. The following section of this report, "Projected Impacts of Demand Decline," uses historical data to quantify the dollar value of the scenarios impacts on relevant economic variables.

The scenarios should be viewed not as stand-alone situations but rather a plausible evolution of change within the industry as the market and regulatory environment continues to emerge. In essence, the first scenario is far more likely in the early years, and other scenarios are more likely to occur later in the timeline, potentially after another scenario has occurred. Therefore, the first scenarios discussed provide information on short-term and medium-term impacts only, and later ones include long-term impacts as well. As an industry that requires significant investment and planning, change typically occurs slowly and within a sequence of events rather than in large disruptive events.

The scenarios are outlined in Table 19. Scenarios 1 and 2 describe minor changes in demand or production. Scenarios 3, 4 and 6 describe a change in products. Scenarios 5, 6, 7 and 8 describe a change of function for the refineries. Compliance with GHG emission limits in each scenario would depend on the overall composition of choices and circumstances at the refineries. These scenarios apply to individual refineries, and compliance with GHG emission limits is dependent on site specific infrastructure and efficiency.

Table 19: Scenarios, likely time periods, and comments on GHG emissions compliance.

Scenario Number	Scenario description	In which timeframe is this scenario most likely?	Comments on compliance with GHG emission limits
1	Minor demand changes; shift in product mix	Likely in short term, but time limited. Other scenarios may occur after this scenario ends.	This scenario is most likely in the short term, followed by other scenarios. It is unlikely to be compliant with tightened GHG emission allowances over time, and will likely lead to other scenarios.
2	Minor demand changes; increase in exports	Likely in short term, but time limited. Other scenarios may	This scenario is most likely in the short term, followed by other scenarios. It is unlikely to be compliant with tightened GHG

Scenario Number	Scenario description	In which timeframe is this scenario most likely?	Comments on compliance with GHG emission limits
		occur after this scenario ends.	emission allowances over time, and will likely lead to other scenarios.
3	Change in products; Joint venture/Co-Location	Likely in medium and long term.	This scenario is likely in the medium and long term, and is likely to follow Scenarios 1 or 2 as businesses adjust to a changing market and produce alternative fuels. This could extend to a total conversion of facility capacity to alternative fuels, or a portion of capacity. Reduced emissions may result from lower production capacity and lower CI of alternative fuels.
4	Change in products; Fully alternative fuel production	Likely in medium and long term.	This scenario is likely in the medium and long term, based on the needed changes to infrastructure required. It may follow a period of closure as refineries change equipment to produce alternative fuels. Reduced emissions may result from lower production capacity and lower CI of alternative fuels.
5	Change in function; Tank farm or storage facility	Likely in all time frames	This scenario is possible in all time frames, if refineries utilize existing infrastructure. This could be an end point as refineries transition use, or a middle stage followed by other scenarios. The scenario may be compliant due to a reduction in emissions as production stops or decreases.
6	Change in function and products; Combination of Scenarios 3 and 5	Likely in all time frames	This scenario is likely in all time frames, as refineries may have existing infrastructure for this type of change. It may be compliant with GHG emission limits based on production changes described in Scenarios 3 and 5.
7	Change in function; Closure and redevelopment	Most likely in the medium and long term.	This change is compliant with GHG emission limits, as facilities would have no emissions with closure. This scenario may be followed by Scenarios 3, 4, or 5 if workforce is reduced with a change in operations and significant changes to infrastructure are needed.
9	Change in function; Closure and no redevelopment	Most likely in the medium and long term.	This scenario is likely compliant with GHG emissions limits, as most alternative future uses have lower GHG emissions, excluding energy generation.

Later sections of this report will discuss in depth the projected impacts of these scenarios on workers, included in the workforce analysis focused on petroleum refining and potential alternative industries in Chapter 4. For each scenario, information is provided describing key aspects as well as high-level commentary about economic impacts. Specific numeric calculations regarding the economic impacts are provided in the "Projected Impacts of Demand Decline" section. It is important to be aware of the fact that these analyses focus only on the potential changes in the refinery sector and not the broader ways in which the rest of the economy might experience changes alongside or to respond to these.

Each scenario also includes an economic viability assessment. **Under the assumption that Washington will reach net zero targets by 2050, it is likely that all refineries will experience a change in product or function. The following analysis outlines what impacts may be seen in the short, long and medium terms of 2026,**

2035 and 2050 for each scenario outlined earlier. All scenarios may be followed by other scenarios, as multiple changes may occur over the assessed period. Each scenario is analyzed through impacts to employment, wages and personal income, job switching, refinery profit, GDP and tax revenue.

Scenario 1: Minor demand changes; shift in product mix

Scenario 1 can be understood as "business as usual" for refinery production with a few exceptions. Production levels have not shifted, but the type of fuel produced has changed to a moderate degree. Auto fuel demand has declined, and there is an increase in diesel production, with most exported out of state. Additionally, conventional aviation fuel increases production and is expected to be consumed locally. The high-level impacts of these changes are a decrease in tax revenue for Washington in the form of road and retail and sales (R&S) taxes, as gas tax income drops in conjunction with demand. The impact of Washington's decrease in demand for auto fuel is absorbed by other changes, as other fuel types increase, but tax revenues within the state may decrease overall because some are tied directly to petroleum product production at present.

This scenario forecasts that demand for auto fuel will decrease and demand for aviation fuel will increase in Washington and that refineries will respond by shifting production accordingly. Refineries have a certain amount they can adjust their production without changing inputs and with limited technological changes to the production process. While this amount varies refinery to refinery based on their process and inputs, a certain amount of "swing" is available that can allow refineries to produce more or less of a certain fuel type. Constraints for the refineries can include storage facilities on site and ability to adjust distribution pathways for final products.

The impacts of this shift will likely be most prominent in the short term: As refineries adapt to new levels of demand, there will likely be temporary inefficiencies and disruptions. These temporary disruptions could be as minor as slight drops in refinery profit or as severe as modest layoffs. The medium and long-term conditions will likely be more stable as refineries and the state adapt to new demand and production levels. It is possible that there will be growth in key variables in the medium and long term, especially as the aviation fuel market continues to grow.

The refineries may make investments to decarbonize their existing operations, such as efficiency upgrades or production/procurement of cleaner feedstocks such as green electrolytic as opposed to fossil-derived hydrogen, as part of compliance with current state climate and clean fuels laws. Refineries may also already be engaging in some circular production, using relevant outputs to fuel the production of more profitable products. These investments may be expensive and impact other aspects of this scenario.

This scenario is likely time limited and followed by another scenario. As such, it is only analyzed in the short and medium term. Scenario 2 is also analyzed in the short and medium term, with all following scenarios analyzed through the long term.

Economic Viability Assessment

This scenario contains analysis that has been provided for the short and medium term. This scenario is much more likely in the earlier stages of transition and may be followed by other scenarios. In the short term, there is potential for initial disruptions to employment or layoffs as auto fuel production decreases and refineries begin to produce more aviation fuel. Employees who are not cross trained on multiple units within refineries may be more at risk. Wages may also be impacted through decreased hours or layoffs during the transition

period. Staffing may remain the same over time as refineries shift product mix, as significant refinery reconfiguration is unlikely in this scenario. Refinery profits may temporarily decrease to initial inefficiencies or transition costs. A drop in auto fuel use could decrease GDP as refineries' contribution to state GDP may decline due to a potential disruption in profit. Retail and sale tax revenue and fuel tax revenue, among others, may decrease some.

In the medium term, overall stability in employment may improve. Reduction of workforce is more likely in the medium term as efficiencies improve and refineries respond to demand changes. Retrofitting or construction jobs related to efficiency upgrades may provide some temporary increases in employment. As workers resume normal shift schedules and full production, wages may recover and stabilize. Profit is expected to stabilize as inefficiencies decrease, employees become more specialized and procedures are streamlined. As profitability increases, there may be a positive impact to GDP, if the jet fuel market expands. However, based on the timing and size of this impact, it may not outweigh the impact to GDP of lost automotive fuel production. Changes in tax revenue will likely balance out and other methods of supporting road maintenance may be implemented to account for decreases in fuel tax revenue. These changes are highly dependent on the timing and size of changes at the refinery, and may lead to other later scenarios.

Scenario 2: Minor demand changes; increase in exports

Scenario 2 differentiates demand regionally. Similar to Scenario 1, this scenario forecasts that conventional auto fuel usage decreases, but in this scenario, the drop is primarily local to Washington. It assumes that there is an increase in the export of conventional auto fuel domestically, but exports abroad do not shift dramatically. This is attributed to the significant costs of shipping fuel and availability of other international suppliers. There are some fluctuations with aviation and diesel, but the significant changes occur only with auto fuel demands.

This scenario forecasts that demand for auto fuel decreases locally but refineries will continue to produce conventional auto fuel at comparable levels with the excess production being transported to other states or regions. These two effects (decrease in local demand and increase in exports) tend to have opposite effects, making many future changes largely dependent on the relative sizes and timing of these effects. For example, state GDP and refinery profit would likely fall if the effect of decreased local demand outweighs the increased export demand, resulting in a net zero change. However, GDP and refinery profit would likely rise if export demand is greater than the local decrease in demand. Local sales and domestic exports of conventional auto fuels have differing costs of transportation, likely meaning that an increase in exports would have to outweigh the added transportation costs.

This is also impacted by shifting policies in the region. Different regions require different fuel specifications, meaning that not every area can import the same type of fuel mix. Additionally, the closure or conversion of refineries in other areas may increase the demand for exports from refineries, making it more profitable for refineries to export conventional auto fuel domestically.

Since the size and timing of the effects is unknown, some predictions are difficult to make. Changes to employment will likely be similar to those for Scenario 1, with added potential for new roles in auto fuel export. Given the maintained production levels, positions in operations and production are unlikely to be significantly affected. However, positions across local fuel distribution networks may be affected as distribution is consolidated or retailers become dependent on other revenue as auto fuel sales decrease. Additionally, positions related to long distance distribution of auto fuel may increase as exports increase. This is dependent upon the volume and capacity of current distribution networks and is more likely to occur in the medium term

due to infrastructure requirements. Currently, fuel products are moved via land and water using a variety of methods, which require differing infrastructures.

Changes in tax revenue will also be similar to Scenario 1. Expected revenue from the production of relevant fuels is not expected to decrease significantly, but a drop in retail and sales taxes due to a drop in local demand is likely.

As with Scenario 1, this is not expected to be a long-term position but rather a likely early transitory stage as the industry continues to adapt to a changing market and regulatory environment.

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Similar to Scenario 1, this scenario is analyzed in the short and medium term. This scenario reflects a change in demand in Washington, with an increase in exports to other regions. This is not expected to be a long-term position, but rather a transitory stage as the industry continues to adapt to a changing market and regulatory environment.

In the short term, adjustments to employment are expected, with some potential for layoffs. Local jobs related to distribution, or the sale of gasoline may be negatively impacted, while positions related to distribution across the region may increase. However, utilization of existing systems, such as the Olympic Pipeline or loading of marine vessels in both directions may decrease any potential positive job effects from increased exports of fuel. It is likely that the existing number of jobs may be maintained due to the utilization of existing distribution system capacity. With this disruption, there is some potential for changes or decreases to personal income and wages reflected in decreased hours or layoffs. Changes to refinery profit and GDP will depend on the relative sizes and timing of local drops in auto fuel usage and the costs of increased exports. Shifts away from local auto fuel use will likely decrease fuel tax revenue, alongside retail and sales tax revenue from decreased local sales.

In the medium term, it is expected that employment levels should stabilize as new roles related to distribution and export develop. However, this stabilization is likely to Wages may increase if export markets remain profitable but may fall if they do not. Changes to refinery profit will be highly dependent on the costs of export and may improve with the development of cost effective infrastructure. The relative sizes and timing of these changes will also affect refinery profit, which will be reflected in the changes to GDP. If there were an extreme drop in auto fuel use, fuel tax revenue would sharply decrease. This may prompt the adoption of other policies to support road maintenance.

Scenario 3: Change in products; Joint venture/Co-Location

Scenario 3 forecasts that there could be new production of alternative jet fuel (AJF), renewable diesel fuel or other alternative fuels as a result of the decrease in conventional auto fuel demand. In this scenario, refineries add a business unit, likely by co-locating or establishing joint ventures. An example of this kind of venture is the Marathon Martinez refinery in California. The project, called Martinez Renewables [171] is a joint venture

[171] Marathon News Releases, "Marathon Petroleum Corp Announces Closing of Martinez Renewables JV with Neste", September 21, 2022. Marathon Petroleum Corp Announces Closing of Martinez Renewables JV with Neste | Marathon Petroleum Corporation

between Marathon Petroleum Corp and Neste. The venture plans to split costs of feedstock and conversion between the two firms and is targeted to help support California's Low Carbon Fuel Standard (LCFS).

This scenario would be more likely to occur if incentives are present for the new market. Examples of these incentives include California's LCFS and other increases in regulation such as Cap-and-Trade programs that limit and establish a system to pay for allowances associated with GHG emissions.[172] Scenario 3 homogenizes the state's refineries and largely takes decarbonization targets into account. Washington's Clean Fuel Standard and Cap-and-Invest policies that came into effect more recently (January 2023) are also already having impacts on the state's fuel systems and economy.

This scenario, as well as others relating to new fuel types, can take many forms. It is likely the industry will transition over time and new sources will bridge fuel gaps rather than fully replace current systems. Additionally, these transitions are impacted by zoning and permitting regulations. For example, refineries housed in Whatcom County are subject to a policy that prohibits the building of new conventional petroleum refineries, transshipment facilities and other industrial infrastructure in their coastal industrial zone.[173] This policy has already prompted a refinery to withdraw from plans to build a renewable diesel plant in Whatcom, alongside their existing conventional fuel plant.[174] However, the policy does not prohibit the development of alternative fuel refineries as a permitted use in the High Impact Industrial (HII) zone, dependent on an evaluation of impacts to Whatcom residents.[175]

This scenario is more likely in the medium- and long-term phases evaluated due to the investment and market evolutions required. The permitting process alone for the construction and alteration of current facilities takes a significant amount of time in addition to the time it takes to build new infrastructure.

Employees and workers will likely see the greatest impacts in this scenario. The expansion of facilities and the pursuit of new ventures may create temporary positions in construction or retrofit of facilities. However, in the long term, employment is likely to remain stable or decrease, as the capacity for alternative fuels is sharply limited by feedstock availability and technology. The addition or alteration of current operating units to include alternative co-processing could result in retraining of existing employees or new positions. Additionally, some distribution jobs may be created as infrastructure develops to help move alternative feedstocks to refineries.

These considerations are highly dependent upon the refineries' existing infrastructure. In theory, these changes could be seen at just one of the refineries or at all of them. This uncertainty greatly impacts the overall scale of each impact and makes more precise impacts difficult to project. The environmental impact of this scenario is significant. The decrease in auto fuel use will have effects on local air quality, and a shift to alternative fuels will largely decrease overall emissions from the state. However, this is dependent upon the assumption that alternative feedstocks capture an equivalent or greater amount of carbon to the usage of their final product.

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[172] Green Car Congress. "Clean fuels replaced more than 50% of the diesel used in California Low Carbon Fuel Standard (LCFS) program, largely responsible for the decline in transportation emissions from the program." Published on August 24, 2023. Accessed on May 3, 2024. https://www.greencarcongress.com/2023/08/20230824-lcfs.html#:~:text=Clean%20fuels%20replaced%20more%20than%2050%25%20of%20the%20diesel%20used,is%20largely%20responsible%20for%20the

[173] The Energy Mix, "Whatcom County Became First U.S. Refinery Community to Ban New Fossil Fuel Infrastructure", December 27, 2021.

[174] Phillips 66 News Releases. "Phillips 66 and Renewable Energy Group Withdraw Renewable Diesel Project in Washington State", January 21, 2020.

[175] Whatcom County Council, "Adopting Amendments to the Whatcom County Comprehensive Plan and Whatcom County Code Relating to the Cherry Point UGA, Fossil Fuel Facilities, Renewable Fuel Facilities, Piers, SEPA, Greenhouse Gas Emissions, and Other Matters".

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Scenario 3 forecasts that there could be new production of alternative jet fuel (AJF), renewable diesel fuel or other sustainable or alternative fuels as a result of the decrease in conventional auto fuel demand. Fuel production in this scenario can take many forms, especially as the industry transitions over time. This scenario is analyzed in the short, medium and long term, with the understanding that it may be part of multiple changes to the industry, rather than a final destination for the industry.

In the short term, there may be initial disruptions to employment as refineries begin to engage in joint ventures and shift production types, which may also disrupt wages for workers through decreased hours. Works may change roles as alternative production increases and auto fuel demand drops. This may trigger layoffs or employees transitioning to other units following a retraining period. High costs related to development, restructuring or co-location may initially reduce profit. This may also be reflected in changes to GDP, as the timing and relative sizes of effects from capital investment and declining fuel tax revenue act in opposite directions. Shifts away from local auto fuel use will decrease fuel tax revenue, while new facilities and capital investments may contribute to increase in property tax revenues.

In the medium term, employment may be boosted as facilities are retrofitted or constructed for alternative fuel production. Retained employees will likely require retraining as new units come online and need operators. As a reflection of this, wages may become more stable or increase depending on the profitability and demand for new and specialized skills related to shifting operations. New roles in alternative fuel production may be filled from the existing workforce or new hires. As joint ventures are established and the alternative fuels market expands, refineries may experience increases to profit. Changes to GDP will again depending on the timing and relative sizes of effects. However, as the market for alternative fuels stabilize and grow, GDP may increase. Consumption tax revenue may increase as demand for alternative fuels continues to grow, supplementing fuel tax revenue. However, this may not outweigh the declines to fuel tax revenue based on auto fuel sales. Continued changes to facility infrastructure may impact property tax revenues.

In the long term, employment and job switching are expected to stabilize. A long term increase in wages may result from expanded operations, demand for specialized skills and improving profitability of alternative fuels. All things being equal, it is expected that profits will increase compared to Scenarios one and two, particularly if the alternative fuels market continues to be profitable, contributing to positive effects on GDP. Tax revenue will likely stabilize in the long term, dependent on the size and timing of refinery stability. Incentives for alternative fuel production may lower tax revenue, even with increased fuel production. However, these incentives are likely impermanent, and will phase out over time, such as the Clean Fuels Production Credit. The Clean Fuels Production Credit, or 45Z, is only available from 2025 to 2027.

Scenario 4: Change in products; Fully alternative production

Scenario 4 forecasts that there could be new ownership of refinery facilities and refineries could change production completely to the production of alternative fuels. Change of ownership is possible with every scenario, but within this scenario especially. This could include green hydrogen production, AJF production or other similar fuels.

The Rodeo facility of Phillips 66, a San Francisco refinery, is an example of a refinery that made this transition to meet growing demands for alternative fuels.[176] However, this has long-term impacts on local distribution networks and any "sister refinery" upstream of a converted refinery. The Rodeo facility consisted of two linked refineries, the Santa Maria and Rodeo refineries. The Rodeo Renewed project, which converted the Rodeo facility, subsequently shut down operations at the Santa Maria refinery. The Santa Maria refinery was positioned upstream of the Rodeo facility, providing intermediate products that were upgraded into a final product at the Rodeo refinery. The Santa Maria facility is now slated for demolition and remediation, pending permitting.

This scenario will likely have extreme effects on employment. In California, a similar transition led to hundreds of layoffs and forced workers to relocate and take lower paying jobs.[177] This can be attributed to the significantly more limited production capabilities of biorefineries. This is in part due to feedstock availability and technological capability. Smaller refineries are more primed for conversion to biorefineries due to their smaller existing capacity. Previous refinery capacity has declined anywhere from 70-85% when converting to alternative fuel production, although some refineries saw smaller capacity losses after conversion. This indicates that the limitations to feedstock supply and current size of the market for alternative fuels means new biorefineries tend to be operating at lower capacity than a conventional refinery. It is possible that in future with more secure feedstock supply, technological improvements and growing demand, the number of jobs supported and the economic impacts of a biorefining operation could more closely approximate the economic impacts of conventional refineries in Washington.

The extreme change in production type will likely also affect GDP and tax revenues, although the expected negative effects will likely dissipate over time. Refinery profit will likely drop in the short term as there are temporary shutdowns and large investments made, but profitability too can be expected to improve over time. This scenario would have the most positive effects for the environment in the form of decreased greenhouse gas emissions and improved air quality.

As in scenario 3, this is more likely in the medium- and long-term phases evaluated due to the market evolutions required. In order for this scenario to occur, a current operator would need to conclude their current operations no longer meet their return-on-investment requirements and that a new operator must see a likely acceptable return on investment. Additionally, petroleum refinery operations typically make changes on a timeline of decades, rather than years, due to permitting and scale of infrastructure changes. Refineries with existing transferable infrastructure can transition to producing alternative fuels much faster than refineries that have to build new infrastructure. Alternative fuels have lower CIs than conventional fuels based on lower lifecycle emissions,[178] but their emissions from production may be maintained or increased.[179] Alternative fuel production may release greater amounts of hazardous emissions than conventional refineries,[179]and evolving process safety management has resulted in safety concerns.[180] Worker safety considerations for alternative fuel production are discussed in Chapter 4. Alternative fuel production may maintain the existing environmental, cultural, and treaty impacts as conventional fuel production.

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[176] Phillips 66. "San Francisco Refinery." Accessed on May 3, 2024.
[177] Labor Center UC Berkeley. "Fossil fuel layoff: The economic and employment effects of a refinery closure on workers in the Bay Area." April 26, 2023. Accessed on May 16, 2024.
[178] Environmental Protection Agency, "Economics of Biofuels", March 15, 2024.
[179] Environmental Integrity Project, "Farm to Fumes- Hazardous Air Pollution from Biofuel Production", June 12, 2024.
[180] California Occupation Safety and Health Standards Board, "Proposed Petition Decision of the Occupational Safety and Health Standards Board (Petition File No. 601)", June 20, 2024.

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This scenario involves the transition of total refinery capacity to produce alternative fuels and could include new ownership of refinery facilities. Based on examples out of California, conversion to alternative fuel can have extreme impacts on employment as described in the Scenarios section. This scenario is analyzed in the short, medium and long term and may require an initial closure of facilities during retrofitting or construction of alternative fuel production infrastructure.

In the short term, this scenario is expected to severely disrupt employment. This could involve the layoff of between 70% to 80% of employees or an even greater proportion of employees during the construction or retrofit of facilities to support alternative fuels production. Previous examples have involved the closure of refineries for years as changes are made to support biofuel production. Some construction jobs may be supported by in the short term as old infrastructure is dismantled or retrofitted. For retained employees, there may be a decrease in hours as units are retrofitted, in addition to the decrease in overall wages due to laid off workers. This scenario likely has reduced profits in the short term due to capital investments required to convert a conventional petroleum refinery to a biofuel refinery. These investments in new technologies and infrastructures may counteract the effects of layoffs on GDP, resulting in maintained or even slightly increased GDP. Some tax revenues, such as the oil spill tax, petroleum products tax or hazardous substance tax would decrease as production stops. Property tax revenue changes will be dependent upon the valuation of new infrastructure at refineries.

In the medium term, employment may increase as biofuel production begins and increases over time. It is unlikely that this will match the previous employment levels of conventional petroleum refineries, but some workers may return as operators for biofuel production. Similarly, construction jobs may peak before or during this period as changes are completed and maintenance returns to a more intermittent schedule. Wages may remain diminished for displaced refinery employees as they seek to transition into other industries, as many workers may not return after layoffs. Additionally, workers may seek to transition to clean energy sector. At this time, refineries may see increased profits as production expands and demand for alternative fuels grows. Investments in distribution systems for alternative fuels may affect profit. Compliance with decarbonization efforts may result in sales of carbon credits between refineries. It is expected that tax revenues will stabilize if alternative fuel revenue is stable and profitable. Changes to property tax revenue may continue to change based on changes to infrastructure.

In the long term, employment will likely stabilize at the diminished rate. Overall, employment will depend on the demand for biofuels, as production changes in response. Wages will likely also stabilize, consistent with positions in conventional fuel production. It is likely displaced workers will continue to seek positions in the clean energy sector as it expands and stabilizes in response to increased demand. Refineries may expect to see increased profit as demand for alternative fuels grows, particularly if other states move away from conventional auto fuel in the long term. Effects on GDP should be positive as alternative fuel markets stabilize and grow, with expected increases to tax revenue as well.

Scenario 5: Change in function; Tank farm or storage facility

Scenario 5 forecasts the conversion of part of a refinery site for either holding finished goods or acting as a waypoint for crude oil as a tank farm. This would mean that refining operations would cease, as crude or unrefined products are passed through from Washington for refining and use in other jurisdictions. Similar to Scenarios 3 and 4, this scenario has the predicated demand changes in addition to a change in products. Similar to Scenarios 6 and 7, this scenario incorporates drastic changes in refinery operation and function.

Due to the number of market-based or regulatory changes that must occur before the underlying business model implications would be met this scenario is not forecasted to become likely until late in the medium-term or long-term horizons. There could be implications before the steps would be taken, however, as each individual operator makes strategic decisions to maintain their required return on investment. Business operations may continue at lower production levels or they may cease outright. The ownership of the tank farms and production sites may remain the same, but employment in the refineries would significantly drop. One example of this includes the conversion of a Phillips 66 refinery in Belle Chasse, Louisiana into a terminal facility [181] that was then acquired by Harvest Midstream.[182]

The Belle Chasse terminal transition resulted in layoffs at the approximately 500 full time employees and 400 contractors at the site. Four hundred and seventy employees were laid off in the wake of the refinery closure in 2022, with the layoffs expected to be permanent.[183] Any conversion of existing refineries to storage facilities can reasonably expected to significantly decrease employment at the site. The Belle Chasse example also comes in the wake of significant damages after Hurricane Ida, affecting the viability of the refinery based on cost of repairs.

The required ratio or range of storage to production space to keep business operations profitable would need to be investigated. Additionally, there are limitations on the construction of new storage tanks based on a variety of safety standards. A refinery in Australia experienced this shift, as after its closing it began operating as a waypoint for crude oil and imports.[183] This altered worker placement and transportation costs for the industry. This scenario assumes the value of land and space to manufacture is constant or has decreased, as an increase could make this transition unaffordable.

To some extent, refineries may already serve or plan to serve as waypoints for other petroleum products. The Phillips 66 Ferndale refinery has completed modifications to existing structures to allow the receipt, storage and distribution of renewable diesel using existing truck and rail loading facilities.[184] The project plans to repurpose and existing diesel tank for renewable diesel storage, and take advantage of the facilities ability to receive product via marine vessel. However, this is a smaller change than the scenario described above, as the proposal both involves no new storage tanks, and production at the facility is ongoing.

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Scenario 5 reflects the conversion of a refinery in total or in part to a tank farm or storage facility, either to hold finished goods or crude oil. This would reflect in either a reduction or stoppage of refining operations, as the facility is used to move products to other facilities or around the region. This scenario is more likely in the medium term or long-term horizon, based on the required market based or regulatory changes that could prompt this scenario.

In the short term, this could have extreme effects on employment, with large scale layoffs of employees. Some increases in employment could result from construction jobs as a facility is converted. Wages would likely decrease significantly as workers transfer to other facilities or industries, while retained employees may see no changes to wages. Profits for refineries would likely decline but stabilize as costs of operations decrease and operation as a waypoint increases. This scenario is expected to significantly reduce revenue as taxes

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[181] Anthony McAuley, "Phillips 66 to Shutter Alliance Refinery, Convert It to Fuel Terminal; 900 Jobs in Jeopardy," Nola.com, Nov. 8, 2021; Phillips 66, "Phillips 66 to Convert Alliance Refinery to Terminal Facility," Nov. 8, 2021,
[182] Harvest Midstream. "About Us: History, Our Story" Accessed June 25, 2024.
[183] William Taylor Potter, "Nearly 500 employees to be laid off from Belle Chasse Phillips 66 refinery", November 29, 2021.
[184] Phillips 66, "Ferndale Refinery Renewable Diesel Infrastructure Project Narrative", July 7, 2023.

related to production of petroleum products decrease, and changes to infrastructure may shift property tax revenue. GDP is expected to decline initially as production declines or ceases.

In the medium term, temporary construction jobs may peak, and significant reduction or total elimination of production jobs may be complete. Tax revenue is expected to stabilize, potentially with a sustained decline. Wages for displaced workers may stabilize at lower rates, and retained workers may see maintained wages provided oil demand supports the facility.

In the long term, any declines described above may be sustained or stabilized. Displaced workers may seek positions in the clean energy sector or at other refineries. Changes to tax revenue, GDP and refinery profits may stabilize, dependent on demand for oil and facility operations.

Scenario 6: Change in function and products; Combination of Scenarios 3 and 5

Scenario 6 forecasts that refineries might convert to production of sustainable fuels, such as AJF and/or renewable diesel. In addition, they might convert some of the current production space to become a storage or waypoint facility exporting petroleum products throughout the region. This is a combination of Scenarios 3 and 5.

For this scenario to become viable, a number of conditions would likely need to be met which would take a substantial amount of time to achieve. For example, demand for sustainable fuels would have to increase significantly and production by other suppliers would have to be insufficient, creating an opportunity and incentive for refineries to step in. Refineries would also have to conclude that the return on investment of their current production is insufficient, and demand for conventional fuels would have to decrease significantly in the coming years or decades.

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Scenario 6 describes a dual change at a refinery, wherein parts of the facility are converted for biofuel production and storage. This scenario is a combination of Scenarios 3 and 5 and is likely to have significant impacts to employment.

In the short term, it is expected that there will be initial job losses based on a transition from conventional fuel production to sustainable fuel production. There is some potential for construction and retrofitting positions to increase as facilities change use to support this transition. Additional storage facilities may also be developed, also driving this construction work. Retained workers can expect to maintain wages, but displaced workers are likely to place into lower paying positions. Depending on the stage of career for displaced workers, they may retrain into sustainable fuels production, jobs in the clean energy sector or transition into an early retirement. The high costs of restructuring operations and infrastructure are likely to negatively impact refinery infrastructure. The decline in production volume may decrease associated tax revenues, in addition to tax incentives utilized to support a transition to alternative fuels. The contribution to the State's GDP will depend on the volume of sustainable fuel production and is likely to decrease due to capacity limitations.

In the medium term, the net effect of jobs created by transition to sustainable fuel production could be positive, driven by the construction of new infrastructure or changes to existing infrastructure. Wages for workers who retrain into sustainable fuel production will likely have completed training for full operator pay rather than trainee pay. Displaced workers may have also completed retraining for new positions and see

some increase in wages, unlikely to match wages from conventional fuel production. Profits may rebound depending on demand for sustainable fuel and utilization of tax incentives. Tax revenue may remain low or rebound some. Tax revenue from storage operations may not offset tax revenue lost from the reduced production post transition, and incentives for sustainable fuel production may still be in place. Changes in GDP will demand on the volume of sustainable fuel production and overall activities at the converted facilities.

In the long term, each of these variables is likely to stabilize as operations become more stable, with some sustained decreases. Refinery profits may initially continue to improve in this time period as initial high costs begin to decline and incentives for sustainable fuel are utilized. Tax revenue may also increase as some tax incentives for sustainable fuel expire. Technological improvements and feedstock availability may also result in improvements to employment levels and GDP over time.

Scenario 7: Change in function: Closure and redevelopment

Scenario 7 is the closure of refinery facilities, with expected redevelopment. This scenario requires cleanup of refinery sites and transition of use. Heavy manufacturing sites must meet significant property remediation requirements before any redevelopment projects could move forward. Workers would relocate to new occupations, industries or regions, outlined in the workforce analysis section of this report. The tax base would change significantly in Washington. Legislative changes, business shifts and new development would occur across the region.

This scenario may be less likely to occur in the short term than previous scenarios but could occur if the underlying business requirements cannot be met by an operator. This is more likely in the long term after other possible operational modifications to production or function have been considered or attempted. For this scenario to occur, the refineries would have to conclude that their facilities have little or no potential to be profitable. A lack of profitability may result from too little demand for refinery products or increasingly stringent environmental policies, for example related to the cost of purchasing emissions allowances or of complying with clean fuels standards. Strong incentives for producers and investors to transition into the clean energy market or breakthroughs in clean energy and electric vehicle technology may also lead to the shutdowns described in this scenario.

Potential uses for refinery sites after closure are discussed in greater detail within Chapter 5 of this report.

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The scenario covers the closure of refinery facilities, with expected redevelopment by alternative industries after remediation activities are completed. This scenario would have extreme impacts on employees, potentially prompting relocation into new occupations or industries. Workers who remain in the refining industry may transfer to other facilities in the region or even outside of it.

In the short term, employment would sharply decline. Some workers may be laid off at a later interval than others as demolition or transition of the site may involve some short-term work. This would have a negative impact to wages, prompting job switching as workers find new positions in other refineries, industries or even regions. There would be no profit for the refineries in this situation and even potential losses based on the cost of site remediation. Dramatic declines to local and state tax revenue would occur as all taxes related to production and assessed value of the site stop collection. GDP would be negatively impacted as operations cease.

In the medium term, employment is expected to be at zero. Some positions may result from remediation activities, and planning for alternative site use may be underway. At this point, displaced workers will have transitioned into other industries or facilities. The site may contribute to some tax revenue from material costs used for remediation, but overall, no contribution to tax revenue and GDP is expected.

In the long term, employment is expected to remain low as monitoring of remediation efforts takes place. Alternative site usage may be in development, prompting construction and planning jobs as facilities are constructed. Overall, no expected contributions to GDP or tax revenue for a site undergoing remediation. Sites under development may contribute to GDP or tax revenue during construction activities or as new ventures are established.

Scenario 8: Change in function: Closure and no redevelopment

Scenario 8 is closure of refinery facilities, with remediation and no redevelopment for industrial use. Heavy manufacturing sites have significant property remediation and support of redevelopment. Workers would relocate to new occupations, industries or regions, as outlined in Chapter 4 of this report. Similar to Scenario 7, the tax base would change significantly in Washington. Legislative changes and business shifts would occur across the region.

This scenario may be less likely to occur in the short term than previous scenarios but could occur if the underlying business requirements cannot be met by an operator. This is more likely in the extreme long term after all possible operational modifications have been attempted.

For this scenario to occur, the refineries would have to conclude that their facilities have little or no potential to be profitable. Additionally, conversion to another use would have to not be viable, based on local permitting and zoning regulations. The sites could remain as habitat preserves or conservation-aimed uses. Additionally, several of the refineries are built on sites with cultural significance to local tribal nations, who are impacted by the presence of the refineries. Due to being located on sites of cultural significance, a return to tribal ownership is considered in alternative uses for refinery sites. Additional potential benefits to surrounding communities as a result of decreased pollutants are discussed within Chapter 5.

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This scenario is similar to Scenario 7, but without redevelopment of the site. In this scenario, the sites may be remediated with the goal of habitat preservation or conservation. Additionally, these sites may be remediated over time to a level where safe usage for cultural practices and harvesting on usual and accustomed land is possible.

In the short term, employment would sharply decline. Some workers may be laid off at a later interval than others as demolition or transition of the site may involve some short-term work. This would have a negative impact to wages, prompting job switching as workers find new positions in other refineries, industries or even regions. There would be no profit for the refineries in this situation and even potential losses based on the cost of site remediation. Dramatic declines to local and state tax revenue would occur as all taxes related to production and assessed value of the site stop collection. GDP would be negatively impacted as operations cease.

In the medium term, employment is expected to be at zero. Some positions may result from remediation activities, and planning for alternative site use may be underway. At this point, displaced workers will have

transitioned into other industries or facilities. The site may contribute to some tax revenue from material costs used for remediation, but overall no contribution to tax revenue and GDP is expected. Some long-term maintenance for monitoring and habitat development may begin as remediation activities begin. In the long term, employment is expected to remain low as monitoring of remediation efforts takes place. Overall, no expected contributions to GDP or tax revenue is expected for a site undergoing remediation or being monitored.

Projected Impacts of Demand Decline

This section utilizes IMPLAN Economic Impact Software to model eight different potential declines of refinery output, based on the demand projections and projected scenarios contained within this report. CEBR used real data to examine the impact of decline in refineries production output on the Washington economy. From IMPLAN, we obtained a total output valued at $29,249,428,120.27 for Petroleum and Coal Products Manufacturing in Washington as of 2022. This value may be greater than expected, as it is less granular than a six-digit North American Industry Classification System (NAICS) code. IMPLAN creates an industry code based on the Bureau of Economic Analysis' (BEA) Input-Output accounts, which allows them to aggregate NAICS codes into IMPLAN's Industries. This analysis uses IMPLAN Industry code 324 - Petroleum and Coal Products Manufacturing, which may capture slightly more than the five refineries located in Washington. Similarly, CEBR utilized IMPLAN's industry employment feature to model potential impacts of changes to the refineries' employment based on three change of use scenarios.

Wherever possible, each of these cases is grounded in a real world example or the projected petroleum demand declines at the beginning of Chapter 3.

Table 20: Production and employment decline case descriptions and reasoning

Case Label	IMPLAN Event Type	Decline Percentage	Description of Case Reasoning
Case 1.1	Industry Output	—	Reference case based on 2022 output at refineries
Case 1.2	Industry Output	6% decline	AEO Reference case for petroleum fuel consumption drop by 2050
Case 1.3	Industry Output	14% decline	High oil price based scenario for Washington petroleum fuel consumption drop by 2050
Case 1.4	Industry Output	95% decline	Scenario to model impact of CCA 95% emissions reduction goal, assuming a large reduction in Washington petroleum fuel consumption by 2050
Case 2.1	Industry Employment	—	Reference case based on 2022 employment at refineries
Case 2.2	Industry Employment	70% decline	Models conversion to biofuel refinery
Case 2.3	Industry Employment	85% decline	Models conversion to biofuel refinery
Case 2.4	Industry Employment	95% decline	Models conversion to storage facility

Industry Output Models

The work to inform this study included the creation of three cases of production, which then applied the "Industry Output Event" feature in IMPLAN to analyze the impact of these cases on the state. With this analysis, we focused on the impact on employment, labor income or wages and taxes. An important note is that the employment projections modeled here are not full time equivalents (FTEs), but rather an annual average that accounts for seasonality. IMPLAN utilizes the same definition for employment as the Bureau of Labor Statistics (BLS) and BEA. For each model, we also explored the linkage between the refinery sector and

other sectors in Washington's economy by ranking the sub-sectors that are impacted significantly by the reduction in petroleum production in the state. A total current production model is also displayed, to provide a frame of reference.

In particular, for the case 1.2 we assume a petroleum production decline of 6%. Using IMPLAN, we conduct an impact analysis of the 6% decline on the state economy through the variables described above. In case 1.3, we analyze the impact of a 14% decline in refineries' production on the state's economy. These cases were created utilizing projected declines in consumption, discussed in the projected fuel scenarios section.

Within this section, we also provide case 1.4, based on Washington's Climate Commitment Act (CCA). The CCA is a part of Washington's climate policy plan and commits the state to a statewide 95% reduction in greenhouse gas emissions by 2050. While not all these reductions must come from the petroleum refining industry, it is reasonable to expect that demand for conventional petroleum fuels will decline as compliance with CCA results in more alternative fuels and energy-based infrastructure development. This case assumes the 95% reduction in emissions results in a 95% reduction in production. This case also assumes that Washington can export petroleum products to other states, such as potential markets in Canada and Europe. While most exports currently go to states and provinces with their own statutory net-zero and GHG reduction requirements, it is reasonable to assume that some conventional refinery products would find a market in regions without these policies. These potential markets are discussed in more detail within another section of the report. This analysis does not conclude that to reach the CCA 95% reduction goal, there must be a 95% reduction in petroleum refinery production. However, these potential changes in demand are likely to result in changes to products or function at existing refineries, up to and including closure. This is explored through a more narrative lens in Chapter 2 of this report.

Industry Employment Models

Additionally, we utilized the "Industry Employment" model to analyze the impacts of potential use conversion scenarios on the Washington economy. These scenarios represent the conversion of existing petroleum refineries to biofuel refineries or storage facilities. A baseline employment level is modeled to provide a frame of reference for the current employment within the state. Notably, this number differs slightly from the baseline in the production model. Within this model, industry output is determined utilizing the industry's output per worker relationship to estimate direct effect values. The baseline employment is similar to existing estimates of total employment at Washington's refineries and was used for internal consistency.

The first two cases are both based on a refinery transition to biofuel production. Case 2.2, a 70% decline in employment, is based on the conversion of the HF Sinclair refinery in Cheyenne, Wyoming. Prior to conversion to biofuels, the Cheyenne refinery employed a reported 280 employees, which decreased to 80 employees when biofuel production began.[185] Case 2.3, an 85% decline in employment, is based on the conversion of the Marathon refinery in Martinez, California. Prior to conversion, the Martinez refinery employed 740 employees,[186] but reportedly employs 110 employees now that it produces biofuels.

Case 2.4 is based on a transition to a storage facility. While this does not necessarily exclude some production at the facility, the example referenced for this case ceased production. The Phillips 66 refinery transitioned to an oil terminal in 2020 after damage sustained during Hurricane Ida. The refinery was deemed too expensive

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[185] McKim, Cooper. "Cheyenne Refinery Announces ~200 Layoffs", Wyoming Public Radio, June 1, 2020.
[186] Goldberg, Ted, "Shutdown of Marathon's Martinez Refinery Prompts Calls for 'Just Transition' for Oil Workers', KQED, August 3, 2020; Angst, Maggie, "After a Martinez refinery closure, laid-off fossil fuel workers got hit with a 'gut punch'", Sacramento Bee via Red Bluff Daily News, April 27, 2023.

to repair, prompting the change in use and later sale to Harvest Midstream. Prior to the shift, the Belle Chasse refinery had 500 employees,[187] while it now operates with a reported 30 employees as a storage terminal.

These employment decline estimates do not include contractor employment at refinery sites. Depending on refinery operations and design, contractors can double the number of workers on site. For turnarounds and other significant maintenance activities, contractors can triple the number of workers on site. Contractors are an important part of refinery operations, but the inconsistent nature of their presence creates difficulty in capturing their impacts. These examples were chosen due to the publicly available data showing their pre-conversion and post-conversion employment numbers, how recently they were complete and for their location within the United States. There is a limited pool of references available for reference when discussing completed conversions of conventional refineries to storage terminals or biofuel refineries. As such, the employment modeling is grounded in these real-world examples.

Impact Analysis Results Part A: Production Decline

Part A of this report illustrates the projected impact of three cases of petroleum production decline at the refineries. In Part A, an analysis of the economic impacts of 6%, 14% and 95% declines in petroleum production is provided. It also includes a "current" production level case, which uses 2022 production level data to help orient the comparisons provided. For the purposes of this section, any scenario or information described as "current" should be understood to be based on 2022 output data.

Within this section, supplemental analysis about the potential health impacts of each scenario have been included for Cases 1.2 to 1.4. To do this, the Environmental Protection Agency (EPA) CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) was used. To quantify impacts, the same percentage decline in production was used for each assessed pollutant. COBRA is a tool used to explore how changes in air pollution can affect human health, and provide estimates of the economic value of these health benefits. [188] Discussion related to specific health impacts and current economic valuation is include in Chapter 5. While the tables only present results for Washington as a whole, Pierce County, Skagit County, and Whatcom County, air pollution is not restricted to a single jurisdiction and does not observe county or state lines. Each of the scenarios focused on pollutant reductions in Washington as a result of "Petroleum Refineries & Related Industries". The positive values in the table represent the annual reductions in the number of cases and avoided associated costs. COBRA modeling presents "Low" and "High" values based on differences in methods to calculate some health impacts.[189]

Overview of Effects

Table 21 summarizes the estimated direct effects of each production decline scenario as well as the baseline scenario, or current production level scenario. The table shows the projected impacts to five variables: employment, labor income, value added, output and tax revenue.

The “Current Production Levels” column shows the direct economic impacts refineries currently have on Washington. As shown, current production activity directly supports about 2,495 jobs, about $734.04 million in labor income, about $7.37 billion in value added, $29.25 million in output and $540.94 million in tax revenue. This value for direct jobs is higher than IMPLAN's estimated employment and other estimates for direct

[187] William Taylor Potter, “Nearly 500 employees to be laid off from Belle Chasse Phillips 66 refinery”, November 29, 2021
[188] Environmental Protection Agency, "What is COBRA?", April 23, 2024. What is COBRA? | US EPA
[189] Read more about COBRA and it's methodology here: COBRA Questions and Answers | US EPA

employment. This is a function of the output employment relationship within IMPLAN's model, which has a set ratio of output to employee.

Each of the "Case" columns shows the direct impact of the respective decline scenario. As the table demonstrates, the larger the production decline, the greater the estimated impact to each of the variables. Case 1.2 is estimated to have the mildest impact on the variables, while Case 1.4 is estimated to have to most significant impact. Case 1.4, a 95% decline in production, is intended to capture the impacts of the Climate Commitment Act on refinery production.

Table 21: Summary of Direct Effects by Industry Output IMPLAN Model, Cases 1.1 to 1.4.

Direct Effect	Current Production Levels, Case 1.1	Case 1.2: 6% Production Decline	Case 1.3: 14% Production Decline	Case 1.4: 95% Production Decline
Employment	2494.55	-149.67	-349.24	-2,220.15
Labor Income	$734,039,323	-$44,042,359	-$102,765,505	-$653,294,997
Value Added	$7,365,066,054	-$441,903,963	-$1,031,109,248	-$6,554,908,787
Output	$29,249,428,120	-$1,754,965,687	-$4,094,919,937	-$26,031,991,027
Total Impact to Tax Revenue	$540,940,328	-$32,456,420	-$75,731,646	-$481,436,892

Case 1.1 represents estimated economic impacts based on IMPLAN's current industry output value. This is intended to provide a reference case to compare against the declines in Cases 1.2 through 1.4.

Table 22 shows the employment and labor income multipliers derived from the estimated direct, indirect and induced employment and labor income effects.

The Type 1 multiplier represents the number of jobs (or, in the case of labor income, dollars of labor income) indirectly created by each direct job (or direct dollar of labor income). This type of multiplier does not consider induced jobs or income. The Type 1 Employment Multiplier of 8.49 suggests that each refinery job is estimated to indirectly create 8.49 additional jobs. The Labor Income multiplier of 3.52 suggests that each dollar of labor income earned directly at refineries is estimated to indirectly create 3.52 additional dollars of labor income elsewhere in the economy.

The SAM Multiplier considers induced jobs as well as directly and indirectly created jobs. The SAM Employment Multiplier of 12.28 suggests that each direct refinery job is estimated to create 12.28 total jobs elsewhere in the economy, either indirectly or through induction. The SAM Labor Income Multiplier of 4.44 suggests that each dollar of labor income earned at the refineries is estimated to create a total of 4.44 additional dollars of labor income, either indirectly or through induction.

Table 22: Employment and Labor Income Multipliers

Multiplier Type	Employment	Labor Income
Type 1 Multiplier	8.49	3.52
SAM Multiplier	12.28	4.44

Case 1.1: Current Production Levels

Table shows the economic conditions supported by current petroleum refinery production levels. Current production is estimated to directly support 2,494 jobs, $734.04 million in labor income (inclusive of benefits), $7.37 billion in value added and $29.25 billion in output. These direct impacts of the refineries have cascading effects, indirectly creating and inducing further employment, income, value added and output in other parts of the economy. The total number of jobs supported by current production is estimated to be 30,640, and the total amount of labor income supported is $3.26 billion. The table further breaks down the effects of current production.

Table 23: Summary Impacts of Case 1.1, Current Production Levels

Impact	Employment	Labor Income	Value Added	Output
Direct	2,494.55	$734,039,323	$7,365,066,054	$29,249,428,120
Indirect	18,694.75	$1,852,519,150	$3,521,958,680	$7,339,893,114
Induced	9,451.58	$671,520,600	$1,277,735,577	$2,051,658,328
Total	30,640.88	$3,258,079,073	$12,164,760,311	$38,640,979,562

Table 24 lists the five industries estimated to be most impacted by current production in order of jobs supported, including indirect and induced effects. Looking at employment, the wholesale trade sector is ranked as the most supported industry, with an estimated 2,853 jobs indirectly supported by the refineries. Across all industries, an estimated 30,641 jobs are supported.

Table 24: Case 1.1, Top Five Industries Supported at Current Production Levels, Ranked by Estimated Impact to Employment.

Industry	Direct (Impact Employment)	Indirect (Impact Employment)	Induced (Impact Employment)	Total (Impact Employment)
Wholesale Trade	0	2,608.19	244.85	2,853.04
Professional, Scientific and Technical Services	0	2,219.21	409.31	2,628.52
Petroleum and Coal Products Manufacturing	2494.55	111.45	3	2,609.01
Administrative and Support Services	0	1,794.57	389.43	2,184
Construction	0	2,068.96	107.75	2,176.71

Industry	Direct (Impact Employment)	Indirect (Impact Employment)	Induced (Impact Employment)	Total (Impact Employment)
All 88 Industries	2494.55	18,694.74	9,451.56	30,640.88

Table 25: shows the estimated direct, indirect, induced and total tax impacts of current refinery production. The effects are further organized by the level of government for each tax. IMPLAN's modeling includes values for direct, indirect and induced effects as a total within this table. While IMPLAN does its best to capture all potential taxes, this may not be inclusive of all applicable taxes based on variation at the county and local level. IMPLAN estimates for Case 1.1 result in an estimated $540.94 million in tax revenue directly and $1.73 billion in total.

Table 25: Case 1.1, Estimated Tax Revenue at Current Production Levels.

Impact	Sub County General	Sub County Special Districts	County	State	Federal	Total
Direct	$13,872,487	$21,972,380	$11,205,939	$89,538,016	$404,351,507	$540,940,328
Indirect	$38,325,202	$60,701,374	$30,957,913	$246,861,064	$494,979,452	$871,825,006
Induced	$13,817,501	$21,884,627	$11,161,315	$89,016,764	$180,114,105	$315,994,312
Total	$66,015,191	$104,558,381	$53,325,167	$425,415,844	$1,079,445,064	$1,728,759,646

Case 1.2: A 6% Decline in Production

Table 26: summarizes the direct, indirect and induced impacts of the first production decline scenario in which the refineries reduce production by 6%. The estimated impacts of this scenario are direct declines in employment, labor income and output. These direct negative impacts are estimated to create additional indirect and induced impacts.

Considering direct, indirect and induced impacts, Case 1.2 is estimated to cause a 6% decline in total employment, labor income, value added and output.

Table 26: Case 1.2, Summary Impacts of a 6% decline in Production.

Impact	Employment	Labor Income	Value Added	Output
Direct	-149.67	-$44,042,359	-$441,903,963	-$1,754,965,687
Indirect	-1121.69	-$111,151,149	-$211,317,521	-$440,393,587
Induced	-567.09	-$40,291,236	-$76,664,135	-$123,099,500
Total	-1838.45	-$195,484,744	-$729,885,619	-$2,318,458,773

Table 27: 7 contains estimated job losses for Case 1.2. Consistent with Case 1.1, wholesale trade has the largest estimate impact with a loss of 171 jobs. The professional, scientific and technical services industry was estimated to lose 157 jobs, and petroleum and coal products manufacturing was estimated to lose 156

jobs. An estimated 130 jobs are lost in the construction industry, following the loss of 131 jobs in administrative and support services. Across all industries, 1,838 jobs were estimated to be lost. Of these 1,838 jobs, 1,689 are from indirect or induced effects.

Table 27: Case 1.2, Top Five Industries Ranked by Estimated Impact to Employment under 6% decline in Production.

Industry	Direct (Impact Employment)	Indirect (Impact Employment)	Induced (Impact Employment)	Total (Impact Employment)
Wholesale Trade	0	-156.49	-14.69	-171.18
Professional, Scientific and Technical Services	0	-133.15	-24.56	-157.71
Petroleum and Coal Products Manufacturing	-149.67	-6.69	-0.18	-156.54
Administrative and Support Services	0	-107.67	-23.37	-131.04
Construction	0	-124.14	-6.47	-130.6
All 88 Industries	-149.67	-1,121.65	-567.06	-1,838.45

Table 28: 7 shows the estimated direct, indirect, induced and total tax impacts of a 6% decline in refinery production. The effects are further organized by the level of government for each tax. IMPLAN's modeling includes values for direct, indirect and induced effects as a total within this table. While IMPLAN is relatively comprehensive in capturing and reflecting changes to all potential taxes, this may not be inclusive of all applicable taxes based on variation at the county and local level. IMPLAN estimates for Case 1.2 a direct decline of $32.46 million in tax revenue, while total tax revenue across all levels of government was estimated to decline by $103.73 million.

Table 28: Case 1.2, Estimated Tax Revenue Loss from a 6% decline in Production.

Impact	Sub County General	Sub County Special Districts	County	State	Federal	Total
Direct	-$832,349	-$1,318,342	-$672,356	-$5,372,280	-$24,261,090	-$32,456,419
Indirect	-$2,299,512	-$3,642,082	-$1,857,474	-$14,811,663	-$29,698,767	-$52,309,500
Induced	-$829,050	-$1,313,077	-$669,678	-$5,341,005	-$10,806,846	-$18,959,658
Total	-$3,960,911	-$6,273,502	-$3,199,509	-$25,524,950	-$64,766,703	-$103,725,578

Table 29 contains the estimated monetary value of avoided healthcare costs over a year from reduced emissions in 2023. This model estimates the changes of $PM_{2.5}$ and ozone (O_3) based on changes to emitted $PM_{2.5}$, SO_2, NO_x, and VOCs. COBRA then presents a range of values for health incomes based on the modeled changes in air quality. Air pollutants do not observe state or county lines, so the model provides values for the contiguous United States. This report focuses on Washington as a whole and counties that house petroleum refineries. The low estimates for the monetary value of a 6% decrease in key pollutants are $1 million, with a high estimate of $1.6 million in 2023 dollars. This estimate is the result of a combination of willingness-to-pay values for reducing negative health outcomes or cost-of-illness estimates, using the value of a statistical life.

For more information about this methodology, please refer to the EPA COBRA page.[190] Estimates of county impacts range from $90 thousand to $160 thousand for low values, and $150 thousand to $280 thousand for high values.

Table 29: COBRA estimates of health impacts and economic value of avoided costs of a 6% decrease in pollutants from petroleum refineries.

Impact	Pierce County	Skagit County	Whatcom County	Washington
Monetary value* of total health effects, Low	$92,000	$90,000	$160,000	$1,000,000
Monetary value* of total health effects, High	$150,000	$150,000	$280,000	$1,600,000
Changes in Incidence**, Minor Restricted Activity Days ($PM_{2.5}$)	2.4	1.9	5.9	31
Changes in Incidence**, Asthma Onset and Symptoms	5.534	2.918	7.244	55.34

*Monetary value is calculated in 2023 dollars annually. This value is based on the healthcare costs of the health endpoint and willingness to pay to avoid the health endpoint.
**Incidence refers to the number of new cases of a health endpoint over a specified period of time, based on statistical risk reductions aggregated over the population.
The complete table of results for Washington from this COBRA analysis can be found in Appendix B.

Case 1.3: A 14% Decline in Production

Table 30 summarizes the direct, indirect and induced impacts of Case 1.3 in which the refineries reduce production by 14%. Similar to Case 1.2, the estimated impacts of Case 1.3 are direct declines in employment, labor income, value added and output. The direct negative impacts are estimated to create additional indirect and induced impacts.

Considering direct, indirect and induced impacts, Case 1.3 is estimated to cause a 14% decline in total employment, labor income, value added and output.

Table 30: Case 1.3, Summary Impacts of a 14% decline in production.

Impact	Employment	Labor Income	Value Added	Output
Direct	-349.24	-$102,765,505	-$1,031,109,248	-$4,094,919,937
Indirect	-2,617.27	-$259,352,681	-$493,074,215	-$1,027,585,036
Induced	-1,323.22	-$94,012,884	-$178,882,981	-$287,232,166
Total	-4,289.72	-$456,131,070	-$1,703,066,444	-$5,409,737,139

[190] Read more about COBRA and it's methodology here: COBRA Questions and Answers | US EPA

Case 1.3 remains consistent with Case 1.1 and Case 1.2. Looking at job loss, wholesale trade was estimated to see the largest impact, losing an estimated 399 jobs. Professional, scientific and technical services was estimated to lose 368 jobs, and petroleum and coal products manufacturing was estimated to lose 365 jobs. Across all industries, 4,289 jobs were estimated to be lost.

Table 31: Case 1.3, Top Five Industries Ranked by Estimated Impact to Employment for a 14% decline in production

Industry	Direct (Impact Employment)	Indirect (Impact Employment)	Induced (Impact Employment)	Total (Impact Employment)
Wholesale Trade	0	-365.15	-34.28	-399.43
Professional, Scientific and Technical Services	0	-310.69	-57.3	-367.99
Petroleum and Coal Products Manufacturing	-349.24	-15.6	-0.42	-365.26
Administrative and Support Services	0	-251.24	-54.52	-305.76
Construction	0	-289.65	-15.09	-304.74
All 88 Industries	-349.24	-2,617.25	-1,323.23	-4,289.72

Table 322 shows the estimated direct, indirect, induced and total tax impacts of Case 1.3. The 14% production decline was estimated to directly cause a $75.73 million decline in tax revenue, while total tax revenue (the sum of direct, indirect and induced tax revenues) was estimated to decline by $242.03 million.

Table 32: Case 1.3, Estimated Tax Revenue Loss from a 14% decline in production.

Impact	Sub County General	Sub County Special Districts	County	State	Federal	Total
Direct	-$1,942,148	-$3,076,133	-$1,568,831	-$12,535,322	-$56,609,211	-$75,731,646
Indirect	-$5,365,528	-$8,498,192	-$4,334,108	-$34,560,549	-$69,297,123	-$122,055,501
Induced	-$1,934,450	-$3,063,848	-$1,562,584	-$12,462,347	-$25,215,975	-$44,239,204
Total	-$9,242,127	-$14,638,173	-$7,465,523	-$59,558,218	-$151,122,309	-$242,026,350

Table 33contains the estimated monetary value of avoided healthcare costs over a year from reduced emissions in 2023. This model estimates the changes of $PM_{2.5}$ and ozone (O_3) based on changes to emitted $PM_{2.5}$, SO_2, NO_x, and VOCs. COBRA then presents a range of values for health incomes based on the modeled changes in air quality. Air pollutants do not observe state or county lines, so the model provides values for the contiguous United States. This report focuses on Washington as a whole and counties that house petroleum refineries. The low estimates for the monetary value of a 14% decrease in key pollutants are $2.4 million, with a high estimate of $3.8 million in 2023 dollars. Estimates of county impacts range from $210 thousand to $380 thousand for low values, and $340 thousand to $640 thousand for high values.

Table 33: Case 1.3, COBRA estimates of health impacts and economic value of avoided costs of a 14% decrease in pollutants from petroleum refineries.

Impact	Pierce County	Skagit County	Whatcom County	Washington
Monetary value* of total health effects, Low	$220,000	$210,000	$380,000	$2,400,000
Monetary value* of total health effects, High	$340,000	$340,000	$640,000	$3,800,000
Changes in Incidence**, Minor Restricted Activity Days ($PM_{2.5}$)	5.7	4.4	14	73
Changes in Incidence**, Asthma Onset and Symptoms	13.08	6.842	17.1	130.8

*Monetary value is calculated in 2023 dollars annually. This value is based on the healthcare costs of the health endpoint and willingness to pay to avoid the health endpoint.

**Incidence refers to the number of new cases of a health endpoint over a specified period of time, based on statistical risk reductions aggregated over the population.

The complete table of results for Washington from this COBRA analysis can be found in Appendix B.

Case 1.4: A 95% Decline in Production

Table 34 summarizes the direct, indirect, and induced impacts of Case 1.4 in which the refineries reduce production by 95 percent. The estimated impacts of Case 1.4 are direct declines in employment, labor income, value added, and output. The direct negative impacts are estimated to create additional indirect and induced impacts. This case is intended to help capture potential impacts from the target 95% reduction in GHG emissions driven by the CCA. This case represents some of the most extreme potential impacts, and does not include information on how this reduction might be achieved or its feasibility.

Table 34: Case 1.4, Summary Impacts of a 95% decline in production

Impact	Employment	Labor Income	Value Added	Output
Direct	-2220.15	-$653,294,997.52	-$6,554,908,787.84	-$26,031,991,027.04
Indirect	-16638.33	-$1,648,742,043.50	-$3,134,543,225.33	-$6,532,504,871.24
Induced	-8411.91	-$597,653,334.38	-$1,137,184,663.59	-$1,825,975,911.93
Total	-27270.39	-$2,899,690,375.41	-$10,826,636,676.76	-$34,390,471,810.21

Case 1.4 remains consistent with previous cases, albeit with much larger impacts. Looking at job loss, wholesale trade was estimated to see the largest impact, losing an estimated 2,539 jobs. Professional, scientific, and technical services was estimated to lose 2,339 jobs, and petroleum and coal products manufacturing was estimated to lose 2,322 jobs. Across all industries, 27,270 jobs were estimated to be lost.

Table 35: Case 1.4, Top Five Industries Ranked by Estimated Impact to Employment for a 95% decline in production

Industry	Direct (Impact Employment)	Indirect (Impact Employment)	Induced (Impact Employment)	Total (Impact Employment)
Wholesale Trade	0	-2321.29	-217.92	-2539.21
Professional, Scientific, and Technical Services	0	-1975.1	-364.28	-2339.38
Petroleum and Coal Products Manufacturing	-2220.15	-99.19	-2.67	-2322.02
Construction	0	-1841.37	-95.9	-1937.27
Truck Transportation	0	-1862.33	-67.97	-1930.31
All 88 Industries	-2220.15	-16638.32	-8411.96	-27270.39

Table 36 shows the estimated direct, indirect, induced, and total tax impacts of Case 1.4. The 95% production decline was estimated to directly cause a $481.44 million decline in tax revenue, while total tax revenue (the sum of direct, indirect, and induced tax revenues) was estimated to decline by $1.54 billion.

Table 36: Case 1.4, Estimated Tax Revenue Loss from a 95% decline in production.

Impact	Sub County General	Sub County Special Districts	County	State	Federal	Total
Direct	-$12,346,513.34	-$19,555,417.95	-$9,973,285.39	-$79,688,834.36	-$359,872,840.96	-$481,436,892.00
Indirect	-$34,109,430.19	-$54,024,222.97	-$27,552,542.82	-$219,706,346.74	-$440,531,712.54	-$775,924,255.26
Induced	-$12,297,576.17	-$19,477,318.11	-$9,933,570.05	-$79,224,920.25	-$160,301,553.10	-$281,234,937.69
Total	-$58,753,519.70	-$93,056,959.03	-$47,459,398.26	-$378,620,101.35	-$960,706,106.60	-$1,538,596,084.94

Table 37 contains the estimated monetary value of avoided healthcare costs over a year from reduced emissions in 2023. This model estimates the changes of $PM_{2.5}$ and ozone (O_3) based on changes to emitted $PM_{2.5}$, SO_2, NO_x, and VOCs. COBRA then presents a range of values for health incomes based on the modeled changes in air quality. Air pollutants do not observe state or county lines, so the model provides values for the contiguous United States. This report focuses on Washington as a whole and counties that house petroleum refineries. The low estimates for the monetary value of a 95% decrease in key pollutants are $16 million, with a high estimate of $26 million in 2023 dollars. For each county, low estimates range between $1.4 million and $2.6 million while $2.3 million and $4.4 million.

Table 37: Case 1.4, COBRA estimates of health impacts and economic value of avoided costs of a 95% decrease in pollutants from petroleum refineries.

Impact	Pierce County	Skagit County	Whatcom County	Washington
Monetary value* of total health effects, Low	$1,500,000	$1,400,000	$2,600,000	$16,000,000

Impact	Pierce County	Skagit County	Whatcom County	Washington
Monetary value* of total health effects, High	$2,300,000	$2,300,000	$4,400,000	$26,000,000
Changes in Incidence**, Minor Restricted Activity Days ($PM_{2.5}$)	38	30	93	500
Changes in Incidence**, Asthma Onset and Symptoms	87.54	46.28	110.69	875.4

*Monetary value is calculated in 2023 dollars annually. This value is based on the healthcare costs of the health endpoint and willingness to pay to avoid the health endpoint.
**Incidence refers to the number of new cases of a health endpoint over a specified period of time, based on statistical risk reductions aggregated over the population.
The complete table of results for Washington from this COBRA analysis can be found in Appendix B.

Impact Analysis Results Part B: Employment Decline

Part B of this report illustrates the projected impact of three cases of employment decline at the refineries. In Part B, an analysis of the economic impacts of a 70%, 85% and 95% decline in refinery employment. The 70% and 85% employment decline scenarios assume employment loss due to conventional refineries converting to biofuel refineries, while the 95% employment decline scenario assumes employment loss due to conversion to storage terminal facilities. These decline estimates are based on real world examples of before and after conversion employment at other U.S. refineries. See the methodology section for more information on how these scenarios were designed. It also includes a "current" employment level case, which uses 2022 data to help orient the comparisons provided. For the purposes of this section, any scenario or information described as "current" should be understood to be based on 2022 employment data.

Overview of Effects

Table 38 summarizes the estimated direct effects of each employment decline scenario as well as the baseline scenario, or current employment level scenario. The table shows the projected impacts to five variables: employment, labor income, value added, output and tax revenue.

The “Current Employment Levels” column shows the direct economic impacts refineries currently have on Washington. As shown, current production activity directly supports about 2,155 jobs, about $634.28 million in labor income, about $6.36 billion in value added, $25.27 million in output and $467.42 million in tax revenue. It is important to note that these results are slightly lower than the previous baseline case. IMPLAN utilizes a linear output per employee value. In this case, the discrepancy is a result of the reported employees in IMPLAN's system (which is relatively closely aligned with employment estimates pf 2,200 employees) not accounting for the full output value. CEBR chose to use the employment number reported within IMPLAN for internal consistency.

Each of the “Case” columns shows the direct impact of the respective decline scenario. As the table demonstrates, the larger the production decline, the greater the estimated impact to each of the variables. Case 2.2 is estimated to have the smallest impact on the variables, while Case 2.4 is estimated to have to most significant impact. However, all of these changes are quite extreme. These scenarios were developed to help better relay the impacts of Scenarios 4-8, in section three of this chapter.

This analysis utilizes total employment across all five refineries, while in reality it is unlikely that all five refineries would make these transitions at the same time.

Table 38: Summary of Direct Effects by Industry Employment IMPLAN Model, Cases 2.1 to 2.4.

Direct Effect	Current Employment Levels, Case 2.1	Case 2.2: 70% Employment Decline	Case 2.3: 85% Employment Decline	Case 2.4: 95% Employment Decline
Employment	2,155.53	-1,508.87	-1,832.20	-2,047.75
Labor Income	$634,279,766	-$443,995,836	-$539,137,801	-$602,565,778
Value Added	$6,364,117,323	-$4,454,882,126	-$5,409,499,725	-$6,045,911,457
Output	$25,274,286,861	-$17,692,000,803	-$21,483,143,832	-$24,010,572,518
Total Impact to Tax Revenue	$467,423,875	-$327,196,712	-$397,310,294	-$444,052,681

Case 2.1: Current Employment Levels

Table 39 shows the economic conditions supported by current petroleum refinery employment levels. Current employment is estimated to directly support 2,155 jobs, $634.28 million in labor income (inclusive of benefits), $6.36 billion in value added and $25.27 billion in output. These direct impacts of the refineries have cascading effects, indirectly creating and inducing further employment, income, value added and output in other parts of the economy. The total number of jobs supported by current production is estimated to be 26,476 and the total amount of labor income supported is $2.82 billion. The table further breaks down the effects of current employment.

Table 39: Summary Impacts of Case 2.1, Current Employment Levels.

Impact	Employment	Labor Income	Value Added	Output
Direct	2,155.53	$634,279,766	$6,364,117,323	$25,274,286,861
Indirect	16,154.04	$1,600,752,679	$3,043,307,159	$6,342,365,510
Induced	8,167.06	$580,257,645	$1,104,085,023	$1,772,827,862
Total	26,476.64	$2,815,290,090	$10,511,509,505	$33,389,480,233

Table 40 lists the five industries estimated to be most impacted by current production in order of jobs supported, including indirect and induced effects. Looking at employment, the wholesale trade sector is ranked as the most supported industry, with an estimated 2,254 jobs indirectly supported by the refineries. Professional, scientific and technical services support an estimated 2,465 jobs, and petroleum and coal products manufacturing support an estimated 2,254 jobs. Across all industries, an estimated 26,477 jobs are supported.

Table 40: Case 2.1, Top Five Industries Supported at Current Employment Levels, Ranked by Estimated Impact to Employment.

Industry	Direct (Impact Employment)	Indirect (Impact Employment)	Induced (Impact Employment)	Total (Impact Employment)
Wholesale Trade	2,155.53	96.30	2.59	2,254.43
Professional, Scientific and Technical Services	0.00	2,253.72	211.58	2,465.30
Petroleum and Coal Products Manufacturing	0.00	1,917.61	353.68	2,271.29
Administrative and Support Services	0.00	1,808.13	65.99	1,874.12
Construction	0.00	1,787.78	93.11	1,880.88
All 88 Industries	2155.53	16153.99	8167.08	26,476.64

Table 41 shows the estimated direct, indirect, induced and total tax impacts of current refinery production. The effects are further organized by the level of government for each tax. IMPLAN's modeling includes values for direct, indirect and induced effects as a total within this table. While IMPLAN is relatively comprehensive in including all potential taxes, this may not be inclusive of all applicable taxes based on variation at the county and local level. IMPLAN estimates for Case 2.1 result in an estimated $467.42 million in tax revenue directly and $1.49 billion in total.

Table 41: Case 2.1, Estimated Tax Revenue at Current Employment Levels.

Impact	Sub County General	Sub County Special Districts	County	State	Federal	Total
Direct	$11,987,148	$18,986,225	$9,682,996	$77,369,359	$349,398,147	$467,423,875
Indirect	$33,116,619	$52,451,759	$26,750,580	$213,311,430	$427,709,308	$753,339,696
Induced	$11,939,635	$18,910,399	$9,644,437	$76,918,948	$155,635,711	$273,049,130
Total	$57,043,401	$90,348,382	$46,078,104	$367,599,737	$932,743,166	$1,493,812,700

Case 2.2: A 70% Decline in Employment

Table 42 summarizes the direct, indirect and induced impacts of the first employment decline scenario in which the refineries reduce employment by 70% through conversion to a biofuel refinery. The estimated impacts of this scenario are direct declines in employment, labor income and output. These direct negative impacts are estimated to create additional indirect and induced impacts.

Considering direct, indirect and induced impacts, Case 2.2 is estimated to cause a 70% decline in total labor income, total value added and total output in addition to the 70% decline in total employment.

Table 42: Case 2.2, Summary Impacts of a 70% decline in Employment.

Impact	Employment	Labor Income	Value Added	Output
Direct	-1,508.87	-$443,995,836	-$4,454,882,126	-$17,692,000,803
Indirect	-11,307.83	-$1,120,526,875	-$2,130,315,011	-$4,439,655,857
Induced	-5,716.95	-$406,180,352	-$772,859,516	-$1,240,979,504
Total	-18,533.65	-$1,970,703,063	-$7,358,056,653	-$23,372,636,163

Table 43 contains estimated job losses for Case 2.2. Consistent with Case 2.1, wholesale trade has the largest estimate impact with a loss of 1,725 jobs. The professional, scientific and technical services industry was estimated to lose 1,589 jobs, and petroleum and coal products manufacturing was estimated to lose 1,578 jobs. An estimated 1,311 jobs are lost in the construction industry, just after the loss of 1,316 jobs in administrative and support services. Across all industries, 18,533 jobs were estimated to be lost. Of these 18,533 jobs lost, 17,025 are from indirect or induced effects.

Table 43: Case 2.2, Top Five Industries Ranked by Estimated Impact to Employment under 70% decline in Employment.

Industry	Direct (Impact Employment)	Indirect (Impact Employment)	Induced (Impact Employment)	Total (Impact Employment)
Wholesale Trade	0	-1577.6	-148.1	-1725.71
Professional, Scientific and Technical Services	0	-1342.32	-247.58	-1589.9
Petroleum and Coal Products Manufacturing	-1508.87	-67.41	-1.82	-1578.1
Administrative and Support Services	0	-1251.44	-65.18	-1316.62
Construction	0	-1265.69	-46.2	-1311.89
All 88 Industries	-1508.87	-11307.8	-5716.95	-18533.65

Table shows the estimated direct, indirect, induced and total loss of tax revenue based on a 70% decline in employment. The effects are further organized by the level of government for each tax. IMPLAN's modeling includes values for direct, indirect and induced effects as a total within this table. While IMPLAN is relatively comprehensive in including all potential taxes, this may not be inclusive of all applicable taxes based on variation at the county and local level. IMPLAN estimates for Case 2.2 a direct decline of $327.2 million in tax revenue, while total tax revenue across all levels of government was estimated to decline by $1.05 billion.

Table 44: Case 1.2, Estimated Tax Revenue Loss from a 70% Decline in Employment.

Impact	Sub County General	Sub County Special Districts	County	State	Federal	Total
Direct	-$8,391,003	-$13,290,358	-$6,778,098	-$54,158,551	-$244,578,703	-$327,196,712

Impact	Sub County General	Sub County Special Districts	County	State	Federal	Total
Indirect	-$23,181,633	-$36,716,231	-$18,725,406	-$149,318,001	-$299,396,516	-$527,337,787
Induced	-$8,357,744	-$13,237,279	-$6,751,106	-$53,843,264	-$108,944,998	-$191,134,391
Total	-$39,930,381	-$63,243,868	-$32,254,610	-$257,319,816	-$652,920,216	-$1,045,668,890

Case 2.3: An 85% Decline in Employment,
Table summarizes the direct, indirect and induced impacts of the first employment decline scenario in which the refineries reduce employment by 85% through conversion to a biofuel refinery. The estimated impacts of this scenario are direct declines in employment, labor income and output. These direct negative impacts are estimated to create additional indirect and induced impacts.

Considering direct, indirect and induced impacts, Case 2.3 is estimated to cause an 85% decline in total labor income, total value added and total output in addition to the 85% decline in total employment.

Table 45: Case 2.3, Summary Impacts of an 85% decline in Employment.

Impact	Employment	Labor Income	Value Added	Output
Direct	-1,832.20	-$539,137,801	-$5,409,499,725	-$21,483,143,832
Indirect	-13,730.94	-$1,360,639,777	-$2,586,811,085	-$5,391,010,683
Induced	-6,942.00	-$493,218,996	-$938,472,269	-$1,506,903,683
Total	-22,505.14	-$2,392,996,576	-$8,934,783,079	-$28,381,058,198

Case 2.3 remains consistent with Case 2.1 and Case 2.2. Looking at job loss, wholesale trade was estimated to see the largest impact, losing an estimated 2,095 jobs. Professional, scientific and technical services was estimated to lose 1,930 jobs, and petroleum and coal products manufacturing was estimated to lose 1,916 jobs. Across all industries, 22,505 jobs were estimated to be lost.

Table 46: Case 2.3, Top Five Industries Ranked by Estimated Impact to Employment for an 85% decline in Employment.

Industry	Direct (Impact Employment)	Indirect (Impact Employment)	Induced (Impact Employment)	Total (Impact Employment)
Wholesale Trade	0	-1915.66	-179.84	-2,095.5
Professional, Scientific and Technical Services	0	-1629.97	-300.63	-1,930.59
Petroleum and Coal Products Manufacturing	-1832.2	-81.86	-2.2	-1,916.26
Administrative and Support Services	0	-1519.61	-79.14	-1,598.75
Construction	0	-1536.91	-56.1	-1,593

Industry	Direct (Impact Employment)	Indirect (Impact Employment)	Induced (Impact Employment)	Total (Impact Employment)
All 88 Industries	-1832.2	-13730.92	-6942.01	-22,505.14

Table 47 shows the estimated direct, indirect, induced and total tax impacts of Case 2.3. The 85% production decline was estimated to directly cause a $397.31 million decline in tax revenue, while total tax revenue (the sum of direct, indirect and induced tax revenues) was estimated to decline by $1.27 billion.

Table 47: Case 2.3, Estimated Tax Revenue Loss from an 85% decline in Employment.

Impact	Sub County General	Sub County Special Districts	County	State	Federal	Total
Direct	-$10,189,076	-$16,138,291	-$8,230,547	-$65,763,955	-$296,988,425	-$397,310,294
Indirect	-$28,149,126	-$44,583,995	-$22,737,993	-$181,314,716	-$363,552,912	-$640,338,742
Induced	-$10,148,690	-$16,073,839	-$8,197,772	-$65,381,106	-$132,290,355	-$232,091,760
Total	-$48,486,891	-$76,796,125	-$39,166,312	-$312,459,776	-$792,831,691	-$1,269,740,795

Case 2.4: A 95% Decline in Employment

Table 48 summarizes the direct, indirect and induced impacts of the first employment decline scenario in which the refineries reduce employment by 95% through conversion to a storage facility. This also roughly approximates the impacts of closure and redevelopment, although these impacts may be closer to 100% reduction, it was assumed that this case provided a close approximation to a closure scenario. The baseline case may also be referenced to help understand potential losses from closure. The estimated impacts of this scenario are direct declines in employment, labor income and output. These direct negative impacts are estimated to create additional indirect and induced impacts.

Considering direct, indirect and induced impacts, Case 2.4 is estimated to cause a 95% decline in total labor income, total value added and total output in addition to the 95% decline in total employment.

Table 48: Case 2.4, Summary Impacts of a 95% decline in Employment.

Impact	Employment	Labor Income	Value Added	Output
Direct	-2,047.75	-$602,565,778	-$6,045,911,457	-$24,010,572,518
Indirect	-15,346.34	-$1,520,715,045	-$2,891,141,801	-$6,025,247,234
Induced	-7,758.71	-$551,244,763	-$1,048,880,771	-$1,684,186,469
Total	-25,152.80	-$2,674,525,585	-$9,985,934,030	-$31,720,006,221

Case 2.4 remains consistent with previous cases. Looking at job loss, wholesale trade was estimated to see the largest impact, losing an estimated 2,342 jobs. Professional, scientific and technical services was estimated to lose 2,157 jobs, and petroleum and coal products manufacturing was estimated to lose 2,141 jobs. Across all industries, 25,152 jobs were estimated to be lost.

Table 49: Case 2.4, Top Five Industries Ranked by Estimated Impact to Employment for a 95% decline in Employment.

Industry	Direct (Impact Employment)	Indirect (Impact Employment)	Induced (Impact Employment)	Total (Impact Employment)
Wholesale Trade	0	-2,141.03	-201	-2,342.03
Professional, Scientific and Technical Services	0	-1,821.73	-336	-2,157.72
Petroleum and Coal Products Manufacturing	-2,047.75	-91.49	-2.46	-2,141.71
Administrative and Support Services	0	-1,698.39	-88.45	-1,786.84
Construction	0	-1,717.72	-62.7	-1,780.42
All 88 Industries	-2,047.75	-15,346.37	-7,758.72	-25,152.8

Table 50 shows the estimated direct, indirect, induced and total tax impacts of Case 2.4. The 95% production decline was estimated to directly cause a $444.05 million decline in tax revenue, while total tax revenue (the sum of direct, indirect and induced tax revenues) was estimated to decline by $1.4 trillion.

Table 50: Case 2.4, Estimated Tax Revenue Loss from a 95% decline in Employment.

Impact	Sub County General	Sub County Special Districts	County	State	Federal	Total
Direct	-$11,387,790.26	-$18,036,913.90	-$9,198,846.60	-$73,500,891.05	-$331,928,239.23	-$444,052,681.04
Indirect	-$31,460,787.86	-$49,829,170.65	-$25,413,051.45	-$202,645,858.54	-$406,323,842.82	-$715,672,711.32
Induced	-$11,342,653.13	-$17,964,878.62	-$9,162,215.21	-$73,073,000.48	-$147,853,925.64	-$259,396,673.08
Total	-$54,191,231.24	-$85,830,963.18	-$43,774,113.26	-$349,219,750.07	-$886,106,007.69	-$1,419,122,065.43

Potential Tax Impacts of Changes to Washington's Refineries

This section provides an evaluation of potential tax revenue losses that may result from changes to Washington's oil refining industry. A particular emphasis is placed on tax revenues that support environmental programs in the state and transportation gas tax revenues. These programs support oil spill prevention and preparedness resources, including the remediation of spill sites. These programs help address environmental harms from the movement and refining of oil. Refiners paid an estimated $292.4 million in state and local taxes in 2023, although 2023 values were not available for the motor vehicle fuel tax, retail sales and use tax, oil spill tax, and unemployment compensation tax. To help supplement the available data, values from the Washington Research Council's (WRC) 2021 study [191] were used where 2023 values were not available. The total amount of state and local taxes paid has been increasing in recent years. To contrast, the amount paid in 2019 was $279.1 million.[191] As in previous years, the largest share of taxes paid was the Hazardous Substance Tax (HST) at over 46.3% ($141.3 million) of the total paid by refiners. The refineries currently receive no-cost emission allowances as EITEs under the Climate Commitment Act, meaning that their contribution to revenue is likely to be very small, but may begin to increase in 2027 as their no cost allowances are reduced. Currently, the CCA has generated approximately $2 billion in revenue, which is being invested in critical climate and air quality projects in Washington.[192] [193] [194]

Table 51: Taxes Due from Refineries by tax type

Tax Type	Total Due (in Millions $)	Source Year	Tax Revenue Uses
Retail sales and use tax	$2.0	2019	General Fund, Cities, Counties, Other [195]
Business and occupation tax	$96.6	2023	General Fund, Cities/Towns, Counties, Other[192]
Property tax	$21.7	2019	Local Schools, State Levy, Cities, Counties, Fire Authorities [192]
Unemployment compensation tax	$1.4	2019	Unemployment Programs, UI Trust Fund [196]
Hazardous substance tax total (By volume & value)	$141.4	2023	MTCA, Other [197]
Oil spill tax	$12.5	2019	Spill Prevention and cleanup, Other[198]

[191] Washington Research Council Economic Profile, "The Economic Contribution of Washington State's Petroleum Refining Industry in 2019", June 2021 https://researchcouncil.org/wp-content/uploads/2021-Refinery-Report-Final.pdf
[192] Washington Department of Ecology, "Climate Commitment Act", Climate Commitment Act - Washington State Department of Ecology
[193] Washington State Department of Ecology, "Allowance Allocation to Emissions-Intensive, Trade-Exposed Industries for the First Compliance Period: 2024 vintage allocation", October 2023. Allowance Allocation to Emissions-Intensive, Trade-Exposed Industries for the First Compliance Period
[194] Washington Department of Ecology, "Overburdened Communities", Overburdened communities - Washington State Department of Ecology
[195] Washington State Fiscal Information, "A Legislative Guise to Washingtons Tax Structure" Accessed November 7th 2024
[196] Employment Security Department, Washington State, "Unemployment Taxes" Accessed November 7th, 2024
[197] Washington state Department of Ecology, "Hazardous Substance Tax - Washington State Department of Ecology" Accessed August 3, 2024.
[198] Washington state Department of Revenue, "Oil spill response tax and oil spill administration tax | Washington Department of Revenue" Accessed August 3, 2024.; Washington DOR Tax Reference Manual, "Oil Spill Tax", August 2023. Oil Spill Tax - Tax Reference Manual (wa.gov)

Tax Type	Total Due (in Millions $)	Source Year	Tax Revenue Uses
Petroleum Products tax	$14.3	2023	Pollution Liability Insurance Program Trust, Environmental Cleanup, Other[199]
Motor vehicle fuel tax	$0.1	2019	DOT, CRAB, TPA, TIB, Other [200]
Total	**$290.0**		

Potentially Affected Tax Revenues: Environmental Protection

Taxes grouped in the environmental protection section are taxes paid by refineries, based on current production that is then invested into pollution cleanup or prevention. This group contains the Hazardous Substance Tax, Oil Spill tax, and Petroleum Products Tax.

Hazardous Substance Tax

Washington's Hazardous Substance Tax is a tax on the first possession of hazardous substances in Washington. HST applies to petroleum products, certain pesticides and certain chemicals; the revenue provides funding for the Department of Ecology and the Model Toxics Control Act (MTCA).[201] [202]

The aggregated HST paid by Washington's five refineries in calendar year 2023 was $137,890,531 by volume and $3,476,261 by value.[203] Total revenue collected for the HST from Washington's refineries was $141,366,792 in calendar year 2023. This is an important distinction because petroleum products are difficult to measure on a per-barrel basis. A barrel is considered approximately 42 gallons, but the finished products of petroleum are not exclusively liquid. These products include, but are not limited to, petroleum coke, propane and butane. Products that can be measured on a per barrel basis include, but are not limited to, gasoline, aviation fuel, diesel, lubricating oil and bunker fuel.[204] Since July 1, 2019, the HST has been a fixed volumetric tax that is adjusted each year per inflation. From July 1, 2022, to June 30, 2023, the rate was $1.20 per barrel and from July 1, 2023, to June 30th, 2024, the tax rate per barrel was $1.40[204].

Any potential closures or significant changes to the volume of petroleum products produced at Washington's refineries could impact both MTCA's operations and the Department of Ecology's operations when paired with an overall decrease in refined petroleum product consumption. While imports of refined petroleum products to meet demand would maintain some of this revenue, HST paid in other states can be deducted from HST paid in Washington. This may lead to HST revenue decreases. Looking to the future, it is reasonable to expect a decline in petroleum production as Washington works toward the Climate Commitment Act (CCA) goal of a 95% reduction in statewide emissions. These changes would lead to a decrease in this revenue, with potentially significant impacts to operations. While these changes could also lead to a decrease in pollution,

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[199] Washington state Department of Revenue "Petroleum products tax | Washington Department of Revenue" Accessed September 16th, 2024

[200] Washington state County Road Administration Board, "Fuel Tax Distribution", Accessed November 7th, 2024

[201] Washington state Department of Ecology, "Hazardous Substance Tax - Washington State Department of Ecology" Accessed August 3, 2024.

[202] Washington State Department of Ecology, "Model Toxics Control Act Capital Account: Ten-Year Financing Report 2022 (wa.gov)" January 2023.

[203] Information provided by the Department of Revenue by request, received July 29, 2024.

[204] Washington state Department of Revenue, "Hazardous substance tax | Washington Department of Revenue" Accessed August 3, 2024.

which would decrease need for environmental programs, there might continue to be legacy pollution that may not be addressed.

Oil Spill Tax

The Oil Spill Tax (OST) refers to the combined administration of the Oil Spill Response Tax and the Oil Spill Administration Tax.[205] OST is applied at a per barrel rate. The Petroleum Product Tax (PPT) is applied to the wholesale value of petroleum products. This tax is not collected every year, but rather reinstated or suspended as needed to maintain account balances. The OST is collected when the oil spill response account falls to $8 million and is suspended when the account reaches a balance of $9 million. Generally, the tax is applied when products are delivered to a marine terminal or bulk oil terminal via vessel or barge, rail tank car or pipeline. The OST was expanded in 2018 to include some crude oil or petroleum products delivered via pipeline. The Oil Spill Administration Tax pays for work related to oil spill prevention, response and habitat restoration, while the Oil Spill Response Tax pays for oil spills with cleanup costs exceeding $50,000. Only $12.5 million was collected toward this tax in fiscal year 2019, 0.02% of all state taxes.[4] [206]

On June 14, 2024, Ecology adopted a new chapter of rule, Chapter 173-187 WAC Financial Responsibility. The adopted rule ensures that vessel and facility owners and operators have adequate financial resources to pay cleanup and damage costs arising from an oil spill. Anyone responsible for spilling oil into state waters is liable for damages resulting from injuries to natural, cultural and historic and publicly owned resources. Ecology works with other federal, state and local agencies and tribes to determine how best to assess injuries and restore impacted resources.

Petroleum Products Tax

The Petroleum Products Tax (PPT) is a tax on the first possession of petroleum products in Washington and is imposed on the wholesale value of petroleum products. PPT is collected when the Pollution Liability Insurance Program Trust (PLIPT) falls below $15 million in the previous calendar quarter and is suspended once the account balance exceeds $30 million in the previous calendar quarter. PPT is currently in effect and has been since January of 2020.[207] These funds are administered by the Pollution Liability Insurance Agency (PLIA) for the pollution liability insurance program and emergency program. This includes the cleanup releases from active and currently registered heating oil tanks, with up to $60,000 not covered by other insurances. PLIA also administers a technical assistance program for qualifying petroleum sites.[208] $24,776,000 was collected toward this tax in fiscal year 2021, 0.08% of all state taxes.[205] The five refineries paid an aggregated $14,282,975 in PPT for 2023.[209]

Other Potentially Affected Tax Revenues

Other significant taxes will be those that generally are paid by most corporations. These taxes do not involve pollution related activities. The direction the funds raised by the state vary by tax type, refer to Table 47 for these brief allocation descriptions.

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[205] Washington state Department of Revenue, "Oil spill response tax and oil spill administration tax | Washington Department of Revenue" Accessed August 3, 2024.; Washington DOR Tax Reference Manual, "Oil Spill Tax", August 2023. Oil Spill Tax - Tax Reference Manual (wa.gov)

[206] Washington Research Council Economic Profile, "The Economic Contribution of Washington State's Petroleum Refining Industry in 2019", June 2021 https://researchcouncil.org/wp-content/uploads/2021-Refinery-Report-Final.pdf

[207] Washington state Department of Revenue "Petroleum products tax | Washington Department of Revenue" Accessed September 16th, 2024

[208] Pollution Liability Insurance Agency, "About PLIA - The Pollution Liability Insurance Agency (wa.gov)"

[209] Information provided by the Department of Revenue by request, received July 29, 2024.

Motor Vehicle Fuel Tax

The Motor Vehicle Fuel Tax (MVFT) is paid by suppliers, distributors, refiners and blenders of fuel on each gallon of fuel imported, produced or delivered from a terminal rack in Washington. This includes motor vehicle fuel and special fuels, such a diesel, biodiesel, natural gas and propane.[210] The WRC reported an aggregated value of $100,000 paid by the refineries in 2019. The MVFT is used to provide funds for road repair and maintenance, among other things.

However, it is important to consider that as Washington begins using more electric vehicles to meet decarbonization goals, this tax revenue will decline. The revenue collected by the MVFT has been decreasing since 2019 and is expected to continue declining as electric vehicles become more integrated into Washington's fleet. Current fuel tax revenue models do not account for this change. The Washington State Economic and Revenue Forecast Council (ERFC) revenue model currently forecasts a slow decline in gasoline sales and relatively constant diesel sales. The next round of modeling, which is currently in progress, will integrate potential EV adoption rates in its modeling. It can be expected that gasoline sales and the corresponding tax revenue will fall by 14% or more, informed by the projected fuel demands discussed in other sections of this report. When and how fast this decline happens is highly dependent upon incentives and infrastructure that facilitate the move away from internal combustion engine vehicles.

The Washington State Transportation Council's (WSTC) revenue model, which was updated in June 2024, predicted 8% and 11% of Vehicle Miles Traveled (VMTs) originating from electric vehicles by 2050 using two EIA reference cases. They also modeled two other scenarios, with the most optimistic case (based on Bloomberg's high electrification scenario) culminating in 87% of VMT attributed to EVs in 2050. This model reported an anticipated MVFT of just $223,682,315 in 2050, using these electrification scenarios. However, this model also forecasted increasing revenues from a Road Usage Charge (RUC), to help compensate for the loss of revenue from MVFT. The RUC is recommended by WSTC to begin implementation as a voluntary program in 2025 and become required in 2027 for all models year 2028 and newer. This program would utilize annual odometer mileage readings to administer per mile fees. This program has been in development since 2012, as improved fuel efficiencies and EVs began to threaten this revenue source. The WSTC model projects a gross revenue of $1.068 billion by 2050, with separate rates based on urban or rural residency. There is an estimated $6 million cost of administration for this same scenario. Current forecasts include a drop to under $1 billion in revenue from MVFT by 2035, coinciding with a mandate for 100% zero emissions vehicles sales in Washington and a full phase out of new internal combustion engine vehicles.

Local Property Taxes

The refineries are significant contributors to local revenue, paying an estimated $21.7 million in property taxes in 2019.[211] If the refineries transition use or close outright, the removal or renovation of equipment may significantly impact local revenues. Per discussions with the Skagit County Assessor, the refineries impact overall property tax rates due to their significant contributions in their tax districts. The reduction in payments by refinery owners would result in an increase in tax obligations of other property owners, due to Washington's budget-based approach to levying property taxes. [212]

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[210] Washington state Department of Revenue "Motor Vehicle Fuel Tax" Accessed September 16th, 2024

[211] Washington Research Council Economic Profile, "The Economic Contribution of Washington State's Petroleum Refining Industry in 2019", June 2021 https://researchcouncil.org/wp-content/uploads/2021-Refinery-Report-Final.pdf

[212] MRSC, "Property Tax Basics", Accessed November 7th, 2024.

Business & Occupation Taxes

The Business & Occupation (B&O) tax was the second largest share of total taxed paid by refineries in 2023, at $96.6 million, or 33% of the total.[213] The B&O tax rate on manufacturers was 0.484% (0.00484) of total gross receipts. [214] Goods manufactured and sold within the state are subject to both the manufacturing B&O tax and retail sales tax.

Retail Sales and Use Taxes

In 2019, refineries contributed $2 million to retail sales and use tax revenues, which is 6.8% of the $290 million total.[215]

Unemployment Compensation Taxes

In 2019 refineries accounted for $1.4 million to Unemployment Compensation taxes, which is less than 1% of the total.[215]

[213] Department of Revenue, data pulled by request "Combined Excise Tax Returns" Accessed July 29th, 2024; See Table 47
[214] Washington state Department of Revenue "Business and Occupation (B&O) tax | Washington Department of Revenue" Accessed September 16th, 2024
[215] Washington Research Council Economic Profile, "The Economic Contribution of Washington State's Petroleum Refining Industry in 2019", June 2021 https://researchcouncil.org/wp-content/uploads/2021-Refinery-Report-Final.pdf

Chapter 4: Refinery Workforce Analysis

Key Finding 8. Alternative industries for impacted workers exist in Pierce, Skagit and Whatcom counties, though at present these opportunities are not sufficient for scenarios where refinery workforce declines significantly.

- 8.1 Apprenticeships and on-the-job training (OJT) are commonly used at refineries, but many workers lack formal credentials and certifications. This could make transferring to alternative industries difficult.
- 8.2 Refinery workers have hard and soft skills which could be valuable in other professions.
- 8.3 There are industries in nearby counties which could be suitable for displaced refinery workers, though there are not currently a sufficient number of such opportunities to make up for a significant employment decline at refineries.
- 8.4 Displaced employees are likely to experience lower levels of pay upon transitioning to careers outside of the refinery industry.

Introduction

This chapter aims to present key data regarding refinery worker skillsets and compare skillsets, benefits and other refinery workforce characteristics with potential alternative sectors and industries. This information could be valuable to refinery workers considering future changes to their employment, including from refinery layoffs or closures. It could also help these workers, their unions where relevant and the broader communities surrounding refineries to consider and plan for possible changes in career that may result from changes to the refinery sector. As this section will demonstrate, there are alternative sectors in Pierce, Skagit and Whatcom Counties that may utilize the skills of many classes of refinery employees. However, there are limitations to the extent and availability of such jobs within these counties. Additionally, there is uncertainty about the timing of these potential transitions. In addition, other emerging industries may develop over time which this report does not attempt to model but which may provide additional opportunities for workforce transition in future.

The Washington refinery industry serves as a pivotal hub for refining operations on the West Coast of the United States. As Washington advances economy-wide deep decarbonization in accordance with state mandates to reduce greenhouse gas (GHG) emissions, clean fuel standard programs in Washington and around the region and other related policies, refinery operations are expected to shift. These potential shifts — including changes in product mix or function as described in Chapter 3— would have significant implications on refinery employment and employees themselves.

Useful regional analyses that assess the potential workforce implications of a transition to a clean energy economy indicate that there may be significant job growth in the fuels sector in Washington and the Northwest. However, it is still important to assess more specific details about how accessible such jobs may be for refinery workers, relative pay and benefits, geographic proximity and other relevant considerations.

Washington's current refinery workforce

Washington's refineries employ approximately 2,200 people across all five facilities as permanent employees, with an equal or greater number of contractors over the course of a year. To understand and articulate the potential impacts of shifts in Washington refinery operations on this employment base, this report

incorporates and builds on analysis from the Clean Energy Transition Institute (CETI) in the Net-Zero Northwest Workforce Analysis[216] (NZNW). Discussions with Washington's Workforce Training and Education Coordinating Board and the United Steelworkers (USW) Union also helped inform this analysis.

This report uses a mix of national industry and occupation data to help discuss employment at refineries without discussing one refinery in particular. The analysis utilizes the JobsEQ Real-Time Analysis (RTI) Job Posting database. The national data set pulls information from 45,000 source websites to show the number of job postings for a relevant search and corresponding hard skills, soft skills, education levels and on-the-job training (OJT) referenced within postings. This assessment is localized to Washington and to employers within the state. Hard skills are considered to be measurable capabilities that are specific to the job, while soft skills are attributes that are considered transferrable between jobs and often form as a result of reacting to one's surroundings. The most desired hard and soft skills are provided, along with common education and OJT metrics listing. Utilizing petroleum as a keyword, 332 job postings in Washington from August 2023-2024 were identified to inform the following analysis.

Certifications and Training Programs

Petroleum refineries employ a diverse set of workers, requiring varying levels of prior education and training. Notably, any positions progress through registered apprenticeship programs or other forms of OJT, while some other positions require four-year degrees.

The Role of Apprenticeships

Per the Bureau of Labor Statistics, an apprenticeship is defined as a "formal relationship between a worker and a sponsor that consists of a combination of on-the-job training and related occupation-specific instruction in which the worker learns the practical and theoretical aspects of an occupation." [217] In Washington, the Department of Labor and Industries (L&I) manages a database of registered apprenticeship programs and provides oversight regarding accessibility and standards. [218] Apprenticeships exist in many sectors including aerospace, medical, technology and many building and construction trades.

In refineries specifically, some occupations that may utilize apprenticeships include machinists, millwrights, carpenters, welders, plumbers, pipefitters, steamfitters and boilermakers. In addition to the permanent employees on site, contractors may work on site for maintenance or repairs to refinery infrastructure. This often includes additional plumbers, welders, painters and helpers (who support materials handling and work area management) to supplement the existing workforce. Particularly during turnarounds, a type of maintenance event that typically occurs every three to five years, large numbers of contractors may double or triple the number of workers on site. These contractors may come from out of state to help support turnarounds.

On-the-job training and other pathways

Many of the permanent (as opposed to contractor) refinery workforce sectors are not part of occupations that offer apprenticeships. These workers often progress through long careers at the refineries through OJT, provided by the employer and/or a relevant union. Of Washington's five refineries, four have a permanent workforce that is represented by a union, the United Steelworkers (USW) union.

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[216] https://www.nznw.org/workforce
[217] Bureau of Labor Statistics, “Glossary”, Accessed August 24th, 2024. https://www.bls.gov/bls/glossary.htm
[218] Washington State Department of Labor and Industries, “Become an Apprentice,” accessed 9.20.2024. https://www.lni.wa.go`v/licensing-permits/apprenticeship/become-an-apprentice

Certifications and credentials

A unique challenge faced by many refinery employees who might seek to transition to other facilities or industries is a lack of formal certifications that can be obtained throughout their careers in the refinery sector. For many operations staff, the only formal educational requirement is a high school diploma, or for some positions, an associate's degree. Few formal certifications accompany a traditional career in refineries. Because testing and certification that would result in these formal credentials are not typically offered, refinery workers, even those with many years of experience, may have difficulty in providing detailed information regarding specific skills they have been trained in or mastered related to their refinery position.

The UC Berkeley Labor Center report "Fossil fuel layoff: The economic and employment effects of a refinery closure on workers in the Bay Area" [219] captured some of these difficulties through surveys and interviews with refinery workers seeking employment after the closure of Marathon's Martinez, a California refinery. The refinery has since been converted to a biofuel refinery, with sustained decreases in employment. [220] Recommendations from the report on how to assist workers in the transition included identifying or creating technical classes with formal certifications. These formal certifications, if recognized within the refining industry and related industries, can help workers verify skills and communicate them as part of future job searches. For workers who do not participate in union apprenticeship programs, but rather learn on site through employer training programs, verification of skills may be difficult absent additional programming or other forms of support to review and catalogue skills. Contrastingly, engineers working at refineries may have a bachelor's or a master's degree, alongside other professional licensing.

Employment verification was also identified as a key issue in the UC Berkeley report. Refineries can and do change owners, who may only verify employment after their acquisition of operations. The report also recommends the expansion of training programs in clean energy fields, a conclusion echoed in the results of the True Transition survey American Oil & Gas workers.[221] Generally, unit operators are among the most vulnerable of employees in the event of refinery closure. As discussed later, the wide variance of refinery infrastructure and operations can limit transferable skills.

To help better understand refinery workforces, the Bureau of Labor Statistics (BLS) major occupational groups, as defined in the Standard Occupational Classification (SOC), are compiled in Table 52. These groups aggregate occupations based on work performed and sometimes based on skills, education or training required for the work. Currently, cross industry and occupational data is only available at the national level.

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[219] Parks, Virginia, and Ian Baran. 2023. "Fossil fuel layoff: The economic and employment effects of a refinery closure on workers in the Bay Area." Berkeley, CA: UC Berkeley Labor Center.
[220] Mukherjee, S., "Martinez oil refinery cleared to start producing more 'renewable' biofuels". East Bay Times: Web Edition Articles (CA).
[221] Milliken Biven, Megan and Leo Lindner, "The Future of Energy & Work in the United States: The American Oil & Gas Worker Survey", True Transition, March 2023.

Table 52: Major Occupational Groups within the Petroleum and Coal Manufacturing Industry (NAICS 324100), ordered by percentage of total employment, per Bureau of Labor Statistics Analysis. [222]

SOC Code	Major occupation group	Percentage of total employment	Example positions contained in this occupational group
51-0000	Production occupations	38.92%	Machinists, plant and system operators, welders, helpers
53-0000	Transportation and material moving occupations	8.88%	Heavy and tractor trailer truck drivers, pumping station operators, industrial truck and tractor operators
11-0000	Management occupations	8.56%	Executives, general and operations managers, construction managers, facilities managers, emergency management directors
49-0000	Installation, maintenance and repair occupations	7.97%	Millwrights, machinery maintenance workers, industrial machinery mechanics
17-0000	Architecture and engineering occupations	7.55%	Chemical engineers, environmental engineers, industrial engineers (including health and safety), petroleum engineers
47-0000	Construction and extraction occupations	7.44%	Boilermakers, construction laborers, plumbers, pipefitters, steamfitters, electricians
13-0000	Business and financial operations occupations	6.69%	Compliance Officers, logisticians, accountants and auditors
43-0000	Office and administrative support occupations	5.99%	Financial clerks, payroll and timekeeping clerks, procurement clerks, dispatchers
19-0000	Life, physical and social science occupations	3.96%	Chemists, environmental scientists and specialists (including health), occupational health and safety specialists
41-0000	Sales and related occupations	2.13%	Sales representatives, sales engineers
15-0000	Computer and mathematical occupations	1.11%	Software developers, information security analysts, computer systems analysts
33-0000	Protective service occupations	0.28%	Firefighters, security guards, crossing guards and flaggers
37-0000	Building and grounds cleaning and maintenance occupations	0.17%	Landscaping and groundskeeping workers, janitors and cleaners

[222] U.S. Bureau of Labor Statistics, "May 2023 National Industry-Specific Occupational Employment and Wage Estimates: NAICS 324100- Petroleum and Coal Products Manufacturing", Petroleum and Coal Products Manufacturing - May 2023 OEWS Industry-Specific Occupational Employment and Wage Estimates (bls.gov)

SOC Code	Major occupation group	Percentage of total employment	Example positions contained in this occupational group
27-0000	Arts, design, entertainment, sports and media occupations	0.15%	Public relations specialists, graphic designers

Approximately sixty-four percent of petroleum and coal products manufacturing workers are in the following four major occupational groups, with the largest proportion of workers in production occupations at 38.92%.[223] These occupations were chosen because of their involvement in day-to-day productions and maintenance. Other occupational groups, such as management occupations or architecture and engineering occupations, appear in the table above but are not discussed as closely here. Unit operators, who are especially vulnerable in the event of a refinery closure, fall under production occupations.

- Production Occupations, which includes:
  - Petroleum Pump System Operators, Refinery Operators and Gaugers
  - Chemical Processing Machine Setters, Operators and Tenders
  - Machinists
    - Welders, Cutters, Solderers and Brazers
    - Stationary Engineers and Boiler Operators
- Transportation and Material Moving Occupations, which includes:
  - Heavy and Tractor-Trailer Truck Drivers
  - Industrial Truck and Tractor Operators
  - Pump Operators, Except Wellhead Pumpers
  - Tank Car, Truck and Ship Loaders
- Installation, Maintenance and Repair Occupations, which includes:
  - Electrical and Electronic Equipment Mechanics, Installers and Repairers
  - Control and Valve Installers and Repairers
  - Industrial Machinery Mechanics
  - Maintenance Workers, Machinery
- Construction and Extraction Occupations, which includes:
  - Boilermakers
  - Construction Laborers
  - Electricians
  - Plumbers, Pipefitters and Steamfitters

[223] U.S. Bureau of Labor Statistics, "May 2023 National Industry-Specific Occupational Employment and Wage Estimates: NAICS 324100- Petroleum and Coal Products Manufacturing", Petroleum and Coal Products Manufacturing - May 2023 OEWS Industry-Specific Occupational Employment and Wage Estimates (bls.gov)

Evaluating 332 job postings in Washington between August 2023 and August 2024 [224] using the JobsEQ RTI database, the consultant team sorted desired certifications into three categories. This analysis helps identify certifications sought by refineries, which workers may also utilize in another industry. Certifications that are more likely to belong to administration and management are in Table 54, whereas skills for refinery operations and maintenance are grouped into another table. A final category is composed of requirements related to engineering occupations. The majority of these certifications are pertinent to refinery operations and maintenance, with only two falling into management and administration and six related to engineers or scientists in refineries. Some themes include emergency response skills, hazardous material safety and handling and equipment operating skills.

Some transferable credentials applicable to refinery employees include the Transportation Worker Identification Credential (TWIC), Commercial Driver's License (CDL), Certified Welding Inspector (CWI) and National Center for Construction Education & Research Certification (NCCER). TWIC is particularly relevant because of Washington refineries' access to marine terminals and may not be relevant at inland refineries. This credential is issued after the Transportation Security Administration conducts a security threat assessment, or background check, to determine eligibility. All five of Washington's refineries have marine terminal access, which means that the Maritime Transportation Security Act requirements for workers and TWIC requirement applies.

Others of these certifications are trade-specific and require a mixture of on-the-job experience and education. For example, the Certified Welding Inspector certification is offered by the American Welding Society (AWS). AWS requires a mixture of education and experience before you can apply and test for CWI. CDL's require a knowledge test for permitting, followed by a skills test before licensure. Certain CDL's require HAZMAT training before the license is issued.

For refinery employees that have completed four-year degrees, some relevant transferable credentials include the Certified Industrial Hygienist (CIH), Licensed Professional Engineer and Certified Safety Professional (CSP). Each of these certifications require a four-year degree. Some of these certifications build on each other. The Engineer-in-Training (EIT) license and certification indicates the completion of the NCEES Fundamentals of Engineering exam in addition to a four-year degree. To attain a Professional Engineer (PE) license, an engineer must have an EIT license and work under a Professional Engineer for four years. Once this experience requirement is met, the Principle and Practice of Engineering exam can be taken to become a PE. In this way, these certifications are cumulative due to a mix of continuing education and experience.

Table 53: Most Desired Certifications for Refinery Operations and Maintenance, ranked by occurrence.

Skill Name	Number of Active Job Ads	Percentage of Active Job Ads
Driver's License	78	23.5%
Transportation Worker Identification Credential (TWIC)	42	12.7%
Commercial Driver's License (CDL)	39	11.7%
HAZMAT	26	7.8%
Class A Commercial Driver's License (CDL-A)	12	3.6%
Certification in Cardiopulmonary Resuscitation (CPR)	11	3.3%

[224] Chmura, JobsEQ Real-Time Intelligence (Job Postings) Data set, retrieved August 24, 2024.

Skill Name	Number of Active Job Ads	Percentage of Active Job Ads
First Aid Certification	9	2.7%
Class B Commercial Driver's License (CDL-B)	8	2.4%
Forklift Certified	4	1.2%
Secret Clearance	4	1.2%
Certified Welding Inspector	3	0.9%
Emergency Response	3	0.9%
National Center for Construction Education and Research Certification (NCCER)	3	0.9%
API 510 Pressure Vessels Inspector Certification	2	0.6%
API 570 Piping Inspector Certification	2	0.6%
Industrial Electronics Certification (IND)	2	0.6%
OSHA 30	2	0.6%

Source: JobsEQ RTI Database.[225]

Table 54: Most Desired Certifications for Refinery Management and Administration, ranked by occurrence.

Skill Name	Number of Active Job Ads	Percentage of Active Job Ads
Certified Public Accountant (CPA)	20	6%
Project Management Professional	3	0.9%

Source: JobsEQ RTI Database.[225]

Table 55: Most Desired Certifications for Refinery Engineers and Scientists, ranked by occurrence.

Skill Name	Number of Active Job Ads	Percentage of Active Job Ads
Certified Industrial Hygienist (CID)	27	8.1%
Certified Safety Professional (CSP)	17	5.1%
Engineer in Training (EIT)	15	4.5%
Licensed Professional Engineer	14	4.2%
Exercise Physiologist Certification (EPC)	4	1.2%
Certified Hazardous Materials Manager (CHMM)	2	0.6%

Source: JobsEQ RTI Database.[226]

Trade Work in Petroleum Refining

For many of the trades involved in refinery operations, a GED or high school diploma are the required education for an entry-level position. This allows an employee to take either an apprenticeship or a position as a helper or tradesperson. Helpers and tradespeople are entry-level positions in trade work, and typically lead to an apprenticeship. From there, an apprentice completes a mixture of OJT and classwork. In many trades, positions progress in this order: helper or tradesperson; apprentice; journeyman; and then master. Typical minimum requirements for apprenticeships include 2,000 hours of OJT over three to five years. Each of these steps involve different experience requirements and testing for licensure. Many of these trades are supported by unions, which help operate training programs and advocate for workers. Union membership in the U.S. peaked in the 1950s at approximately 34% of workers, plateauing to 10% of workers in 2022. Unions help provide protections for workers through non-wage benefits, in addition to a "union wage premium". [227]

"Unit operators" refers to a broad range of positions in a refinery, including board operator, crude unit operator, hydrotreater operator and more. The number of operating units at a refinery varies based on their operational specifics. Common units include hydrocracking units, crude oil distillation units, reformers, fluid catalytic cracking units, coking units, alkylation units, sulfur recovery units and isomerization units.

Unit operators are often trained in a position for 10 months to a year, with commonly anywhere from four to eight positions in a unit. Three or four years are spent working as a trainee, with steps toward full operator pay as they gain more experience. It can take anywhere from six to eight years, or even longer, to be fully trained on a unit. The United Steelworkers Union in Washington represents union unit operators. Unit operator training is

[225] Chmura, JobsEQ Real-Time Intelligence (Job Postings) Data set, retrieved August 24, 2024.
[226] Chmura, JobsEQ Real-Time Intelligence (Job Postings) Data set, retrieved August 24, 2024.
[227] Feiveson, Laura, "Labor Unions and the U.S. Economy", U.S. Department of the Treasury, August 28, 2023.

typically done on site through an employer. Additional vocational training or an associate's degree are common, but not required. Operators begin at a facility as an operator trainee or utility helper and progress through the operations department into different positions.

Of refineries in Washington where there is union representation, approximately half of their total employees are union members. Four of Washington's five refineries employ union workers. Notably, nationally non-union workers' weekly earnings were 86% of union workers' earnings in 2023. [228] In 2015, USW workers went on strike at nine refineries, including the Tesoro Anacortes refinery, [229] now owned by Marathon. USW and other unions have raised concerns that as union workers retire or leave a refinery contractors replace them. This particularly affects building trade union workers who perform maintenance and construction at refineries.[230]

Contractors in Petroleum Refining

Contractors, as opposed to permanent employees, are workers who are hired to perform a specific task or project for a limited period of time. They work at the refineries only for the duration of their contract. Some contractors are local, but other contractors may come from different states to meet refinery needs. Contractors may also be represented by unions. Over the course of a year, more than 2,000 contractors are employed across all five refinery sites, which is approximately equal to the number of permanent refinery employees. These contractors can work nearly year-round in an area, on a variety of projects or may come to an area for a few months specifically for turnaround operations and other shutdowns.

Turnarounds are elaborate, large scale maintenance events that can double or even triple the number of workers on site and involve round the clock work to minimize operations impacts. Turnarounds happen every three to five years and can take anywhere from a few weeks to several months.[231] They require extensive planning processes and logistical management, sometime as long as two years.[232] Turnarounds require large numbers of skilled workers, and some contractors exclusively coordinate and manage turnover. This can send workers all over the country as they travel to refineries to supplement the existing workforce and complete specialized work.[233] Turnarounds require additional safety procedures and are essential to maintaining the safety of refinery operations. In addition to replacing or repairing equipment, upgrades are often also implemented. Delaying a turnaround can lead to increased costs at a refinery, raise safety concerns and lead to an unplanned shutdown. Concerns have been raised by unions about refineries nationwide hiring non-union contractors despite long established relationships with union contractors, particularly in periods of new ownership.[230]

Shutdowns are another type of disruption to operations and can be planned or unplanned. They involve the shutdown of specific units for maintenance and are used to help bridge the gap between turnarounds. Unplanned shutdowns may be delayed by equipment and contractor availability, due to a shorter planning window. Emergency shutdowns can be triggered for a variety of reasons, including but not limited to a loss of utilities, unsafe conditions due to extreme weather or a fire. While shutdowns may not require the same number of contractors as a turnaround, they may be involved in helping refineries resume normal function.

All of these events reduce or can temporarily halt refinery output. This is largely determined by the refinery's internal processes, which vary broadly and are outside the scope of this report. Turnarounds are typically in the

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[228] Bureau of Labor Statistics, "News Release: Union Members 2023", January 23, 2024.
[229] United Steel Workers, "National Oil Bargaining Talks Break Down: USW Calls for Work Stoppage at Nine Oil Refineries, Plants", February 1, 2015.
[230] Sanicola, Laura, "Unions push back as U.S. refiners shunt aside longtime trade workers", Reuters, May 3, 2021.
[231] Kendrick Oil Company, "What are Refinery Shutdowns and Turnarounds?", June 2, 2017.
[232] Energy Information Administration, "Refinery Outages: Description and Potential Impact on Petroleum Product Prices", March 2007.
[233] Barnes, Sam. "Far-flung turnaround, maintenance contractors tackle culture shock and new environs.", 10/12 Industry Report.

fall or spring, during periods of expected lower demand for gasoline. As such, there are seasonal flows to contractor employment. The limited nature of highly specialized employees for turnaround work, means that they are in high demand seasonally. Contractors, depending on length of stay, can provide significant revenue to local communities by purchasing food, lodging and other items. It is difficult to calculate precise impacts of contractor presence in a community due to the irregular nature of their stays.

In Demand Occupations

When analyzing RTI job posting data between August 2023 and August 2024, some occupations that are relevant to the refining industry but outside of production-related occupations were captured. To help separate them, this analysis replicates the tables of desired certifications, but includes an additional retail workforce table. Occupations in Table 56 are reflective of work that is important to the overall management of refineries as a business, but is less hands-on than occupations related to operations and maintenance in **Error! R eference source not found.**. Table 57 captures the occupations related to retail workforce, such as cashiers, first-line supervisors of retail sales workers and stockers and order fillers. These positions are more closely associated with the sales and distribution of final petroleum products, rather than with their production. Table 58 contains occupations relevant to engineers and scientists, which may require a four-year degree or more to complete. Positions are ranked by number of active job ads. This chapter does not otherwise discuss positions related to retail sales of refined petroleum products.

Table 56: Most Desired Positions for Refinery Operations and Maintenance, ranked by occurrence.

Occupation Name	Number of Active Job Ads	Percentage of Active Job Ads
Heavy and tractor-trailer truck drivers	85	25.6%
Maintenance and repair workers, general	56	16.9%
Automotive service technicians and mechanics	27	8.1%
Bus and truck mechanics and diesel engine specialists	15	4.5%
Inspectors, testers, sorters, samplers and weighers	15	4.5%
Production workers, all other	13	3.9%

Source: JobsEQ RTI Database.[234]

Table 57: Most Desired Positions for Refinery Management and Administration, ranked by occurrence.

Occupation Name	Number of Active Job Ads	Percentage of Active Job Ads
Accountants and auditors	33	9.9%
Human resources specialists	24	7.2%
Human resources specialists	24	7.2%
Secretaries and administrative assistants, except legal, medical and executive	20	6%
First-line supervisors of material-moving machine and vehicle Operators	18	5.4%

[234] Chmura, JobsEQ Real-Time Intelligence (Job Postings) Data set, retrieved August 24, 2024.

Occupation Name	Number of Active Job Ads	Percentage of Active Job Ads
Bookkeeping, accounting and auditing clerks	16	4.8%
Sales representatives of services, except advertising, insurance, financial services and travel	15	4.5%

Source: JobsEQ RTI Database.[235]

Table 58: Most Desired Positions for Retail Workforce of Refinery Products, ranked by occurrence.

Occupation Name	Number of Active Job Ads	Percentage of Active Job Ads
Retail salespersons	61	18.4%
Cashiers	38	11.4%
First-line supervisors of retail sales workers	34	10.2%
Stockers and order fillers	33	9.9%

Source: JobsEQ RTI Database.[236]

Table 59: Most Desired Positions for Refinery Engineers and Scientists, ranked by occurrence.

Occupation Name	Number of Active Job Ads	Percentage of Active Job Ads
Occupational health and safety specialists	47	14.2%
Architectural and engineering managers	40	12%
Civil engineers	21	6.3%
Environmental scientists and specialists, including health	21	6.3%
Environmental engineers	16	4.8%
Architectural and civil drafters	15	4.5%
Inspectors, testers, sorters, samplers and weighers	15	4.5%
Compliance officers	14	4.2%

Source: JobsEQ RTI Database.[237]

Hard and Soft Skills

Most Relevant Hard Skills

In addition to analyzing the desired certifications and positions, the consultant team analyzed the most relevant hard skills for various refinery jobs. This section utilizes RTI job posting data on hard skills to identify desired skills for refinery employees. It is clear within the listed skills that physical capability is an essential component of many refinery jobs. Additionally, skills utilized by on-site engineers such as Computer Aided Design Software (CAD) are present in the dataset. Welders and other tradesmen may also utilize this type of software. These results are sorted into two tables. The first table contains skills relevant to refinery operations,

[235] Chmura, JobsEQ Real-Time Intelligence (Job Postings) Data set, retrieved August 24, 2024.
[236] Chmura, JobsEQ Real-Time Intelligence (Job Postings) Data set, retrieved August 24, 2024.
[237] Chmura, JobsEQ Real-Time Intelligence (Job Postings) Data set, retrieved August 24, 2024.

the second contains skills relevant to management and administration. Skills related to Microsoft Office products like Microsoft Word and PowerPoint have been consolidated into one skill, labeled Microsoft 365. As a result, the Microsoft 365 skill is counted more times than the total number of ads. English is also contained within both tables. Due to the overlap in some skills between operators and engineers, they are contained in the same table.

Table 60: Most Desired Hard Skills Related to Refinery Operations, ranked by occurrence.

Skill Name	Number of Active Job Ads	Percentage of Active Job Ads
Ability to lift 51-100 lbs.	174	52.4%
Ability to lift 41-50 lbs.	132	39.8%
Mathematics	76	22.9%
Tankers	54	16.3%
Autodesk AutoCAD	53	16%
Plumbing	53	15.4%
Mechanical	51	15.4%
Hazardous Waste Operations and Emergency Response Standard (HAZWOPER)	36	10.8%
Teaching/training, job	34	10.2%
Forklifts	24	7.2%
English	24	7.2%
Ability to lift 21-30 lbs.	22	6.6%
Hazardous materials safety & handling	21	6.3%
Data analysis	20	6%
Computer Aided Design Software (CAD Software)	19	5.7%

Source: JobsEQ RTI Database.[238]

Table 61: Most Desired Hard Skills Related to Refinery Management and Administration, ranked by occurrence.

Skill Name	Number of Active Job Ads	Percentage of Active Job Ads
Microsoft 365	489	147.3%
Technical writing	29	8.7%
Finance	25	7.5%
Systems applications and products, enterprise resource planning software	25	7.5%
English	24	7.2%

[238] Chmura, JobsEQ Real-Time Intelligence (Job Postings) Data set, retrieved August 24, 2024.

Skill Name	Number of Active Job Ads	Percentage of Active Job Ads
Personal Computers (PC)	23	6.9%
Point of Sale Systems (POS Systems)	20	6%

Source: JobsEQ RTI Database.[239]

Most Relevant Soft Skills

Communication, cooperativeness and attention to detail are all included within the top five soft skills. This is consistent with the demanding environment of petroleum refineries; wherein meticulous attention is important to ensure safety and smooth operations. Additionally, the shift-based team operations require communication and teamwork. Similarly, adaptability, willingness to learn and ability to work in a fast-paced environment are consistent with the variable nature of refinery work. Many refinery employees develop their skills through apprenticeships or other forms of OJT. These skills are not separated in the same manner as previous sections, in part because they could apply to a broad range of positions. Additionally, multiple mentions of skills in job postings has resulted in two skills with more mentions than total job ads.

Table 62: Most Desired Soft Skills for Workers at Petroleum Refineries in Washington, ranked by occurrence.

Skill Name	Number of Active Job Ads	Percentage of Active Job Ads
Communication (verbal and written skills)	727	219%
Cooperative/team Player	400	120.5%
Customer service	270	81.3%
Detail oriented/meticulous	265	79.8%
Self-motivated/ability to work independently/self leadership	258	77.7%
Organization	253	76.2%
Analytical	156	47%
Project management	148	44.6%
Supervision/management	142	42.8%
Problem solving	128	38.6%
Adaptability/flexibility/tolerance of change and uncertainty	125	37.7%
Interpersonal relationships/maintain relationships	105	31.6%
Ability to work in a fast-paced environment	100	30.1%
Good judgment	89	26.8%
Prioritize	89	26.8%
Work ethic/hard working	74	22.3%
Punctual	69	20.8%
Coachable/willingness to learn	58	17.5%
Multi-task	54	16.3%

[239] Chmura, JobsEQ Real-Time Intelligence (Job Postings) Data set, retrieved August 24, 2024.

Skill Name	Number of Active Job Ads	Percentage of Active Job Ads
Initiative	53	16%
Time management/time utilization	46	13.9%
Enthusiastic/energetic	45	13.6%
Negotiation	44	13.3%
Competitiveness	43	13%
Efficiency	43	13%

Source: JobsEQ RTI Database.[240]

Looking Ahead

This study involves developing and assessing numerous scenarios that refineries may experience in future years and investigating the economic and workforce impacts. The eight scenarios could result in varying durations and severity of job dislocation (full discussion of impacts occurs in Chapter 3). Multiple scenarios investigated in this report would correspond to significant layoffs for workers, including:

- Scenario 5: Change in Function; Storage Facility
- Scenario 7: Change in Function; Closure and Redevelopment
- Scenario 8: Change in Function; Closure without Redevelopment

Given these employment shifts and the potential for layoffs in certain scenarios, it is important to consider what other job opportunities might be accessible for the refinery workforce given their existing skills. These jobs may be either in other refinery operations or in other sectors of the economy. This study evaluates the anticipated availability of such alternate positions in Pierce, Skagit and Whatcom Counties. Evaluating opportunities in the counties where refineries are based is important in order to support workers that wish to remain in the same geographic area and because relocation costs can present a significant economic burden for workers and their families.

Worker Impacts Post-Closure or Conversion

Variance of specific systems and equipment used across refineries can impede the ability of workers to transfer to another site after closure of their current site. For unit operators, refinery closure can mean significant geographic relocation to remain in the field. These workers may transfer within the operating company they were already employed with, which can result in a maintained wage rate. For workers who relocate to a refinery owned by a different company, a significant pay decrease while training at the new facility is common. Even if workers have decades of experience, they may be starting off at entry-level wages. Depending on experience level, this can be a $15-20/hour decrease from a worker's previous wage levels. Particularly for workers who change from union positions to non-union positions, wages levels may significantly decrease.

Several potential future refinery scenarios examined in this study involve changing in function from conventional refineries to biorefineries. Currently, the majority of U.S. biorefineries operate with significantly

[240] Chmura, JobsEQ Real-Time Intelligence (Job Postings) Data set, retrieved August 24, 2024.

less staff[241] compared to prior operations as a conventional refinery. [242] An exception to this is the Dickinson, North Dakota refinery, which grew by 20 employees after converting to renewable diesel production.[243] These conversions could cause workers to move to other positions in oil and gas, the utility sector or chemical treatment in an attempt to retain previous wage rates. A UC Berkeley report[244] found that workers report worse working conditions in new positions, with a specific emphasis on significant safety concerns.

The relatively new emergence of alternative refining leaves many potential hazards unknown due to each facility's unique design.[245] Marathon's Martinez Biofuel Refinery, a recently converted facility, has experienced safety incidents and violations that have impacted workers. Two fires in November 2023 reinforced union claims that training for biorefining units was deficient.[246] California Division of Occupational Safety and Health (Cal/OSHA) fined the refinery $188,000 for eight serious safety regulation violations and three other violations. The U.S. Chemical Safety and Hazard Investigation Board (CSB) investigation is still ongoing, and Marathon contests the violations.[247] The violations include: failure to address hazards on unit during process hazard analysis, failure to implement written procedures with clear instructions, failure to prepare training certification and that testing procedures did not ensure competency of job skill levels and safe and healthy work practices.[248] Changes to unit configuration when converting the diesel hydrotreater unit to a hydrodeoxygenation unit are referenced by CBS and Cal/OSHA as potential contributing factors. The injured Marathon employee suffered burns to 90% of his body, resulting in the loss of both pinky fingers, and he is still undergoing treatment six months after the fire.[249]

Additionally, the establishment of new biofuel production facilities can be hindered by the large capital investment required by facility owners, which makes repurposing existing brownfield sites and relevant equipment a possible strategy to developing alternative fuel capacity. [250]Another notable concern for refineries that convert to biofuel facilities is the timelines for retraining. [246] Newer training programs may operate on a 6-8 month timeline, as opposed to a typical 10-12 month training at conventional refineries. Unions have raised concerns about these shorter timelines, claiming that training for biorefining units are deficient.**Error! B ookmark not defined.**

Another consideration is related to Process Safety Management (PSM), a set of regulations that help workers and refinery owners protect against and reduce risk of catastrophic incidents.[251] PSM regulations apply in oil

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[241] Specific examples of refinery employment impacts can be found in Chapter 3, including the Marathon Martinez biofuel refinery among others.
[242] Alexander, Ann, "Biofuel Conversions: A Chance to Model Just Transition", Natural Resources Defense Council, November 19, 2020.
[243] Marathon Petroleum Corporation/One Energy, "Marathon Dickinson Renewable Fuels Facility."
[244] Parks, Virginia, and Ian Baran. 2023. "Fossil fuel layoff: The economic and employment effects of a refinery closure on workers in the Bay Area." Berkeley, CA: UC Berkeley Labor Center.
[245] California Occupation Safety and Health Standards Board, "Proposed Petition Decision of the Occupational Safety and Health Standards Board (Petition File No. 601)", June 20, 2024.
[246] Goldberg, Ted, "Federal Agency Probes Marathon's Martinez Refinery After Two Large Fires Last Month", KQED, Dec 5, 2023.
[247] Occupational Safety and Health Administration, "Inspection Detail; Inspection: 1711945.015- Tesoro Refining & Marketing Company Llc.", Accessed August 24, 2024.
[248] California Occupation Safety and Health Standards Board, "Citations-Tesoro-Refining-Marathon", Published May 30, 2024 at 650 x 1000 in Citations, Legislation in Renewables Incident.
[249] Goldberg, Ted, "Marathon's Martinez Refinery Hit With State Fines Over Fire That Burned Worker", KQED, May 29, 2024.
[250] Brandt, K., Camenzind, D., Zhu, J.Y., Latta, G., Gao, J. and Wolcott, M. (2022), Methodology for quantifying the impact of repurposing existing manufacturing facilities: case study using pulp and paper facilities for sustainable aviation fuel production. Biofuels, Bioprod. Bioref., 16: 1227-1239; Lifeng Zhang, Ana Inés Torres, Bingzhen Chen, Zhihong Yuan, Ignacio E. Grossmann, "Optimal Retrofitting of Conventional Oil Refinery into Sustainable Bio-refinery under Uncertainty", Computer Aided Chemical Engineering, Elsevier, Volume 52, 2023, Pages 247-253, ISSN 1570-7946, ISBN 9780443152740,.
[251] Washington State Department of Labor & Industries, "Refinery Safety & Health and Process Safety Management (PSM)", https://www.lni.wa.gov/safety-health/safety-topics/industry-topics/refineries-psm

refineries but there have been different perspectives on whether they would apply in biorefining. A finding in California led to the conclusion that these protective policies should also apply in biorefining.[249] A decision by the California Occupational Safety and Health Standards Board requested expedited rulemaking to update regulations to include biofuel refining. This decision came after the fires at Marathon's Martinez Biofuel Refinery and subsequent petitioning from the USW Local 5. Biodiesel facilities, when compared to conventional petroleum refineries, have a much higher number of accidents per billion barrels produced.[252]In particular, the process hazard analysis (PHA) conducted for biofuel facilities is crucial, as it helps identify and analyze hazards and improve worker safety in an evolving industry.

Alternative Industries

Utilizing the SOC codes and analysis skills, alternative industries that refinery workers are best suited to transition to have been identified. Projections for future employment in these alternative industries are included in Appendix C as tables, using 10-year projections by JobsEQ in for Washington and Pierce, Skagit and Whatcom counties. These projections include the industry and projected changes in demand for each position over 10 years, organized by occupation. Some key takeaways from this analysis include:

- Non-Energy Manufacturing and Utilities: Food Manufacturing, Aerospace Manufacturing and the Utilities sector offer strong employment opportunities for displaced workers. This includes petrochemical manufacturing, among other related industries. Skills such as collaborative workflow, emergency response and troubleshooting large industrial operations transfer well to other manufacturing sectors.
- Energy Sector Manufacturing: Trade workers —including machinists, electricians and mechanics— are well-suited to leverage employment opportunities across a broad range of manufacturing industries, while operators have more options in manufacturing housed within the general petroleum and coal manufacturing sector. For example, construction equipment operators can transition into roadway and bridge construction, among other heavy construction fields.
- Water Treatment and Utilities: Plant and systems operators may be well-suited to work in waste treatment and disposal, either in other private manufacturing operations or public utilities systems. Particularly, experience as a process operator transfers well,[253] as operating processing equipment and monitoring conversion processes can have broad similarities even with differing inputs. Prior experience working in processing systems can aid in adjusting to new jobs.

Overall, workers with certifiable skills — such as welding, pipefitting and maintenance — have more mobility than workers such as unit operators when assessing alternative industries. However, unit operators also have transferable skills such as operations monitoring and problem sensitivity, which are required in other manufacturing fields as well.

Opportunities in Pierce, Skagit and Whatcom counties

Relevant clean energy workforce analyses such as the Net Zero Northwest (NZNW) Workforce Analysis[254] have indicated that while refineries jobs may be lost as the Pacific Northwest moves toward net-zero emissions, there will still be overall job gains across the fuels sector. In Washington, NZNW estimates 600 jobs displaced in "Other Fossil Fuels," which houses conventional petroleum refining, by 2030. However, the study also

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[252] Hao WU, Igor PEÑARRUBIA, Lin CUI, Jinsong ZHAO. "Process safety management considerations for biofuel production", Front. Eng, 2017, 4(3): 357–367 https://doi.org/10.15302/J-FEM-2017025

[253] Parks, Virginia, and Ian Baran. 2023. “Fossil fuel layoff: The economic and employment effects of a refinery closure on workers in the Bay Area.” Berkeley, CA: UC Berkeley Labor Center. https://laborcenter.berkeley.edu/fossil-fuel-layoff/.

[254] Clean Energy Transition Institute. Net-Zero Northwest: Technical and Economic Pathways to 2050, Workforce Analysis. April 2024.

estimates approximately 1,000 emerging jobs each in hydrogen and biofuels production. Combined with job displacement in natural gas subsectors, the study finds a net 700 position change (+5%) in the fuels sector by 2030. Fuels sector installation and repair occupations are expected to grow by 25% between 2021 and 2030. The following section further elaborates on the results of the NZNW study.

However, it is important to evaluate the extent to which alternative opportunities exist in the same counties or in close proximity to refineries, so that workers could access these jobs without facing long commutes or the necessity of relocation. The JobsEQ demand projections are based on existing conditions, meaning that they do not include facilities that are planned but not yet operational. Contrastingly, the NZNW study projections include projections for facilities that are not yet operational. Three tables including the potential demand of the top three alternative industries are included in Appendix C. The analysis in this study identifies the following about the opportunities that are currently or expected to be available in these counties, based on JobsEQ demand projections:

- In Whatcom County, some alternative industries include grain and oilseed milling and other food manufacturing. Other chemical product and preparation manufacturing is also included. There is some potential growth in these industries in Whatcom County over the next 10 years. Other industries like pulp, paper and paperboard mills are potential alternative industries for displaced workers, but are expected to decline in total employment over the next 10 years.
- In Skagit County, some alternative industries include metalworking machinery manufacturing, ship and boat building and seafood product preparation and packaging. Commercial fishing in Skagit County makes up only one part of the maritime sector enabled by the natural deep-water port.
- In Pierce County, some alternative industries include animal food manufacturing, aerospace products and parts manufacturing and utility system construction. Aerospace manufacturing has a much stronger presence in Pierce County than in Whatcom or Skagit, due to the location of Boeing manufacturing in Frederickson. Additionally, other Boeing manufacturing facilities in King County may be more accessible to displaced workers in Pierce County than in Whatcom or Skagit.

A misalignment between existing opportunities in alternative industries located in these counties may provide significant obstacles for workers. The demand for displaced occupations may not align with when the workers are seeking employment, forcing workers to look farther afield for suitable work. Similarly, workers may accept less well-matched positions to their skillsets to remain in their current areas. Many of the jobs identified in these alternative industries include opportunities for union represented employment.

Pathways to early retirement

A large percentage of workers in refineries are later in their careers, with a significant number of workers 45 years old or older. While it is unclear how close workers are to retirement, it is apparent that a significant number of Washington refinery workers are not far from retirement age. For such workers, seeking new employment that requires retraining or relocation may be particularly challenging. While evaluating the full extent of this need and suggesting possible approaches for these workers is outside the scope of this study, it is worth highlighting that the Washington State Workforce Training and Education Coordinating Board has been given legislative direction to study the feasibility of a transition to retirement program for workers close to retirement age.[255] This study may provide additional guidance related to opportunities to preserve income and benefits for refinery workers nearing retirement age.

[255] HB 1176 (laws of 2023). https://lawfilesext.leg.wa.gov/biennium/2023-24/Pdf/Bills/Session%20Laws/House/1176-S2.SL.pdf?q=20240920132545

Industry's Top Occupational Data

A table with details about the top 25 occupations within the refining sector, including the SOC code, occupation title, number of employees and average annual wages is contained in Appendix C. Exits, transfers, employment growth and total demand refer to a projected two-year demand for the listed occupations. There is very little expected growth among these occupations, along with few expected exits in the next two years. The top 25 occupations range in average annual salary from $97,100 to $191,800. This is important to note as it is significantly above the average annual wages in Pierce, Skagit and Whatcom counties, where the refineries are housed. Pierce, Skagit and Whatcom Counties have average annual wages of $66,941, $61,668 and $61,901 respectively.

Breaking this down into the categories used previously, we can look at jobs related to production and facilities maintenance, administration and management and for engineers and scientists at the refineries. For workers in production-related positions, annual wages range from approximately $44,000 to $138,000. This range includes entry level positions such as helpers, in addition to positions like industrial machinery mechanics, chemical plant and system operators, welders and machinists. Management and administration positions at refineries have an annual wage ranging from $51,000 to $363,000, including positions from receptionists and information clerks to chief executives. For engineers and other scientists working at refineries, annual wages range from approximately $42,000 to $179,000, including technician positions, professional engineers and occupational health and safety professionals.

Toward Net Zero

The Clean Energy Transition Institute (CETI) published the Net Zero Northwest (NZNW) study [256] in 2023. The broader study regarding changing regional energy supply and demand expectations as the Northwest transitions to a net zero economy was coupled with a Workforce State Analysis that investigates the modeled employment change as a result from this transition. This study investigates the Northwest as a whole and provides analysis specific to Washington workers. The following data is drawn from the Washington-specific workforce analysis.

This study classifies relevant petroleum refinery jobs within “Other Fossil Fuels” in their subsector analysis, with a baseline employment of 6,888 jobs in 2021 in Washington. This is inclusive of positions outside of direct petroleum refinery operations, including kerosene and coal, and therefore is larger than the value referenced earlier in the report (2,000) for total employment at Washington refineries. It is important to note that Other Fossil Fuels made up 47% of fuel sector employment in 2021, with an expected 9% decrease from 2021 to 2030. This total employment includes direct, indirect and induced employment as one sum. Biofuels encompasses ethanol, bio-gasification and biomass pyrolysis, accounting for 4,283 jobs in 2021. The analysis expects an additional 980 jobs by 2030 in the biofuels sector. Scenario 4 in Chapter 3 discusses the impacts of a conversion from conventional refining to biofuel refining.

NZNW finds that the need for clean fuels--like hydrogen and biofuels--is more acute in the Northwest than other regions of the United States. With a relatively clean grid due to hydroelectric resources, the Northwest cannot achieve significant emissions reductions from cleaning the electricity grid. That fact, combined with Washington's aggressive 2030 emission reductions target (45% below 1990 levels), drives the need to decarbonize fuels earlier than in other regions.

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[256] Clean Energy Transition Institute. Net-Zero Northwest: Technical and Economic Pathways to 2050, Workforce Analysis. April 2024. https://www.nznw.org/workforce

From 2021 to 2030, NZNW estimates a net gain of 700 positions in the fuels sector, with approximately 1,000 jobs emerging in each hydrogen and biofuels and 1,400 jobs displaced in other fuels sectors, along with approximately 800 jobs displaced in natural gas and natural gas distribution combined.

Therefore, NZNW expects some employment growth through 2030 due to growth in supply chain operations and construction as facilities are built or retrofitted for biofuels and hydrogen. It is not anticipated that all of these jobs will remain in the long term, as completed facilities will require fewer construction workers. Nevertheless, NZNW finds that additional demands for building retrofitting and the expansion of existing electrical grid systems will continue along with demand for many of the total construction jobs through 2050. Changes to existing infrastructure and the creation of new infrastructure cannot all be completed simultaneously, and significant investment into renewables and low carbon building technologies will help provide consistent demand.

When examining employment by industry, NZNW finds that combined direct and indirect jobs in manufacturing comprised 2,389 jobs, or 48% of total other fossil fuel subsector jobs in 2021. NZNW projects an expected decrease to 2,182 jobs by 2030 and a decrease to 1,587 jobs by 2040. However, throughout this time period, manufacturing remains 48% of total subsector jobs as decreases are seen relatively equally across the industry categories within the Other Fossil Fuels subsector. In terms of occupations, installation and repair occupations comprised 58% of fuel sector growth in 2030, while production/manufacturing and administrative positions declined.

By 2040, NZNW projects that 57% of direct and indirect fuel sector employment will be in Biofuels (8,259 projected total jobs) and 15% in Hydrogen (2,086 projected jobs). An important note is that as vehicle electrification efforts and other emissions reductions efforts take hold in Washington, demand for biofuels and other liquid fuels may decrease as overall fuel consumption declines. [257]The NZNW modeling takes this into consideration and finds that while fuels may be used less in on-road vehicles, space heating, and some industrial processes, growth in biofuels and hydrogen-derived clean fuels would continue in aviation, maritime, and related sectors that do not have the same electrification options. [258]

Retraining of existing workers into clean energy jobs, such as hydrogen and biofuels, can help displaced conventional fuel workers. However, the timing, magnitude and location of new positions are all complicating factors.[259] In this way, biofuel refining may help transition petroleum refining workers, but may not maintain employment as demand continues to decline for liquid fuels. It is important to begin developing training programs and support systems for potentially displaced workers ahead of these anticipated changes. While biofuel jobs are expected to grow significantly in 2040, this growth is driven largely by shorter-term construction jobs and then by other supply chain and professional services industries. It is therefore important to begin developing training programs and support systems for potentially displaced workers ahead of these anticipated changes.

NZNW notes that the majority of fuel sector employees have a wage at or above $30/hour, but the study did not examine wage impacts for specific subsectors. As referenced earlier in this report, petroleum refinery

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[257] Washington Department of Commerce, "Green Electrolytic Hydrogen and Renewable Fuels: Recommendations for Deployment", January 5, 2024.
[258] Washington Department of Commerce, "Green Electrolytic Hydrogen and Renewable Fuels: Recommendations for Deployment", January 5, 2024.
[259] Location is a major barrier for transferring US fossil fuel employment to green jobs

workers earn higher wages than average, complicating decisions to change fields for employees. Table 63 contains the estimated changes to the fuel sector employment by year and fuel subsector through 2050.

Table 63: Net-Zero Northwest: Washington Fuels Sector Employment (Direct and Indirect Jobs)

Fuels Subsector	2021	2025	2030	2035	2040	2045	2050
Biofuels	3,266	3,266	4,006	4,006	8,259	10,871	7,426
Hydrogen	0	142	841	1,217	2,086	3,200	3,631
Other Fossil Fuels (Including refinery jobs)	4,962	4,890	4,531	3,956	3,295	2,814	2,681
Natural Gas Distribution	2,090	1,959	1,552	968	513	249	157
Natural Gas	332	329	302	259	227	203	195
FUELS TOTAL	10,650	10,585	11,231	10,406	14,380	17,337	14,089
Net Change from 2021		-64	581	-244	3,731	6,687	3,440

Chapter 5: Refineries in Transition

Key Finding 9. Alternative uses for refinery sites exist, with industrial uses likely to be more feasible than non-industrial.
Depending on the type and extent of contamination, remediation may be very expensive, time-intensive and require a variety of remediation methods.

- 9.1 Depending on the type and extent of contamination, remediation may be very expensive, time-intensive and require a variety of remediation methods.
- 9.2 The Department of Ecology oversees remediation efforts, and legal and financial obligations usually fall on current or previous site owners. The Model Toxics Control Act (MTCA) can also help determine liable parties or fund cleanup processes.
- 9.3 There are several potential future uses for refinery sites which present varying levels of economic, health, and environmental benefits and burdens.
- 9.4 Some scenarios are more feasible than others, depending on contamination levels and other factors.

Key Finding 10. Refinery operations contribute to human health and environmental harms, with associated economic costs, impacting their local economies, environments, neighboring tribal nations and surrounding communities.

- 10.1 Proximity to refineries (as with most heavy industrial facilities) is linked to higher risks of cancer, respiratory issues, cardiovascular diseases, neurological damage, and reproductive health problems.
- 10.2 Pollutants emitted at these sites include benzene, sulfur dioxides, formaldehyde, and particulate matter, contributing to smog, ozone formation, and other environmental hazards.
- 10.3 Many overburdened populations are located near refineries and face disproportionate pollutant exposure. The Environmental Health Disparities map highlights the increased risk to vulnerable communities in these areas.

Background

This chapter aims to contextualize the scenarios in Chapter 3 in Washington policy around environmental remediation, as well as describing anticipated characteristics and costs for cleanup at a refinery site. While specific analysis of costs and timelines for cleanup would need to be completed on a refinery-by-refinery basis using site-specific data, that data was not available for this study. The analysis in this chapter provides high-level guidance regarding the most significant cleanup-related considerations and potential future uses that may be feasible for Washington refinery sites.

Two scenarios included in this report evaluate the impacts of a refinery closure. The refineries could be remediated and redeveloped for alternative use or remediated and not redeveloped. This review of Washington's cleanup accountability policies, such as the Model Toxics Control Act (MTCA) will illustrate potential impacts to Washington residents of usage transitions and remediation efforts.

Understanding potential future uses of refinery sites is a vital aspect of this report, as it is important to consider what other opportunities might be available at these locations should any of the refineries close in the future. Early planning around what the sites may be suited for, as well as understanding the associated economic and workforce opportunities such future uses could bring, may help refinery communities consider options and establish local priorities. While detailed analysis of specific uses for individual refinery sites is

beyond the scope of this report, the following analysis and findings provide context about broad challenges and opportunities for future uses.

While there are numerous possible future uses for any given refinery site, this study has identified six broad examples of potential future use, which are described in this section. These future uses encompass a broad range of possibilities to account for the fact that redevelopment decisions are constrained by permitting and zoning laws and may be influenced by market demand. Many of the refineries are located adjacent to port sites, which enables them to ship products in and out of the refineries. Additionally, some sites are located in scenic regions,[260] but the long history of industrial production creates significant challenges for conversion to commercial or residential property uses. The environmental conditions of refinery sites will likely limit the options for redevelopment due to extensive contamination. Standards for remediation, current infrastructure and decarbonization policies impact these development decisions. Conversion to other energy-related uses, industrial uses or heavy manufacturing are likely contenders for these properties given their location and infrastructural assets such as access to open water, rail, high rated roads, utility placement and zoning.

This chapter also includes a review of previously remediated refinery sites in the United States. Information related to the contamination, cleanup costs, liability for cleanup efforts and the timeline of remediation is included in these case studies. However, public information on some aspects of cleanup is limited, particularly for privately owned and remediated sites. As such, the information presented has been gathered based on the best publicly available data.

Cleanup Accountability Policies

Legal and financial considerations for cleanup obligations

The specific extent of contamination at the refinery sites is currently unclear. With operations dating back close to 70 years, contamination is likely extensive. Refineries are engaged in remediation activities at present, though these are aimed at mitigation of existing impacts rather than full restoration to environmental conditions prior to refinery operation. Full remediation is not possible while on-site operations continue, as the sites continually produce contaminants through normal operations. Previously, refineries in Washington have faced penalty fines due to excessive pollution, even as recently as 2021.[261] Remediation in Washington is a layered process, with the Department of Ecology overseeing remediation efforts. However, remediation are left to the landowner at sites with an active liable party and often include contractors conducting the actual cleanup. Once the extent of the contamination is determined, a remediation area is established and a feasibility study is conducted to evaluate remediation options. Certain types of pollution can travel a very long distance, resulting in large areas of remediation. Examples of contaminants that result from refinery operations include benzene, particulate matter, nitrogen oxides, carbon monoxide, sulfur dioxide, ammonia and oil residuals.

Model Toxics Control Act

Washington's Model Toxics Control Act (MTCA) helps protect Washington residents from bearing the cost of remediation. MTCA funds and directs the investigation, cleanup and prevention of additional pollution at sites that are contaminated with hazardous substances. MTCA is funded by the Hazardous Substance Tax (HST),

[260] These locations may have additional value in potential residential or commercial uses because of waterfront views and access.
[261] Ysabelle Kempe, The Bellingham Herald. "A refinery spewed black smoke into this NW community. Now this oil giant will pay." Updated July 27, 2021. Accessed July 2, 2024.

which also provides approximately 40% of the Department of Ecology's base operating budget.[262] The aggregated HST paid by Washington's five refineries in calendar year 2023 was $141,366,792 total, with $137,890,531 paid by volume and $3,476,261 paid by value.[263] This is an important distinction because petroleum products are difficult to measure on a per-barrel basis. A barrel is considered approximately 42 gallons, but the finished products of petroleum are not exclusively liquid. These products include, but are not limited to, petroleum coke, propane and butane. Products that can be measured on a per barrel basis include, but are not limited to, gasoline, aviation fuel, diesel, lubricating oil and bunker fuel.[264] Products that can be measured on a per barrel basis are taxed based on volume. Other products are taxed based on their wholesale value, as they cannot be easily measured on a per barrel basis. Both revenue streams contribute to the HST. How this tax is collected may be impacted by current product composition at the refineries, which fluctuates based on feedstock and operational processes.

It is important to emphasize that up to 90% of MTCA funding comes from the petroleum-based HST revenue.[265] Any potential closures or significant changes to the volume of petroleum products produced at Washington's refineries could have a significant impact on both MTCA's operations and the Department of Ecology's operations, though some of the pollution and cleanup-related needs that the program and the agency address would also be reduced. Looking to the future, it is reasonable to expect a decline in petroleum production as Washington works toward the Climate Commitment Act (CCA) goal of a 95% reduction in statewide emissions, and this study evaluates scenarios that assume achievement of the net zero emission requirements.

MTCA operates on a "polluter pays" principle, meaning that the entity deemed responsible for the contamination is responsible for the cleanup. This includes current site owners or operators, a former owner or operator who disposed of or released a hazardous substance or an individual who brought or caused a hazardous substance to be released at the assessed site.[266] MTCA also helps fund the cleanup of "orphan sites", or sites wherein the potentially liable persons are financially unable or unavailable to fund remediation at a contaminated site.[267] Additionally, oversight under the Resource Conservation and Recovery Act (RCRA) may make environmental obligations not dischargeable were a corporation to enter Chapter 11 bankruptcy. This allows for corporate successors to be tasked with remediation, preventing the burden of remediation from shifting to taxpayers.[268] This is important because these programs would increase the likelihood that future owners of these sites will be responsible for the costs of environmental remediation even if the current owners were to face bankruptcy. Even in cases where refinery owners may sell a refinery to another party who may later declare bankruptcy, there are provisions to seek to recover costs from past owners.

However, a scenario in which Washington taxpayers may bear some costs associated with site remediation include the acquisition of former refinery properties by a local government. MTCA remediation funding is only available to local governments conducting cleanup actions under an order or decree. Every even-numbered

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[262] Washington state Department of Ecology, "Hazardous Substance Tax - Washington State Department of Ecology" Accessed August 3, 2024.
[263] Information provided by the Department of Revenue by request, received July 29, 2024.
[264] Washington state Department of Revenue, "Hazardous substance tax | Washington Department of Revenue" Accessed August 3, 2024.
[265] Washington State Department of Ecology, "Model Toxics Control Act Capital Account: Ten-Year Financing Report 2022 (wa.gov)" January 2023.
[266] Department of Ecology State of Washington, "Contaminated Property Considerations: Focus on Real Estate Transactions", March 2022, Toxics Cleanup Program.
[267] Department of Ecology State of Washington, "Colville Post &Poles Site", February 2015, Toxics Cleanup Program.
[268] Ross Levine, UC Berkley, "Environmental Liabilities, Creditors, and Corporate Pollution: Evidence from the Apex Oil Ruling", Harvard Law School Forum on Corporate Governance, April 22, 2022.

year, grant applications are accepted from local governments that fund anywhere from 10-50% of cleanup costs. These funds are allocated and managed by Ecology through the Model Toxics Control Accounts, which also helps fund the Toxics Cleanup Program.

A relevant example of this kind of acquisition is the Georgia-Pacific West Bellingham cleanup. The former pulp and tissue mill was acquired by the Port of Bellingham in 2005, with plans to redevelop the site for non-industrial uses. Due to the scale and separation of contaminated sites, remediation responsibilities were split between the Port and the state Department of Ecology. Investigation into the site began in 2009, with remediation at the northern site completed in 2016. The southern site is still in the cleanup design stage of remediation.[269] A July 2014 publication cited an expected a total remediation construction[270] cost of $5.7 million.[271] The Port supplied the other funding for cleanup, not provided for through MTCA funding, with their own revenues. At least half of the costs must be provided for by the Port, as MTCA can only provide half of the funding.

The City of Bellingham (COB) is another local government engaging with partners to clean up and redevelop the city's waterfront. A relevant example site is the Central Waterfront cleanup, which included a former Chevron bulk fuel storage facility. A July 2019 release estimated construction[270] costs associated with cleaning up the site to be approximately $4 million.[272] Per COB, the 54% of funding not covered by MTCA is provided by COB's Environmental Remediation Fund. The COB is administering multiple cleanup sites, with a current expected total cost of $30 million as of August 2024. COB's Environmental Remediation Fund is maintained by the solid waste utility tax.[273]

An important note is that Ecology may pursue polluters to recover costs for remediation. Per MTCA, the state is required to seek to recover the amounts spent for investigative and remedial actions, agreed orders, enforcement orders and consent decrees from Pollution Liable Parties (PLPs). These costs include the costs of direct activities, support costs of direct activities (overhead) and any interest charges for past due payments. All consent decrees, agreed orders and enforcement orders must include a provision for cost recovery, wherein any PLPs are typically expected to pay costs as they occur. For Voluntary Cleanup Program sites, this also includes persons requesting advice and review from Ecology for independently run cleanups. At sites with an issued order for repayment, the Attorney General's Office may file an action in court to recover costs, with noncompliant PLPs liable for up to three times the costs incurred by the state due to noncompliance and a $25,000 per day civil penalty for noncompliance. [274]

Other means of funding remediation activities include the use of pollution liability insurance, pursuance of historical custom insurance policies or pursuit of liable operators in court. Before 1986, a comprehensive general liability insurance policy customarily included coverage relevant to pollution-related damages. However, these comprehensive general liability insurance policies were replaced in 1986 by the commercial general liability (CGL) policies, which introduced a pollution exclusion. As a result of strengthening environmental policy in the 1970s and 1980s, insurance carriers began to exclude pollution-related damages from coverage. As environmental regulations strengthened, insurance carriers saw a flood of pollution claims

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[269] Washington State Department of Ecology, "Bellingham Bay Cleanup: 2024 Cleanup Update"\
[270] Construction costs refer to the costs of building and implementing the chosen remediation method, and does not encompass administrative or design costs related to site investigations.
[271] Washington State Department of Ecology, "Georgia Pacific West Factsheet"
[272] Washington State Department of Ecology, "Central Waterfront Factsheet".
[273] City of Bellingham Municipal Codes, "4.76.040 Environmental remediation fund | Bellingham Municipal Code" Current through June 17, 2024.
[274] Washington State Department of Ecology, "Toxics Cleanup Program Policy 550A (wa.gov)", revised December 2017

under liability and property policies, which contributed to the changes described above to CGL policies. Concurrently, the U.S. Environmental Protection Agency (EPA) began to pursue corporate polluters to curtail their pollution and initiate remediation. This resulted in the creation of separate environmental liability policies, which are used today. These pre-1986 policies are sometimes pursued and called into effect nearly 50 years later to help support remediation costs.[275] However, for this to occur, records of held insurance and attributable releases while that policy was in effect must be present. This method of recovering costs may be pursued if a responsible business no longer exists but has both documented releases and insurance. Managers of industrial sites (such as the Port of Bellingham) may also require tenants to have pollution liability insurance to help with cleanup costs related to both accidental releases and contamination from ongoing operations.

Additional taxes related to environmental stewardship include the Petroleum Product Tax (PPT) and the Oil Spill Tax (OST). The OST refers to the combined administration of the Oil Spill Response Tax and the Oil Spill Administration Tax. OST is applied at a per barrel rate, and PPT is applied to the wholesale value of petroleum products. Neither type of tax is collected annually, but rather they are reinstated or suspended as needed to maintain minimum account balances.

PPT is collected when the Pollution Liability Insurance Program Trust (PLIPT) falls below $15 million in the previous calendar quarter and is suspended once the account balance exceeds $30 million in the previous calendar quarter. PPT is currently in effect and has been since January of 2020.[276] These funds are administered by the Pollution Liability Insurance Agency (PLIA) for the pollution liability insurance program and emergency program. This includes the cleanup releases from active and currently registered heating oil tanks, with up to $60,000 not covered by other insurances. PLIA also administers a technical assistance program for qualifying petroleum sites.[277]

Similarly, the OST is collected when the oil spill response account falls to $8 million and is suspended when the account reaches a balance of $9 million.[278] Generally, the tax is applied when products are delivered to a marine terminal or bulk oil terminal via vessel or barge, rail tank car or pipeline. The OST was expanded in 2018 to include some crude oil or petroleum products delivered via pipeline. The oil spill administration tax pays for work related to oil spill prevention, response and habitat restoration, while the oil spill response tax pays for oil spills with cleanup costs exceeding $50,000. Responsible parties for spilled oil[279] (or other hazardous substances) into state waters may be required to pay for:

1) A resource damage assessment.

2) Reimbursement of the state's expenses to respond, assess and investigate the incident.

3) A penalty for violation of the state's law or rule.

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[275] EnviroForensics, "How to manage environmental risk through historical and modern insurance agreements (enviroforensics.com)", October 15 2024.
[276] Washington state Department of Revenue, "Oil spill response tax and oil spill administration tax | Washington Department of Revenue" Accessed August 3, 2024.; Washington DOR Tax Reference Manual, "Oil Spill Tax", August 2023.
[277] Pollution Liability Insurance Agency, "About PLIA - The Pollution Liability Insurance Agency (wa.gov)"
[278] Washington state Department of Revenue, "Petroleum products tax | Washington Department of Revenue" Accessed August 3, 2024.; Washington DOR Tax Reference Manual, "Oil Spill Tax", August 2023. Petroleum Products Tax - Tax Reference Manual (wa.gov)
[279] Spill Prevention, Preparedness, and Response Program, "Focus on: State Costs for Spills", Washington State Department of Ecology, Revised May 2020, Publication 08-08-006

Payment for oil spill damages go into the state's Coastal Protection Fund. These funds can only be used for environmental restoration projects, oil spill studies and habitat mapping systems. However, the responsible party or spiller may also propose restoration projects in place of monetary damages for resource damage assessments. A large spill could cost the state $10.8 billion in costs and 165,000 jobs based on 2006 numbers. [280] For large oil spills that cause great resource injuries, federal trustee agencies will conduct natural resource damage assessments, under the authority of the Oil Pollution Act of 1990. There is no limit of liability for the costs of spilled oil. Vessels and facilities that transport or handle hazardous materials are required to demonstrate different levels of financial responsibility based on the worst-case spill or total capacity.[281] Of the spills in Washington, many are related to sunken or otherwise damaged marine vessels. Since 2020, there have been three pipeline-related releases. Since 2014, there have been four railway-related releases, due to either damaged transport cars or derailment.

The size of parent entities of Washington's refineries may make it unlikely that the sites will become orphan sites after a potential refinery closures. The history of industrial usage at each site also makes cleanup to industrial standards the most probable pathway for these sites. The likely existing contaminants from industrial operations take significant amounts of time to clean up to residential standards, in addition to needed changes to local zoning. MTCA standards are based on exposure-based cancer risk, exposure-induced illness and impacts on nearby plants and animals. Industrial zones, compared to commercial and residential zones, have fewer exposure pathways. As a result, the minimum acceptable risk and cleanup standards for sites that will be used for industrial purposes after remediation are not as stringent as those that will be used for residential purposes, which have more exposure pathways. Industrial operations have policies to prevent exposures, such as the following:

- Personal Protective Equipment (PPE)
- Restricted areas, through physical controls and barriers
- Required safety trainings for employees

These policies change the minimum acceptable risk, and therefore cleanup standards, for an industrial area as opposed to a residential area. It is also possible to clean up contaminated sites to different standards, such as for residential use. Residential standards are much higher than industrial stands, as there are more pathways to exposure. Some pathways to exposure in residential areas [282] that are less likely in industrial areas include:

- Ingestion via home gardens or contact with soil
- Recreation activities, such as swimming, fishing or playground usage
- Exposure to contaminants without PPE or information about risks

However, this does not eliminate the possibility of the sites being bought by a public agency or local government or being redeveloped for commercial or residential use. While unlikely, there is a precedent in some areas, including the Bellingham Waterfront Cleanup, of industrial areas being redeveloped after cleanup into commercial office spaces, new housing developments or recreational areas.

Potential Future Uses

The following sections discusses six potential future use categories that may be options in the case of refinery closure, based on assessing state and local factors such as contamination and cleanup responsibilities,

[280] Spill Prevention, Preparedness, and Response Program, "Spill Prevention, Preparedness, and Response Program", Washington State Department of Ecology.
[281] Regulations & Permits, "Financial responsibility for oil spills", Washington State Department of Ecology.
[282] Agency for Toxic Substances and Disease Registry "Element 3: Exposure Points", Updated April 14, 2022.

zoning, and related regional geographic and economic factors. This study assesses broad categories of potential future uses of refinery sites, and considerations related to co-benefits that may be associated with these different types of future use. The broad categories of potential future use evaluated in this study are:

- Energy industrial
- Non-energy industrial
- Industrial symbiosis
- Heavy manufacturing
- Return to tribal ownership
- Residential or commercial uses

Each potential future use is evaluated in relation to specific topics of interest. This can be done at a high level only, as quantifiable impacts related to potential future uses can only be assessed in the context of particulate proposed projects and their specifications, such as specific details regarding facility size, fuel types and amounts, energy demand and source, technology selection, air and water pollution mitigation processes, and others.

It is important to note that specific potential future uses should be carefully assessed to ensure they do not exacerbate impacts on overburdened communities that flow from past siting decisions of refineries and other industrial facilities. Particular consideration will also be needed in relation to tribal lands and treaty rights.

Table 64: Considerations for each scenario.

Consideration	Scenario notes
Greenhouse gas emissions	All categories of potential future use may be expected to lead to reduced GHG emissions. This is true even for heavy manufacturing and industrial uses, due to assumptions that new facilities will be designed in ways that plan for low-carbon and efficient processes. Any new facilities with higher (over 25,000MT/yr CO_2e) would be regulated under the Climate Commitment Act and would need to comply with planned reductions (it is possible though not certain that these facilities may be categorized as new EITEs). Return to tribal ownership may have very low GHG emissions.
Local pollution and environmental health	Alternative future uses would need to be carefully evaluated to assess local pollution and environmental health impacts on a case by case basis. Biomass based feedstocks can still emit harmful air pollutants, noise and dust pollution, and fire and safety risks likely exist that would need to be addressed for storage and handling. All manufacturing processes have their own pollution and environmental health impacts that would need to be analyzed.
Direct and indirect employment benefits	As Washington's refineries are significant employers and pay higher than average wages in the counties where they are located, employment benefits may decrease in the potential future use scenarios. Heavy manufacturing is likely to have higher employment benefits in general. Return to tribal ownership may have the lowest direct employment benefits for work after remediation.
Estimated tax impacts	Refineries pay high levels of state and local taxes at present, which potential future uses of these sites may not equal, though this depends on specific proposals.
Potential costs to Washington residents	Economic costs for Washington residents will depend on specific future uses, the number and quality of jobs proposed, and whether these uses require new grants or incentives to direct facilities to locate in Piece, Skagit and Whatcom counties.

Consideration	Scenario notes
	Additionally, remediation costs related to new uses may impact Washington residents if the land is purchased by a local governmental entity.
Feasibility based on relevant market trends	Energy industrial, non-energy industrial operations are increasing in Washington, though they face limitations including on feedstocks and electricity capacity. Heavy manufacturing operations have declined in recent years, though Washington has established statutory targets to double manufacturing jobs in the state. The number of acres of land returned to tribal ownership is low in Washington and across the country although there is increased interest in this approach, especially where it aligns with climate resilience goals and funding. Commercial or residential uses may be of interest, as seen through the redevelopment projects like the Bellingham Waterfront Cleanup.

Energy Industrial

This report defines an energy industrial facility as a facility that produces or stores electrical energy. Various types of energy industry could fall into this category, including processing raw methane into renewable natural gas, biomass energy production, green electrolytic or renewable hydrogen production, renewable electricity production including utility-scale wind, solar and geothermal and related categories. Numerous examples of energy industrial facilities exist in Washington already, including natural gas and biomass plants and energy storage facilities.

Many considerations would impact the selection of certain kinds of energy industrial use over others. One principal consideration is compliance with state greenhouse gas limits and laws, including the Climate Commitment Act. New energy industrial projects would need to evaluate anticipated GHG emissions to understand how their operations could be incorporated under the Climate Commitment Act's regulations regarding major sources of emissions, as well as the state's GHG limits as discussed previously. Additionally, the Clean Energy Transformation Act (CETA) requires moving to 100% clean electricity by 2045. Much of Washington's electrical grid is already renewable due to the abundance of hydroelectric power in the state, which accounts for approximately 60% of total annual electricity generation in Washington. Any future development of energy production facilities must be in line with state and federal climate and clean energy regulations.

Other considerations include proximity to feedstocks and quality of renewable energy generating potential. Certain types of energy industrial use, such as renewable natural gas or bioenergy projects, are highly dependent on available feedstock and infrastructure at the site or in close enough proximity to transport feedstocks. Bioenergy feedstocks do not need to be available in the immediate vicinity, but proximity to feedstocks will reduce costs and improve reliability, meaning that these types of energy industrial opportunities will need to evaluate how to source reasonably proximate biomass materials. Woody biomass residues and agricultural residues are available in Washington and could be leveraged for biofuel production. Infrastructure is also important; previously closed pulp and paper mills may have existing infrastructure, such as biomass boilers, which make them particularly well suited to conversion to this type of energy industrial use. Clean energy production projects will require strong wind and solar potential to be commercially viable;

wind and solar resources are less abundant on shore in western Washington, which could limit these opportunities.[283]

Additionally, siting and permitting will be a consideration for any kind of new energy industrial use. Washington is currently working to help expedite siting and permitting processes for certain types of clean energy projects, specifically for wind, solar and green electrolytic and renewable hydrogen. The Washington State Department of Ecology is currently working to generate Programmatic Environmental Impact Statements (PEISs) on the potential impacts and mitigation for clean energy facilities, which could help to facilitate the siting, and permitting of these specific kinds of clean energy facilities.[284]

Conversion from petroleum refining to either biorefineries or green hydrogen facilities could reduce the GHG emissions of the refinery sites. A 2023 RMI report[285] discussed the ways in which smaller facilities[286] (such as the Tacoma refinery) are potentially more suited to conversion. The smaller capacity is more closely matched to the availability of feedstocks for biorefining, helping to minimize capital expenditures needed for production and maximizing use of current infrastructure. The report estimated a potential for between 1,000 to 3,000 barrels of SAF per day at the Par Pacific/U.S. Oil Tacoma Refinery. Biomass feedstocks involved in biofuel production may offset the CO_2 produced when biofuels are burned, leading to a net neutral change in GHG emissions.[287] In part, this is because biomass materials sequester CO_2 as they grow, which may offset the CO_2 emissions from producing or burning biofuels, although this is dependent on how lifecycle emissions are calculated.[288] Chapter 3 of this report touches on feedstock availability and the demand for biofuels in Washington. An example of a green electrolytic hydrogen project in Washington is Douglas County Public Utility District's green hydrogen facility. The facility is set to begin producing hydrogen in late 2024 and will help provide flexibility to its adjacent Wells Hydroelectric Project through storage and use of hydrogen to generate electricity in periods of high demand, in addition to providing publicly accessible light, medium and heavy-duty hydrogen vehicle fueling.[289] The PUD's ownership of low-cost hydroelectric power generation resources helps make this project cost-effective.

Research indicates that clean energy facilities of a variety of types can drive economic development. One recent example is the Net-Zero Northwest[290] (NZNW) Workforce Analysis and Energy Pathways Analysis, conducted by the Clean Energy Transition Institute (CETI). This analysis evaluated various sectors of the energy economy and their prospects as the Northwest moves toward a net-zero economy and found that many are poised to grow and could result in higher employment, driven by construction and maintenance of infrastructure investments at these facilities. However, absent specific project proposals, it is unclear if the operational needs of an energy industrial facility will ultimately increase or decrease compared to refinery operations. By 2030, NZNW expects an additional 4,176 jobs in electricity distribution, an additional 2,619 jobs in transmission, an additional 587 jobs in solar, and an additional 1,055 jobs in land-based wind. After 2035, NZNW Energy Pathways modeling assumes that new gas generating capacity will use biomass methane gas,

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[283] Washington State Department of Natural Resources, "Clean Energy", Clean Energy | WA - DNR
[284] Department of Ecology State of Washington, "Focus on: Clean Energy Programmatic Environmental Impact Statements", September 2023, Shorelands & Environmental Assistance Program. Clean Energy Programmatic Environmental Impact Statements (wa.gov)
[285] Veysey, Drew, Meghan Peltier, and Joseph Fallurin, Rocky Mountain Institute, "Five Ways US Oil Refineries Can Reduce Emissions Today", June 5, 2023. Five Ways US Oil Refineries Can Reduce Emissions Today - RMI
[286] The RMI report "Oil Refining Emissions Cut Points" defined a small facility as a refinery with 160,000 tons CO_2 equivalent per year, and specifically utilizes the Par Pacific/U.S. Oil Tacoma Refinery as an example of a small facility in their report.
[287] U.S. Energy Information Administration, "Biofuels explained", Updated April 13, 2022.
[288] U.S. Energy Information Administration, "Biomass explained", Updated April 17, 2022. Biomass and the environment - U.S. Energy Information Administration (EIA)
[289] HydroReview, "Douglas PUD purchases second electrolyzer for hydrogen project near Wells hydropower", February 21, 2023.
[290] Clean Energy Transition Institute, "Net-Zero Northwest", Home | Net-Zero Northwest (nznw.org)

which may offer transition points for current natural gas generation workers. These projections may be impermanent, as some of the job growth can be attributed to infrastructure upgrades. Both hydropower and offshore wind jobs peak in 2030 due to assumptions about the timing of upgrades and development. Average annual wages across the electric power generation, transmission and distribution in Washington ranged from $69,000 to $143,000 as of Q1 2024 per Chmura.[291] As Washington's demand for affordable, reliable clean electricity grows, new clean energy generation or co-production of alternative fuels and green hydrogen may be as an opportunity to anticipate future need while meeting climate action goals.

New energy industrial facilities would likely be able to access a variety of incentives from the Inflation Reduction Act (IRA) aimed to help promote emissions reductions and cleaner products. The RMI report includes a breakdown of IRA incentives aimed to promote emissions reductions, in addition to the Alternative Fuels Data Center IRA summary table.[292] A variety of tax credits, grants and financing opportunities with the IRA can help make energy facilities economically viable. It is unclear how a shift from refining to energy generation could impact local tax revenues, but it is understood that any changes to current infrastructure could have a great impact on collected property tax. The value of equipment and infrastructure used in energy generation could be assessed at a significantly different value, which could contribute to changing levy rates and collected revenue for the local district. For example, levy rates in Anacortes tax code area 900 are notably lower at $7.52 per thousand as opposed to Mount Vernon tax code area 930 at $10.21 per thousand. Conversations with the Skagit County Assessor's office attributed this in part due to the presence of refineries in Anacortes, because of their higher property value.

State incentives to site new energy industrial facilities in certain regions may also help to attract such operations to particular areas. For example, policies are under consideration in Washington to incentivize new alternative jet fuel production in the state with a focus on sites in economically depressed regions. There are no current state incentives in place to encourage the siting of new energy industrial facilities in refinery communities in Washington, although these could be considered. Federally, several IRA and other clean energy funding programs specifically seek to direct funding to "Energy Communities," such as areas where closed coal mines and coal-fired energy facilities are located, for the purpose of economic revitalization through new clean energy projects.[293] Other potential tools for focusing clean energy investments could include use of the Environmental Health Disparities map (EHD). The map identifies communities overburdened by environmental health risks and burdens, and which some policies such as the Climate Commitment Act use to target at least 35% of clean energy and climate resilience grants to overburdened communities and at least 10% for projects with tribal support. It is important to note that it should not be assumed that communities will support siting and permitting of such projects in their communities and that siting and permitting processes should include meaningful community engagement to understand concerns and consider equitable distribution of benefits and burdens.[294]

Nonenergy Industrial

For the purposes of this report, nonenergy industrial encompass all industrial uses that are not energy- or heavy manufacturing-related. Many nonenergy industrial facilities focus on producing and distributing consumer goods. Examples include warehouses, distribution centers, ports, terminals and light

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[291] JobsEQ, Industry Snapshots. Labor Market Analytics | JobsEQ by Chmura Economics & Analytics
[292] Alternative Fuels Data Center, "Laws & Incentives: Inflation Reduction Act of 2022", Alternative Fuels Data Center: Inflation Reduction Act of 2022 (energy.gov)
[293] Interagency Working Group on Coal & Power Plant communities & Economic Revitalization, "Energy Community Tax Credit Bonus",
[294] This guidance regarding meaningful community engagement applies equally to all potential future uses discussed in this chapter.

manufacturing[295] facilities. While heavy manufacturing primarily produces products intended for business and industrial use, light manufacturing produces consumer goods. Examples of light manufacturing facilities include those that produce textile and electronic products for direct consumption. Heavy manufacturing focuses on producing goods that are used in producing other products, such as raw materials, machinery and equipment. Light manufacturing is sometimes smaller in scale than heavy manufacturing.

The location of Washington's refineries on or near bodies of water could potentially offer benefits in storage and distribution of goods received by ship or support processing of materials for export by ship. However, any alternative usages would require significant changes to current facilities, with the continued understanding that this is constrained by permitting, zoning and potential capital expenditures necessary to transform the current sites. Refineries are sometimes converted to storage terminals, utilizing existing infrastructure and helping to support distribution networks to and from operating refineries. Overall, a nonenergy industrial use of current refinery sites could reduce scope one emissions compared to current operations. However, it would be important to consider the energy use of any new operations, as well as the associated upstream or downstream (scope three) emissions. For example, conventional shipping currently relies on use of high-GHG bunker fuel, and any non-energy industrial reliant on shipping would need to address conversion to cleaner fuels in order to assume overall global emissions would be reduced in this type of future site use. Therefore, the GHG impacts of this type of potential future use - as with others discussed in this chapter - will vary depending on project-specific decisions and data for proposed projects.

Additionally, the existing wastewater treatment plants at refinery sites could potentially be repurposed to assist in local utility management and waste management. However, this would require significant local investigation and viability assessments around connecting these systems and the potential improvements to capacity. Similarly, refineries already employ workers to manage wastewater treatment systems, which could lead to some job retention upon repurposing the existing treatment plants for public utilities use.

Economic considerations for non-energy industrial uses

The impact on employment will largely depend on the type of non-energy industrial facility developed. However, the refineries are some of the largest employers in Skagit and Whatcom counties with wages significantly above average, and it is likely that total direct employment would decrease in the long-term once additional jobs from construction and renovations at the redeveloped site are no longer needed. Changes to site infrastructure have the potential to greatly affect property value, which can also reduce local tax revenue. Current production-related infrastructure at the refineries adds significant value to the properties, in addition to the marine and rail terminals that service the sites, which correspond to property taxes. The removal of refining equipment and replacement with other industrial infrastructure (like a canning facility, for example), could trigger significant changes to collected property tax revenue. This is because the equipment and infrastructure on site contribute to the assessed value of a property. It is not possible without site-specific equipment evaluations to say if property value would be maintained. Additionally, other industries may not match the average annual wages of $185,973 per worker. For example, cut and sew apparel manufacturing, which is categorized as light manufacturing, has an average annual wage per worker of $64,342 in Washington, and general warehousing and storage has an average annual wage per worker of $53,464.[296] Though difficult to predict, non-energy industrial uses are likely to have lower annual wages and tax revenues than the current petroleum refining operations.

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[295] "Light manufacturing" and "heavy manufacturing" are both considered to be synonymous with "light industry" and "heavy industry", and may be used interchangeably within this report.

[296] JobsEQ, Industry Snapshots. Labor Market Analytics | JobsEQ by Chmura Economics & Analytics

Industrial Symbiosis

Industrial symbiosis is a broad term referring to industrial operations that involve collaborations and exchanges between multiple industries, allowing for a circular transformation of materials through industrial processes. Through an exchange of resources and energy, interdependent networks are created between industries, allowing for the excess or waste materials from one industry to be used in the production process of another industry.[297] This process may help reduce consumption of resources production of waste as well as address environmental challenges related to energy inefficiencies. An example of industrial symbiosis is co-location, where intermediate goods producers are located near one another, allowing for lower transportation costs and less waste.

The use of paper mill byproducts to generate electricity and heat in a biomass-based energy plant is an example of industrial symbiosis. A local example is the BP Cherry Point Refinery, which has expanded their facilities to introduce co-processing, allowing it to produce lower carbon intensity renewable diesel.[298] This co-processing expanded biofuel production in Washington, as conventional crude oil and biomass-based feedstocks are used[299] to produce a blended fuel. By transitioning the existing processing unit to co-processing, the facility shifted to begin producing renewable diesel in addition to conventional diesel. Initially, the feedstock used in co-processing used beef tallow from slaughterhouses and rendering facilities, which is considered a waste product in the meat industry. As co-processing can involve the use of another industry's waste product in the production of a product in a separate industry, it is an example of industrial symbiosis. Similarly, the extracted sulfur and calcined petroleum coke at the Cherry Point Refinery as byproducts are feedstocks for other industries. Sulfur is commonly used for fertilizer and pesticide productions.[300] Calcined petroleum coke is an important input to industrial processes such as aluminum smelting, fertilizer production and brick and glass manufacturing.[301] As such, some current or potential future co-processing operations at existing refineries overlap with this concept.

Industrial symbiosis, by its very nature, is designed to reduce GHG emissions and/or other environmental impacts associated with manufacturing or production processes. Industrial symbiosis can help eliminate transportation costs of inputs to facilities, also helping reduce the emissions associated with production. However, that is dependent upon the location of the facilities that utilize byproducts, as industrial symbiosis does not require co-location. When compared to traditional manufacturing practices, it often decreases GHG emissions. However, this is highly dependent on intentional design and interconnected efforts of production facilities to minimize waste within the production process and maximize mutual benefits.

While the benefits of industrial symbiosis or a circular process are appealing, it is often misunderstood by the general public. This type of arrangement can have undeniable environmental and economic advantages due to its enhanced efficiencies, but these are not absolute and at best reduce impacts without completely eliminating them. Depending on the processes, environmental risks may be reduced, unchanged, or increased. Each circumstance is unique and requires an independent assessment to understand what benefits or risks may apply. All industrial activities come with pollution and GHG emissions to varying degrees of severity.

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[297] Laura Sokka, Suvi Pakarinen, Matti Melanen,"Industrial symbiosis contributing to more sustainable energy use – an example from the forest industry in Kymenlaakso, Finland", Journal of Cleaner Production, Volume 19, Issue 4, 2011, Pages 285-293, ISSN 0959-6526.
[298] Advanced Biofuels USA, "BP Completes Renewable Diesel Coprocessing Expansion Project in Washington", November 29, 2022.
[299] Examples of biomass-based feedstocks include food waste, beef tallow, canola oil, soybean oil, and used cooking oil among others.
[300] National Pesticide Information Center, "Sulfur: General Fact Sheet"
[301] National Association of Manufacturers, "Petroleum Coke: Essential to Manufacturing", American Petroleum Institute.

Economic considerations for industrial symbiosis

Co-processing could increase employment in an area if existing facilities are expanded. Construction or alterations to existing infrastructure may drive employment gains for a time, before returning to a previous or slightly higher than previous level upon completion. It is difficult to speak strongly to the impacts of industrial symbiosis on employment, as associated improvements may also improve efficiencies, reducing the number of employees needed. The local production of materials may impact jobs related to the transportation of materials. Some positions may be eliminated as more environmentally friendly production methods are utilized, but these new methods may also create positions. For example, in the Tanzanian sugar sector industrial symbiosis led to overall job growth, primarily through added positions related to reducing inefficiencies.[302] Additionally, potential impacts to local tax revenues are highly dependent on the type of production and infrastructure on site. Echoing the previous examples, additional infrastructure could drive increase assessed property value and local property tax revenue. Additionally, manufacturing-related tax collections (such as Business & Occupation taxes), may change based on production changes. Washington has provided grants to support industrial symbiosis in the past, and there are proposals under consideration that could provide greater levels of policy and funding support that might help advance these types of use. [303]

Heavy Manufacturing

Heavy manufacturing supplies large industrial products and involves the use of heavy machinery and complex industrial processes. Heavy manufacturing companies often sell their products to large purchasers, which use them to create other products. Examples of heavy manufacturing include the production of machinery used in other manufacturing or material inputs used by light manufacturing to create a final product, such as production of steel or chemicals that may be used to generate other products. Comparatively, light industry more often sells directly to consumers through retailers with goods in their final form.[304] Heavy manufacturing companies are often large, as they require a great deal of costly capital to operate including heavy equipment, large facilities and complex infrastructure. Examples of heavy manufacturing industries include oil and gas, aerospace, mining and chemical production.

Many of these manufacturing types are limited by availability of inputs and local zoning restrictions. Each of them has complex infrastructure requirements and involve specialized training for operators. Heavy manufacturing is also unlikely to significantly decrease local pollution effects or emissions. Heavy manufacturing operations can be highly energy-intensive and are conventionally dependent on fossil fuels. Even facilities that can operate primarily on electricity rather than fuels like natural gas face challenges in securing sufficient levels of reliable and low-cost electricity, which can limit the opportunities for heavy manufacturing. For example, the Alcoa aluminum smelter that operated for over 50 years in Ferndale closed largely due to inability to secure sufficient levels of clean electricity at prices that allowed the operation to continue.[305] However, there are emerging technologies and opportunities to establish low carbon heavy manufacturing facilities if appropriate energy inputs can be secured reliably and affordably. Electric heaters used to generate steam, or replacement of natural gas with green electrolytic hydrogen or other alternative fuels to generate heat are expected to become more accessible over the coming years. Federal grants supporting the decarbonization of manufacturing and heavy industry may help to increase awareness of these

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[302] Rweyendela, Amani George, and Mwegoha, William John, "Employment effects of industrial symbiosis in the Tanzanian sugar sector", International Labor Organization, August 2023.
[303] Commerce funds four more projects seeking to repurpose industrial and agricultural waste
[304] For example, heavy manufacturing may produce the stainless steel plates a silverware factory then use to produce cutlery. The stainless steel plates are used to create another good, which is then sold to consumers either directly or through a retailer.
[305] Shirley, Julie, Mittendorf, Robert, and Belcher, Jack, "Idled Whatcom County Intalco smelter closure announced by Alcoa", Bellingham Herald, March 16, 2023.

approaches and reduce the costs of using lower carbon fuels and infrastructure, including in chemical manufacturing, cement and iron and steel production.[306] New facility development presents an opportunity to invest in more sustainable fuels and technology.

Economic considerations for heavy manufacturing

The establishment of new heavy manufacturing operations at a closed refinery site would be expected to contribute both short-term and longer-term economic benefits, depending on the specifics of a facility. In an oil refining to heavy manufacturing conversion scenario, local tax revenue is likely to decrease in the short-term as infrastructure is renovated and while siting and permitting processes take place. Alternative sectors in heavy manufacturing would require adjustments to existing permits or securing new ones, and this process could take anywhere from a few years to a decade as the review and public comment process for development takes place.

The construction of new manufacturing facilities would be expected to lead to the creation of numerous temporary construction jobs. In terms of ongoing operations, a smaller or larger stable base of employees compared to current refinery operations may emerge, depending on the scale of operations. The refineries have a range of permanent employees from approximately 200 employees to over 900. As such, it would depend on the type and scale of manufacturing to assess the impact to employment. For example, the majority of chemical manufacturing facilities are owned and operated by small and medium enterprises that employ less than 500 people.[307] This may be greater or fewer than the number of existing positions at refinery sites. Facilities such as the Alcoa aluminum facility in Ferndale, now closed, supported approximately 700 local manufacturing jobs for over 50 years. Heavy manufacturing is the closest of the assessed options to "business as usual" with refinery operations, with specific effects highly dependent on local zoning and infrastructure.

Return to Tribal Ownership

Within this alternative use, the land currently used for petroleum refining is returned to local tribes. There are a variety of ways in which this could happen after a refinery closure. Some relevant pathways include the purchasing, gifting, or relinquishment of land from current owners to tribal governments. Land return, rematriation,[308] and conservation work led by indigenous peoples supports biodiversity and sustainable land management. Additionally, after restoration the land can support the revitalization of traditional practices and help protect traditional values. As described in Chapter 1, native communities have carried a disproportionate burden of pollution from the refineries and other nearby industrial activities. The return of these lands to tribal ownership represents an opportunity to help alleviate that burden and help support traditional practices.

Within this return to tribal ownership, cleanup liability is a primary concern. Within any of the pathways to tribal ownership referenced above, designation of remediation responsibility is possible within the contractual processes related to ownership transfers. For example, if a tribe were to purchase the land after closure, the terms of sale may require remediation from the previous owners, or share responsibility for cleanup costs. After the closure of the refineries, a thorough environmental site assessment before a transfer of titles can help establish cleanup liability. As described in other sections of this chapter, the remediation process is lengthy, often spanning decades from investigations to construction and monitoring. However, with diligent care, contaminated areas can be restored. The cleanup of a BP refinery in Casper, Wyoming is an example

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[306] Industrial Efficiency and Decarbonization Funding Opportunity Announcement

[307] Cybersecurity & Infrastructure Security Agency, "Chemical Sector Profile", March 2022.

[308] Rematriation refers to the rebuilding of traditional indigenous stewardship and caretaking practices to ancestral places.

where formerly contaminated land was remediated to a standard that allowed human usage, rather than relying on restricted access to limit exposure pathways.

This option presents a pathway in which the Treaty tribes are able to hunt, fish, and gather on land that has been restricted due to contamination in the future. Similarly, the disproportionate burden of industrial pollution experienced by tribal members is lowered in this use case, as opposed to other industrial developments. This is also discussed within Scenario 8 contained in Chapter 3. In addition to the considerations above, a return to tribal ownership could also include an industrial or manufacturing enterprise, such as the other alternative uses described in this section.

Commercial or Residential Usages

Refinery sites have been developed for mixed commercial or residential use in the past, as described in the case studies later in this chapter. The BP Casper refinery was remediated to mixed use, creating recreational use areas and wildlife habitat. The Philadelphia Energy Solutions refinery is currently being remediated and redeveloped for warehousing and other commercial uses. This usage would require cleanup of contamination to more stringent standards than other industrial uses, as more exposure pathways exist in commercial and residential uses than industrial uses. Some industrial site cleanups, like the Bellingham Waterfront Cleanup, have focused on developing mixed-use residential and commercial areas. Site-specific assessments of contamination and remediation costs would be required to assess the viability of this option. This option is potentially limited by the extent of contamination, and the potential expense of remediating to residential standards.

Site Remediation

This section discusses the potential methods that may be utilized to remediate, or clean up, the refinery sites after a potential closure. These methods are summarized to be an overview of the potential methods involved in remediation, broken into six groupings. These groupings include extraction-based methods, barrier and capping methods, "greener" cleanup methods, "in situ" remediation methods and heat-based methods.

This summary is limited to methods referenced in other refinery site cleanups or other applicable examples. Each of these methods are widely considered safe when designed and implemented with the appropriate level of care. Additionally, many of them minimize potential negative impacts to nearby residents. As part of the remediation process, the feasibility and cost-effectiveness of these methods at a site is assessed. These methods balance cost-effectiveness and protection of both human health and the environment. Some methods require long-term monitoring, sometimes for decades, to ensure that contamination is still contained. Other methods may not reduce contamination to levels that allow unlimited use and unrestricted exposure, requiring a five-year review of contamination levels.

When investigating a site for cleanup, responsible parties will coordinate with the appropriate experts to assess a variety of remediation plans, using a combination of the methods. The chosen remediation plan is intended to balance cost effectiveness with the timely removal or containment of contaminants. The investigation stage of a site cleanup can take much longer than the initial construction of an implemented cleanup, which must then be monitored for effectiveness.

To better contextualize this information, information about several previously closed refinery sites and their remediation efforts has been collected into case studies. Where available, these case studies provide cost information, methods used in cleanup and the timeline of remediation.

Extraction based methods

Extraction based methods involve pulling contaminated soil or water from the ground and treating the material at the surface. Solidification and stabilization are included in this section as they are often used in tandem with extraction methods. Some of these treatments are components used in tandem or as part of other remediation methods, such as granular activated carbon (GAC), which is used in pump and treat and "in situ" carbon amendments.**Error! Bookmark not defined.** The amount of time for these treatments to be effective varies g reatly depending on the extent of contamination and mobility of contaminants.

Table 65: Extraction Based Remediation Methods

Method	Description
Excavation [309]	Contaminated materials are excavated for “ex situ” treatment or disposal in a landfill. Excavated areas are typically backfilled with clean or treated soil. This method is used in all of the examples referenced in this report. Excavation can take days to years.
Pump and treat [310]	Contaminated groundwater is pumped to an aboveground treatment system, which may employ multiple cleanup methods based on contaminants. Granular activated carbon, air stripping and bioreactors are often used in tandem with this method. The process can take a few years to several decades to complete.
Granular Activated Carbon (GAC) [311]	Contaminated water or air is moved through the GAC, and contaminants stick to the surface and are removed. GAC treatment is commonly used as a treatment step in other treatment methods and is the most common approach to treating contaminated groundwater and soil vapor. It can be used to sorb a wide range of contaminants. The process can take several months to years.
Air stripping [312]	Air is moved through contaminated water to help evaporate VOCs, and then chemical vapors are collected. This method is commonly used as part of the pump and treat cleanup method. The process can take several months to years.
Soil Vapor Extraction (SVE) and Air Sparging [313]	These methods are often used together. Air sparging involves drilling injection wells into groundwater-soaked soil and using an air compressor to pump air underground, allowing air bubbles to carry contaminant vapors through the groundwater and into the soil. SVE involves drilling extraction wells and creating a vacuum that pulls air and vapors to the surface for treatment. This process often takes several years.
Solidification and Stabilization[314]	Solidification binds contaminants into a solid block of less permeable material using cement, asphalt or clay to prevent movement. Stabilization utilizes chemical reactions that reduce the chances of contaminants leaching into the environment. These mixtures can be covered with a cap or removed and used to backfill excavated areas or disposed of in a landfill. These methods are often used in tandem with capping or excavation. This process can take weeks or months and is a relatively quick and low-cost way to prevent exposures.

Barriers and Capping

Capping involves placing a cover over contaminated materials such as landfill waste or contaminated soil. This method is used to isolate contaminants and prevent their spread due to wind, rainfall or runoff and limit

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[309] Office of Land and Emergency Management, “Community Guide to Excavation of Contaminated Waste,” Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.
[310] Office of Land and Emergency Management, “Community Guide to Pump and Treat,” Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024,.
[311] Office of Land and Emergency Management, “Community Guide to Granulated Activated Carbon Treatment,” Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.
[312] Office of Land and Emergency Management, “Community Guide to Air Stripping,” Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.
[313] Office of Land and Emergency Management, “Community Guide to Soil Vapor Extraction and Air Sparging,” Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.
[314] Office of Land and Emergency Management, “Community Guide to Solidification and Stabilization,” Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.

potential exposures. Barriers serve a similar purpose. They are placed to control the spread of contaminants, by either blocking the flow or trapping contaminants. These methods are monitored for effectiveness and may be assessed in the aftermath of extreme weather events or natural disasters. Damage to caps or other barriers should be repaired quickly, and sampling should be done to confirm that contamination has not spread beyond the containment area.

Table 66: Barrier and Capping Remediation Methods

Method	Description
Conventional Capping [315]	Capping involves placing a cover over contaminated materials, preventing spread due to wind, rainfall and runoff. Conventional Caps may have several layers made of asphalt or concrete, a vegetative layer, a drainage layer, geomembrane or clay. Construction can range from a few days to months, and caps require continued monitoring and maintenance.
Amended Sediment Caps [316]	These covers are placed on top of contaminated sediment in rivers, streams, bays and lakes. They can both isolate and treat contaminated sediment. Contaminants either stick to amendments or are converted to forms that cannot pass through the cap and spread. Three main types of amendments include activated carbon, organoclays and phosphate additives. This method is often used in combination with dredging. These caps require ongoing maintenance.
Evapotranspiration (ET) Covers [317]	ET covers prevent water from seeping into waste by storing rain or snowmelt until the water evaporates or plant roots take up the water. Typically, a layer of organic-rich silty soil is laid over the contaminated material. Plants with extensive roots well-suited for the local climate often work best. This process often takes several months.
Permeable Reactive Barriers (PRBs) [318]	PRBs are walls created below ground to clean up contaminated groundwater. The walls are permeable, which allows groundwater to flow through them. The reactive materials used to construct the wall, like iron, limestone, carbon or mulch, trap harmful contaminants or make them less harmful. This method is often used in tandem with bioremediation. PRB may take many years to clean up contaminated groundwater but is relatively inexpensive.
Vapor Intrusion Mitigation [319]	This method prevents the movement of dangerous chemical vapors from contaminated soil, groundwater or sewer lines into nearby buildings through cracks or seams in the foundation, gaps around utility lines or sump pits. This method involves sealing openings, installing vapor barriers, passive venting, sub-slab depressurization or building over-pressurization. Air treatment units can be used in tandem.
Vertical Engineered Barriers (VEBs) [320]	VEBs are walls built below ground to control the flow of groundwater. VEBs may divert the flow of contaminated groundwater to keep it from reaching other water sources. They can also isolate contaminated soil and groundwater, but unlike PRBs, they do not treat the isolated materials. They are made of impermeable or slightly permeable materials, sometimes with a protective cap and a monitoring well. This can take several days to several months and must be maintained to stay effective.

[315] Office of Land and Emergency Management, "Community Guide to Capping," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.
[316] Office of Land and Emergency Management, "Community Guide to Amended Sediment Caps," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.
[317] Office of Land and Emergency Management, "Community Guide to Evapotranspiration Covers," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.
[318] Office of Land and Emergency Management, "Community Guide to Permeable Reactive Barriers," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.
[319] Office of Land and Emergency Management, "Community Guide to Vapor Intrusion Mitigation," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.
[320] Office of Land and Emergency Management, "Community Guide to Vertical Engineered Barriers," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.

Greener Cleanups

Greener cleanups are a modern remediation strategy. They seek to reduce the environmental and carbon footprint throughout the life of a remediation project. This can include a wide range of methods, including emphasis on equipment efficiency, recirculation of water, increased protections for local ecosystems and waste minimization strategies. This category refers to a broad set of cleanup methods that utilize naturally occurring microbes and plants to aid in remediation.

The microbes and plants used in greener cleanups are preferably native to an area and chosen based on their suitability for an area and persistence when exposed to contaminants. Similarly, naturally occurring microbes may be introduced to an area in bioremediation and therefore pose no risk to adjacent communities. These methods are typically utilized during later stages of remediation efforts to handle low concentrations of contaminants.

Table 67: Advanced Sustainable Remediation Methods

Method	Description
Ecological revitalization [321]	This method involves returning a contaminated site to more natural conditions and restoring habitat. Structures on the site are removed, wetlands are restored and native plants and wildlife are reintroduced. Capping and phytotechnologies are often incorporated. It can take many years for an ecosystem to become established.
Monitored Natural Attenuation (MNA) [322]	MNA relies on natural processes like biodegradation, sorption, dilution, evaporation and chemical reactions to decrease contaminant concentrations. It is best implemented as the last step in a cleanup when concentrations are low and requires monitoring. MNA sites must be monitored, and the process can take several years to decades.
Phytotechnologies [323]	Phytotechnologies, such as phytoremediation, evapotranspiration covers, hydraulic control and wetland construction, use plants to clean or contain contaminants in soil, sediment and water. Plants can absorb, degrade or bind pollutants, preventing their spread. Constructed wetlands can treat contaminated surface water and runoff. These methods are typically used for low contamination levels and can also control erosion, reduce noise, improve air quality and enhance site aesthetics. This approach is currently used at the former BP Casper Refinery site in Wyoming. This method often takes several years and can be lengthened by a short growing season or extreme weather conditions.
Bioremediation [324]	Bioremediation utilizes microbes, which eat and digest contaminants, to clean contaminated soil and groundwater. Amendments may be pumped through underground wells to help encourage microbe activity, or soil may be dug up to clean in aboveground containers. This process can take months to years to complete.

In Situ Treatments

In situ treatments are remediation treatments that are conducted in place, without having to excavate the soil or groundwater for aboveground cleanup. Methods that remove contaminated soil or water for treatment before returning them to the site are called "ex situ" treatments. In situ methods of cleanup include carbon

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[321] Office of Land and Emergency Management, "Community Guide to Ecological Revitalization," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024, https://semspub.epa.gov/work/HQ/401587.pdf.
[322] Office of Land and Emergency Management, "Community Guide to Monitored Natural Attenuation," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024, https://semspub.epa.gov/work/HQ/401611.pdf.
[323] Office of Land and Emergency Management, "Community Guide to Phytotechnologies," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024, https://semspub.epa.gov/work/HQ/401615.pdf.
[324] Office of Land and Emergency Management, "Community Guide to Bioremediation," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024, https://semspub.epa.gov/work/HQ/401583.pdf.

amendments, chemical oxidation, chemical reduction, sediment amendments and thermal treatments. These methods may be used in tandem or prior to capping or barrier methods described above.

Table 68: In Situ Remediation Methods

Method	Description
In Situ Carbon Amendments [325]	In Situ Carbon Amendments are materials placed underground to treat groundwater. Amendments are often injected through vertical pipes to reach contamination, or trenches are filled with amendments. Amendments form a reactive zone across the flow of the contaminated groundwater so that water flows through it. The amendments either contain or transform contaminants into less harmful substances. This treatment is often used alongside bioremediation. Treatment using carbon amendments can range from several months to a few years.
In Situ Chemical Oxidation (ISCO) [326]	ISCO involves oxidants being added to contaminated soil and groundwater, resulting in a chemical reaction that destroys contaminants and produces harmless byproducts. Oxidants are typically injected underground via wells or injection points at different depths. Recirculation may be used to help treat a large area faster, and multiple injections may be needed. If significant gases are produced due to heat underground, they can be captured and treated. ISCO is typically followed by methods such as pump and treat or monitored natural attenuation. Cleanup with ISCO can take a few months or years.
In Situ Sediment Amendments [327]	In Situ Sediment Amendments, like activated carbon and organoclays, are mixed into the surface layer of sediment in rivers, streams, bays and lakes. The amendments stick to contaminants and reduce their bioavailability. Microbes may also be used in this process to degrade contaminants. It can take a few days to several months to place and becomes more effective over time as complete mixing occurs.
In Situ Thermal Treatments [328]	In Situ Thermal Treatment methods move or "mobilize" harmful chemicals in soil and groundwater using heat. The chemicals move through soil and groundwater to wells, where they are collected and piped to the surface to be treated. This method is particularly useful for chemicals that do not dissolve readily in groundwater and is used in tandem with soil vapor extraction and air sparging.

Heat-Based Methods

Heat-based remediation methods utilize heat to destroy contaminants or separate them for further treatment. Incineration and thermal desorption are relatively fast remediation options. Depending on the technology available, these treatments may be done on site or after materials have been excavated and removed to another facility for processing.

Table 69: Heat-Based Remediation Methods.

Method	Description
Incineration[329]	Incineration involves burning hazardous materials to destroy contaminants. Materials may be excavated or pumped into containers before incineration and may need to be further prepared. Temporary onsite incinerators or offsite incinerators may be used. This method is useful in

[325] Office of Land and Emergency Management, "Community Guide to In Situ Carbon Amendments for Groundwater," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024, https://semspub.epa.gov/work/HQ/401599.pdf.
[326] Office of Land and Emergency Management, "Community Guide to In Situ Chemical Oxidation," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024, https://semspub.epa.gov/work/HQ/401601.pdf.
[327] Office of Land and Emergency Management, "Community Guide to In Situ Sediment Amendments," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024, https://semspub.epa.gov/work/HQ/401605.pdf.
[328] Office of Land and Emergency Management, "Community Guide to In Situ Thermal Treatment," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024, https://semspub.epa.gov/work/HQ/401607.pdf.
[329] Office of Land and Emergency Management, "Community Guide to Incineration," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.

Method	Description
	situations where a fast cleanup is important to minimize harm. This approach can take a few weeks to several years to complete.
Thermal Desorption [330]	Contaminated materials are excavated, and a thermal desorper removes contaminants by heating them so they un-stick from oil, sludge or sediment. Contaminants evaporate and the vapors are separated and treated. This method may be faster and provide better cleanup than other methods, particularly at sites with high contaminant concentrations. This can take from a few weeks to a few years.

Previously Closed Refinery Sites: Case Studies

The following case studies provide real-world examples of refineries that have closed and the nature and scale of cleanup work. While there are limits to the availability of data regarding some of these cases, every effort has been made to generate useful lessons based on the best available public data.

Diamond Head Oil Refinery

The Diamond Head site (DHS) is a 30.5-acre property in Kearny, New Jersey that is home to a former oil refinery. The refinery was in operation from 1949 to 1979. Several companies transitioned in and out of ownership throughout the refinery's operational life, the last of which being Ag-Met Oil Service, Inc. (later renamed Newtown Refining Corporation). Six years after operations concluded, the site was sold to Hudson Meadows Urban Development Corporation in 1985.[331] Due to extensive contamination of chromium, dioxin, lead and PCBs detected onsite, the U.S. EPA designated the DHS as a Superfund Site in 1991.

Remediation efforts at the site are in progress. The initial remedial investigation of the site by the EPA began in 2002 and concluded in 2009. The EPA has fenced the site and developed a comprehensive cleanup plan, which involves dividing the site into three Operable Units (OUs) to address different contamination aspects grouped by complexity and geography.[332] For OU 01, remedial action began in 2022, with an estimated remedial action completion date of November 2026. Remedial action in OU 2 is estimated to follow a similar timeline, beginning in 2022 and ending in 2026. OU 03, which focuses on groundwater remediation, will begin a combined remedial investigation/feasibility study in November 2026.[333] This site is zoned for commercial and industrial use, and the final redevelopment plan will likely depend on the level of cleanup achieved.[334]

Across all Operable Units, the remediation strategy involves the removal or capping of contaminated soil and sediment, installation of vegetative soil covers, institutional controls to restrict future use, wetland restoration and backfilling of excavated areas with clean soil. A total cost of $24 million has been estimated to implement the remediation strategy at OU 01 and OU 02, with three potentially responsible parties: the town of Kearny, the New Jersey Department of Transportation and Hudson Meadows Urban Renewal Corporation.[335],[336] Cleanup is

[330] Office of Land and Emergency Management, "Community Guide to Thermal Desorption," Contaminated Site Clean-Up Information Web Site, EPA, accessed September 23, 2024.
[331] U.S. Department of Health and Human Services, "Site Visit Report: Diamond Head Oil Refinery Division Kearny, Hudson County, New Jersey, EPA Facility ID: NJD092226000", May 11, 2001.
[332] Environmental Protection Agency, "DIAMOND HEAD OIL REFINERY DIV. | Superfund Site Profile | Superfund Site Information | US EPA", Accessed August 10, 2024.
[333] Environmental Protection Agency, "DIAMOND HEAD OIL REFINERY DIV. | Superfund Site Profile | Superfund Site Information | US EPA", Accessed August 10, 2024.
[334] D'Auria, Peter, "Who Will Foot $24M Bill to Clean up of One of Hudson County's Most Polluted Sites?" Accessed September 24, 2024.
[335] D'Auria, Peter, "Who Will Foot $24M Bill to Clean up of One of Hudson County's Most Polluted Sites?" Accessed September 24, 2024.
[336] Environmental Protection Agency, "Diamond Head Oil Refinery Div. Kearny, NJ: Comprehensive Remedial Investigation Report for OU1 and OU2", May 30, 2017.

currently being done using funds provided through the Bipartisan Infrastructure Law.[334] There is no estimated cost for OU 03 at this time.

Hudson Refinery

The Hudson Refinery site in Cushing, Oklahoma, operated from as early as 1917 until 1982 when it closed. [337] Land O'Lakes, Inc. is the surviving corporation of Midland, a former refinery operator. As such, Land O'Lakes is responsible for the extensive soil, groundwater and surface water contamination left behind.[338] The site has been designated an EPA Superfund Site, and there is state and federal involvement and oversight.[339]

Cleanup efforts, which included removing asbestos-containing material (ACM), scrap metal, contaminated soils, waste and treating and monitoring groundwater and surface water, began in early 2010. Several structures were demolished in the cleanup process and contaminated materials were disposed of off-site, where they were stabilized. While remediation took less than a year after construction began, the selected remedy was estimated to cost $9,650,443 total.[340]

Cleanup concluded in late 2010, and monitoring and maintenance are the ongoing responsibilities of Land O'Lakes. The site remedy has been deemed protective of human health and the environment during the most recent five-year review in 2020.[341] The site is zoned for industrial use, and institutional controls have been put in place to limit future land uses.

Philadelphia Energy Solutions (PES) Refinery

The Philadelphia Energy Solutions (PES) refinery site (previously Sunoco Philadelphia Refinery), operated from the early 1900s until 2019, when the facility closed after a fire and multiple explosions in June 2019.[342] In 2012, Sunoco transferred ownership to PES. Sunoco remains responsible for environmental liabilities through 2012, while PES is responsible for legacy environmental liabilities after 2012.[343] The site was purchased in 2020 by Hilco Redevelopment Partners, who have also assumed liability for some of the cleanup.

The refinery has had intermittent cleanup efforts since 1997, including light non-aqueous phase liquid, groundwater recovery, sewer ventilation and biofiltration. Cleanup efforts have focused on addressing hydrocarbons and lead contamination in the soil and groundwater. Remediation is ongoing, and Hilco has reported the removal of more than 90% of the pipeline and the removal of 99% of legacy petroleum products. Hilco has not reported total costs of remediation efforts.

Hilco has begun construction of the warehouses that comprise the beginning of a commercial hub. The property has since been renamed the "Bellwether District," and there are plans to redevelop the land into a sprawling campus for commercial purposes.[344] In 2022, cleanup levels were consistent with future industrial

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[337] "HUDSON REFINERY | Superfund Site Profile | Superfund Site Information | US EPA." n.d.
[338] Environmental Protection Agency, "RECORD OF DECISION FOR HUDSON REFINERY SUPERFUND SITE (epa.gov)", November 2007
[339] "HUDSON REFINERY | Superfund Site Profile | Superfund Site Information | US EPA." n.d.
[340] Environmental Protection Agency, "RECORD OF DECISION FOR HUDSON REFINERY SUPERFUND SITE (epa.gov)", November 2007
[341] Environmental Protection Agency, "Second Five-Year Review Report; Hudson Refinery Superfund Site", February 11, 2020.
[342] Brockmeier, Erica, "After the shutdown, what comes next for the former Philadelphia Energy Solutions refinery?", PennToday, January 26, 2022.
[343] "Hazardous Waste Cleanup: Philadelphia Energy Solutions Refining and Marketing LLC (Formerly: Sunoco Incorporated Girard Point) in Philadelphia, Pennsylvania | US EPA." 2024. US EPA. September 12, 2024.
[344] Brockmeier, Erica, "After the shutdown, what comes next for the former Philadelphia Energy Solutions refinery?", PennToday, January 26, 2022.

use. Current efforts aim to ensure environmental safety and prepare the site for redevelopment into the commercial campus.

Pester Refinery

The Pester Refinery Superfund site in El Dorado, Kansas has undergone cleanup since the 1990s. The refinery was owned by Fina Oil and Chemical Company until 1977, when Pester Refinery Company bought it.[345] Ownership was transferred again in 1985 when Coastal Derby refining Company bought the site. Soon after, the refinery shut down and remediation became the responsibility of Pester Refining Company and Fina Oil and Chemical Company, with the Kansas Department of Health and the Environment overseeing the project.

Remediation activities began in 1998 and were completed in 1999. Cleanup included sludge excavation, soil bioremediation and groundwater monitoring. In 2005, efforts expanded to include solidification of contaminated soils, regrading terrain, placing a soil cover and installing interceptor trenches. Groundwater monitoring is ongoing.[346]

Approximate costs for remedial action were $2,374,800 in 1992 but may have increased due to unforeseen remediation costs.[347] Future uses of the site are limited to industrial uses based on the completed level of remediation.

Empire Oil Refinery

The Empire Oil Refinery site in Gainesville, Texas, was owned and operated by The Empire Oil Company from 1916 until the 1935. Oxy USA and COOPCO, an energy and petroleum manufacturing company, bought the site in 1982. The site was left heavily contaminated after operations ceased. Contaminants discovered include but are not limited to petroleum hydrocarbons, polycyclic aromatic hydrocarbons, PAHs and metals. Some unclassifiable constituents may have included organochlorine dioxin furan and PCB compounds or like compounds.

Remediation began in 2008, and efforts involved the stabilization and capping of contaminated sediment and the construction of wetlands, riparian and prairie habitats, to be persevered in perpetuity. The cleanup concluded in 2014.[348] Cost estimates were not available. Success criteria were evaluated relevant to the survival of planted vegetation, maintenance of berms and spillways, control of invasive species and a minimum amount of water retained by the constructed wetlands. Sites were monitored based on wildlife utilization, pond utilization, vegetative cover growth and more.

BP Casper Refinery

The BP Casper Refinery was built in 1913 on the banks of the North Platte River in Wyoming. Refinery operations ceased in 1991, leaving behind almost a century's worth of oil spillage, sludge and over 200 miles of buried pipeline. The refinery remained idle until 1998, when a BP and Amoco merger resulted in BP's

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[345] Environmental Protection Agency, "Fourth Five-Year Review Report for Pester Refinery Superfund Site, El Dorado, Butler County, Kansas (epa.gov)", May 15, 2019.
[346] Environmental Protection Agency, "PESTER REFINERY CO. | Superfund Site Profile | Superfund Site Information | US EPA", Accessed August 10, 2024.
[347] Environmental Protection Agency, "Fifth Five-Year Review Report for Pester Refinery Superfund Site, El Dorado, Butler County, Kansas (epa.gov)", May 15, 2019.
[348] U.S. Department of the Interior, "Case details: Former Empire Oil Refinery Site", Accessed August 15, 2024.

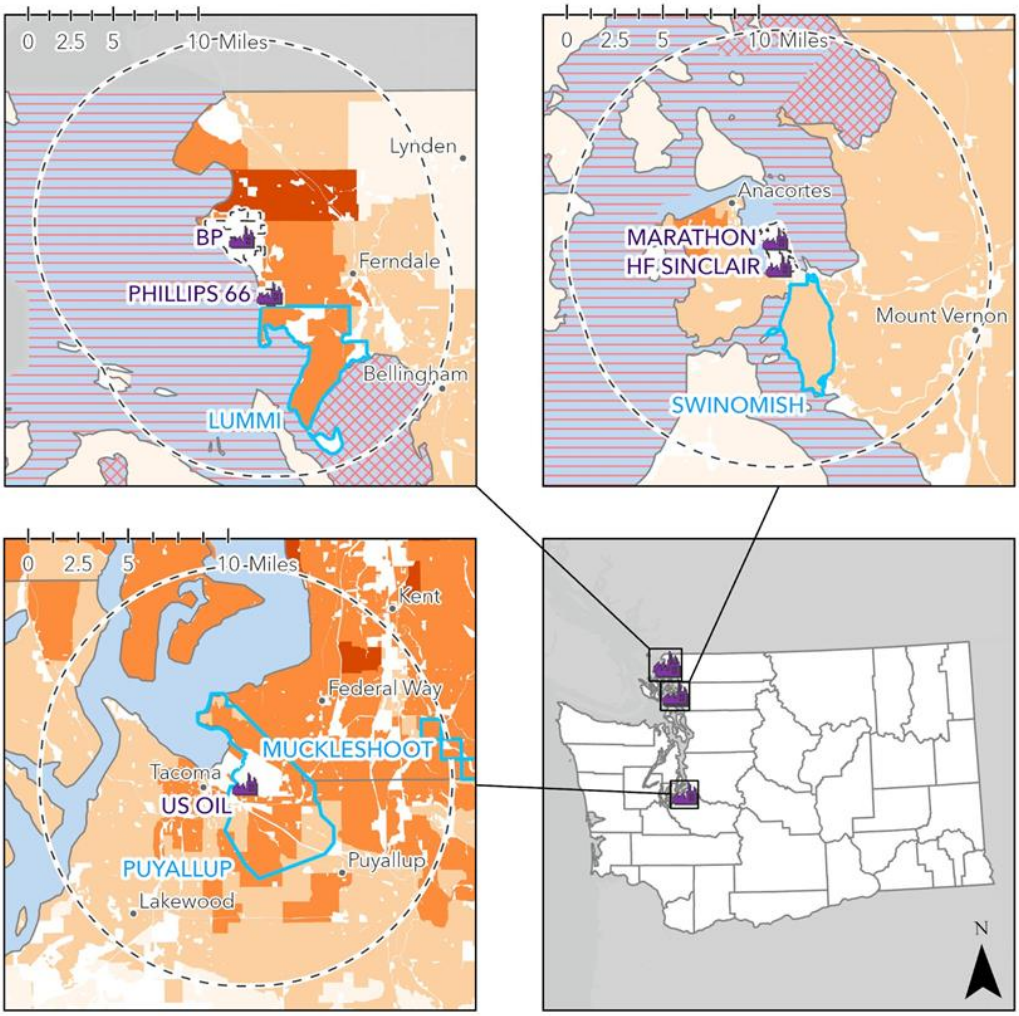
acquisition of the site. BP and the Wyoming Department of Environmental Quality agreed in 1998 to collaborate on remedial activities and reuse options.[349]

The site entered Wyoming's Voluntary Cleanup Program in the late 1990s, and cleanup began shortly after. Cleanup on the property included the removal and disposal or recycling of trash and wastes, instillation of a subsurface barrier wall to contain seepage, removal of pipelines, excavation of soil, phytoremediation and pump and treat systems. Identified contaminants included hydrocarbons, metals and sludge. An innovative wastewater treatment plant was designed via engineered wetland. Cleanup was completed in 2005.[350]

Institutional controls have been implemented to contain and limit exposure to remaining contamination, as some of these methods take significant time to complete cleanup. As the site was redeveloped, community input helped inform the development of a golf course and restaurant, business park, kayak course and miles of bike and walking trails. [351]

[349] Environmental Protection Agency, "BP Former Refinery, Casper, Wyoming Overview", October 2007.
[350] Wyoming Department of Environmental Quality, "RCRA Facility Fact Sheet; BP's Former Amoco Refinery", Accessed August 14, 2024.
[351] Environmental Protection Agency, "BP Former Refinery, Casper, Wyoming Overview", October 2007.

RSEI Concentrations in Proximity to Oil Refineries and Shellfish Harvesting Restrictions



Average RSEI Concentrations

- 2.3 - 380
- 390 - 1,900
- 2,000 - 7,500
- 7,600 - 29,000
- 30,000 - 110,000

Shellfish Biotoxin Closure Zones

- All Species
- Butter Clams, Varnish Clams
- None

- Refinery
- Native Reservation

Source: WA Dept. of Ecology, WSDOT

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Figure 10: RSEI Concentrations in Proximity to Oil Refineries and Shellfish Harvesting Restrictions.

This section contains a discussion of the environmental and health impacts of refinery operations and resulting pollutants. These impacts disproportionately affected Native American communities and communities of color. Figure 10 utilizes the EPA Risk-Screening Environmental Indicators (RSEI) model. The RSEI model utilizes data from the EPA Toxic Release Inventory (TRI), which monitors toxic chemical environmental releases and other waste management activities at industrial facilities across the United States. The buffer rings around each refinery site capture a 10-mile ring around the refineries. Total analysis was completed using a 30-mile zone, broken into 10-mile increments. Approximately 3,722,475 people are contained within these buffer zones, based on census tract data. Some cities contained within the buffer rings include Tacoma, Seattle, Bellevue, Anacortes and Bellingham. Fifty percent of the entire population across all depicted buffer zones live northeast of a refinery, equal to 1,850,246 people. Roughly 40% of the population, or 1,307,806 people, live between 20-30 miles from one of the refineries.

Areas northeast of refineries were found to have higher RSEI scores the further the distance from the pollution source. This is likely a result of wind direction, which can impact the movement of air pollutants. Historically, for most of the year wind direction in the interior Puget Sound corridor blows from southwest to northeast. Native populations have a greater concentration south of refineries, where hazardous materials are found in higher concentrations within a close proximity to the refineries. Additionally, native population density is highest within the 0–10 mile buffer zone and the southwest region. While wind direction may typically move pollutants northwest of the refineries, this does not mean that wind direction is only southwest to northeast.

However, days with little wind or inversions may result in stagnation of pollutants within the 10-mile buffer ring. This figure also displays the shellfish harvesting restrictions in areas adjacent to the refineries. Two refineries in close proximity to each other result in irregular circles due to overlapping ranges, encompassing the Swinomish and Lummi reservations. An important note is that there may be other polluters within these ranges who contribute additional pollution. RSEI utilizes “worst-case assumptions” about toxicity and potential exposure and does not indicate compliance with federal or state regulations. A low RSEI score does not indicate a complete lack of risk, but rather that TRI data only includes what is reported, and therefore is limited. It does not include all exposure pathways and explicitly does not include food ingestion except for fish consumption. Additionally, this analysis uses census information to inform the demographic analysis above.

Health Impacts on Adjacent Communities

Communities in close proximity to refineries are known to experience an increased risk of developing adverse health impacts. Oil refining operations have been linked to a variety of health issues, including but not limited to, respiratory issues,[352] increased cancer risks,[353] and cardiovascular issues.[354] Populations living within 10 miles of oil refineries experience higher cancer rates than populations at a greater distance.[355] Various chemicals in petroleum products in refineries can also cause birth defects, harm reproductive systems in men

[352] Fleischman, L., Kingland, D., Maxwell, C., & Rios, E. (n.d.). Clean Air Task Force (CATF)• League of United Latin American Citizens (LULAC) National Hispanic Medical Association (NHMA).
[353] Cordiano, R., Papa, V., Cicero, N., Spatari, G., Allegra, A., & Gangemi, S. (2022). Effects of Benzene: Hematological and Hypersensitivity Manifestations in Resident Living in Oil Refinery Areas. Toxics, 10(11), 678.
[354] Oberschelp, C., Pfister, S., & Hellweg, S. (2023). Global site-specific health impacts of fossil energy, steel mills, oil refineries and cement plants. Scientific Reports, 13, 13708.
[355] Williams, S. B., Shan, Y., Jazzar, U., Kerr, P. S., Okereke, I., Klimberg, V. S., Tyler, D. S., Putluri, N., Lopez, D. S., Prochaska, J. D., Elferink, C., Baillargeon, J. G., Kuo, Y. F., & Mehta, H. B. (2020). Proximity to Oil Refineries and Risk of Cancer: A Population-Based Analysis. JNCI cancer spectrum, 4(6), pkaa088.

and women, neurological damage, and blood disorders.[356] Refinery operations pose exposure risks to a variety of chemicals, including but not limited to acetaldehyde, benzene, carbon monoxide, polycyclic aromatic hydrocarbons (PAHs), formaldehyde, and sulfur dioxides. Emissions from refineries also contribute to ground level ozone formation, smog or haze, and particulate matter pollution. As described in the COBRA analyses in Chapter 3, reductions in refinery emissions would have benefits through reduced healthcare costs and reduced instances of premature mortality and other conditions.

Washington's Environmental Health Disparities (EHD) map[357] also has a filter utilizing RSEI scores, a part of 19 total indicators to help compare environmental health disparities across communities.[358] This map can also display TRI sites in area, including the refineries. The presence of the refineries and additional TRIs in and adjacent to communities with higher proportions of people of color can contribute to adverse health impacts. For example, a 2020 analysis[359] found that 49.4% of the population within three miles of Superfund sites are community members of color and tribal nations, despite comprising 39.6% of the U.S. population. That same study found that 15.1% of populations living within three miles of refinery sites were below the poverty level, compared to 13.7% of the total U.S. population. Per the EHD map[360] filtered by the social determinant "People of Color", census tracts near the Tacoma refinery and other industrial facilities have a ranking of 9, indicating that communities of color also experience disproportionate impacts from industrial pollution. Similarly, low income communities are often in close proximity to industrial facilities, disproportionately burdening them with negative health impacts.[361] These populations, which can and do overlap, face similar systemic injustices and disenfranchisement to native communities as described in Chapter 1.

These areas with concentrations of industrial activities and marginalized communities may be referred to as "sacrifice zones".[362] Sacrifice zones, or "fenceline communities", contain low income communities and communities of color adjacent to heavily polluted areas as a result of decades-old policies like redlining[363] and a lack of enforcement of environmental standards.[364] These community members may be unable or unwilling to relocate as a result of health hazards associated with nearby refinery operations and other TRIs. Particularly for native communities, the refineries are located on and near lands they have called home since time immemorial. The placement of refineries next to tribal reservations and/or Usual and Accustomed territories is particularly problematic for a range of reasons. Native Americans have specific relationships with the lands and waters they have stewarded from time immemorial. Their place is embedded in their identity. Economic constraints can also prevent or complicate moving off reservation lands. Additionally, with varying impacts from nation to nation, some tribal citizens have access to some of their nation's rights and resources only when they reside on reservation land, further complicating the capacity of some tribal citizens to move away from polluting refineries. The EHD map has various layers that allow users to explore the cumulative impacts of pollution exposure, vulnerability described through socioeconomic factors, and other environmental threats.

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[356] California Government Proposition 65 Warnings, "Environmental Exposure from Refineries", Petroleum Products - Environmental Exposure from Refineries - Proposition 65 Warnings Website
[357] The map can be accessed here: https://fortress.wa.gov/doh/wtn/WTNIBL/
[358] The map utilizes census tracts, referenced as communities, which receive rankings from one to 10 in each indicator.
[359] Environmental Protection Agency, "Population Surrounding 1,857 Superfund Remedial Sites", September 2020.
[360] EHD map
[361] Jane Kay and Cheryl Katz, "Pollution, Poverty and People of Color: Living with Industry", Scientific American, June 4, 2012.
[362] Lerner, Steve, "Sacrifice Zones: The Front Lines of Toxic Chemical Exposure in the United States", 2010, MIT Press. ISBN: 9780262518178
[363] Vermeer, Danielle, "Redlining and Environmental Racism", University of Michigan School for Environment and Sustainability, August 16, 2021.
[364] Environmental Protection Agency, "Environmental Justice in Enforcement and Compliance Assurance", December 18, 2023.

The Department of Health is working to include more layers and information in the EHD map, including gathering input from tribal communities.

An issue of particular concern is "flaring", in which a refinery burns excess gasses, often for safety reasons. Flaring can be planned or unplanned, with unplanned flaring utilized to help control pressure in a system and avoid serious system failures that risk worker safety. Communities adjacent to refineries may be able to see flames spewing from flares at a great distance. Flares also introduce additional pollutants into an area, which can include oxides of sulfur (SOx), oxides of nitrogen (NO_x), particulate matter (PM_{10}), carbon monoxide (CO) and reactive organic gases (ROG) including Volatile Organic Compounds (VOCs). Refinery operations in Washington have been fined as recently as 2021[365] for exceeding legal visible emissions standards related to flaring, with prior fines in 2016,[366] 2011,[367] and 2005.[368] Flaring at the HF Sinclair refinery in Anacortes generated significant community concern in March 2023. A public statement was released on HF Sinclair's Facebook page the day after to acknowledge the flaring event and let community members know that the required agencies had been notified.[369] In 2015, an unplanned flare at the then Shell Anacortes refinery reportedly prompted 67 complaints. This incident impacted more than 550 people who live and work on the Swinomish Reservation, with reported symptoms including headaches, nausea, fatigue and irritation of eyes, throat and lungs.[370]

Flares, along with all other refinery equipment, are subject to Reasonably Available Control Technology (RACT) standards for Greenhouse Gas (GHG) emissions. A report was developed by the Northwest Clean Air Agency, Puget Sound Clean Air Agency and Ecology in 2013 that outlines RACT policies at time of writing.[371] Ecology was court-ordered to adopt existing source minimum controls standards by May 2014. Since then, Washington emissions standards have evolved to add additional standards, including a requirement that refineries maintain an above-average efficiency rating or reduce their GHG emissions by 10% by 2025.[372] At the time of writing this report, Phillips 66 Ferndale refinery and U.S. Oil/Par Pacific Tacoma Refinery have decreased their total GHG emissions output between 2020 and 2022, by 83,131 and 34,991 metric tons of carbon dioxide equivalent respectively. Overall, the petroleum refining industry remains steady with approximately 6.2 million tons of Carbon dioxide equivalent (CO_2e) each year. Unplanned flaring can result in the release of methane, black soot, and nitrous oxide alongside other potent GHGs.[373] $PM_{2.5}$ from burned fossil fuels contributes to

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[365] Ysabelle Kempe, The Bellingham Herald. "A refinery spewed black smoke into this NW community. Now this oil giant will pay." Updated July 27, 2021. Accessed July 2, 2024.
[366] Preston, Seth. "Shell's Puget Sound Refinery penalized for chemical release | Northwest Clean Air Agency (nwcleanairwa.gov)", Northwest Clean Air Agency, November 16. 2016; Environmental Protection Agency, "Tesoro and Par Clean Air Act Settlement | US EPA", July 18, 2016.
[367] Environmental Protection Agency, "02/01/2011: U.S. Oil and Refining Co. in Tacoma, Wash. settles with federal and local air authorities for Clean Air Act violations (epa.gov)", February 1, 2011
[368] Environmental Protection Agency, "01/27/2005: U.S. Announces Clean Air Agreement with Largest Domestic Petroleum Refiner : ConocoPhillips to Reduce Air Emissions at Facilities in Seven States (epa.gov)", January 27, 2005.
[369] Alzola, Briana, "Flames above refinery cause concern in community | News | goskagit.com" Go Skagit. March 5, 2023. ; HF Sinclair Puget Sound Refinery Facebook page, At approximately 10:30... - HF Sinclair Puget Sound Refinery | Facebook, March 6, 2023.
[370] Preston, Sean. "Shell's Puget Sound Refinery penalized for chemical release | Northwest Clean Air Agency (nwcleanairwa.gov)", Northwest Clean Air Agency, November 16. 2016; Environmental Protection Agency, "Tesoro and Par Clean Air Act Settlement | US EPA", July 18, 2016.
[371] Washington State Department of Ecology, "Washington Oil Refinery RACT - Technical Support Document", November 25, 2013.
[372] Washington State Department of Ecology, "Oil refinery requirements - Washington State Department of Ecology", Accessed July 16, 2024.
[373] International Energy Agency, "Gas Flaring".

increased risk of death from cardiovascular diseases and lung cancer, increased risk of asthma, and increased risk of lower birth weight and infant mortality.[374]

Train derailments also represent a significant risk of refinery operations, as evidenced by derailments in 2014[375], 2020[376], and 2023[377]. The 2020 and 2023 derailments both resulted in releases of toxic chemicals. The 2023 derailment occurred on the Swinomish Indian Tribal Community Reservation.[378] Communities of color are also often at risk during derailments. A 2024 study found higher densities of communities of colors along railways.[379] Pipelines like the Olympic Pipeline and McChord Pipeline also pose spill risks. In 2023, approximately 25,326 gallons of gasoline were released from the Olympic Pipeline, triggering months of cleanup and monitoring.[380]

The completion of a Trans Mountain Pipeline expansion in British Columbia has also increased marine vessel traffic to Washington's refineries.[381] This increase of traffic, including to Washington's refineries, has also increased the number of oil tankers passing through more treacherous waters. The routes to Cherry Point in Ferndale through the Rosario Strait pass with just a mile between underwater hazards, with similar risks in the Guemes Channel passage to Anacortes.[382] A San Juan County study found a range of total damages, using values for commercial fishing, aquaculture, tourism spending, and damages to property value, recreational use value, and ecosystem services. For the 4 million gallon spill of diluted bitumen scenario, total damages ranged between over $142 million to over $509 million. For the 1 million gallon spill of heavy fuel oil scenario, total damages ranged from over $84 million to over $243 million.[383] Based on 2006 numbers, a large spill could cost Washington $10.8 billion and 165,000 jobs.[384]

Another risk associated with petroleum refining are explosions. Older refineries, with older component parts and equipment, may present increased risks. The catastrophic failure of a nearly forty-year-old heat exchanger at the then Tesoro refinery in Anacortes killed seven employees in 2010.[385] The 2019 Philadelphia Energy Solutions refinery fire and explosions,[386] attributed in part to the rupturing of an elbow pipe installed in 1973, resulted in a widespread fire and multiple. Between August 2, 207 and March 3, 2023 153 refineries nationwide reported a total of 1,539 injuries and 7 deaths.[387] Alternative fuel refineries are not exempt from these hazards. Biodiesel facilities, when compared to conventional petroleum refineries, have a much higher number of accidents per billion barrels produced.[388] The Marathon Martinez Biofuel Refinery experienced two fires in

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[374] Union of Concerned Scientists, "Oil Refineries: A Deadly Industry", September 26, 2024.
[375] Washington State Department of Ecology, "BNSF Bakken Crude derailment", July 25, 2014.
[376] Washington State Department of Ecology, "Custer Crude Oil derailment 2020", January 12, 2021.
[377] Environmental Protection Agency, "BNSF Swinomish Channel Derailment UNIFIED COMMAND", March 18, 2023.
[378] Tribal Business News, "Swinomish Tribe awarded nearly $400 million after BNSF Railway trespassed on reservation land." June 18, 2024.
[379] Toxic Free Future, "How rail transport of vinyl chloride puts millions at risk, an analysis one year after the Ohio train derailment", January 22, 2024.
[380] Washington Department of Ecology, "Olympic Pipeline gasoline spill near Conway.", April 2, 2024.
[381] Scruggs, Gregory, "Oil tanker traffic surges in WA waters with Trans Mountain Pipeline expansion", October 20, 2024.
[382] The Seattle Times Archive, "Tugs, pilots form thin line of spill insurance", November 16, 1989.
[383] San Juan County, "San Juan County Oil Spill Risk Consequences Assessment", February 2019.
[384] Spill Prevention, Preparedness, and Response Program, "Spill Prevention, Preparedness, and Response Program", Washington State Department of Ecology.
[385] Chemical Safety and Hazard Investigation Board, "Tesoro Anacortes Refinery Fatal Explosion and Fire", May 1, 2014.
[386] Chemical Safety and Hazard Investigation Board, "Philadelphia Energy Solutions (PES) Refinery Fire and Explosions", October 11, 2022.
[387] Gibbons, Brendan, "Small western PA refinery topped list for most injuries among workers, with 119 over five years, federal data show", Oil & Gast Watch Environmental Integrity Project, August 10, 2023.
[388] Hao WU, Igor PEÑARRUBIA, Lin CUI, Jinsong ZHAO. "Process safety management considerations for biofuel production", Front. Eng, 2017, 4(3): 357–367 https://doi.org/10.15302/J-FEM-2017025

2023, one of which left an employee with burns on over 90% of his body. Refinery releases like the Marathon refinery fire in Garyville, Louisiana can cause worsened respiratory symptoms among other symptoms in their immediate aftermaths,[389] and incur costs to evacuated residents. Contributing factors to this risk include the relatively new emergence of alternative fuels refining. Many potential hazards are unknown due to each facility's unique design.[390]

[389] Kherkher, Steve, "Marathon Refinery Fire Making Headlines for Offsite Impact", Kherkher Garcia LLP, September 17, 2024.
[390] California Occupation Safety and Health Standards Board, "Proposed Petition Decision of the Occupational Safety and Health Standards Board (Petition File No. 601)", June 20, 2024.

Figure 11: Native Population Proximity to Oil Refineries and Shellfish Harvesting Restrictions.

Figure 11 captures the density of native populations near refineries and restricted shellfish harvesting zones. While overall population increases with distance from the refineries, tribal lands and citizens are located in close proximity to several refineries. An important note here is that several of the refineries are located directly adjacent to reservation land of tribal nations and, in some cases, are on unceded tribal lands and known sacred and culturally significant sites. The proximity of Washington refineries to tribal nations substantively impacts tribal communities. There are significant impacts to native citizens' ability to support traditional subsistence gathering in these areas as a result.

Native communities also face the compounding effects of exposure from air pollutants, ground and water pollutants, and fish consumption. Compared to other nearby communities without the same fish consumption rates, native communities again experience a disproportionate burden of pollution effects.

Impacts to the Environment and Wildlife

The long-term presence of oil refineries and other industrial facilities along Fidalgo Bay and the Puget Sound has introduced toxic pollutants to the area. As a result, seafood—a formerly abundant source of food with significant cultural value—has been negatively impacted. The Washington Department of Health [391]concluded that

> "eating seafood at tribal scenario rates is expected to harm children and adults' health.… If any of the tribes or nations are using Fidalgo Bay for harvesting and eating seafood at tribal scenario rates, this would represent a 'public health hazard'."

Treaty tribes in the Puget Sound have reserved the right to take fish, hunt and gather off their reservations, as described in relevant treaties.[392] [393] [394] This includes marine and freshwater areas in and around Puget Sound. The Swinomish Indian Tribal Community stated that Fidalgo Bay is an important historic harvest site that has been impacted by contamination and has therefore had limited harvest in recent years. To better understand potential exposures for Swinomish citizens, testing was completed from 2002 to 2006 of littleneck clams, Dungeness crabs and butter clams, three species common in Swinomish diets. The study found a variety of metals, polyaromatic hydrocarbons and organotoxins present in sampled species.[395] Remediation of Fidalgo Bay was launched in 2007, but marine biotoxin and pollution closure zones are still widespread in 2024. In July 2023, the National Oceanic and Atmospheric Administration (NOAA) administered funding to the Swinomish Indian Tribal Community for the construction of the first modern clam garden in the United States. This

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[391] Washington State Department of Health, "Health Consultation; Fidalgo Bay, Anacortes, Skagit County, Washington", February 25, 2010.
[392] "Tribal scenario rates" refers to the developed consumption pattern used to assess risk within the study. Tribal members consume an estimated six to 11 times more fish than non-tribal members according to the EPA Columbia River Fish Contaminant Survey 1996-1998.
[393] Calculated using U.S. Census Tract Demographic data.
[394] Pacific Fishery Management Council, "Tribes".
[395] Swinomish Water Resources Program, December 1, 2006, Bioaccumulative Toxics in Subsistence-Harvested Shellfish – Contaminant Results and Risk Assessment, Swinomish Indian Tribal Community, La Conner, WA.

program aims to teach traditional cultural practices and ceremonial subsistence harvesting practices in Swinomish youth, while also bolstering the resiliency of littleneck clam populations.[396]

Similarly, industrial development and activities among other factors at Cherry Point has contributed strongly to the decline of Cherry Point Herring stock. While Cherry Point Herring once had the highest spawning biomass in the state[397], their population has been in significant decline for decades. By 2001, the once most prolific stock in Puget Sound had declined by 94%.[398] In 2023, no spawning was observed for the Cherry Point herring stock, for the first time since formal monitoring began.[399] Cherry Point herring are an important food source for a variety of species significant to tribal communities, including Chinook and Coho salmon.

At a more general level, oil refinery effluents can also impact marine wildlife, with negative effects on growth and reproduction.[400] As an example, crude oil-derived polycyclic aromatic hydrocarbons (PAHs) are highly toxic to Pacific herring embryo and larvae, with declining Puget Sound herring stocks less likely to withstand the short-term impacts of a small, localized spills.[401] When adult fish are exposed to oil, they may experience reduced growth, enlarged livers, changes in heart and respiration rates, fin erosion and reproduction impairment. Even if exposure to oil does not have lethal impacts to a species, it can make fish and shellfish unsafe for human consumption as outlined above.[402] Over time, even small spills can have a cumulative negative impact on local wildlife populations. The effects can ripple up the food chain as affected species are consumed. For example, Pacific herring are food for every large fish-eating species in the Salish Sea, including Pacific salmon, seals and orcas.[403]

Additionally, PAHs released via refinery effluent may alter aquifers' community structure and soil microflora. Effluent discharge may also contain heavy metals and other pollutants, which can bioaccumulate in fatty tissues of humans and animals.[404] Oil leaks during shipping or discovery, tank spillage, or incorrect disposal of petroleum waste can contribute to soil pollution at petroleum refineries.[405] These pollutants can bioaccumulate in soil, water, and living tissues, contributing to ecosystem damage and negative health outcomes. Heavy metals like nickel, copper, zinc, lead, and arsenic are sometimes found in refinery effluent.[406] Heavy metals, alongside previously mentioned contaminants, can result in bioaccumulation and biomagnification in ecosystems. The persistence of these contaminants increases vulnerability to disease,

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[396] Environmental Protection Agency, "Fish and Shellfish Program Newsletter", July 2023.
[397] Northwest Ecosystem Alliance, "Petition to list the Cherry Point population of Pacific herring, Clupea pallasi, as 'threatened' or 'endangered' under the Endangered Species Act, 16 U.S.C. § 1531 et seq. (1973 as amended).", January 21, 2004.
[398] Washington Department of Fish & Wildlife, "News release: State scientists seek answers on Cherry Point herring decline", July 10, 2001.
[399] Puget Sound Vital Signs, "Biomass of Spawning Pacific Herring", March 13, 2024.
[400] Helen Wake, "Oil refineries: a review of their ecological impacts on the aquatic environment", Estuarine, Coastal and Shelf Science, Volume 62, Issues 1–2, 2005, Pages 131-140, ISSN 0272-7714.
[401] Spromberg, Julann A., Sarah E. Allan, and Nathaniel L. Scholz. 2024. "Potential Population-Level Impacts of Future Oil Spills on Pacific Herring Stocks in Puget Sound." Human and Ecological Risk Assessment: An International Journal 30 (1–2): 138–63. doi:10.1080/10807039.2023.2301529.
[402] National Oceanic and Atmospheric Administration, "How does oil impact marine life?", Updated June 16, 2024.
[403] Environmental Protection Agency, "Toxics in the Food Web: Pacific Herring and Harbor Seals".
[404] Imam, A., Kanaujia, P. K., Ray, A., & Suman, S. K. (2021). Removal of Petroleum Contaminants Through Bioremediation with Integrated Concepts of Resource Recovery: A Review. Indian journal of microbiology, 61(3), 250–261.
[405] Almutairi H. H. (2024). Microbial communities in petroleum refinery effluents and their complex functions. Saudi journal of biological sciences, 31(7), 104008.
[406] P. Tsamos, S. Stefanou, F. Noli, "Assessment of distribution of heavy metals and radionuclides in soil and plants nearby an oil refinery in northern Greece", Case Studies in Chemical and Environmental Engineering, Volume 9, 2024, 100593, ISSN 2666-0164.

instances of early mortality, and have negative effects on the nervous systems, livers, kidneys, and endocrine systems.[407]

Flaring, through the emission of sulfur oxides, nitrogen oxides and carbon dioxide can contribute to acid rain,[408] which negatively impacts plants and animals. Negative impacts are most prominent in aquatic environments, where species may be very sensitive to pH level and concentrations of aluminum. Soil acidification may also negatively impact vegetation and agricultural activities.[409] These same emissions also contribute to $PM_{2.5}$ and O_3 pollution, contributing to nutrient depletion in soil, damaging sensitive forests, reducing photosynthesis, and negatively affecting ecosystem diversity.[410] [411]

Overall, proximity to refineries may result in negative health impacts for surrounding communities and the environment. These negative impacts can be a direct result of refinery operations or the transport of refinery products or inputs.

[407] Environmental Protection Agency, "Salish Sea- Toxics in the Food Web", June 2021.
[408] Gobo AE, Richard G, Ubong IUJ. Health impact of gas flares on Igwuruta/Umuechem communities in Rivers state. Journal of Applied Sciences and Environmental Management. 2009;13(3):27-33
[409] O. Sojinu S and Ejeromedoghene O (2019) Environmental Challenges Associated with Processing of Heavy Crude Oils. Processing of Heavy Crude Oils - Challenges and Opportunities. IntechOpen.
[410] Environmental Protection Agency, "Health and Environmental Effects of Particulate Matter (PM)".
[411] Environmental Protection Agency, "Ecosystem Effects of Ozone Pollution"

Conclusions

This report provides key data and analysis regarding economic impacts of current operations of Washington's five refineries, and evaluates how these impacts may change in the future. It is intended to provide a source of unbiased information that can be used by refineries, refinery workers, tribal nations, and residents of neighboring communities to inform evaluation and future planning. While this report does not make policy recommendations, the findings do indicate that Washington's refineries are expected to undergo significant changes as Washington state moves to a net-zero economy, and that these changes will have broad impacts on workers and communities. Key gaps are identified in this report that could provide the basis for future study. These could include evaluating and making available new resources to support the current workforce to be able to transition to other comparable jobs in these counties, and the importance of ensuring tribal engagement is centered in follow on planning will be critical.

In addition, due to the exclusive use of public data, there are some gaps in the specificity that could be provided related to particular refinery locations, worker demographics, and other key considerations. Future analysis that is able to utilize additional refinery-specific data may provide further nuance that can help planning for worker transition, potential remediation costs, and potential future uses of refinery sites. A comprehensive cost-benefit analysis of alternative site uses, informed by community needs, may provide crucial information. Non-industrial uses of refinery sites face additional hurdles related to remediation and zoning, but any change of site use will be a drawn out process. Collaborative planning between the state, refineries, and local communities is needed to navigate the transition as Washington decarbonizes.

Study data and scope limitations

It is important to note that this study relies exclusively on publicly available data. This is to ensure that confidential business information is not inadvertently shared which could carry economic and legal risks. It also means that some specific analyses and calculations were not possible to complete, such as analyzing the particular costs associated with adding alternative fuel co-processing units at a particular refinery, or calculating the costs of cleanup and remediation at particular refinery sites.

Another important scope consideration is that the budget and time available for this study did not permit a full cost-benefit analysis of alternative refinery scenarios. A cost-benefit analysis would evaluate expected costs and benefits of key changes in business activity. The study instead provides an economic impact analysis, which evaluates a potential change in economic activity and models the anticipated changes to outputs, including jobs, worker income, and taxes. This study primarily relies on an economic impact analysis approach using IMPLAN, incorporating the use of additional tools and expertise related to assessing additional impacts and co-benefits of refinery sector changes to the extent feasible.

Gaps and future research opportunities

This study assesses a wide range of possible scenarios that refineries may choose as they respond to energy system changes and anticipated reductions in demand for petroleum products. The articulation of key findings and the related analysis presented provides context that the legislature, refinery owners, refinery workers, and communities impacted by refineries may choose to use as part of next steps following from the study. While this study does not provide policy recommendations, certain gaps and research opportunities were identified that may be considered for future work. These include:

- Analysis of individual refinery data to evaluate the costs of producing alternative fuels at specific refinery sites.

- Analysis of individual refinery data to evaluate the costs of cleanup of specific refinery sites to different desired remediation standards.
- Analysis of specific refinery workforce demographics (age, wages and benefits, years of experience, skill mastery), to provide a more thorough understanding of the needs of workers who may be dislocated in future. As a note, some of this analysis as it pertains to the scope of potential state pathways to early retirement programs may be provided in forthcoming research by the State Workforce and Training Board.
- Detailed calculation of greenhouse gas emissions, local pollution, employment benefits and other criteria related to specific proposals for future uses of refinery sites. Note that this will require detailed data associated with particular project specifications.
- Additional evaluation of opportunities to align economic growth and development with strategic needs for refinery workforce transition, that might direct new employment opportunities with aligned skill sets for the current refinery workforce to Pierce, Skagit and Whatcom Counties.

Evaluation of opportunities to incentivize growth of existing industries or the future siting of future facilities in Pierce, Skagit, and Whatcom counties that may align with the skills crosswalk discussed in this report. This could benefit from review of future industrial decarbonization strategies or related state policies and incentives.

Appendix A: Engagement

ESSB 5187 included the following language regarding engaging tribal nations and stakeholders in developing this research study:

> (d) The study must include a robust public engagement process including local and state elected officials, labor groups, fence line communities, port districts, economic development associations, and environmental organizations in Skagit, Whatcom, and Pierce counties, and the five Washington refineries.
>
> (e) The department must offer early, meaningful, and individual consultation with any affected Indian tribe for the purpose of understanding potential impacts to tribal rights and resources including cultural resources, archaeological sites, sacred sites, fisheries, and human health.

To facilitate meaningful engagement with tribal nations and the full spectrum of impacted stakeholders as directed by the Legislature, Commerce and WWU developed a multi-pronged engagement strategy. For tribal nations, the project team — led by WWU's Executive Director of American Indian/Alaska Native and First Nations Relations Laural Ballew and Commerce's Director of the Office of Tribal Relations Michelle Gladstone-Wade — notified tribes in Whatcom, Skagit, and Pierce counties about the project, attended tribal conferences and events to discuss the project, and facilitated a number of one-on-one discussions with interested tribal nations. For stakeholders, the project team conducted direct, one-on-one engagement with Washington's refinery operators, convened a project advisory committee, and facilitated a public webinar.

Tribal Engagement and Consultation

The project team developed and implemented tribal engagement and consultation activities at the direction of Commerce's Office of Tribal Relations and WWU's Office of American Indian/Alaska Native and First Nations Relations. Throughout the project development process, the team conducted the following engagement:

- January 27 – February 1: Members of the project team attended the Affiliated Tribes of Northwest Indians (ATNI) Winter Convention in Portland, Oregon. The team distributed printed materials with information about the study (before it was officially kicked-off), briefly presented preliminary information about the study in the Energy and Transportation committee meetings, and initiated informal conversations about the study with tribal staff and leaders.

- February – April: The Commerce Office of Tribal Relations and WWU Office of American Indian/Alaska Native and First Nations Relations notified the Tulalip Tribe of Washington, Lummi Nation, Muckleshoot Indian Tribe, Nisqually Indian Tribe, Nooksack Indian Tribe, Muckleshoot Indian Tribe, Puyallup Tribe, Samish Indian Nation, and Swinomish Indian Tribal Community via a Dear Tribal Leader letter about the study, including background on the proviso and an initial project timeline and scope, and offered the opportunity for direct one-on-one consultation and/or engagement.

- April 15-17: Members of the project team attended the ATNI Climate Summit at the Muckleshoot Casino in Auburn, Washington. The team distributed printed materials with information about the study and initiated informal conversations about the study with tribal staff and leaders.

- April 19-23: Members of the project team attended the ATNI Mid-Year convention in Canyonville, Oregon. The team distributed printed materials with information about the study and initiated informal conversations about the study with tribal staff and leaders.

- July 2: Members of the project team were invited to travel to the Swinomish Indian Tribal Community and present about the project to the Tribal Senate. Following the presentation, the team answered questions and discussed perspectives on how oil refining has impacted the Swinomish Indian Tribal Community.

- August 5: Members of the project team were invited to travel to the Lummi Nation and present about the project to the Tribal Council. Following the presentation, the team answered questions and discussed perspectives on how oil refining has impacted the Lummi Nation.

- August – November: The project team continues ongoing outreach to tribal nations to offer initial presentations to leadership and staff and follow-up meetings with those that have already engaged.

Refinery Engagement

The research team invited each of the five refineries to a meet and discuss their experiences within the industry. These conversations were limited to each individual refinery operation (as opposed to convening some/all refinery operators in one meeting) to eliminate the risk that any operator could be accused of participating in anti-competitive behavior. At the beginning of each meeting, the research team explicitly instructed the participants to refrain from discussing any non-public item related to their specific refinery and stated that the entire discussion would be framed in terms of the industry in general and not a specific location. Not all refineries chose to participate in these discussions, and those that did not were provided the list of questions and given the opportunity to respond in writing, if they wished.

These discussions enabled the research team to hear from the industry on a number of topics that would inform the study and was supplemented with two on-site tours held later by the research team where they were able to see examples of the processes and facilities that they had studied.

Project Advisory Committee

Throughout the course of the study, the project team convened a project advisory committee. The purpose of the committee was to convene stakeholders, constituents, and leaders/staff from sovereign tribal nations to contribute input and feedback to the development of the study, including research assumptions and sources, methodology, certain elements of the scope, draft findings, engagement, and the final report. The committee was composed of individuals from Washington's refineries, labor unions and contractors, environmental, climate, and justice organizations, local governments, and tribal nations. The following list of organizations, agencies, and tribal nations had representative(s) participate in the advisory committee over the course of the project:

- Anacortes Chamber of Commerce
- BlueGreen Alliance
- BP
- Economic Development Alliance of Skagit County
- Friends of the San Juan's
- Front & Centered
- HF Sinclair Corporation
- Lummi Nation
- Marathon Petroleum
- Nooksack Indian Tribe
- Northwest Central Labor Council
- Par Pacific

- Phillips 66
- Pierce County Council
- Port of Bellingham
- RE Sources for Sustainable Communities
- RMI
- Sightline Institute
- Skagit County Council
- Swinomish Indian Tribal Community
- Tacoma-Pierce County Chamber of Commerce
- United Steelworkers District 12
- United Steelworkers Local 12-591
- Western States Petroleum Association
- Whatcom County Council

The advisory committee convened four times: on May 14, July 1, August 14, and September 16, 2024. Additional ad hoc meetings between refinery committee members and the project team were held to supplement full-committee meetings when necessary.

Advisory committee members were shared a draft report on Monday, October 14 and had two weeks to review and submit feedback and comments. Feedback was due back to the project team on Monday, October 28. The project team considered feedback received within the comment period and made edits that were then integrated into the final report.

Public Webinar

On Wednesday, September 18, the project team facilitated a virtual public webinar on the study. The purpose of the webinar was to raise public awareness about the study, discuss key elements—including background on the legislative request that directed Commerce to conduct the study, the research questions that were named in the proviso, the project team's approach and methodology, initial findings, tribal, stakeholder, and community engagement, and next steps—answer questions, and gather feedback and reactions.

We promoted the webinar through various channels. Promotion included:

- a request to advisory committee members to distribute event details to their partners and constituents,
- direct email communications to staff and leadership at community-based and community-serving organizations throughout Whatcom, Skagit, and Pierce counties,
- a for-purchase ad on Facebook that ran to all account holders located within a 15-mile radius of Anacortes, 10-mile radius of Ferndale, and a 10-mile radius of Tacoma.

The webinar had 268 registrants and max participation of more than 80 audience members. The following day after the webinar, all registrants were sent a recording of the webinar and a copy of the slides used.

In the Q&A portion of the webinar, audience members submitted questions related to the cost and responsibility of environmental remediation at refinery sites, how the project team developed demand projections and whether/how relationships between refineries and Washington military bases were incorporated into them, how the workforce analysis element identified transferrable jobs for refinery workers, and how the study assesses potential future refinery site uses.

The project team recorded questions and feedback from the public webinar and used them to inform the framing and description of the study's findings. Additionally, further case study examples of the impacts of heavy-industrial manufacturing facility closures in Washington were shared by an audience member for the research team to assess and consider integrating into the study.

Appendix B: Additional Materials for Chapter 3

Glossary

Term	Definition
Alternative Jet Fuel (AJF)	Alternative Jet Fuel (AJF) is a broad term for jet fuels with non-crude oil feedstock. This term has been largely replaced by sustainable aviation fuel (SAF) as this new term encompasses desired sustainability attributes.
Anti-Knocking Agents	Anti-knocking agents serve as octane enhancers in fuel blends. Initially, lead was used as an anti-knocking agent in gasoline, before being replaced with MTBE (among others) and then ethanol. Knock occurs when fuel is prematurely ignited in the engine's cylinder, decreasing efficiency and potentially damaging engines. Higher octane fuel blends can improve vehicle efficiency, and potentially lower GHG emissions by reducing petroleum consumption.
Apprenticeship	Per the Bureau of Labor Statistics, an apprenticeship is defined as a "formal relationship between a worker and a sponsor that consists of a combination of on-the-job training and related occupation-specific instruction in which the worker learns the practical and theoretical aspects of an occupation."
Biotoxins	Biotoxins are poisons that come from plants or animals.xiv
Calcined Petroleum Coke (CPC)	Calcine Petroleum Coke (CPC) is a product produced during the crude oil refining process that is used for fabrication of anodes in the aluminum electrolysis process.
Carbon emissions allowance	Carbon emissions allowances are regulated amounts of carbon emissions that businesses and consumers can expend. Each allowance is equal to one metric ton of CO2 equivalent, and businesses can buy allowances at auction. Businesses are required to obtain allowances equal to their covered emissions.
Carbon intensity (CI)	Carbon intensity (CI) is the total amount of carbon dioxide released during a fuel's lifecycle per unit of transportation fuel energy that is released into the air. This includes the time the raw materials are produced, to the time the fuel is used.
Carbon removal	Carbon removal is a process with various approaches that aims to remove carbon dioxide from the atmosphere.
Carbon sequestration	Carbon sequestration aims to lessen global climate change by removing and retaining carbon dioxide from the atmosphere.
Clean Energy Transformation Act (CETA)	The Clean Energy Transformation Act (CETA) aims to commit Washington state to have an electricity supply free of greenhouse gas emissions by the year 2045.
Climate Commitment Act (CCA)	The Climate Commitment Act (CCA) establishes a market-based program which caps GHG emissions from Washington's largest emitting sources and establishes an investment program to fund climate resilience, clean transportation and related programs. The CCA works by capping and requiring reductions in emissions from Washington's largest emitting sources and industries, allowing businesses to find the most efficient path to lower carbon emissions.
Co-Processing	Co-Processing occurs when biogenic carbon sources and crude oil are processed together in an existing petroleum refinery with the resulting fuel typically having a lower CI.
Corporate Average Fuel Economy (CAFE) Standards	CAFE standards determine how many miles vehicles need to get from a gallon of fuel. These standards apply to passenger cars and to light trucks, with additional regulations for medium-duty and heavy-duty trucks and engines.
Cracking	Cracking is a process which uses heat, pressure, catalysts, and sometimes hydrogen to crack heavy hydrocarbon molecules into lighter ones. This process helps refineries to maximize the value of the crude oil that is processed.
Direct Effects	Direct effects are the set of expenditures applied to the I-O multipliers for an impact analysis. It is one or more production changes or expenditures made by

Term	Definition
	producers/consumers as a result of an activity or policy. Direct effects can be positive or negative.
Distillate Fuel Oil	Distillate fuel oil is a light product which encompasses fuel oils used in vessel bunkering, commercial uses (heating, cooking, etc.), industrial uses (heating, smelting, manufacturing, mining, etc.) military uses, off-road diesel fuel, railroad use, residential use, and electrical use.
Elemental Sulfur	Elemental sulfur is an element used in a broad range of industries, with its largest application being the production of phosphate fertilizers.
Emissions-Intensive, Trade Exposed Industries (EITEs)	Emissions-Intensive, Trade Exposed industries (EITEs) are those that face unique challenges because they use high levels of energy and have high GHG emissions, but also have significant national or global competition for their products. Sudden or large changes to operational costs for these facilities could result in the business limiting in state operation, or even relocating outside of the state. These industries often receive no-cost emissions allowances.
Energy industrial	This report defines an energy industrial facility as a facility that produces or stores electrical energy. Various types of energy industry could fall into this category, including processing raw methane into renewable natural gas, biomass energy production, green electrolytic or renewable hydrogen production, renewable electricity production including utility-scale wind, solar and geothermal and related categories.
Environmental Health Disparities Map	The Environmental Health Disparities Map identifies communities overburdened by environmental health risks and burdens, and which some policies such as the Climate Commitment Act use to target at least 35% of clean energy and climate resilience grants to overburdened communities and at least 10% for projects with tribal support.
Feedstock	Feedstocks are organic, raw materials that are used to create products for industrial processes.
Fischer-Tröpsch crude	Fischer-Tröpsch crude is a synthetic oil produced through the Fischer-Tröpsch process, which converts H_2 and CO into hydrocarbons.
Flare	A flare is a gas combustion device used in many industrial plants as a safety tool to release excess pressure of equipment to prevent harm. The use of flares is typically planned for scheduled maintenance, but can be used unplanned in emergency situations.
Fracking	Fracking is a drilling process that relies on high pressure liquid to break up oil-rich shale deposits. Fracking has been instrumental in U.S. crude oil independence.
Fractions	Crude oil is made up of a mixture of hydrocarbons, and the distillation process aims to separate this crude oil into broad categories of its component hydrocarbons, or "fractions." Crude oil is first heated and then put into a distillation column, also known as a still, where different products boil off and are recovered at different temperatures.
Green Electrolytic Hydrogen	Green Electrolytic Hydrogen is hydrogen produced through electrolysis, a process that uses electricity to separate the hydrogen and oxygen molecules in water. When the electricity used comes from renewable sources, this method creates hydrogen in a carbon-free way. This process is done using a device called an electrolyzer.
Hazardous Substance Tax (HST)	Washington's Hazardous Substance Tax (HST) is a tax on the first possession of hazardous substances in Washington. HST applies to petroleum products, certain pesticides, and certain chemicals. The revenue provides funding for the Department of Ecology and the Model Toxics Control Act (MTCA).
Heavy manufacturing	Heavy manufacturing supplies large industrial products and involves the use of heavy machinery and complex industrial processes. Heavy manufacturing companies often sell their products to large purchasers, which use them to create other products. Examples of heavy manufacturing include the production of machinery used in other manufacturing or material inputs used by light manufacturing to create a final product, such as production of steel or chemicals that may be used to generate other products.

Term	Definition
Heavy petroleum products	Heavy petroleum products are products with higher boiling points which are recovered at higher temperatures The "weight" of an oil is based on its API gravity. API gravity is a system of classifying crude oils based on density and sulfur content. Heavy crude oils require additional, more expensive processing to produce high value products.
Hydrocarbon Gas Liquids (HGL)	Hydrocarbon Gas Liquids (HGL) cover natural gas liquids (ethane, propane, normal butane, isobutane, and natural gasoline) and refinery olefins (ethylene, propylene, butylene, and isobutylene).
IMPLAN Economic Impact Software	IMPLAN is a planning software that can show its users the potential economic impacts of various inputs.
Indirect Effects	Indirect effects are the business to business purchases in the supply chain taking place in the region that stem from the initial industry input purchases. As the industry specified spends their money in the region with their suppliers, this spending is shown through the indirect effect.
Induced Impacts	Induced effects are the values stemming from household spending of Labor Income, after removal of taxes, savings, and commuter income. The induced effects are generated by the spending of the employees within the business' supply chain.
Industrial symbiosis	Industrial symbiosis is a broad term referring to industrial operations that involve collaborations and exchanges between multiple industries, allowing for a circular transformation of materials through industrial processes. Through an exchange of resources and energy, interdependent networks are created between industries, allowing for the excess or waste materials from one industry to be used in the production process of another industry.
Inelastic Demand	If a product has inelastic demand, demand is relatively unresponsive to price changes compared to products with elastic demand. Products considered necessities, which consumers must buy regardless of their price, often have inelastic demand.
Job Dislocation	Job Dislocation refers to when employees have been laid off, terminated, or notified of layoff from their jobs due to factors outside of their control. These reasons could be due to changes in the economy, natural disasters, pandemics, industry or business model changes, and company mergers or acquisitions.
Leakage	Emissions leakage occurs when efforts to reduce emissions in one place cause emissions to increase in another location or sector. If Washington's overall emissions are reduced, but only because facilities have moved their operations and emissions to another location, this would be referred to as leakage.
Light petroleum products	Light petroleum products are products with lower boiling points which are recovered at lower temperatures. The "weight" of an oil is based on its API gravity. API gravity is a system of classifying crude oils based on density and sulfur content.
Location Quotient	Location quotient is a measurement of concentration in comparison to the nation. An LQ of 1.00 indicates a region has the same concentration of an industry (or occupation) as the nation. An LQ of 2.00 would mean the region has twice the expected employment compared to the nation.
Low Carbon Fuel Standard (LCFS)	The Low Carbon Fuel Standard (LCFS) is a law that aims to reduce the carbon intensity of California's transportation fuels by expanding access to low-carbon and renewable options.
Model Toxics Control Act (MTCA)	The Model Toxics Control Act (MTCA) is Washington's law for cleaning environmental contamination. MTCA funds and oversees the investigation, cleanup, and prevention of sites with hazardous substances. The law aims to protect health and the environment, while preserving natural resources for the future.iii
Non-energy industrial	In this report, nonenergy industrial encompass all industrial uses that are not energy- or heavy manufacturing-related. Many nonenergy industrial facilities focus on producing and distributing consumer goods. Examples include warehouses, distribution centers, ports, terminals and light manufacturing facilities. While heavy manufacturing primarily

Term	Definition
	produces products intended for business and industrial use, light manufacturing produces consumer goods
North American Industry Classification System (NAICS) codes	North American Industry Classification System (NAICS) codes classify businesses for the purpose of collecting, analyzing, and publishing statistical data, creating comparable categories across industries.
Offset Credits	Offset credits are credits that can be earned by emitters by investing in projects that reduce, remove, or avoid greenhouse gas emissions to cover- or “offset”-their emissions. There are strict criteria which must be met for emitters to earn these offset credits. The programs or solutions that they invest in must result in permanent, quantifiable, verifiable, and enforceable reductions to GHG emissions.
Orphan Sites	Orphan sites are contaminated sites wherein the potentially liable persons are financially unable or unavailable to fund remediation at a contaminated site.
Petroleum Administration for Defense Districts (PADDs)	The Petroleum Administration for Defense Districts (PADDs) are five geographic divisions of the 50 States and the District of Columbia that were established to help coordinate the production and use of petroleum across the country.
Pyrolysis Oil	Pyrolysis oil is a synthetic fuel produced by the pyrolysis process. Pyrolysis oil is made up of many different molecules, some coming from biomass, waste, plastics, and/or tires.
Refinery turnarounds	Refinery turnarounds are elaborate, large scale maintenance events that can double or even triple the number of workers on site and involve around-the-clock work to minimize operations impacts. Turnarounds happen every three to five years and can take anywhere from a few weeks to several months. They require extensive planning processes and logistical management, sometime as long as two years. Turnarounds require large numbers of skilled workers, and some contractors exclusively coordinate and manage turnover.
Renewable Fuel Standard (RFS)	According to the EPA, the RFS program is a national policy that requires a certain volume of renewable fuel be used to replace or reduce the quantity of fossil fuel in transportation fuel, home heating oil, or jet fuel.xxiii
Residual Fuel Oil	Residual fuel oil, which is heavier than distillate fuel oil, is used for vessel bunkering, heating, fuel, and manufacturing.
SAM Multiplier	The SAM Multiplier is a measure of an industry's connection to the wider local economy by way of input purchases, payments of wages and taxes, and other transactions. It is calculated as (Direct Effects + Indirect Effects + Induced Effects) / (Direct Effects). It considers induced, indirect, and direct effects.
Scenic Regions	Scenic regions are areas that are considered aesthetically appealing. These locations may have additional value in potential residential or commercial uses because of waterfront views and access.
Sensitivity Analysis	A sensitivity analysis analyzes how variations in an input can lead to changes in an output.
Shutdowns	Shutdowns are a type of refinery disruption to operations that can be planned or unplanned. They involve the shutdown of specific units for maintenance and are used to help bridge the gap between turnarounds. Unplanned shutdowns may be delayed by equipment and contractor availability, due to a shorter planning window. Emergency shutdowns can be triggered for a variety of reasons, including but not limited to a loss of utilities, unsafe conditions due to extreme weather, or a fire.
Stacking	In the context of incentives for renewable energy, stacking refers to producers adding together federal and state/province policies when making decisions regarding the production of renewable fuel and location.
Standard Occupational Classification (SOC) codes	The Standard Occupational Classification (SOC) system is a federal statistical standard used by federal agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data.

Term	Definition
Stream Day	Stream Day refers to the maximum number of barrels of input that a distillation facility can process within a 24-hour period when running at full capacity under optimal crude and product slate conditions with no allowance for downtime. This number is often higher than barrels per calendar day, which factors in limitations like input quality, environmental constraints, downtime for maintenance or repairs. Stream day capacity is typically about 6% higher than calendar day capacity.
tCO2e	TCO2e stands for “Tonnes of carbon dioxide equivalent.”
The Motor Vehicle Fuel Tax (MVFT)	The Motor Vehicle Fuel Tax (MVFT) is paid by suppliers, distributors, refiners, and blenders of fuel on each gallon of fuel imported, produced, or delivered from a terminal rack in Washington. This includes motor vehicle fuel and special fuels, such as diesel, biodiesel, natural gas, and propane.
The Oil Spill Tax (OST)	The Oil Spill Tax (OST) refers to the combined administration of the Oil Spill Response Tax and the Oil Spill Administration Tax. OST is applied at a per barrel rate, and the Petroleum Product Tax (PPT) is applied to the wholesale value of petroleum products.
The Petroleum Products Tax (PPT)	The Petroleum Products Tax (PPT) is a tax on the first possession of petroleum products in Washington, and is imposed on the wholesale value of petroleum products.
Type 1 Multiplier	The Type 1 is a measure of an industry's connection to the wider local economy by way of input purchases only (no induced effects, no institutions internalized). This type of multiplier does not consider induced effects. It is calculated as (Direct Effects + Indirect Effects) / (Direct Effects).
U.S. Sustainable Aviation Fuel Grand Challenge	The U.S. Sustainable Aviation Fuel Grand Challenge gathers several federal agencies to advance technologies for producing sustainable aviation fuels at a commercial scale.
Union Wage Premium	The union wage premium is the difference in income that union members make in relation to non-union members.
Value added	Value added is the difference between an Industry's or establishment's total Output and the cost of its Intermediate Inputs; it is a measure of the contribution to GDP. Value Added is a large portion of Output, as it encompasses Labor Income (LI), Other Property Income (OPI), and Taxes on Production and Imports (TOPI).
Washington State Clean Fuel Standard (CFS)	Washington State Clean Fuel Standard (CFS) is a policy intended to help limit carbon pollution from transportation. The CFS aims to reduce the emissions from the production and supply of transportation fuels by providing an increasing range of low carbon and renewable alternatives.
Washington’s Clean Fuel Standard (CFS)	The Clean Fuel Standard (CFS) aims to reduce emissions from the production and supply of transportation fuels, which is the largest source of greenhouse gas emissions in Washington. The CFS plans to do this by expanding low-carbon and renewable fuel options to reduce dependence on petroleum.
Washington's Buy Clean and Buy Fair Law	Washington’s Buy Clean and Buy Fair law mandates the disclosure of environmental and workforce impacts linked to the production of building materials for state construction projects.
Workforce crosswalk analysis	A workforce crosswalk analysis assesses potential career paths for workers, taking into consideration their existing skills and experience.

Current and Historical Fuel Demand

Overview

Chapter 3 of the report is two-pronged, covering both a summary of existing petroleum refining capacity and trends, as well import-export data for local, regional, national and global markets.

This section relies on a wide variety of data sets with two primary sources, the U.S. Energy Information Administration (EIA) and the Energy Institute (EI). Within the Department of Energy, the EIA compiles large

amounts of data about a variety of energy sources. The EIA is the primary source for local and regional data in this report. Much of the U.S. and global data presented here was gathered from the Energy Institute's Statistical Review of World Energy, a publication in its 74th addition, dating back to 1952.

Historical Demand for Refined Petroleum Products

Based on the current capacity and markets as discussed in Chapter 1, this section covers demand for different transportation fuels in Washington, the United States and globally.

Washington Demand

The U.S. Energy Information Administration (EIA) collects data on refinery sales volume to end users of petroleum products for motor gasoline and other petroleum products. Between 2008 and 2010 there was a sharp decline in the trend of refinery sales volume in Washington. Between October 2008 and January 2010, there was a 648,000 gallon-per-day decline in gasoline sales and a 900,000 gallon-per-day decline in all petroleum products sold between 2008 and 2010. However, this is not necessarily indicative of a long-term local drop in demand for petroleum in Washington.

The observed decline was likely caused by a combination of factors, including the 2008 recession and changing EPA restrictions around that time. The 2005 Energy Policy Act removed the oxygenate requirement for reformulated gasoline, and the federal Renewable Fuel Standard (RFS) was implemented. [412] The implementation of the RFS, alongside growing concerns about leakage of certain chemicals including methyl tertiary butyl ether (MTBE) into groundwater and reservoirs encouraged refineries to transition from using MTBE as an anti-knocking[413] agent to ethanol.[414] [415] The transition from MTBE to ethanol reduced some refineries' capacities, in addition to lingering impacts of hurricanes in 2005 and 2007 reducing U.S. refining capacity. [416] These events are part of a complex system of factors that impact fuel production and sales.

Leading into the 2008 recession, gas prices were high due to the aforementioned factors alongside changes in the price of crude oil.[417] [418] While the price of gasoline fell in 2008, demand also fell sharply as households spent less due to the recession. Gasoline demand is widely considered relatively inelastic, meaning that it does not change much even when fuel prices change. Similarly, the overall downwards trend in gasoline sales can be partially attributed to improved fuel economy standards for newer vehicle models. Fuel economy improvements since the 1970s have saved enormous amounts of fuel, partially driven by required

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[412] Environmental Protection Agency Archive, "Gasoline: Methyl Tertiary Butyl Ether (MTBE)", Accessed August 6, 2024.
[413] Anti-knocking agents serve as octane enhancers in fuel blends. Initially, lead was used as an anti-knocking agent in gasoline, before being replaced with MTBE (among others) and then ethanol. Knock occurs when fuel is prematurely ignited in the engine's cylinder, decreasing efficiency and potentially damaging engines. Higher octane fuel blends can improve vehicle efficiency, and potentially lower GHG emissions by reducing petroleum consumption.
[414] Federal Trade Commission Bureau of Economics, "Gasoline Price Changes and the Petroleum Industry: an Update", September 2011.
[415] Stolark, Jessie, "Fact Sheet | A Brief History of Octane in Gasoline: From Lead to Ethanol", Environmental and Energy Study Institute, March 30, 2016.
[416] Reuters, "A short history of U.S. oil refining losses due to hurricanes", June 30, 2022.
[417] Federal Trade Commission Bureau of Economics, "Gasoline Price Changes and the Petroleum Industry: an Update", September 2011.
[418] Ristanovic, Anja, Hedge Solutions, "Major Oil Market Crashes in History", Oil & Energy Online, Accessed September 17, 2024.

improvements under Corporate Average Fuel Economy (CAFE) Standards. [419]Despite a growing population and fleet, gasoline consumption in the U.S. likely peaked in 2018, following a previous peak in 2007.[420] [421]

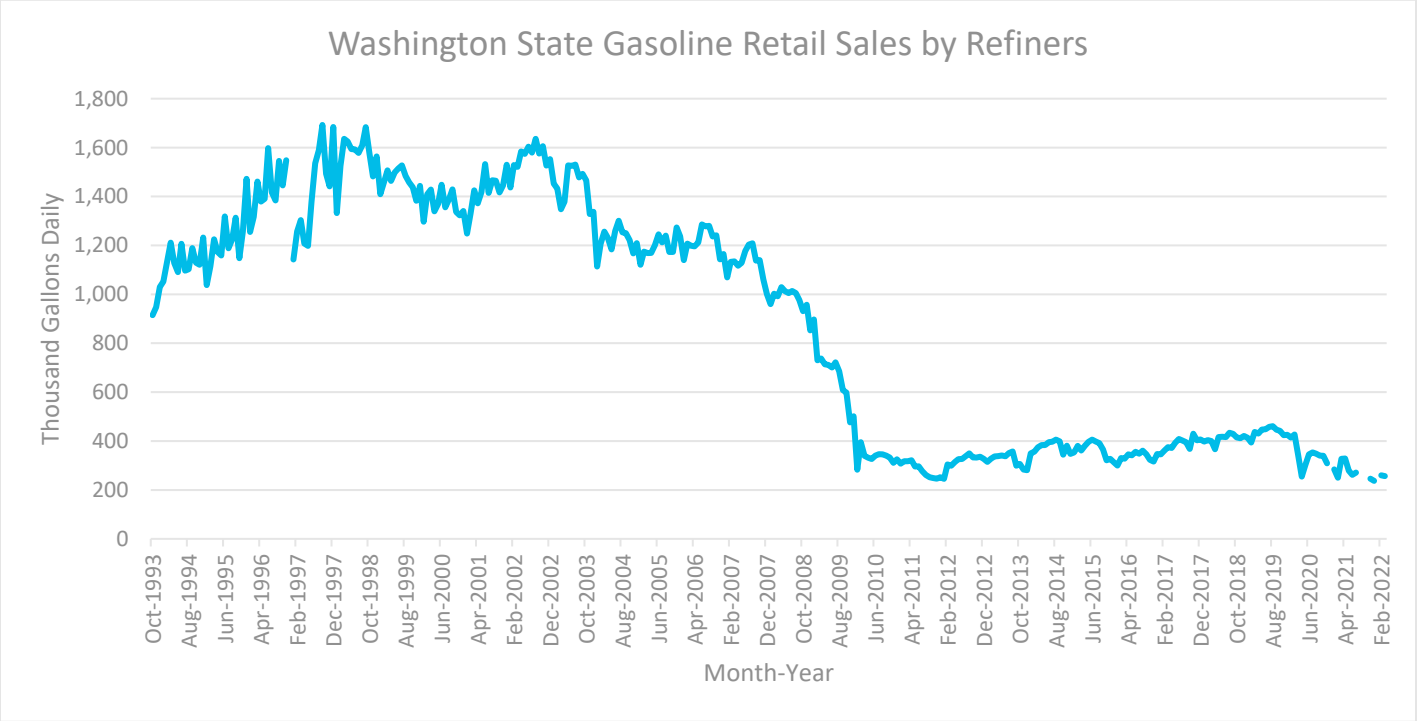


Figure 12: Washington Gasoline Retail Sales by Refiners

EIA, Washington Sales to End Users, Total Refiner Motor Gasoline Sales Volumes.

Figure 12 shows the change in gasoline sales in Washington from 1990 to 2022. After the 2008 crash, sales increased somewhat before peaking in 2019. Similarly, sales from 1990 to 2021for all other petroleum products are displayed in Figure 13. This sales number recently peaked in 2019, following a trough in 2008. To understand overall demand for refinery products, it is important to look at state level use estimates.

[419] Greene, David L., Greenwald, Judith M., and Ciez, Rebecca E., "U.S. fuel economy and greenhouse gas standards: What have they achieved and what have we learned?", Energy Policy, Volume 146, 2020. 111783, ISSN 0301-4215.
[420] Energy Information Administration, "Frequently Asked Questions (FAQs): How much gasoline does the United States consume?"
[421] Kirk, Karin. "Is this the beginning of the end for gasoline?", Yale Climate Connections, May 3, 2023.

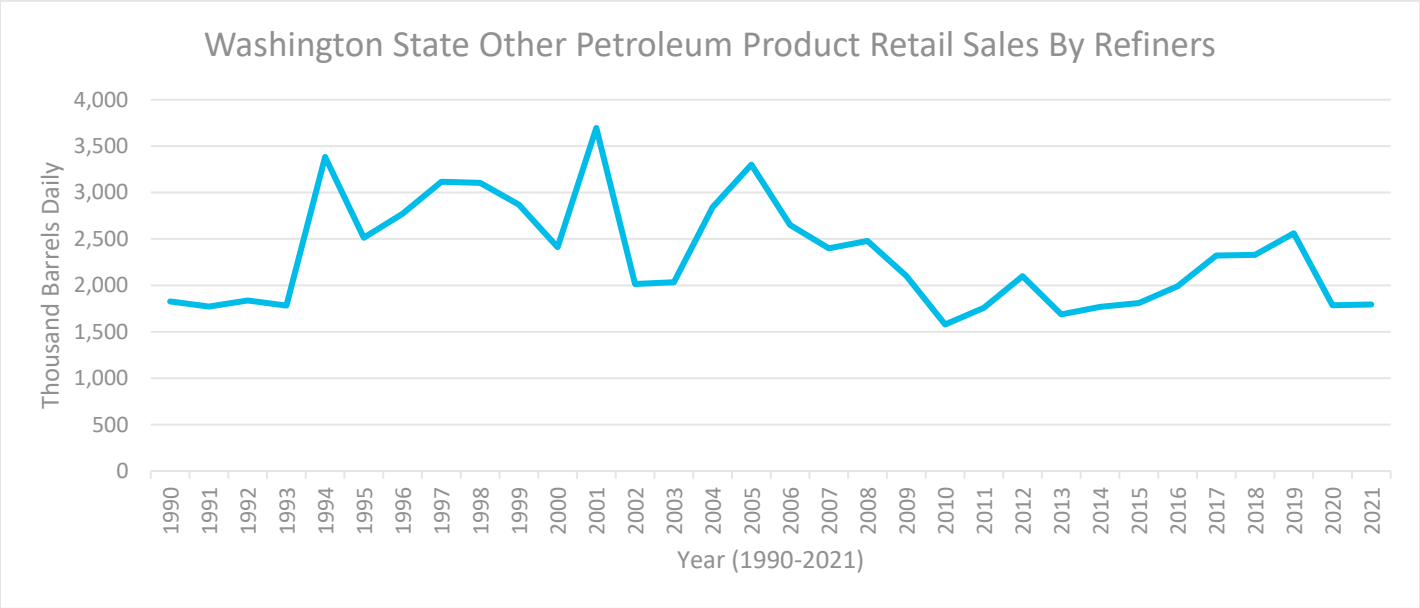
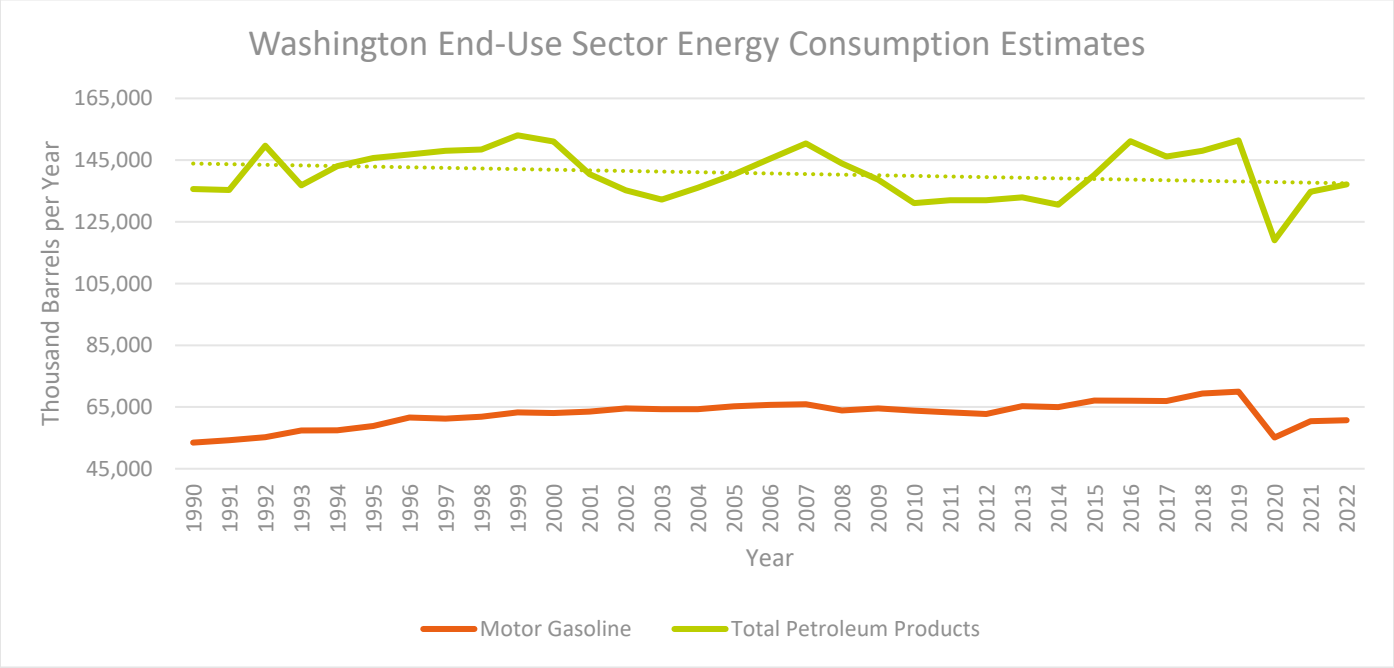


Figure 13: Washington Other Petroleum Product Retail Sales by Refiners

EIA, Washington Sales to End Users Refiners Sales, Volumes of Aviation Fuels, Kerosene, Propane, No. 1 and No. 2 Distillates.

Using the EIA total end-use sector energy consumption estimates[422], part of their State Energy Data System (SEDS), it is possible to plot the trends for both motor gasoline and total petroleum products. End-use estimates for motor gasoline have been steadily increasing since 1990, whereas petroleum usage has stayed relatively flat. A sharp decline can be seen in both total petroleum products and gasoline in 2020 as a result of the COVID-19 pandemic and subsequent travel restrictions. This can be seen in Figure 14.



[422] EIA, "Table CT3. Total End-Use Sector Energy Consumption Estimates, Selected Years, 1960-2022, Washington." EIA. Accessed August 13, 2024.

Figure 14: Washington End-Use Sector Energy Consumption Estimates.

EIA, Table CT3, Total end-use sector energy consumption estimates.

Looking at the petroleum end-use by source, even as motor gasoline increases, end-use estimates for petroleum products are stable or decreasing. Figure15 shows these changes in estimated consumption across six categories.

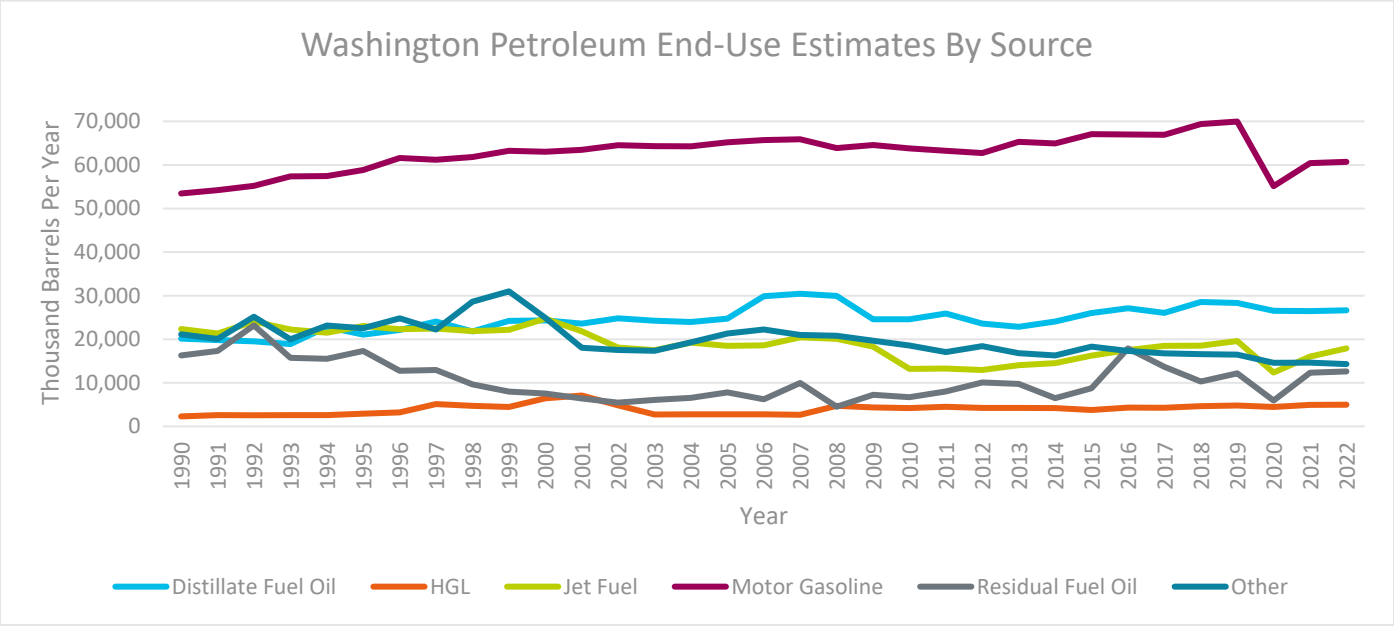


Figure 15: Washington Petroleum End-Use Estimates By Source.

EIA, CT3, Total End-Use Sector Energy Consumption Estimates.

The six categories represented in Figure 15 are:

1) Distillate Fuel Oil: a light product which encompasses fuel oils used in vessel bunkering, commercial uses (heating, cooking, etc.), industrial uses (heating, smelting, manufacturing, mining, etc.) military uses, off-road diesel fuel, railroad use, residential use and electrical use.
2) "Hydrocarbon Gas Liquids (HGL)": which “cover[s] natural gas liquids (ethane, propane, normal butane, isobutane, and natural gasoline) and refinery olefins (ethylene, propylene, butylene, and isobutylene).” “The State Energy Data System (SEDS) assumes that, except for propane, all other HGL products are consumed only by the industrial sector." [423]
3) Jet Fuel: Jet fuel includes both kerosene-type and naphtha-type until 2005. In 2005, naphtha-type was moved into the "other" category.
4) Motor Gasoline: Motor gasoline within the SEDS uses 12 data series aggregated by the EIA to estimate end-use consumption. Most of this data comes from the Federal Highway Administration Publication.

[423] EIA. “Section 4. Petroleum.” State Energy Data System 2022: Consumption. Accessed August 12, 2024.

5) Residual Fuel Oil: Residual fuel oil, which is heavier[424] than distillate fuel oil, is used for vessel bunkering, heating, fuel and manufacturing.
6) Other: The other category is a sum of 12 additional petroleum products, aviation gasoline blending components, biofuels (excluding fuel ethanol), crude oil, petrochemical feedstocks [425] (including naphtha less than 401° Fahrenheit, other oils equal to or greater than 401° Fahrenheit[426], still gas[427]), motor gasoline blending components, miscellaneous petroleum products, still gas, special naphthas, unfinished oils and waxes.

Consumption per capita is steadily trending down, however overall petroleum product use in Washington has remained relatively flat due to a growing population. Fuel efficiency upgrades in passenger vehicles have been a major driver of decreased petroleum use. **Error! Reference source not found.**shows the increase in fuel e fficiency for both Light-Duty vehicles with wheelbases less than 121 inches and for all motor vehicles from 1990 to 2022.

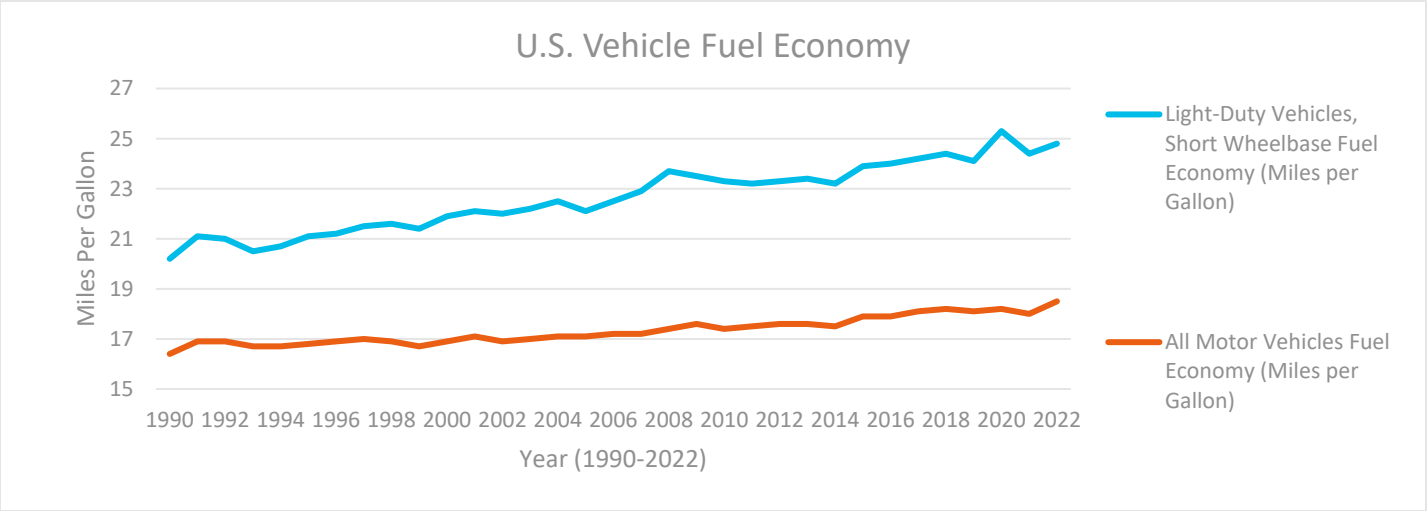


Figure 16: U.S. Vehicle Fuel Economy

EIA, Table 1.8 Motor Vehicle Mileage, Fuel Consumption and Fuel Economy.

Most passenger vehicles on the road today are classified as Light-Duty vehicles with wheelbases less than 121 inches. Between 1990 and 2022 Light-Duty Short Wheelbase vehicles saw a 22.77% increase in fuel efficiency. All vehicles saw a more modest, but still significant 12.8% efficiency increase over the same 22-year span. According to the EIA, the transport sector is responsible for 80% of Washington's petroleum consumption, with half of that composed of motor gasoline. [428]

[424] Heavier or lighter refers to the "weight" of an oil, based on their API gravity. API gravity is a system of classifying crude oils based on density and sulfur content. Heavy crude oils require additional, more expensive processing to produce high value products, and impact the split of products that are made based on that oil's composition.
[425] EIA, "Petroleum & Other Liquids: Definitions, Sources and Explanatory Notes".
[426] 401° Fahrenheit refers to the boiling range. Naphtha less than 401˚F is used as a petrochemical feedstock. Other oils equal to or greater than 401˚F refers to oils with a boiling range equal to or greater than 401˚F intended for use as a petrochemical feedstock.
[427] After 1986, still gas for other uses and petrochemical feedstocks were grouped together. Previously, still gas for other uses was reported separately from still gas for petrochemical feedstocks.
[428] EIA, "Oil and Petroleum Products Explained." Refining crude oil - the refining process - U.S. Energy Information Administration (EIA). Accessed September 10, 2024.

The 2019 Department of Commerce Biennial Energy Report discusses how low gasoline prices brought the cost of driving to a historic low in 1998.[429] Partially due to the higher cost of gasoline in recent years, vehicle miles traveled (VMT) per capita for Washington residents has fallen roughly 1,000 miles between 2010 and 2021.[430]Washington has the fourth lowest per capita VMT, behind only New York, Rhode Island and Hawaii. The largest change in VMT per capita occurred in King County, Washington's most populated county. Much of Washington's population lives in centers with access to public transportation and bicycle infrastructure. Many Washington residents live along the I-5 corridor, which is now being serviced by the Sound Transit Link Light Rail, allowing easier transit access to cities for suburban commuters. Washington Department of Transportation's commitment to reducing VMT through infrastructure improvements has made significant progress. Washington is currently number one in the country in per capita VMT reduction.[431]

U.S. Demand

The Statistical Review of World Energy produced by the Energy Institute compiles energy data from a variety of sources across the globe. Data on refinery throughput helps demonstrate demand for refinery products. This data shows the quantity of petroleum inputs processed domestically. Changes in throughput are driven largely by changes in demand. Crude and condensate are inputs in the petroleum refining process. Throughput is "based on the quantity of crude and condensate processed in atmospheric distillation units and condensate splitters."[432] Throughput is influenced by demand, which is susceptible to shocks. The U.S. refinery utilization rates tend to fluctuate between 80% to 100%, with 90% or above utilization deemed "high".[433] These fluctuations happen based on time of year, shutdowns for facility maintenance and seasonal demand fluctuation.

Ignoring the pandemic-induced dip and continuing recover period, U.S. refineries have processed an increasing amount of petroleum inputs over the past several decades. This result is expected with increasing petroleum product usage in the U.S., as well as increased exports globally. However, this differs somewhat from the relatively flat overall demand in Washington. This also comes as many refineries expand their existing capacity, through reactivation of decommissioned units or small additions. The newest refinery with significant downstream unit capacity coming online in 1977.[434] Historically, capacity additions have outpaced

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[429] Washington State Department of Commerce, "2019 Biennial Energy Report.", December 2018.
[430] "Vehicle Miles Traveled (VMT) Targets –Final Report." Washington State Department of Transportation, June 2023.
[431] "Implementation of Vehicle Miles Traveled Targets and Supporting Actions – Interim Report." Washington State Department of Transportation, June 2024.
[432] "Statistical Review of World Energy 2024." Energy Institute, June 2024.
[433] Paz, Cassia. "What is it- Refinery Utilization", Mansfield Energy, September 6, 2023.
[434] EIA, "Frequently Asked Questions (FAQs), When was the last refinery built in the United States?); EIA, "U.S. refining capacity increased in 2023 with expansions at existing facilities", July 30, 2024.

the loss of capacity due to refinery closures. [435]

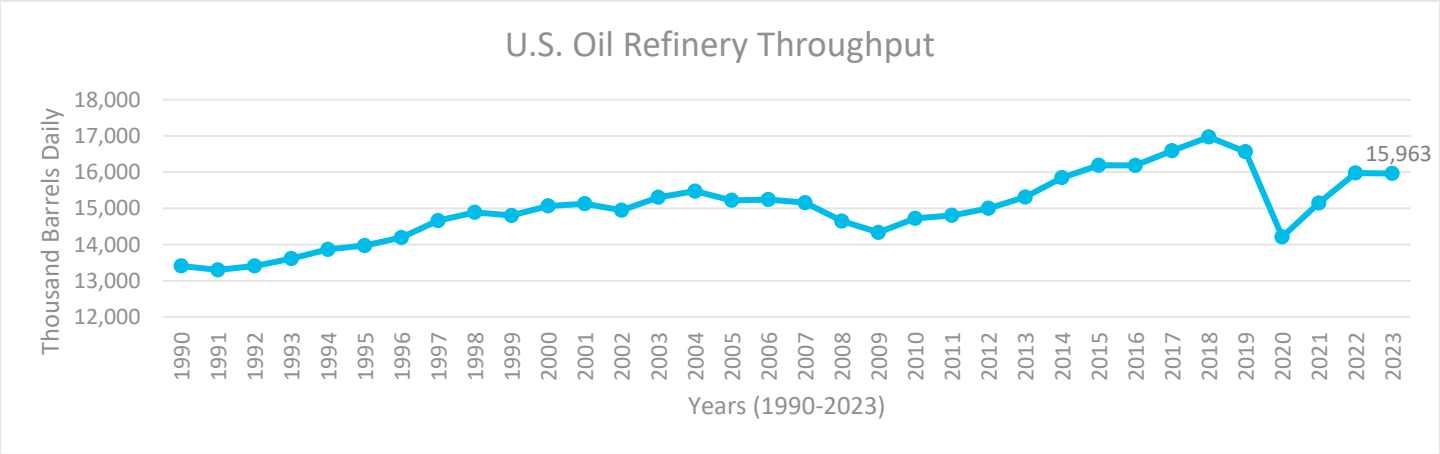

Figure 17: U.S. Oil Refinery Throughput.

Energy Institute, 2024 Statistical Review of World Energy, Oil: Refinery Throughput.

Consumption of most refinery product types has fluctuated over the past several decades. Most product types, except for fuel oil and diesel, are currently trending up after some reductions post 2000 and COVID-19 pandemic-related declines. The decline in diesel consumption may be related to an increasing reliance on biodiesel and alternative fuels for traditionally diesel-run vehicles, while the decline in fuel oil consumption is likely related to the modernization of heating systems. Gasoline and jet fuel consumption saw the most significant pandemic-related declines of all petroleum products.

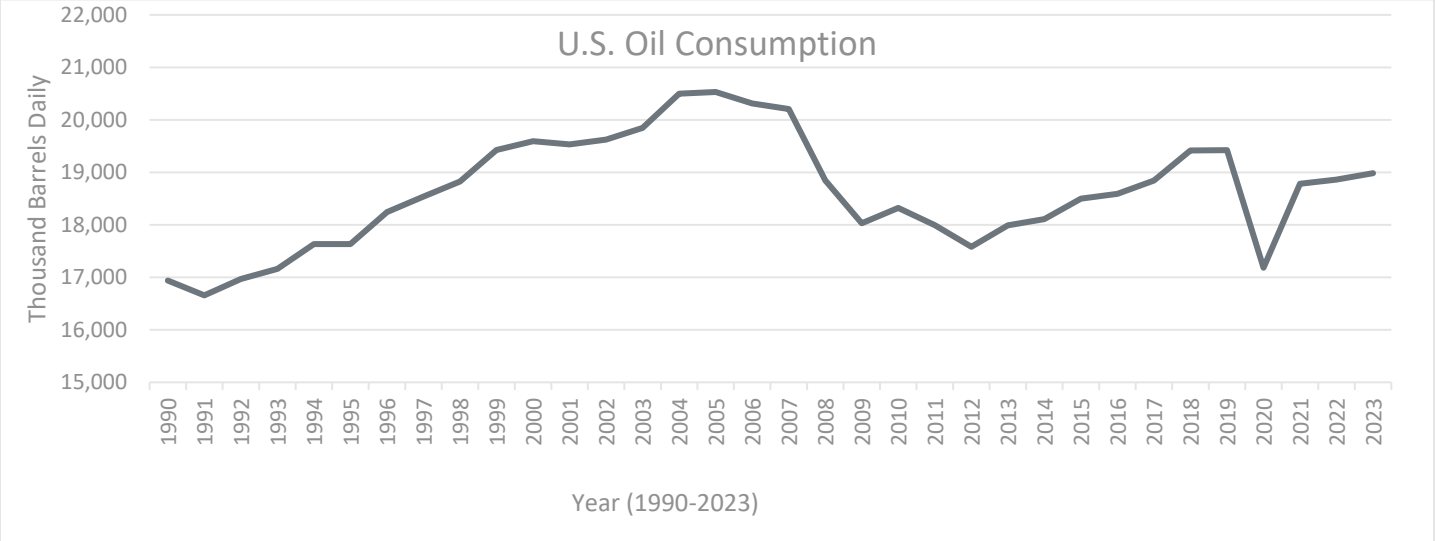

Figure 18: U.S. Oil Consumption.

Energy Institute, 2024 Statistical Review of World Energy, Oil: Consumption.[436]

[435] EIA, 'Ownership of U.S. petroleum refineries has changed significantly since 200", January 29, 2014.
[436] Oil in this table refers to "Inland demand plus international aviation and marine bunkers and refinery fuel and loss. Consumption of biogasoline (such as ethanol) and biodiesel are excluded while derivatives of coal and natural gas are included."

In line with the increasing consumption levels for many refined petroleum products, U.S. oil refining capacity has been steadily increasing for many years. In 1990, capacity equaled 15,676,000 barrels per day, and in 2019, capacity reached 18,974,000 before pandemic declines (**Error! Reference source not found.**). In the U.S., r efining capacity has not yet recovered to pre-pandemic levels. In 2023, capacity was 18,429,000 barrels per day, or 545,000 barrels per day fewer than in 2019.

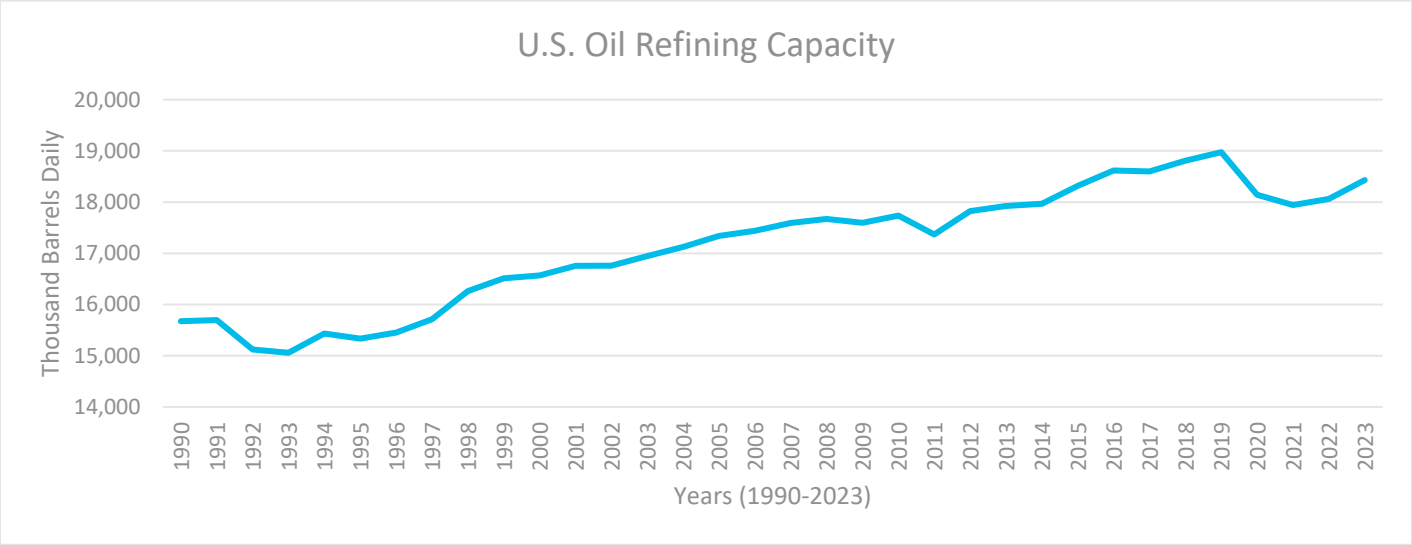

Figure 19: U.S. Oil Refining Capacity.

Energy Institute, 2024 Statistical Review of World Energy, Oil: Refining Capacity.

During the early years of the COVID-19 pandemic, between 2020 and 2022, the U.S. saw seven refineries closed, for a total of 129 operable refineries at the start of 2023.[437] No refineries closed in 2023.[438] The 2022 EIA Annual Energy Outlook discusses the loss of 750,000 barrels per day of total refining capacity either as a result of the COVID-19 pandemic or conversion to renewable diesel production, from six refineries.[439] The Santa Maria Refinery in California's closure resulted in capacity loss of 9,500 barrels per day, which was outweighed by capacity additions from the reactivation of previously retired units. As of this report, four of the seven closed refineries have reopened as biofuel refineries. The HollyFrontier refinery in Cheyenne, Wyoming and the Dakota Prairie refinery in Dickinson, North Dakota have both transitioned to renewable diesel production.[440] The Tesoro (Marathon) refinery in Martinez, California has also transitioned to biofuel production.[441] The Phillips 66 Rodeo, California refinery has transitioned to biofuel production[442], with its upstream partner facility in Santa Maria closing for demolition and remediation.[443] Another facility, the Shell refinery in Convent, Louisiana, is undergoing construction to convert the facility to biofuel production.[444] Two

[437] Energy Information Administration, "Frequently Asked Questions (FAQs): How much gasoline does the United States consume?".
[438] EIA, " Refinery Capacity Report: New, Shutdown, and Reactivated Refineries During 2023", Released June 14, 2024.
[439] "Annual Energy Outlook 2022 - U.S. Energy Information Administration (EIA)." Annual Energy Outlook - Refinery closures lower domestic crude oil distillation operating capacity, but refinery utilization rates remain flat over the long term - U.S. Energy Information Administration (EIA). Accessed September 5, 2024.
[440] "Annual Energy Outlook 2022 - U.S. Energy Information Administration (EIA)." Annual Energy Outlook - Refinery closures lower domestic crude oil distillation operating capacity, but refinery utilization rates remain flat over the long term - U.S. Energy Information Administration (EIA). Accessed September 5, 2024.
[441] Voegele, Erin, "Marathon: Martinez Biorefinery to Reach Full Production in 2023", Biomass Magazine, October 31, 2023.
[442] Epstein, Curt, "Major SAF Plant Goes to Full Capacity, Other Ponder", Aviation International News, July 11, 2024.
[443] Lindt, John, "Phillips 66 refinery to meet the wrecking ball", The Santa Maria Times, March 26, 2024.
[444] Shell, "Shell Convent: A Groundbreaking Transformation Already Underway", nola news, February 12, 2023.

other closed refineries, the Western Refining refinery in Gallup, New Mexico and Philadelphia Energy Solutions in Philadelphia, Pennsylvania, remain indefinitely idled or closed for redevelopment.

Global Demand

Global petroleum product usage has also seen increased amounts of petroleum throughputs in recent decades, albeit with a steep drop during the COVID-19 pandemic restrictions. Global oil consumption has increased by 51% from 66,198,000 barrels in 1990 to 100,221,000 in 2023. This is a much steeper rise in consumption than in Washington or the U.S overall. The drop in consumption seen in 2020 was equivalent to 8,775,000 barrels per day, or nearly 9% of 2019 consumption.

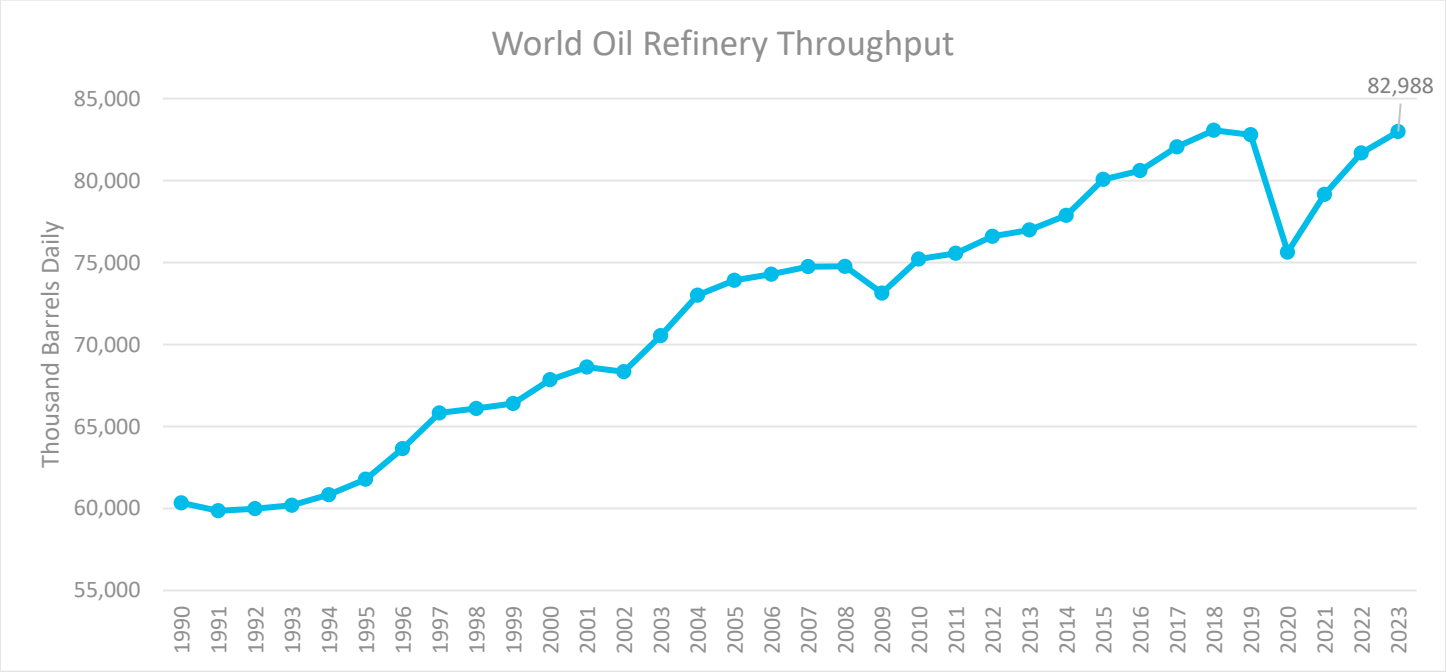

Figure 20: World Oil Refinery Throughput.

Energy Institute, 2024 Statistical Review of World Energy, Oil: Refinery Throughput.

In part, this consumption has been driven by rapid economic growth in several countries in Asia. Dynamic factory activity and infrastructure investments in China have been a significant driver behind increases in global oil demand[445], and higher levels of oil use for transport in India is expected to help drive increases in the future. However, rising electric vehicle adoption, fuel efficiency improvements and shifts away from oil-based electricity generation in these countries and others will likely offset some of this momentum.[446]

[445] Healy, Ciaran, and Bressers, Alexander, "China's slowdown is weighing on the outlook for global oil demand growth", International Energy Agency, September 12, 2024.
[446] International Energy Agency, "Slowing demand growth and surging supply puts global oil markets on course for major surplus this decade", June 12, 2024; International Energy Agency, "Oil 2024: Analysis and forecast to 2030", June 2024.

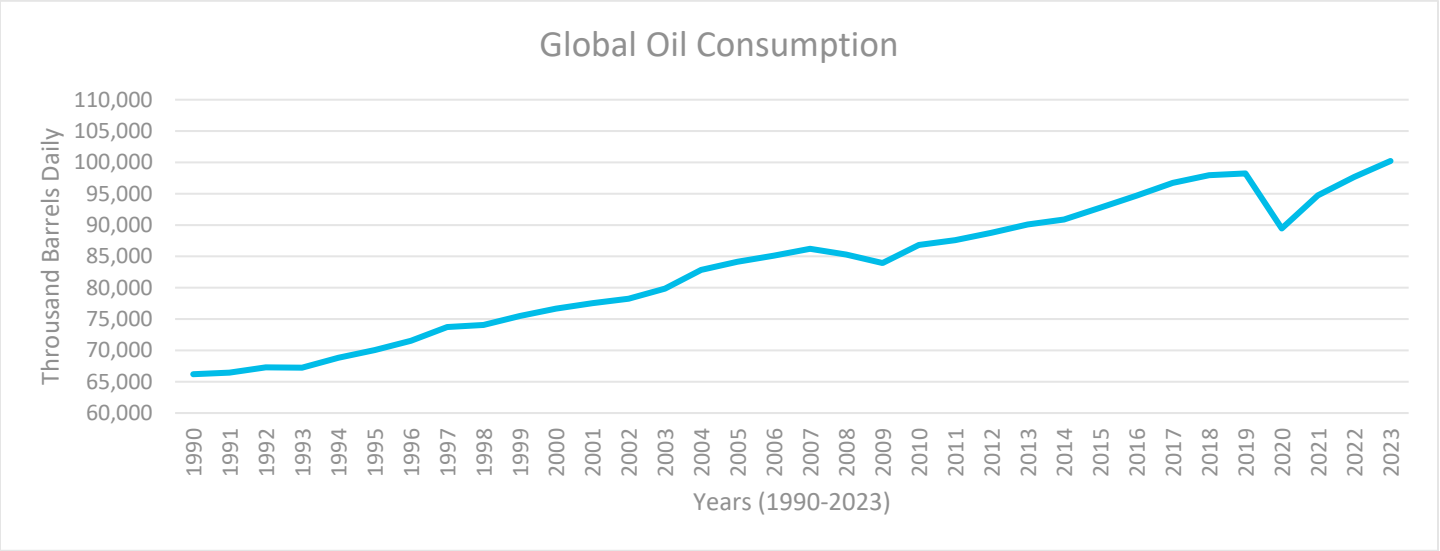

Figure 21: Global Oil Consumption.

Energy Institute, 2024 Statistical Review of World Energy, Oil: Consumption.

Like U.S. consumption patterns, global consumption of most refinery product types has fluctuated over the past several decades. Global consumption of all product types is currently trending up. Fuel oil stands as an outlier among its neighbors, with an overall downward trend that bottomed out in 2020. As defined in this context by the Energy Institute, fuel oil is a product used in marine bunkers and as crude oil used directly for fuel. Besides shipping, fuel oil is used for heating and power generation. The general trend away from using petroleum as a source of electricity in favor of more cost effective and greener alternatives has diminished the role fuel oil plays in global consumption.

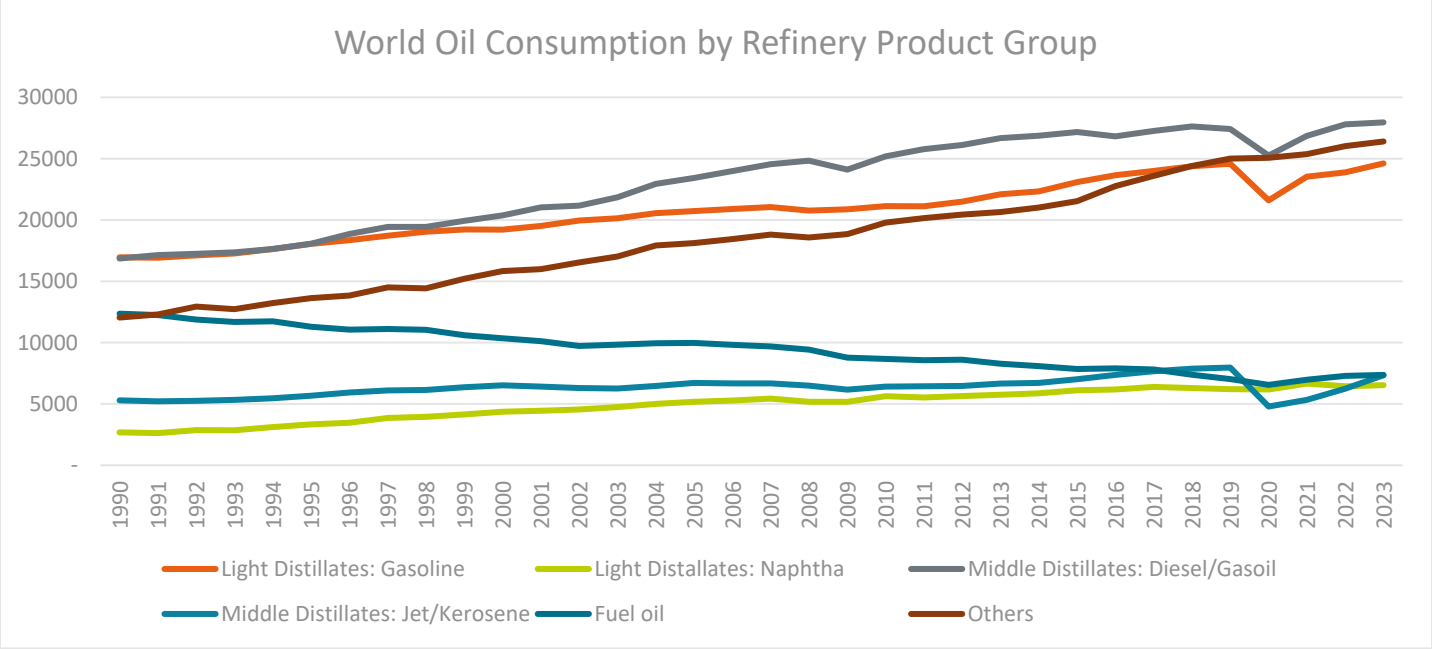

Figure 22: World Oil Consumption by Refinery Product Group.

Energy Institute, 2024 Statistical Review of World Energy, Oil: Regional Consumption.

Of all product types, naphtha has seen the most inconsistent growth in consumption, with declines in 2018, 2019, 2020 and 2022. Consumption of this product, while currently trending up, has not returned to 2021 levels after the 2022 decline. Naphtha is a fraction separated in the distillation process and represents a small share of total petroleum product consumption; it is mainly used as a feedstock in petroleum products like high octane gasoline.[447] Naphtha also finds its way into many petroleum based solvents. Its consumption volatility is indicative of demand for other finished refinery products. Transportation fuels like gasoline, diesel and jet fuel saw the most significant global pandemic-related consumption declines of all petroleum products, as seen in Figure 22. The COVID-19 pandemic drastically reduced the volume of transportation worldwide and demand for coinciding fuels. Compared to a baseline VMT before the pandemic, many European countries saw passenger VMT fall to 25-50% of the baseline, taking months to recover. Belgium and France stayed below the pre-pandemic level of VMT for three months. Falling below the baseline for passenger vehicle VMT in March 2020, the U.S. stayed below pre-pandemic levels of travel until February 2021.[448] Other countries, like Canada and the U.K., took longer to return to their prior baselines.

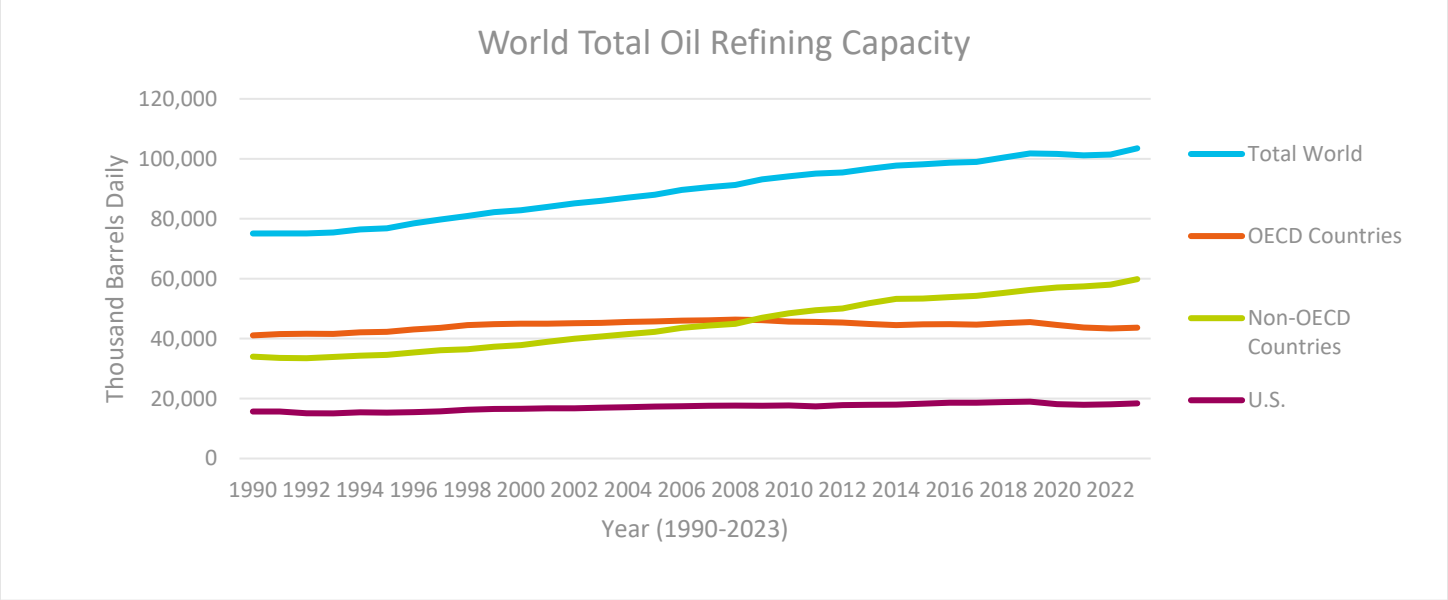

Figure 23: World Total Oil Refining Capacity.

Energy Institute, 2024 Statistical Review of World Energy, Oil: Refining Capacity.

While global oil refining capacity has been increasing for several decades, capacity in Organization for Economic Cooperation and Development (OECD)[449] member countries has seen minor fluctuations for many years. This indicates that the global increase in capacity is mainly supported by refinery activity in non-OECD countries,[450][451] which has steadily increased from 22,989,000 barrels per day in 1990 to 59,844,000 barrels per day in 2023. In particular, China is expected to add 1,500,000 barrels per day of new refining capacity between

[447] "Naphtha." BMT | Cargo Handbook - the world's largest cargo transport guidelines website. Accessed September 10, 2024.
[448] "Daily Vehicle Travel during the COVID-19 Public Health Emergency." Bureau of Transportation Statistics. Accessed September 11, 2024.
[449] The OECD is a unique collaboration of 39 member countries to develop policy standards to promote sustainable economic growth. Some member countries include: the United States, Australia, the United Kingdom, Japan, Chile, and Finland.
[450] Offshore Technology, "Global top five upcoming oil refineries", July 19, 2024.
[451] As of July 2024, 181 announced and planned refineries are expected to come online between 2024 and 2030. By region, Africa is expected to add 70 refineries, Asia is expected to add 46 refineries, and the Middle East is expected to add 30 refineries.

2022 and 2028 to help meet their demand. Growing fuel demand in developing countries is likely, although some developed countries may see fossil fuel demand peak in coming decades.

Imports and Exports of Refined Petroleum Products

Petroleum Administration for Defense District 5

This analysis is conducted at the Petroleum Administration for Defense District (PADD) 5, which covers the west coast of the United States, including Washington, Oregon, California, Nevada, Arizona, Alaska and Hawaii. PADD 5 is geographically isolated from other U.S. refining centers and from global refining centers that can efficiently supply product to the U.S. east coast. While pipelines can move products from the Gulf Coast to New York Harbor on the east coast, no pipelines cross the Rocky Mountains to connect PADD 5 to the Midwest. The monthly import data to PADD 5 (including foreign imports) going back to 2004 is displayed in Figure 24. These imports are typically responsible for 100% of production in PADD 5, due to limited ability to move product in PADD 5. There is an overall upward trend in petroleum product imports, as terminals in PADD 5 receive an increasing amount of petroleum products over time.

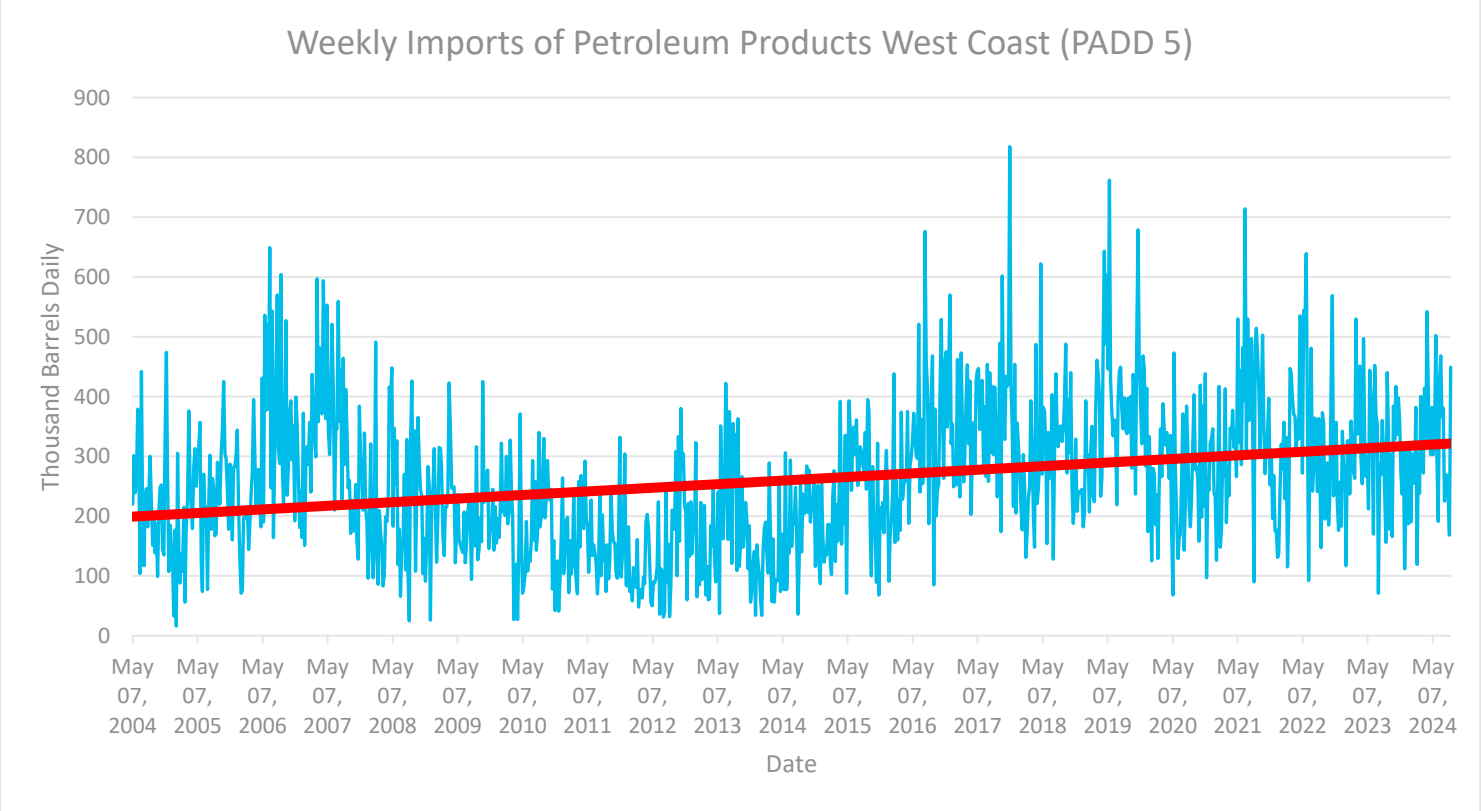

Figure 24: Weekly Imports of Petroleum Products to the West Coast (PADD 5).

EIA, Weekly West Coast (PADD 5) Imports of Total Petroleum Products.

In-region refineries are the primary source of transportation fuels in PADD 5. Specifications for motor gasoline and diesel fuel vary state-to-state and even within some states. Some product specifications, like the California Air Resource Board (CARB) gasoline and diesel fuel are not produced at all refineries in PADD 5, much less the U.S. or rest of the world. PADD 5 is sensitive to in region supply disruptions because even when outside refineries can meet these fuel specifications, supplies are not generally kept on hand and take time to reach PADD 5. Disruptions to in-region production creates reliance on imports to cover gaps, with a majority of these imports coming from waterborne imports. In region imports include via deliveries via pipeline or rail. Notably,

Eastern Washington is supplied largely by refineries in PADD 4, due to a lack of pipeline across the Cascade Range of mountains. [452] Nevada and Arizona also receive some shipments from PADD 3 and PADD 4, which is connected to supply in Southern California and Southern Nevada.

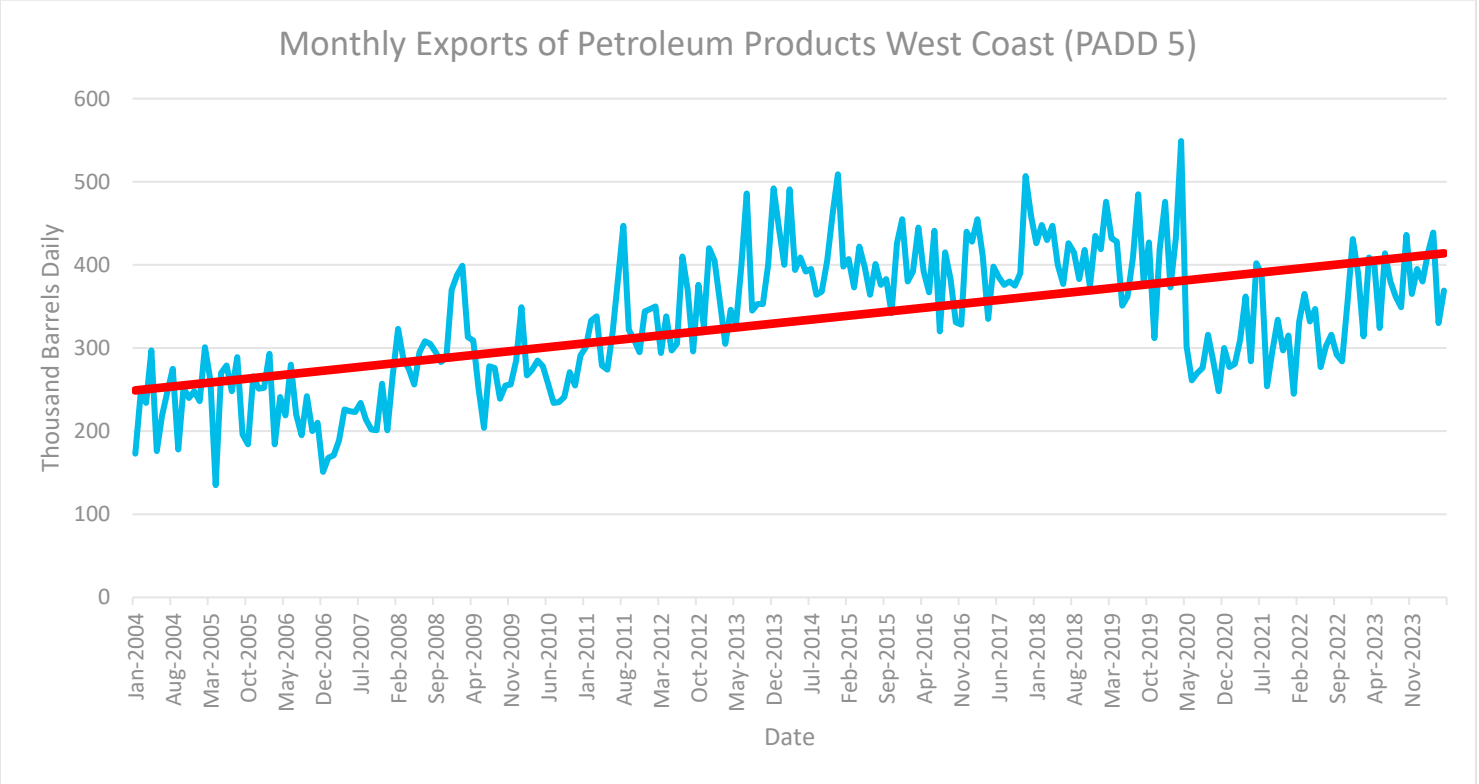

Figure 25: Monthly Exports of Petroleum Products from the West Coast (PADD 5).

EIA, West Coast (PADD) 5 Exports of Total Petroleum Products

Just as the volume of products imported into PADD 5 has increased with time, so has the volume of product leaving PADD 5 to foreign countries. The COVID-19 pandemic-induced dip is likely due to a decrease in domestic production of petroleum products. When assessing the domestic movements of petroleum products, the amount of product received by PADD 5 from other districts saw a large jump around 2009 to 2010. This coincides with a drop in retail gasoline sales by Washington Refiners.

[452] EIA, "PADD 5 Transportation Fuels Markets", September 2015.

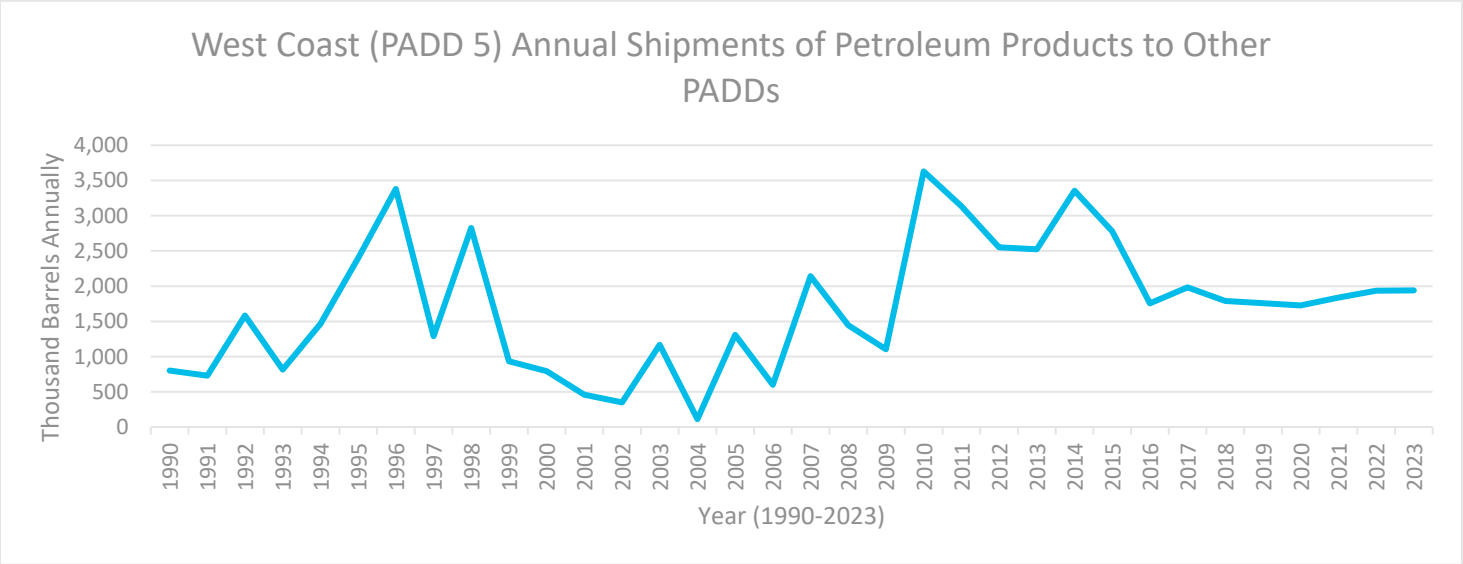

Figure 26: Annual Shipments of Petroleum Products from PADD 5 to Other PADDs.

EIA, West Coast (PADD 5) Shipments by Pipeline, Tanker and Barge to Other PADDs of Total Petroleum Products.

However, over time the net receipt [453]of petroleum products has begun to grow. The number of shipments outgoing from PADD 5 has begun to level out since 2017. Contrastingly, the number of shipments received in PADD 5 has been growing since 2006. Generally, PADD 5 imports more products than it exports, and most of what is produced with PADD 5 remains in the region. The Pacific Coast Collaborative agreement between British Columbia, Washington, Oregon and California has contributed to the development of aligned policies promoting clean energy and reduced GHG emissions. These policies and the standards developed after may contribute to the barriers of importing transportation fuels from other regions.

[453] EIA, West Coast (PADD 5): Net Receipts by Pipeline, Tanker, Barge and Rail between PAD

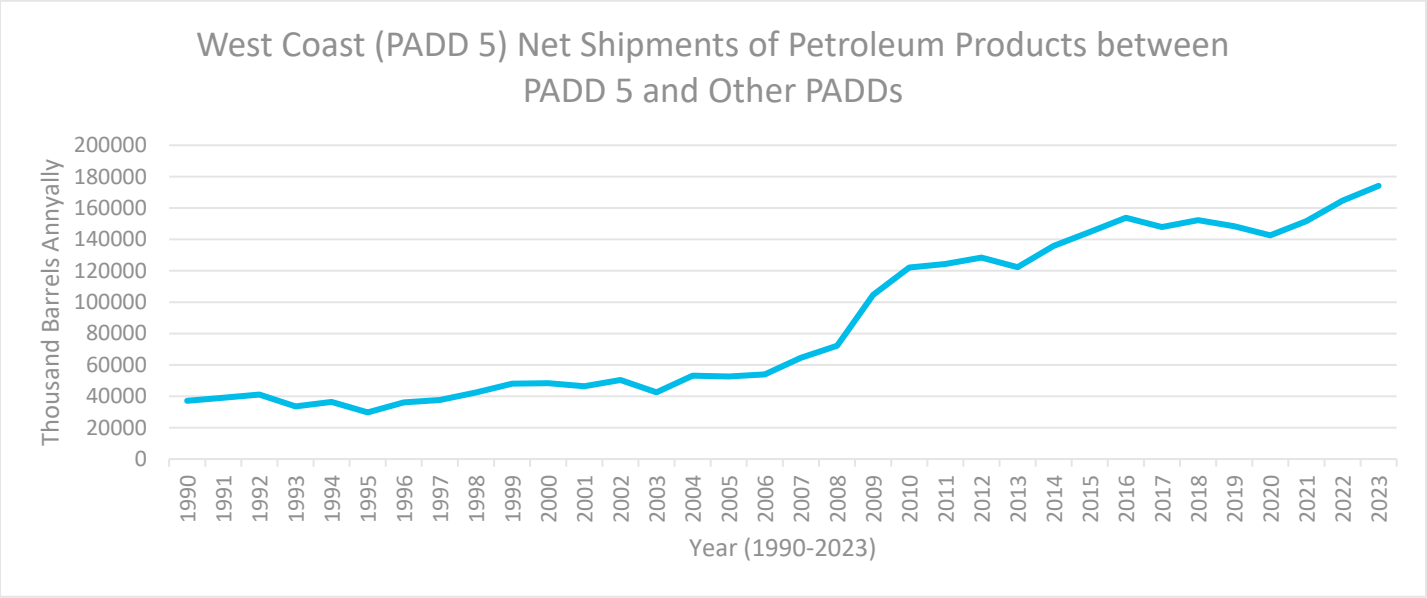

Figure 27: West Coast (PADD 5) annual net receipts of petroleum products from other PADDs, excluding net crude oil movements.

The Pacific Northwest (PNW) exports primarily motor gasoline, jet fuel, distillate fuel and renewable diesel. Primary export markets include Canada, Mexico and other countries in Central and South America.[454]

United States

Even though the U.S. is a net petroleum exporter, the U.S. imports more crude oil than is exported. However, the growth of domestic drilling operations over the past 30 years has reduced American reliance on foreign crude.

[454] EIA, "PADD 5 Transportation Fuels Markets", September 2015.

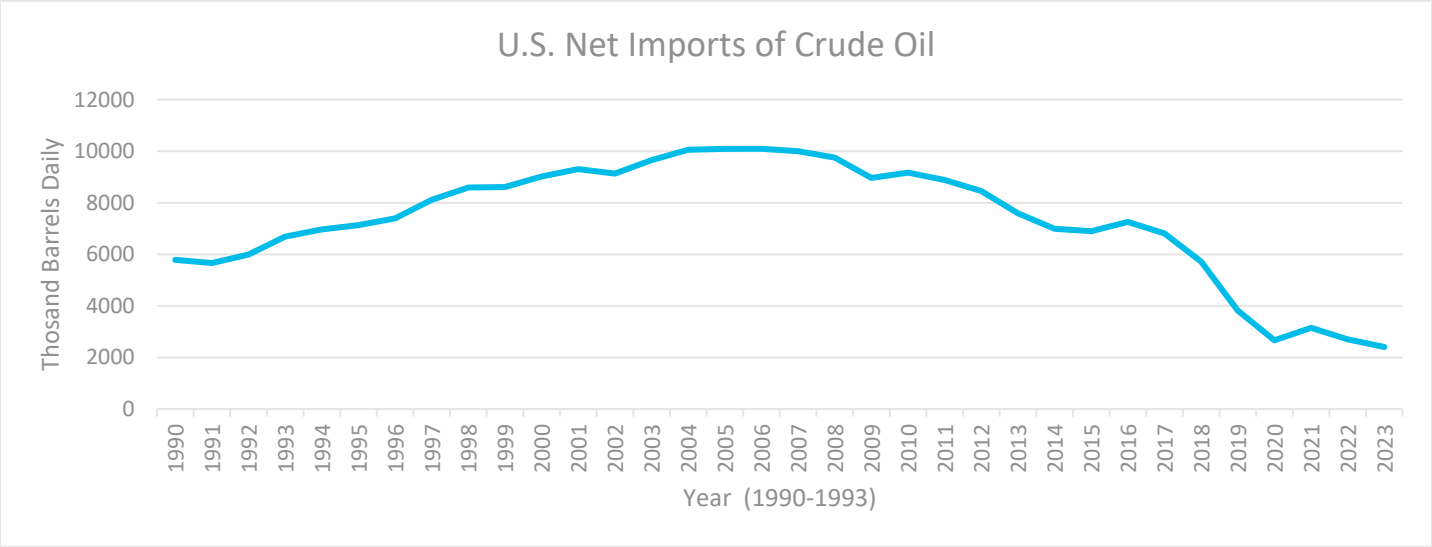

Figure 28: EIA, U.S. Net Imports of Crude Oil.

Fracking, a drilling process that relies on high pressure liquid to break up oil-rich shale deposits, has been instrumental in U.S. crude oil independence. The U.S. leads the world in fracking, with the largest share of shale (tight) oil reserves.[455] In 2023, fracking was responsible for 64% of the U.S. crude oil production.[456]

In May 2011, the U.S. became a net exporter of petroleum products. In 2023, crude oil accounted for 40% of U.S. petroleum product exports. The U.S. is the largest exporter of motor gasoline in the world, with a majority of gasoline exports going to Mexico and the remainder going primarily to Central American and South American countries. Over 90% of these exports come from the U.S. Gulf Coast, part of PADD 3. The majority of U.S. propane exports go to Asia, and distillate fuel exports primarily go to countries in South America and Central America.[457]

[455] Rapier, Robert. "Global Leaders in Shale Oil and Gas Reserves." Forbes, February 19, 2024.
[456] "Frequently Asked Questions (FAQs)." U.S. Energy Information Administration (EIA), March 2024.
[457] EIA, "The United States is the world's largest gasoline exporter", September 24, 2024.

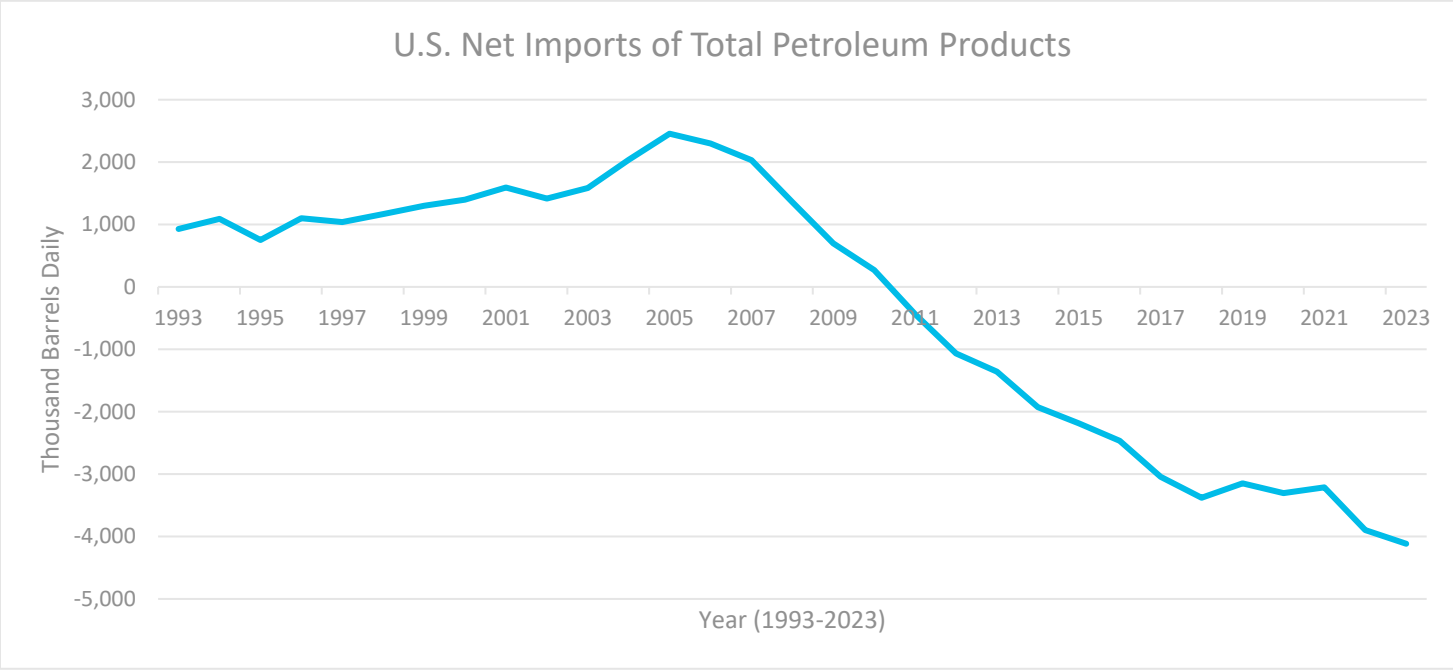

Figure 29: EIA, U.S Net Imports of Total Petroleum Products.

Global

Global oil trade follows a relatively steady growth pattern. Figure 30 depicts total oil trade, which is the total amount of oil imported and exported, in thousand barrels per day. While falling slightly from the peak in 2016, this category has seen 1.5% growth between 2013 and 2023.

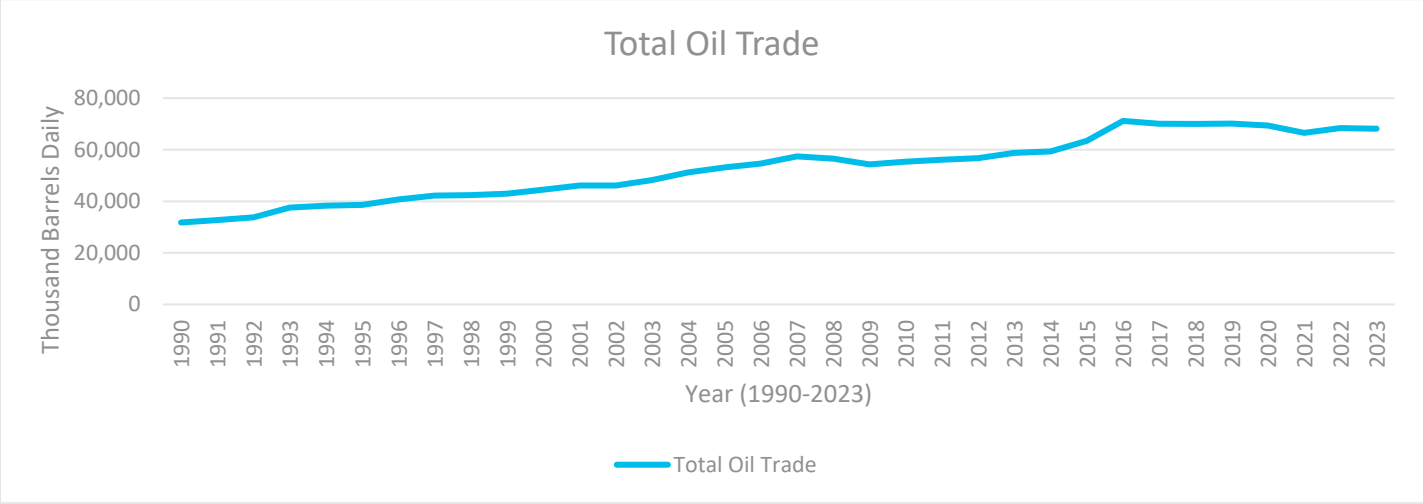

Figure 30: Energy Institute, 2024 Statistical Review of World Energy, Oil: Trade Movements.

Appendix C: Additional Materials for Chapter 4

Table 70: Total Industry Occupation Breakdown of Petroleum Refining in Washington, including one-year projected changes in employment, via JobsEQ.

SOC	Occupation	Current Employment	Current Avg Ann Wages	Exits	Transfers	Employment Growth	Total Demand
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	316	$89,900	8	20	-2	26
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	147	$63,600	5	10	0	15
51-1011	First-Line Supervisors of Production and Operating Workers	120	$124,800	4	7	0	11
49-9041	Industrial Machinery Mechanics	97	$108,300	4	4	2	10
53-3032	Heavy and Tractor-Trailer Truck Drivers	64	$67,600	3	4	0	7
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	51	$59,100	3	4	0	7
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	43	$88,000	2	3	-1	4
47-2061	Construction Laborers	39	$59,000	1	2	0	3
11-3051	Industrial Production Managers	37	$168,900	1	2	0	3
51-8091	Chemical Plant and System Operators	36	$87,700	1	2	0	3
13-1199	Business Operations Specialists, All Other	35	$132,800	1	2	0	3
47-2073	Operating Engineers and Other Construction Equipment Operators	35	$85,300	1	2	0	3
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	35	$126,300	1	2	0	3
53-7051	Industrial Truck and Tractor Operators	34	$70,600	1	2	0	3
11-1021	General and Operations Managers	33	$199,600	1	2	0	3
17-2112	Industrial Engineers	33	$145,200	1	1	0	2

SOC	Occupation	Current Employment	Current Avg Ann Wages	Exits	Transfers	Employment Growth	Total Demand
17-2171	Petroleum Engineers	33	$143,500	1	1	0	2
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	33	$144,700	1	1	0	3
43-5061	Production, Planning, and Expediting Clerks	31	$97,200	1	2	0	3
47-2111	Electricians	31	$126,400	1	2	0	3
51-8099	Plant and System Operators, All Other	30	$78,200	1	2	0	3
19-4031	Chemical Technicians	29	$84,100	1	3	0	3
51-9111	Packaging and Filling Machine Operators and Tenders	29	$54,200	1	2	0	3
51-4041	Machinists	28	$106,900	1	2	0	3
17-2041	Chemical Engineers	25	$141,900	1	1	0	1
19-2031	Chemists	25	$97,000	0	1	0	2
17-2141	Mechanical Engineers	22	$144,100	1	1	0	1
51-9011	Chemical Equipment Operators and Tenders	22	$74,000	1	1	0	2
51-9051	Furnace, Kiln, Oven, Drier, and Kettle Operators and Tenders	21	$75,600	1	1	0	2
13-2011	Accountants and Auditors	21	$108,900	1	1	0	2
49-9071	Maintenance and Repair Workers, General	20	$82,200	1	1	0	2
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	20	$122,600	1	1	0	2
49-2094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	20	$138,900	1	1	0	2
51-2092	Team Assemblers	19	$62,400	1	1	0	2
43-5071	Shipping, Receiving, and Inventory Clerks	19	$65,500	1	1	0	2
13-1082	Project Management Specialists	19	$161,400	0	1	0	1

SOC	Occupation	Current Employment	Current Avg Ann Wages	Exits	Transfers	Employment Growth	Total Demand
43-3031	Bookkeeping, Accounting, and Auditing Clerks	19	$61,000	1	1	0	2
11-9041	Architectural and Engineering Managers	18	$218,000	0	1	0	1
19-5011	Occupational Health and Safety Specialists	17	$133,500	1	1	0	2
43-9061	Office Clerks, General	17	$64,100	1	1	0	2
13-1081	Logisticians	16	$126,500	0	1	0	2
13-1023	Purchasing Agents, Except Wholesale, Retail, and Farm Products	16	$108,400	1	1	0	1
11-9199	Managers, All Other	14	$182,300	0	1	0	1
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	14	$67,400	1	1	0	1
51-9199	Production Workers, All Other	13	$73,300	1	1	0	1
13-1071	Human Resources Specialists	13	$124,100	0	1	0	1
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	13	$142,000	0	1	0	1
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	12	$92,800	0	1	0	1
47-2152	Plumbers, Pipefitters, and Steamfitters	10	$122,600	0	1	0	1
11-2022	Sales Managers	10	$190,100	0	1	0	1
17-2071	Electrical Engineers	10	$152,800	0	0	0	1
43-1011	First-Line Supervisors of Office and Administrative Support Workers	10	$110,100	0	1	0	1
51-4121	Welders, Cutters, Solderers, and Brazers	10	$90,900	0	1	0	1
43-4051	Customer Service Representatives	9	$69,800	1	1	0	1
17-2051	Civil Engineers	9	$171,900	0	0	0	1
13-1041	Compliance Officers	8	$130,900	0	0	0	1

SOC	Occupation	Current Employment	Current Avg Ann Wages	Exits	Transfers	Employment Growth	Total Demand
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	8	$146,100	0	1	0	1
17-2199	Engineers, All Other	8	$142,500	0	0	0	1
13-2051	Financial and Investment Analysts	8	$120,700	0	0	0	1
13-1151	Training and Development Specialists	8	$148,000	0	0	0	1
17-2081	Environmental Engineers	7	$141,500	0	0	0	1
17-2072	Electronics Engineers, Except Computer	7	$147,100	0	0	0	0
17-3023	Electrical and Electronic Engineering Technologists and Technicians	7	$125,400	0	0	0	1
43-6011	Executive Secretaries and Executive Administrative Assistants	7	$81,600	0	0	0	1
11-3031	Financial Managers	7	$182,600	0	0	0	1
13-1111	Management Analysts	7	$155,700	0	0	0	1
13-1161	Market Research Analysts and Marketing Specialists	7	$108,600	0	0	0	1
19-5012	Occupational Health and Safety Technicians	6	$129,600	0	1	0	1
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	6	$143,100	0	0	0	0
49-3031	Bus and Truck Mechanics and Diesel Engine Specialists	6	$76,200	0	0	0	1
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	6	$93,300	0	0	0	1
53-7121	Tank Car, Truck, and Ship Loaders	6	$54,100	0	0	0	1
53-7073	Wellhead Pumpers	6	$82,600	0	0	0	1
47-2071	Paving, Surfacing, and Tamping Equipment Operators	6	$79,100	0	0	0	1
11-3021	Computer and Information Systems Managers	6	$188,000	0	0	0	0

SOC	Occupation	Current Employment	Current Avg Ann Wages	Exits	Transfers	Employment Growth	Total Demand
19-2041	Environmental Scientists and Specialists, Including Health	5	$127,900	0	0	0	0
53-7065	Stockers and Order Fillers	5	$65,100	0	1	0	1
15-1252	Software Developers	5	$158,500	0	0	0	0
43-5032	Dispatchers, Except Police, Fire, and Ambulance	5	$65,900	0	0	0	0
11-9021	Construction Managers	5	$191,600	0	0	0	0
51-9021	Crushing, Grinding, and Polishing Machine Setters, Operators, and Tenders	5	$85,500	0	0	0	1
11-3013	Facilities Managers	4	$198,700	0	0	0	0
11-3071	Transportation, Storage, and Distribution Managers	4	$164,300	0	0	0	0
15-1211	Computer Systems Analysts	4	$143,800	0	0	0	0
51-9198	Helpers--Production Workers	4	$57,900	0	0	0	1
11-2021	Marketing Managers	4	$182,900	0	0	0	0
11-3121	Human Resources Managers	4	$201,700	0	0	0	0
49-9099	Installation, Maintenance, and Repair Workers, All Other	4	$98,700	0	0	0	0
53-3033	Light Truck Drivers	4	$70,800	0	0	0	0
19-4043	Geological Technicians, Except Hydrologic Technicians	4	$56,000	0	0	0	0
51-8021	Stationary Engineers and Boiler Operators	4	$117,100	0	0	0	0
13-1051	Cost Estimators	4	$116,400	0	0	0	0
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	4	$72,300	0	0	0	0
17-3027	Mechanical Engineering Technologists and Technicians	3	$123,200	0	0	0	0

SOC	Occupation	Current Employment	Current Avg Ann Wages	Exits	Transfers	Employment Growth	Total Demand
49-9044	Millwrights	3	$97,600	0	0	0	0
19-2042	Geoscientists, Except Hydrologists and Geographers	3	$162,900	0	0	0	0
15-1299	Computer Occupations, All Other	3	$159,800	0	0	0	0
17-2131	Materials Engineers	3	$141,900	0	0	0	0
17-3026	Industrial Engineering Technologists and Technicians	3	$146,800	0	0	0	0
11-3012	Administrative Services Managers	3	$174,900	0	0	0	0
33-9091	Crossing Guards and Flaggers	3	$57,000	1	0	0	1
11-3061	Purchasing Managers	3	$158,400	0	0	0	0
15-1241	Computer Network Architects	3	$177,200	0	0	0	0
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping	3	$59,300	0	0	0	0
37-2011	Janitors and Cleaners, Except Maids and Housekeeping Cleaners	3	$59,800	0	0	0	0
15-1244	Network and Computer Systems Administrators	3	$118,500	0	0	0	0
49-3042	Mobile Heavy Equipment Mechanics, Except Engines	2	$61,700	0	0	0	0
51-8092	Gas Plant Operators	2	$113,800	0	0	0	0
43-3021	Billing and Posting Clerks	2	$76,900	0	0	0	0
51-2099	Assemblers and Fabricators, All Other	2	$64,700	0	0	0	0
15-1232	Computer User Support Specialists	2	$99,100	0	0	0	0
47-2011	Boilermakers	2	$124,600	0	0	0	0
27-4032	Film and Video Editors	2	$90,900	0	0	0	0
43-3051	Payroll and Timekeeping Clerks	2	$94,300	0	0	0	0

SOC	Occupation	Current Employment	Current Avg Ann Wages	Exits	Transfers	Employment Growth	Total Demand
43-4171	Receptionists and Information Clerks	2	$54,000	0	0	0	0
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	2	$74,200	0	0	0	0
41-1012	First-Line Supervisors of Non-Retail Sales Workers	2	$138,500	0	0	0	0
19-4044	Hydrologic Technicians	2	$72,200	0	0	0	0
53-7011	Conveyor Operators and Tenders	2	$64,700	0	0	0	0
49-9043	Maintenance Workers, Machinery	2	$76,500	0	0	0	0
15-2031	Operations Research Analysts	2	$136,300	0	0	0	0
33-2011	Firefighters	2	$229,300	0	0	0	0
53-7072	Pump Operators, Except Wellhead Pumpers	2	$123,700	0	0	0	0
13-1075	Labor Relations Specialists	2	$126,000	0	0	0	0
17-3019	Drafters, All Other	2	$85,400	0	0	0	0
23-1011	Lawyers	2	$267,800	0	0	0	0
43-4151	Order Clerks	2	$51,900	0	0	0	0
15-1231	Computer Network Support Specialists	2	$128,400	0	0	0	0
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	2	$69,800	0	0	0	0
37-3011	Landscaping and Groundskeeping Workers	2	$49,800	0	0	0	0
51-4081	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	1	$75,500	0	0	0	0
11-1011	Chief Executives	1	$363,900	0	0	0	0
27-1024	Graphic Designers	1	$97,600	0	0	0	0
43-4161	Human Resources Assistants, Except Payroll and Timekeeping	1	$78,100	0	0	0	0

SOC	Occupation	Current Employment	Current Avg Ann Wages	Exits	Transfers	Employment Growth	Total Demand
11-9161	Emergency Management Directors	1	$152,400	0	0	0	0
33-9032	Security Guards	1	$71,700	0	0	0	0
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	1	$59,700	0	0	0	0
49-9096	Riggers	1	$118,100	0	0	0	0
33-1021	First-Line Supervisors of Firefighting and Prevention Workers	1	$236,900	0	0	0	0
47-5022	Excavating and Loading Machine and Dragline Operators, Surface Mining	1	$67,000	0	0	0	0
43-3061	Procurement Clerks	1	$60,800	0	0	0	0
19-2032	Materials Scientists	1	$136,500	0	0	0	0
17-3025	Environmental Engineering Technologists and Technicians	1	$143,900	0	0	0	0
27-3031	Public Relations Specialists	1	$128,200	0	0	0	0
47-2031	Carpenters	1	$76,600	0	0	0	0
11-2032	Public Relations Managers	1	$218,900	0	0	0	0
53-7071	Gas Compressor and Gas Pumping Station Operators	1	$50,600	0	0	0	0
11-9121	Natural Sciences Managers	1	$191,500	0	0	0	0
47-4099	Construction and Related Workers, All Other	1	$76,900	0	0	0	0
17-3024	Electro-Mechanical and Mechatronics Technologists and Technicians	1	$129,800	0	0	0	0
41-9099	Sales and Related Workers, All Other	1	$67,400	0	0	0	0
15-2051	Data Scientists	1	$149,900	0	0	0	0
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	1	$63,400	0	0	0	0

SOC	Occupation	Current Employment	Current Avg Ann Wages	Exits	Transfers	Employment Growth	Total Demand
19-4099	Life, Physical, and Social Science Technicians, All Other	1	$42,700	0	0	0	0
19-4042	Environmental Science and Protection Technicians, Including Health	1	$94,400	0	0	0	0
29-1141	Registered Nurses	1	$118,300	0	0	0	0
53-7021	Crane and Tower Operators	1	$100,900	0	0	0	0
23-2011	Paralegals and Legal Assistants	1	$132,100	0	0	0	0
17-3028	Calibration Technologists and Technicians	1	$130,700	0	0	0	0
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	1	$179,100	0	0	0	0
53-7063	Machine Feeders and Offbearers	1	$44,300	0	0	0	0
47-4021	Elevator and Escalator Installers and Repairers	1	$119,500	0	0	0	0
49-9098	Helpers--Installation, Maintenance, and Repair Workers	1	$51,700	0	0	0	0
17-3013	Mechanical Drafters	1	$87,200	0	0	0	0
11-3131	Training and Development Managers	1	$192,700	0	0	0	0
13-2099	Financial Specialists, All Other	1	$118,200	0	0	0	0
13-1022	Wholesale and Retail Buyers, Except Farm Products	1	$116,100	0	0	0	0
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	1	$49,300	0	0	0	0
27-2012	Producers and Directors	1	$117,600	0	0	0	0
41-3021	Insurance Sales Agents	1	$81,000	0	0	0	0
53-7061	Cleaners of Vehicles and Equipment	1	$41,600	0	0	0	0
15-1242	Database Administrators	1	$121,000	0	0	0	0
	Total	2,241	n/a	73	126	-1	199

Table 71: Statewide Alternative Industries for Top 25 Occupations in Washington, via JobsEQ.

SOC	Occupation	Alternative Industry	NAICS Code	% of Occ Empl	Empl	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	Petroleum and Coal Products Manufacturing	3241	69.8%	418	$89,900	102	265	-21	347
		Management of Companies and Enterprises	5511	6.6%	40	$95,300	10	27	4	41
		Other Pipeline Transportation	4869	5.8%	35	$86,500	9	23	1	32
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	Petroleum and Coal Products Manufacturing	3241	8.6%	195	$63,600	70	127	0	197
		Cement and Concrete Product Manufacturing	3273	7.7%	175	$54,700	63	114	0	176
		Other Food Manufacturing	3119	7.5%	170	$51,500	64	115	15	193
51-1011	First-Line Supervisors of Production and Operating Workers	Aerospace Product and Parts Manufacturing	3364	10.6%	1,583	$97,100	578	900	49	1,527
		Ship and Boat Building	3366	6.3%	946	$80,800	334	520	-36	818
		Grocery and Convenience Retailers	4451	4.2%	622	$80,800	223	347	-6	565
49-9041	Industrial Machinery Mechanics	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	8113	11.4%	996	$66,700	399	455	252	1,106
		Machinery, Equipment, and Supplies Merchant Wholesalers	4238	10.5%	915	$67,900	353	403	151	907
		Aerospace Product and Parts Manufacturing	3364	7.9%	693	$84,000	276	314	165	756
53-3032	Heavy and Tractor-Trailer Truck Drivers	General Freight Trucking	4841	26.9%	11,399	$66,000	5,242	6,873	553	12,668
		Specialized Freight Trucking	4842	11.6%	4,915	$66,000	2,263	2,967	253	5,484
		Grocery and Related Product Merchant Wholesalers	4244	5.7%	2,415	$66,000	1,104	1,447	86	2,637

SOC	Occupation	Alternative Industry	NAICS Code	% of Occ Empl	Empl	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Employment Services	5613	14.0%	7,773	$40,500	3,774	6,369	217	10,361
		Warehousing and Storage	4931	12.5%	6,942	$50,300	3,602	6,078	1,216	10,896
		Couriers and Express Delivery Services	4921	8.4%	4,686	$47,200	2,398	4,047	672	7,117
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	Aerospace Product and Parts Manufacturing	3364	25.8%	3,442	$84,200	1,470	2,519	106	4,095
		Employment Services	5613	4.5%	596	$46,600	254	436	16	706
		Architectural, Engineering, and Related Services	5413	4.1%	552	$68,300	233	399	3	635
47-2061	Construction Laborers	Other Specialty Trade Contractors	2389	22.9%	7,673	$61,000	2,758	3,940	454	7,152
		Residential Building Construction	2361	21.6%	7,233	$57,100	2,655	3,793	761	7,209
		Foundation, Structure, and Building Exterior Contractors	2381	10.9%	3,654	$61,800	1,307	1,867	179	3,353
11-3051	Industrial Production Managers	Aerospace Product and Parts Manufacturing	3364	22.2%	1,116	$159,700	272	487	34	793
		Management of Companies and Enterprises	5511	5.2%	261	$186,900	65	117	24	207
		Scientific Research and Development Services	5417	2.9%	146	$210,200	36	65	9	110
51-8091	Chemical Plant and System Operators	Basic Chemical Manufacturing	3251	27.7%	56	$80,500	14	37	1	52
		Petroleum and Coal Products Manufacturing	3241	23.7%	48	$87,700	12	31	-2	40
		Waste Treatment and Disposal	5622	8.5%	17	$85,500	5	12	2	18
13-1199	Business Operations Specialists, All Other	Management of Companies and Enterprises	5511	9.0%	4,362	$100,300	1,539	2,425	647	4,611
		Aerospace Product and Parts Manufacturing	3364	6.6%	3,217	$125,300	1,076	1,695	99	2,871
		Management, Scientific, and	5416	5.0%	2,419	$100,400	832	1,310	217	2,359

SOC	Occupation	Alternative Industry	NAICS Code	% of Occ Empl	Empl	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
		Technical Consulting Services								
47-2073	Operating Engineers and Other Construction Equipment Operators	Other Specialty Trade Contractors	2389	28.8%	2,601	$83,000	880	1,333	140	2,353
		Highway, Street, and Bridge Construction	2373	10.3%	930	$99,100	317	480	63	859
		Executive, Legislative, and Other General Government Support	9211	9.7%	872	$85,600	294	446	42	783
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	Wholesale Trade Agents and Brokers	4251	12.3%	4,124	$99,100	1,372	2,286	68	3,726
		Grocery and Related Product Merchant Wholesalers	4244	10.4%	3,478	$88,400	1,167	1,945	124	3,236
		Machinery, Equipment, and Supplies Merchant Wholesalers	4238	7.6%	2,544	$77,900	829	1,381	-67	2,143
53-7051	Industrial Truck and Tractor Operators	Warehousing and Storage	4931	32.2%	5,627	$55,600	1,863	3,726	421	6,009
		Employment Services	5613	6.5%	1,140	$43,800	369	739	32	1,140
		Scheduled Air Transportation	4811	4.9%	860	$71,600	276	553	10	838
11-1021	General and Operations Managers	Management of Companies and Enterprises	5511	4.8%	2,824	$228,800	736	1,591	262	2,589
		Restaurants and Other Eating Places	7225	3.3%	1,943	$91,700	500	1,080	126	1,706
		Management, Scientific, and Technical Consulting Services	5416	3.3%	1,920	$201,400	504	1,089	208	1,801
17-2112	Industrial Engineers	Aerospace Product and Parts Manufacturing	3364	41.8%	3,461	$122,700	876	1,095	430	2,401
		Management of Companies and Enterprises	5511	6.8%	567	$124,100	148	185	109	441
		Architectural, Engineering, and Related Services	5413	5.7%	476	$116,700	118	147	34	299
17-2171	Petroleum Engineers	Management of Companies and Enterprises	5511	44.8%	147	$155,900	29	55	14	98

SOC	Occupation	Alternative Industry	NAICS Code	% of Occ Empl	Empl	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
		Architectural, Engineering, and Related Services	5413	21.7%	71	$137,300	14	26	4	44
		Petroleum and Coal Products Manufacturing	3241	13.3%	44	$143,500	8	16	0	24
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	Automotive Repair and Maintenance	8111	7.3%	1,064	$75,100	424	467	49	941
		Building Equipment Contractors	2382	7.0%	1,022	$93,500	402	443	21	866
		Electric Power Generation, Transmission and Distribution	2211	5.2%	752	$143,200	297	328	22	647
43-5061	Production, Planning, and Expediting Clerks	Aerospace Product and Parts Manufacturing	3364	11.8%	1,725	$73,300	682	1,084	53	1,819
		Management of Companies and Enterprises	5511	9.1%	1,326	$72,200	539	857	123	1,520
		Individual and Family Services	6241	2.7%	398	$57,700	175	278	110	563
47-2111	Electricians	Building Equipment Contractors	2382	73.7%	14,188	$90,800	4,875	7,977	1,291	14,143
		Ship and Boat Building	3366	3.7%	712	$91,500	230	376	-28	579
		Employment Services	5613	2.4%	468	$74,100	156	256	13	425
51-8099	Plant and System Operators, All Other	Waste Treatment and Disposal	5622	13.7%	48	$76,600	12	32	5	49
		Pulp, Paper, and Paperboard Mills	3221	11.6%	40	$93,900	9	23	-9	24
		Petroleum and Coal Products Manufacturing	3241	11.2%	39	$78,200	10	25	0	35
19-4031	Chemical Technicians	Architectural, Engineering, and Related Services	5413	19.8%	225	$52,500	48	217	12	277
		Scientific Research and Development Services	5417	16.8%	191	$69,400	41	185	12	238
		Pharmaceutical and Medicine Manufacturing	3254	6.0%	69	$58,900	15	67	6	88
51-9111		Fruit and Vegetable Preserving and	3114	22.2%	1,779	$42,800	873	1,073	90	2,037

SOC	Occupation	Alternative Industry	NAICS Code	% of Occ Empl	Empl	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
	Packaging and Filling Machine Operators and Tenders	Specialty Food Manufacturing								
		Beverage Manufacturing	3121	10.4%	832	$52,400	415	510	70	995
		Other Food Manufacturing	3119	8.9%	710	$43,400	373	459	144	976
51-4041	Machinists	Aerospace Product and Parts Manufacturing	3364	35.9%	2,871	$74,500	1,165	1,660	89	2,913
		Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	3327	17.0%	1,361	$62,400	559	797	79	1,435
		Ship and Boat Building	3366	7.1%	567	$69,400	222	317	-22	518
17-2041	Chemical Engineers	Scientific Research and Development Services	5417	19.4%	104	$123,700	23	32	7	62
		Architectural, Engineering, and Related Services	5413	17.5%	93	$133,700	21	29	5	55
		Management of Companies and Enterprises	5511	11.0%	59	$135,100	13	18	5	37

Table 72: 10-year Demand in Whatcom County for Top 25 Occupations, excluding Petroleum and Coal Products Manufacturing, via JobsEQ.

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	Miscellaneous Nondurable Goods Merchant Wholesalers	4249	0.4%	1	$87,400	0	0	0.00	1
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	Grain and Oilseed Milling	3112	7.2%	11	$51,900	4	7	0	11
		Other Food Manufacturing	3119	6.7%	10	$46,000	4	7	1	12
		Animal Food Manufacturing	3111	5.3%	8	$43,200	3	5	0	9

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
51-1011	First-Line Supervisors of Production and Operating Workers	Other Wood Product Manufacturing	3219	10.7%	55	$65,200	20	31	2	54
		Seafood Product Preparation and Packaging	3117	5.0%	25	$64,500	9	13	-3	19
		Grocery and Convenience Retailers	4451	4.1%	21	$81,800	8	12	0	19
49-9041	Industrial Machinery Mechanics	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	8113	20.9%	68	$66,600	27	31	17	74
		Machinery, Equipment, and Supplies Merchant Wholesalers	4238	8.4%	27	$67,800	10	12	4	26
		Grain and Oilseed Milling	3112	4.6%	15	$72,600	5	6	0	12
53-3032	Heavy and Tractor-Trailer Truck Drivers	General Freight Trucking	4841	28.8%	352	$63,800	161	211	13	386
		Specialized Freight Trucking	4842	11.7%	143	$63,800	65	86	5	156
		Other Specialty Trade Contractors	2389	3.7%	45	$64,400	21	27	2	50
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Employment Services	5613	9.3%	118	$38,300	57	96	3	156
		Couriers and Express Delivery Services	4921	7.3%	93	$44,500	47	80	13	140
		Other Wood Product Manufacturing	3219	6.1%	78	$38,400	38	64	4	106
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	Architectural, Engineering, and Related Services	5413	11.2%	36	$64,200	15	26	1	43
		Other Wood	3219	7.8%	25	$82,800	10	17	-4	23

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
		Product Manufacturing								
		Medical Equipment and Supplies Manufacturing	3391	5.6%	18	$48,000	7	12	-2	17
47-2061	Construction Laborers	Other Specialty Trade Contractors	2389	22.0%	262	$57,700	94	134	12	240
		Residential Building Construction	2361	19.7%	235	$54,100	86	123	22	230
		Nonresidential Building Construction	2362	18.7%	223	$62,600	80	115	14	210
11-3051	Industrial Production Managers	Other Wood Product Manufacturing	3219	15.9%	21	$170,800	5	9	0	14
		Grain and Oilseed Milling	3112	5.6%	7	$141,200	2	3	0	5
		Other Food Manufacturing	3119	3.4%	5	$132,400	1	2	1	4
51-8091	Chemical Plant and System Operators	Other Chemical Product and Preparation Manufacturing	3259	2.6%	1	$78,400	0	0	0	1
13-1199	Business Operations Specialists, All Other	Justice, Public Order, and Safety Activities	9221	12.9%	131	$81,900	43	68	0	111
		Colleges, Universities, and Professional Schools	6113	5.5%	56	$81,900	19	30	3	52
		Executive, Legislative, and Other General Government Support	9211	4.2%	43	$81,900	14	23	2	38

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
47-2073	Operating Engineers and Other Construction Equipment Operators	Other Specialty Trade Contractors	2389	26.9%	81	$81,700	27	41	4	72
		Executive, Legislative, and Other General Government Support	9211	12.2%	37	$85,200	12	19	1	32
		Utility System Construction	2371	9.3%	28	$85,100	9	14	1	25
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	Machinery, Equipment, and Supplies Merchant Wholesalers	4238	12.1%	97	$82,400	31	52	-4	80
		Grocery and Related Product Merchant Wholesalers	4244	7.4%	59	$91,100	20	33	2	55
		Wholesale Trade Agents and Brokers	4251	5.8%	47	$104,900	15	26	0	41
53-7051	Industrial Truck and Tractor Operators	Other Wood Product Manufacturing	3219	15.2%	60	$42,700	20	39	3	62
		Warehousing and Storage	4931	10.0%	40	$51,300	13	26	3	42
		Employment Services	5613	17	$40,400	6	11	0	17	17
11-1021	General and Operations Managers	Restaurants and Other Eating Places	7225	4.0%	60	$82,400	15	33	4	52
		Building Equipment Contractors	2382	2.8%	42	$130,500	11	23	0	34
		Nonresidential Building Construction	2362	2.5%	37	$164,400	9	20	1	30
17-2112	Industrial Engineers	Architectural, Engineering, and Related Services	5413	11.5%	16	$97,900	4	5	1	10
		Medical Equipment and Supplies Manufacturing	3391	8.5%	12	$91,000	3	4	2	9

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
		Electrical Equipment Manufacturing	3353	6.4%	9	$87,900	2	3	1	6
17-2171	Petroleum Engineers	Architectural, Engineering, and Related Services	5413	7.8%	2	$133,300	0	1	0	1
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	Building Equipment Contractors	2382	8.8%	35	$92,900	14	15	1	30
		Automotive Repair and Maintenance	8111	8.8%	35	$74,700	14	15	1	30
		Executive, Legislative, and Other General Government Support	9211	5.6%	22	$90,900	9	10	1	19
43-5061	Production, Planning, and Expediting Clerks	Other Wood Product Manufacturing	3219	5.7%	18	$91,900	7	11	0	18
		Individual and Family Services	6241	4.2%	13	$51,900	5	8	1	14
		Nonresidential Building Construction	2362	3.3%	10	$54,600	5	7	3	15
47-2111	Electricians	Building Equipment Contractors	2382	72.0%	391	$90,700	134	219	33	386
		Nonresidential Building Construction	2362	5.2%	28	$92,600	10	16	3	29
		Executive, Legislative, and Other General Government Support	9211	3.3%	18	$126,400	6	10	0	15
51-8099	Plant and System Operators, All Other	Grain and Oilseed Milling	3112	6.0%	2	$63,800	0	1	0	1
		Pulp, Paper, and Paperboard Mills	3221	3.4%	1	$92,100	0	0	0	0
		Nonmetallic Mineral Mining and Quarrying	2123	3.2%	1	$77,500	0	1	0	1

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
19-4031	Chemical Technicians	Architectural, Engineering, and Related Services	5413	36.1%	18	$57,200	4	17	1	22
		Nonresidential Building Construction	2362	2.6%	1	$68,900	0	1	0	2
		Colleges, Universities, and Professional Schools	6113	2.1%	1	$71,800	0	1	0	1
51-9111	Packaging and Filling Machine Operators and Tenders	Other Food Manufacturing	3119	14.2%	43	$40,900	23	28	9	60
		Dairy Product Manufacturing	3115	13.6%	41	$45,300	20	25	2	46
		Grain and Oilseed Milling	3112	13.5%	41	$47,100	20	24	0	44
51-4041	Machinists	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	3327	30.3%	50	$56,600	20	29	3	52
		Electrical Equipment Manufacturing	3353	9.9%	16	$96,900	7	9	0	16
		Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	8113	6.7%	11	$59,800	5	6	0	11
17-2041	Chemical Engineers	Architectural, Engineering, and Related Services	5413	12.0%	3	$125,500	1	1	0	2

Table 73: 10-year Demand in Skagit County for Top 25 Occupations, excluding Petroleum and Coal Products Manufacturing, via JobsEQ.

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	Petroleum and Petroleum Products Merchant Wholesalers	4249	1.5%	1	$91,100	0	0	0	1
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	Animal Food Manufacturing	3111	17.1%	9	$41,800	3	6	0	10
		Cement and Concrete Product Manufacturing	3273	6.0%	3	$49,300	1	2	0	3
		Other Food Manufacturing	3119	2.7%	2	$44,500	1	1	0	2
51-1011	First-Line Supervisors of Production and Operating Workers	Metalworking Machinery Manufacturing	3335	14.7%	47	$82,300	17	26	-2	41
		Ship and Boat Building	3366	6.8%	22	$80,500	8	12	-1	18
		Seafood Product Preparation and Packaging	3117	6.7%	21	$66,100	7	11	-3	16
49-9041	Industrial Machinery Mechanics	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	8113	10.0%	15	$68,600	6	7	3	16
		Metalworking Machinery Manufacturing	3335	9.1%	14	$73,200	5	6	2	14
		Fruit and Vegetable Preserving and Specialty Food Manufacturing	3114	8.7%	13	$111,400	5	6	2	13
53-3032	Heavy and Tractor-Trailer Truck Drivers	General Freight Trucking	4841	25.0%	184	$65,500	83	109	3	195
		Specialized Freight Trucking	4842	17.8%	130	$65,500	59	77	2	138

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
		Grocery and Related Product Merchant Wholesalers	4244	6.0%	44	$65,500	20	26	0	47
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Couriers and Express Delivery Services	4921	17.2%	138	$45,500	70	118	18	206
		Animal Slaughtering and Processing	3116	5.7%	46	$42,800	22	38	1	61
		Employment Services	5613	4.5%	36	$39,100	17	29	0	47
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	Metalworking Machinery Manufacturing	3335	14.7%	28	$68,000	12	20	-1	31
		Architectural, Engineering, and Related Services	5413	7.6%	15	$76,800	6	11	0	17
		Animal Slaughtering and Processing	3116	7.0%	13	$55,200	6	10	0	16
47-2061	Construction Laborers	Other Specialty Trade Contractors	2389	20.2%	133	$57,800	47	67	3	118
		Residential Building Construction	2361	20.1%	133	$54,100	48	69	10	126
		Nonresidential Building Construction	2362	15.8%	105	$62,700	37	53	4	95
11-3051	Industrial Production Managers	Metalworking Machinery Manufacturing	3335	19.3%	17	$128,400	4	7	-1	10
		Ship and Boat Building	3366	4.3%	4	$139,000	1	2	0	2
		Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	3334	4.2%	4	$139,000	1	2	0	3

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
51-8091	Chemical Plant and System Operators	Basic Chemical Manufacturing	2351	17.8%	1	$81,800	0	1	0	1
		Other Chemical Product and Preparation Manufacturing	3259	11.0%	1	$81,800	0	1	0	1
13-1199	Business Operations Specialists, All Other	Executive, Legislative, and Other General Government Support	9211	5.7%	25	$88,000	8	13	0	22
		Insurance Carriers	5241	5.0%	22	$92,400	8	12	1	21
		Administration of Environmental Quality Programs	9241	4.9%	22	$88,000	7	11	0	18
47-2073	Operating Engineers and Other Construction Equipment Operators	Other Specialty Trade Contractors	2389	21.8%	39	$89,500	13	20	1	34
		Highway, Street, and Bridge Construction	2373	20.3%	36	$106,800	12	19	1	32
		Executive, Legislative, and Other General Government Support	9211	13.1%	23	$96,000	8	12	0	20
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	Grocery and Related Product Merchant Wholesalers	4244	14.8%	64	$92,800	21	35	1	57
		Machinery, Equipment, and Supplies Merchant Wholesalers	4238	7.2%	31	$83,900	10	17	-2	25
		Metalworking Machinery Manufacturing	3335	5.8%	25	$106,000	8	13	-1	21
53-7051	Industrial Truck and	Sawmills and Wood Preservation	3211	11.7%	26	$49,200	8	17	0	25

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
	Tractor Operators	Warehousing and Storage	4931	10.0%	22	$56,500	7	15	1	23
		Veneer, Plywood, and Engineered Wood Product Manufacturing	3212	7.5%	17	$52,600	5	11	0	16
11-1021	General and Operations Managers	Restaurants and Other Eating Places	7225	4.1%	32	$85,900	8	18	1	27
		Building Equipment Contractors	2382	3.1%	25	$136,000	6	13	-1	18
		Metalworking Machinery Manufacturing	3335	3.0%	24	$149,000	6	13	-1	18
17-2112	Industrial Engineers	Metalworking Machinery Manufacturing	3335	18.2%	15	$80,900	4	5	1	9
		Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	3334	8.6%	7	$95,800	2	2	1	5
		Aerospace Product and Parts Manufacturing	3364	7.8%	6	$105,300	2	2	1	4
17-2171	Petroleum Engineers	—	—	—	—	—	—	—	—	—
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	Automotive Repair and Maintenance	8111	9.1%	22	$75,900	9	9	0	18
		Building Equipment Contractors	2382	7.4%	18	$94,500	7	8	0	14
		Automobile Dealers	4411	7.0%	17	$99,900	7	7	0	14
43-5061	Production, Planning, and	Metalworking Machinery Manufacturing	3335	6.6%	12	$63,600	5	7	0	11

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
	Expediting Clerks	Ship and Boat Building	3366	5.0%	9	$64,600	3	5	-1	8
		General Medical and Surgical Hospitals	6221	3.6%	6	$64,600	3	4	0	7
47-2111	Electricians	Building Equipment Contractors	2382	82.0%	438	$98,200	148	243	27	418
		Ship and Boat Building	3366	3.7%	20	$98,700	6	10	-1	16
		Nonresidential Building Construction	2362	2.5%	13	$100,200	5	7	1	13
51-8099	Plant and System Operators, All Other	—	—	—	—	—	—	—	—	—
19-4031	Chemical Technicians	Architectural, Engineering, and Related Services	5413	35.4%	8	$45,400	2	7	0	9
		Scientific Research and Development Services	5417	15.2%	3	$60,000	1	3	0	4
		Basic Chemical Manufacturing	3251	5.2%	1	$55,000	0	1	0	1
51-9111	Packaging and Filling Machine Operators and Tenders	Animal Slaughtering and Processing	3116	19.5%	28	$41,900	13	17	1	31
		Fruit and Vegetable Preserving and Specialty Food Manufacturing	3114	15.9%	23	$44,400	11	13	0	24
		Seafood Product Preparation and Packaging	3117	14.1%	20	$37,500	9	11	-2	18
51-4041	Machinists	Metalworking Machinery Manufacturing	3335	60.1%	146	$64,600	57	82	-5	134

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
		Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	3327	10.7%	26	$64,200	10	15	0	26
		Ship and Boat Building	3366	5.3%	13	$66,100	5	7	-1	12
17-2041	Chemical Engineers	Scientific Research and Development Services	5417	21.3%	2	$112,200	0	1	0	1
		Basic Chemical Manufacturing	3251	9.8%	1	$122,000	0	0	0	1
		Other Chemical Product and Preparation Manufacturing	3259	6.1%	1	$122,000	0	0	0	0

Table 74: 10-year Demand in Pierce County for Top 25 Occupations, excluding Petroleum and Coal Products Manufacturing, via JobsEQ.

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	Other Pipeline Transportation	4869	7.3%	7	$87,100	2	5	0	7
		Petroleum and Petroleum Products Merchant Wholesalers	4247	1.6%	2	$89,900	0	1	0	1
		Miscellaneous Nondurable Goods Merchant Wholesalers	4249	1.2%	1	$89,900	0	1	0	1
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	Cement and Concrete Product Manufacturing	3273	19.2%	43	$55,600	15	28	0	43
		Other Food Manufacturing	3119	7.3%	16	$50,800	6	11	2	19
		Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	3252	5.4%	12	$55,600	4	8	0	13
51-1011	First-Line Supervisors of Production and Operating Workers	Grocery and Convenience Retailers	4451	5.4%	59	$76,900	21	33	0	54
		Plastics Product Manufacturing	3261	4.7%	52	$69,700	19	30	3	52
		Aerospace Product and Parts Manufacturing	3364	4.3%	47	$94,800	17	27	3	48
49-9041	Industrial Machinery Mechanics	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	8113	21.9%	157	$65,700	63	72	41	177
		Machinery, Equipment, and Supplies Merchant Wholesalers	4238	7.9%	56	$66,900	22	25	10	57
		Pulp, Paper, and Paperboard Mills	3221	3.8%	27	$87,600	9	11	-2	19

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
53-3032	Heavy and Tractor-Trailer Truck Drivers	General Freight Trucking	4841	35.7%	2,036	$64,200	937	1,229	102	2,269
		Specialized Freight Trucking	4842	10.3%	585	$64,200	269	353	29	651
		Warehousing and Storage	4931	6.5%	370	$62,600	188	246	102	536
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Warehousing and Storage	4931	24.8%	1,785	$48,100	931	1,571	333	2,835
		Employment Services	5613	16.1%	1,163	$38,800	567	958	43	1,568
		Couriers and Express Delivery Services	4921	11.8%	854	$45,100	440	742	135	1,316
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	Aerospace Product and Parts Manufacturing	3364	11.4%	102	$89,400	44	76	7	127
		Employment Services	5613	10.0%	89	$49,400	38	66	3	107
		Warehousing and Storage	4931	7.1%	63	$61,800	28	48	5	81
47-2061	Construction Laborers	Other Specialty Trade Contractors	2389	23.7%	928	$60,400	334	478	60	872
		Residential Building Construction	2361	16.4%	642	$56,500	236	337	71	644
		Utility System Construction	2371	13.8%	541	$62,700	194	277	27	498
11-3051	Industrial Production Managers	Aerospace Product and Parts Manufacturing	3364	11.2%	33	$163,000	8	15	2	25
		Plastics Product Manufacturing	3261	4.8%	14	$130,600	4	6	1	11
		Cement and Concrete Product Manufacturing	3273	4.4%	13	$143,100	3	6	0	9

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
51-8091	Chemical Plant and System Operators	Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	3252	38.3%	11	$82,100	3	7	0	9
		Basic Chemical Manufacturing	3251	10.6%	3	$82,100	1	2	0	3
		Waste Treatment and Disposal	5622	6.8%	2	$83,700	1	1	0	2
13-1199	Business Operations Specialists, All Other	National Security and International Affairs	9281	14.2%	524	$94,800	173	273	5	452
		Management, Scientific, and Technical Consulting Services	5416	4.4%	162	$106,900	56	88	17	161
		Executive, Legislative, and Other General Government Support	9211	4.3%	159	$94,800	53	84	6	144
47-2073	Operating Engineers and Other Construction Equipment Operators	Other Specialty Trade Contractors	2389	29.1%	325	$84,700	110	167	19	296
		Utility System Construction	2371	18.9%	212	$88,200	72	108	11	191
		Highway, Street, and Bridge Construction	2373	10.2%	114	$101,100	39	59	8	105
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	Grocery and Related Product Merchant Wholesalers	4244	14.8%	431	$82,200	145	242	19	406
		Lumber and Other Construction Materials Merchant Wholesalers	4233	9.8%	284	$82,200	95	158	5	257
		Wholesale Trade Agents and Brokers	4251	8.7%	254	$94,100	85	141	6	232

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
53-7051	Industrial Truck and Tractor Operators	Warehousing and Storage	4931	57.5%	1,449	$52,900	482	964	124	1,570
		Employment Services	5613	6.8%	171	$41,600	56	111	6	173
		Grocery and Related Product Merchant Wholesalers	4244	3.0%	77	$51,500	25	50	3	78
11-1021	General and Operations Managers	Restaurants and Other Eating Places	7225	4.3%	216	$99,400	56	121	17	193
		Office Administrative Services	5611	3.4%	174	$147,800	48	104	41	194
		Building Equipment Contractors	2382	2.6%	134	$157,400	34	73	3	110
17-2112	Industrial Engineers	Aerospace Product and Parts Manufacturing	3364	27.3%	103	$121,800	26	33	17	76
		Architectural, Engineering, and Related Services	5413	6.5%	24	$115,700	6	8	2	16
		Plastics Product Manufacturing	3261	4.5%	17	$99,300	4	5	3	12
17-2171	Petroleum Engineers	Architectural, Engineering, and Related Services	5413	20.3%	4	$134,700	1	1	0	2
		Management of Companies and Enterprises	5511	7.3%	1	$153,000	0	0	0	1
		Management, Scientific, and Technical Consulting Services	5416	4.5%	1	$125,100	0	0	0	1
49-1011	First-Line Supervisors of Mechanics, Installers,	Automotive Repair and Maintenance	8111	9.5%	135	$74,300	54	60	7	121
		Building Equipment Contractors	2382	7.6%	109	$92,500	43	47	3	93

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
	and Repairers	Automobile Dealers	4411	7.1%	101	$97,800	40	44	4	88
43-5061	Production, Planning, and Expediting Clerks	Warehousing and Storage	4931	8.7%	99	$55,200	43	69	27	140
		Individual and Family Services	6241	4.6%	52	$58,100	23	37	15	75
		Aerospace Product and Parts Manufacturing	3364	4.5%	51	$73,900	21	33	3	57
47-2111	Electricians	Building Equipment Contractors	2382	75.4%	1,354	$89,800	467	763	131	1,361
		Employment Services	5613	3.9%	70	$73,300	23	38	3	64
		Utility System Construction	2371	3.1%	56	$92,100	20	32	7	59
51-8099	Plant and System Operators, All Other	Waste Treatment and Disposal	5622	14.1%	5	$75,800	1	4	0	5
		Cement and Concrete Product Manufacturing	3273	9.9%	4	$78,200	1	2	0	3
		Pulp, Paper, and Paperboard Mills	3221	9.0%	3	$93,000	1	2	-1	2
19-4031	Chemical Technicians	Architectural, Engineering, and Related Services	5413	17.9%	13	$48,500	3	13	1	16
		Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	3252	12.4%	9	$55,000	2	9	0	11
		Employment Services	5613	5.2%	4	$42,500	1	4	0	5

SOC	Occupation	Alternative Industry	NAICS Code	% of Occupation Employment	Employment	Avg Ann Wages	Exits	Transfers	Empl Growth	Total Demand
51-9111	Packaging and Filling Machine Operators and Tenders	Employment Services	5613	15.0%	69	$35,200	34	41	3	78
		Other Food Manufacturing	3119	14.8%	68	$42,500	36	44	15	95
		Bakeries and Tortilla Manufacturing	3118	8.2%	38	$41,700	19	23	4	46
51-4041	Machinists	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	3327	21.1%	93	$63,700	38	54	6	99
		Aerospace Product and Parts Manufacturing	3364	19.4%	85	$76,100	35	50	5	91
		Metalworking Machinery Manufacturing	3335	8.7%	38	$64,200	15	22	0	37
17-2041	Chemical Engineers	Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	3252	20.3%	7	$115,100	2	2	1	5
		Architectural, Engineering, and Related Services	5413	14.2%	5	$119,500	1	1	0	3
		National Security and International Affairs	9281	5.8%	2	$115,100	0	1	0	1

Appendix D: Letter from the Swinomish Indian Tribal Community

See next page

Main Office: 360.466.3163
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Swinomish Indian Tribal Community

A Federally Recognized Indian Tribe Organized Pursuant to 25 U.S.C. § 476
* 11404 Moorage Way * La Conner, Washington 98257 *

December 18, 2024

Shannon Pressler
WA Department of Commerce
1011 Plum Street SE
P.O. Box 42525
Olympia, WA 98504-2525

Re: Refinery Impacts to Swinomish Indian Tribal Community

Dear Ms. Pressler:

The Swinomish Indian Tribal Community ("Swinomish" or "the Tribe") appreciates the opportunity to provide input for the Washington Refinery Study conducted by the Department of Commerce and Western Washington University. Swinomish is heavily impacted by the existence and operation of multiple refineries on lands surrounding the Salish Sea and we believe this study is an excellent opportunity to take a hard look at the complex and nuanced impacts, both beneficial and detrimental, direct and indirect, of the refineries on Swinomish.

Historical Context

The Swinomish Tribe is a present day successor in interest to the tribes and bands that signed the 1855 Treaty of Point Elliott ("Treaty") with the United States, which established the Swinomish Reservation. Approximately one hundred years later, two refineries were constructed on March Point, within Swinomish's Treaty-reserved homeland. The refineries, which have subsequently had a number of owners and operators, are now owned and operated by Marathon Petroleum Corporation and by HF Sinclair Corporation.

These refineries were built in an era and world that is vastly different from today. The Federal government's policy at the time was to terminate the existence of Federally-recognized Tribes and to dismantle their sovereignty, self-governance, community, culture and land base. Federal environmental protection at the time was limited, predating the Clean Water Act and other bedrock environmental statutes.

On the state level, the State of Washington persisted in refusing to recognize that Federal treaties with Indian Tribes were and remained the supreme law of the land. It was not until decades after the refineries were built that Judge Boldt reaffirmed the continuing vitality of the treaties, including the Treaty of Point Elliott. *United States* v. *Washington,* 459 F. Supp. 1020, 1049 (1975). It was then more than a decade after that when the State formally acknowledged its government-to-government relationship with Washington Tribes in the Centennial Accord.

In this context of formal Federal and State policies explicitly hostile to Washington Tribes, it is no surprise that the refineries on the Salish Sea were not the product of consultation, let alone collaboration, with the affected tribes by their Federal trustee, State and local governments, or the businesses that conceived of and built the refineries. As a result, despite the explicit recognition of the Swinomish Reservation in the 1855 Treaty, despite the proximity of the refineries to the Swinomish Village and to traditional Swinomish fishing grounds, and despite the scale and foreseeable impacts of the refineries and of accompanying industrial activities, the refineries were not the product of consultation or Tribal consent.

Nonetheless, in subsequent years Swinomish has adapted as much as possible to the presence of the refineries and their accompanying industrial infrastructure. Swinomish also recognizes that there are, as discussed below, benefits brought by the refineries, their employees and contractors. However, the benefits do not alter the fact that Swinomish did not have a role in determining whether these large-scale industrial facilities would be located in its homeland and adjacent to its waters. In this, the ongoing presence of the industrial facilities stands as a stark reminder of the lack of respect and concern for Tribal homelands, Treaty resources and Tribal sovereignty and self-determination at the time of the refineries' construction.

However, past wrongs need not be perpetuated. The March Point refineries have new operators, and this presents an opportunity to demonstrate respect for the Tribe's sovereignty, self-determination, homeland and Treaty rights and resources. Indeed, the operators of the March Point refineries initiated outreach to Swinomish when they recently acquired their facilities, and have continued active communications with Swinomish in the years since. From these beginnings there is an opportunity for increasing respect and trust, as well as cooperation to increase the beneficial impacts of the refineries, reduce their detrimental impacts, and address concerns, challenges and opportunities shared by Swinomish and the neighboring refineries.

Beneficial Refinery Impacts

Swinomish operates a number of economic enterprises in the vicinity of the two March Point refineries operated by Marathon and HF Sinclair. The refineries have direct and indirect positive economic impacts for Swinomish. At the highest and broadest level, the refineries generate income streams that are disbursed throughout the local and regional economy, providing

financial resources that may then find their way, directly or indirectly, to support Swinomish businesses.

Refinery employees and contractors, their families, and friends are important customers and guests at three Swinomish markets and gas stations, as well as the Swinomish Casino & Lodge, Swinomish Golf Links, and Swinomish retail tobacco and coffee shops. Swinomish Shellfish Company oysters are sold at Swinomish markets and at a pop-up bar adjacent to the Swinomish market closest to the refineries. Refinery employees, contractors and families also are among potential customers at seasonal fireworks retailers operated by individual Swinomish Tribal members and their families on Tribal land not far from the refineries, further diversifying the Swinomish economy.

The refineries' economic impacts at Swinomish increase seasonally in a predictable and financially important cycle. During "turnaround" work on a refinery, contractors and their employees live and work in the local area for an extended period of time, and Swinomish businesses observe increased customers and a positive financial impact while the turnaround contractors and employees are present. Year round, business visitors to the refineries and their local contractors also may stay overnight at the Swinomish Lodge.

The refineries themselves generate business, directly and indirectly, for the Swinomish Casino and Golf Links. Direct economic impacts arise from refinery banquets at the Swinomish Lodge and refinery use of Swinomish catering services. Indirect economic impacts generated by refinery employees or business visitors include enjoying lunch at the Casino, playing golf after work, in a league or by hosting outings at Swinomish Golf Links.

Over the decades, the refineries and their contractors have provided employment opportunities to Swinomish Tribal members. Some of this work is year-round, and some is seasonal employment for turnaround contractors. Such locally-available employment paying competitive wages brings important financial resources to Swinomish families and helps to further diversify the Swinomish economy.

The proximity of a local refinery supplier to the Swinomish fuel markets can reduce greenhouse gas and other emissions from transporting refined product to the markets for retail sale to customers, and may as well reduce financial costs incurred in transporting fuel for sale.

The resulting financial benefits from these relationships to Swinomish economic enterprises are particularly important because the enterprises' financial return to the Tribe helps support essential Swinomish governmental services to the Reservation, such as law enforcement, environmental protection and land management. The enterprises also support important Swinomish governmental programs that have been developed to help address disparities in areas

such as health and education that disproportionately affect Swinomish and other indigenous communities. Given limitations on tribal tax jurisdiction, the role played by Swinomish enterprises in supporting Swinomish self-government is critical.

In addition to these business relationships, refinery sponsorship of the Swinomish Boys & Girls Club's annual golf tournaments helps support services to youth in the Swinomish Village. In the absence of the March Point refineries, Swinomish enterprises and the governmental services and programs they support would not enjoy their current level of operations.

Detrimental Refinery Impacts

There are inevitably costs and risks that accompany the benefits and successes that are supported by the local refineries. Like the benefits outlined above, the costs and risks are complex and nuanced, direct and indirect, obvious and subtle. These detrimental impacts are not abstract but intensely local – refineries are located within the Swinomish Treaty Reservation and homeland. The impacts are and will be enduring – Swinomish members have lived in this area since time immemorial and expect to continue to do so for many, many generations into the future.

One of the core rights recognized and guaranteed by the Treaty is the Tribe's right to fish in the Tribe's adjudicated Usual and Accustomed fishing areas in and around the Salish Sea. *United States* v. *Washington,* 459 F. Supp. 1020, 1049 (1975). Those Usual and Accustomed fishing areas are not only adjacent to the March Point refineries but encompass four of the five refineries in the state. Any oil spill or other incident at or adjacent to any one of those facilities, or during the conveyance of crude oil or refined product to or from any of those facilities, could have potentially devastating impacts on the ability of members of the Swinomish community to exercise the Tribe's Treaty reserved right to fish.

Additionally, the two refineries located on March Point pose ongoing risks to the Reservation and the Swinomish community. Those risks are very real, with spills from train derailment (BNSF derailment occurring on an easement across the Swinomish Reservation) and pipelines (Olympic Pipeline Gasoline Spill) happening within the last two years and an unplanned flare from one refinery in 2015 resulting in more than 500 reports of injuries to those on and near the Swinomish Reservation.

In order to guard against those risks, Swinomish expends substantial financial and staff resources. Several Swinomish employees are tasked specifically with emergency management and response as their full-time jobs while biologists, health workers, construction experts, lawyers and other specialists are tasked with attending to a wide range of impacts from the refineries. There are few activities of the Swinomish Indian Tribal Community that are not touched in some way by the reality of the nearby refineries.

Swinomish is impacted, directly and indirectly, by the refineries in at least the following ways:

Vessels:

- Vessel Traffic - More than 27% of Tribal Usual and Accustomed areas for fishing are occupied by shipping lanes and anchorages. Vessels from refineries on the Salish Sea account for a significant portion of that traffic and the majority of vessels at anchor. Anchorages occur almost exclusively within productive crab habitat, preventing those areas from being utilized by Tribal members exercising Treaty fishing rights.
- Vessel Destruction of Fishing Gear - For years Swinomish Tribal members exercising their Treaty-reserved fishing rights have experienced persistent loss or destruction of their valuable fishing gear by vessels operating in the Tribe's Usual and Accustomed fishing areas. Such gear loss impacts Tribal fishers and their families directly when new replacement gear must be purchased, and indirectly when catch is foregone because gear has been lost. Tribal staff and leadership are continuing their years-long efforts to address gear loss.
- Vessel Spill Risk - Shipping Crude Oil and Refined product by vessel accounts for a major risk to the Salish Sea. An allision or collision resulting in an oil spill has the potential to devastate the Salish Sea, decimate populations of fish, crab and other shellfish, and marine mammals, and severely impact Swinomish lands. James Stronach & Aurelien Hospital, *The Implementation of Molecular Diffusion to Simulate the Fate and Behavior Modeling of a Diluted Bitumen Oil Spill and Its Application to Stochastic Modelling*, Conference Paper, (June 2014) https://www.researchgate.net/publication/274083520; Julann A Spromberg, Sarah E. Allan & Nathaniel L. Scholz, *Potential Population-level impacts of future oil spills on Pacific Herring Stocks in Puget Sound*, Human and Ecological Risk Assessment Vol. 30 Nos. 1-2 (February 19, 2024) https://doi.org/10.1080/10807039.2023.2301529. Impacts on marine Treaty resources in turn impact Swinomish community members and their families, as well as the economic, cultural and social life of the community as a whole.
- Bunkering risks - The most common fuel and oil spills occur during bunkering. While vessels are being fueled, it is not uncommon for small amounts of fuel and oil to spill into the water. These minor spills impact local habitat and species and their impacts can be cumulative over time, depending on the types of product involved. National Research Council, *Oil in the Sea III: Inputs, Fates, and Effects*, 134 (2003) http://nap.edu/catalog/10388.html. Again, such cumulative harm to marine Treaty resources in turn impacts Swinomish community members, their families and the broader Swinomish community.
- Vessel Noise - Noise from vessels transporting crude oil or refined products disturbs the local ecosystem and impacts several endangered species including Southern Resident Killer Whales. Simone Cominelli et. al., *Noise Exposure from Commercial Shipping for the Southern Resident Killer Whale Population*, Marine Pollution Bulletin 136 (2018) 177-

200 https://doi.org/10.1016/j.marpolbul.2018.08.050. Swinomish Tribal members diving to exercise Treaty fishing rights have first-hand experience with the noise generated by vessel traffic.

- Vessel Emissions - While underway, at a berth, or at anchor, vessels rely entirely on fossil fuels for their power. They do not connect to local electricity at any point. This continual burning of fossil fuels is a major contributor to the release of greenhouse gasses, associated impacts, and to the degradation of local air quality. Naya Olmer et. al., *Greenhouse Gas Emissions from Global Shipping, 2013-2015*, The International Council of Clean Transportation (October 2017) https://theicct.org/publication/greenhouse-gas-emissions-from-global-shipping-2013-2015/; Cesar Ducruet et. al*., Ports and their Influence on Local Air Pollution and Public Health: A Global Analysis*, Science of the Total Environment Volume 915 (March 2024) https://doi.org/10.1016/j.scitotenv.2024.170099

Rail:

- More than a century ago, a rail line was constructed across the Swinomish Reservation and utilized for about one hundred years without the consent of the Tribe or the United States. As a result, the Tribe and U.S. were required to pursue litigation in Federal Court to vindicate the Tribe's ownership of the burdened land and to obtain compensation for use of the land for the rail line.
- Derailment Risk - Derailment of a train poses serious risk to the Swinomish Tribe as the railway used to transport crude oil and other chemicals to the March Point refineries passes through the Swinomish Reservation and very closely to Swinomish's economic development area including its Casino & Lodge, RV park, and retail stores. Derailment is an ongoing concern to Casino & Lodge management. Guests at the Swinomish Casino & Lodge occasionally comment on the derailment risk, and guests at the RV park stay immediately adjacent to the tracks and are impacted by the noise of moving trains. The local railway also crosses the Swinomish Channel and over a portion of Padilla Bay. Derailments can be *relatively* minor, as was the case when a train derailed on the Swinomish Reservation in March of 2023 and released around 2,100 gallons of diesel fuel, or they can be catastrophic as has been the case multiple times in Washington State, the United States and Canada. A catastrophic derailment on the Swinomish Reservation could result in injury or worse for guests and staff at the Swinomish RV park immediately adjacent to the rail line or at the nearby Swinomish Casino & Lodge, as well as damage to and closure of these and other Swinomish commercial ventures in the area for weeks, months or longer. Such business interruption has the potential to significantly damage the Swinomish economy, and therefore the Swinomish governmental services and programs the Tribe's commercial ventures support, and the community members and Reservation residents who benefit from those programs and services. A catastrophic derailment into the Swinomish Channel or Skagit River could inundate not only the Channel, River and adjacent shorelines with oil, but also more distant areas impacted by spilled fluids swiftly transported by the strong tidal currents in the area, including the Swinomish Reservation's shorelines, the Swinomish Village, the Swinomish Casino & Lodge, the Swinomish Clam

Garden, and important cultural areas such as Lone Tree Point and Kukutali Preserve. On a broader scale, railways for refineries on the Puget Sound are regularly located along and crossing waterways and on the shores of the Salish Sea. Derailments and spills into those waters with their strong and fast tidal currents would also dramatically impact and alter where Swinomish members could fish.

- Bay Access and Land Use Optimization - The presence of the railway impedes direct terrestrial access to Padilla Bay from the adjacent lands of the Swinomish Reservation, and prevents the Tribe's optimal utilization of those lands as part of its economic enterprises.
- Swinomish Channel - In order for the railway to reach the March Point Refineries, it must cross the Swinomish Channel. To do so, the railroad constructed a swing bridge, now many decades old. This bridge severely limits Swinomish fishing and Fisheries Enforcement vessels traveling through the Swinomish Channel when it is "closed" and only allows free access when it is opened. This bridge is a major impediment to Swinomish fishers, particularly with the very short windows for fishing that are common for Swinomish fisheries. Delays in accessing waters north of the Swinomish Channel reduce the time that fishers can actually engage in Treaty fishing. For instance, if fishing for shrimp is opened for four hours north of the Channel but fishers are delayed for an hour by the closure of the swing bridge, the time available for fishing is reduced by 25%. Such travel delays and reduced fishing opportunity have a direct and significant impact on Treaty fishing income to the fishers and their families. Similarly, the swing bridge is a major potential point of failure both from a mechanical standpoint and from a human error standpoint. Any failure of the swing bridge has the potential to cause a catastrophic derailment into the Swinomish Channel.
- Train Emissions - Trains burn fossil fuels and contribute to the increase in greenhouse gases and climate change from which the Swinomish Tribe is experiencing significant impacts. Train emissions also degrade the local air quality resulting in health impacts to community members. *Technology Assessment: Freight Locomotives,* California EPA, Air Resources Board (November 2016) https://www.arb.ca.gov/msprog/tech/techreport/final_rail_tech_assessment_11282016.pdf
- Viewshed – As noted above, the railway was installed in the late 1800s, over the objections of the Swinomish Tribe and the United States, along the shores of Padilla and Fidalgo Bays. Both of those bays have significant cultural importance to the Swinomish people and commercial importance as they provide the main view for the Swinomish Lodge and nearby RV park. While some guests may enjoy watching trains, the regular presence of trains traveling to and from the refineries impedes and impairs the viewshed of those two bays significantly.

Pipeline:

- Decades ago, pipelines for petroleum product transport were constructed across the Swinomish Reservation without the consent of the Tribe or the United States. As a result, the Tribe and U.S. were required to pursue litigation in Federal Court to vindicate the Tribe's ownership of the burdened land and to obtain compensation for use of the land for the pipelines.
- Pipeline Spill Risk- When pipelines spill it is more difficult to both detect and stop those spills than other methods of transporting oil. Mutiu Adesina Adegboye, Wai-Keung Fung & Aditya Karnik, *Recent Advances in Pipeline Monitoring and Oil Leakage Detection Technologies: Principles and Approaches*, Sensors 2019 (June 4, 2019) https://doi.org/10.3390/s19112548. Remediation of underground pipeline spills requires far more effort and land disturbance than spills to the surface. Most recently, the Olympic pipeline spilled near the Swinomish Reservation in December of 2023. The Swinomish Tribe exerted months of effort as part of the remediation and restoration team, a process that continues even today. Three separate pipelines cross the Swinomish Reservation and Swinomish Channel, carrying refined product from the refineries. A spill from any of those pipelines would impact the Reservation and could result in the disruption or closure of the nearby Swinomish Casino & Lodge, the RV park, and several Swinomish owned retail stores. A pipeline spill into the Channel would result in the impacts described in connection with a derailment of rail cars and spill into the Channel.
- Pipeline Presence – Just like the rail line, the continuing presence of three pipelines built across the Swinomish Reservation without the Tribe's consent precludes the Swinomish Tribe from utilizing its land above and adjacent to those pipelines and effectively reduces Swinomish's total usable land. In this, the continuing presence of the pipelines diminishes the land base reserved by the Tribe for its own use in the Treaty of Point Elliott.

Refineries:

- Refinery Operations - Refineries are inherently dangerous and large industrial plants. The location of two refineries on March Point poses a significant threat to the Swinomish Tribal members, to the Reservation, and to guests and staff of Swinomish economic enterprises. Industrial accidents can and do occur which result in impacts to neighboring communities. For instance, the 2010 explosion and fire at the Tesoro Anacortes Refinery killed 7 workers at the refinery and released chemicals into the air which sickened those nearby, including Tribal members. In 2015, an unexpected flare sickened more than 500 on and near the Swinomish Reservation, including Tribal members. Additionally, populations living within 10 miles of refineries experience increased risk of multiple types of cancer – and the entirety of the Swinomish Reservation is within 10 miles of both the March Point refineries. Stephen B. Williams, et. al., *Proximity to Oil Refineries and Risk of Cancer: A population Based Analysis*, JNCI Cancer Spectrum, Volume 4 Issue 6 (October 7, 2020) https://doi.org/10.1093/jncics/pkaa088
- Refinery Emissions and products - Refinery operations and the use of refinery products release greenhouse gases contributing to climate change and degrading local air quality. Refinery emissions pose potential health risks to the Reservation population, Swinomish

business guests and employees, and the Swinomish Shellfish Company aquaculture operation in Similk Bay, located directly south of the refineries. Indeed, odors from the refinery can be detected at times by Shellfish Company staff. Some guests at the Casino & Lodge do not like the proximity of the refineries, concerned that they are polluting.

- Viewshed - The March Point refineries are located on the shores of Padilla and Fidalgo bays, and their infrastructure physically dominates the area. The refineries are visible from the Swinomish Links Golf course, and from some locations at the Swinomish Casino & Lodge. Like the rail line, the presence of extremely large industrial plants on these waters severely degrades the viewshed of the area.
- Refinery Presence Precludes Land Use - The March Point refineries are located on lands that are part of the Swinomish Treaty Reservation that were illegally occupied by non-tribal settlers and then purportedly severed from the Reservation by an Executive Order. Those lands were important areas for traditional food production, including camas propagation and harvesting, and for cultural practices. The presence of the refineries precludes access to and use of the land for those purposes and has potentially permanently eliminated those lands for food production purposes.

Future Refinery Impacts

The March Point refineries could provide opportunities for a greater sharing of their benefits with the Swinomish Tribe and its members, and for reducing their risks and detrimental impacts on the Tribe, its members, resources and Reservation. In addition, as the larger economy transitions to address global warming, there may be opportunities for achieving some degree of historical justice as refineries transition, downsize or close. The lands that now support the refineries will remain should operations cease. It could bring Swinomish a measure of historical justice and an opportunity to create its own, alternative future, to have those lands returned to Tribal ownership as the Treaty provided in 1855.

Thank you again for this opportunity to participate in evaluating the future of refineries in Washington. We look forward to further discussions on the impacts to the Swinomish Indian Tribal Community from Oil Refineries and their operations and the myriad options for the future. If you have any questions about these comments or would like to discuss them, please do not hesitate to contact me.

Sincerely,

Steve Edwards

Steve Edwards, Chairman