ANALYSIS AND RECOMMENDATIONS TO INFORM WASHINGTON STATE'S OIL REFINERIES ON CAP-AND-INVEST

by

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Executive Summary

When I first heard about the passing of the Climate Commitment Act in 2021, I worked as a laboratory supervisor in an oil refinery in Washington State. At the time, no one could adequately explain the impacts the Cap-and-Trade program would have on the company I worked for, or if we would even be able to remain operational once it was implemented. I was struck with a deep curiosity to understand the policy, how the market would interact with California and Quebec's market, and what it would mean for the oil refineries in the state. This curiosity and desire to understand is what lead me to enroll in the Energy Policy and Climate program in the first place. I divided my time in the program between classes focused on energy policies, and classes focused on the technological aspects of energy. My intention in doing so was to learning as much as possible about carbon pricing policies and energy technologies, so that I could better understand how they interact.

The United States is in the middle of a slow-moving energy transition. The switch from fossil fuels to renewable, zero emissions sources of energy has to happen in order to avoid the most critical consequences of climate change. During my time in the EPC program, a couple of extremely important things that I really came to understand it that this change will not happen overnight, and that a just and equitable transition requires us to provide affordable and reliable energy to all. It is a human right. The use of fossil fuels has to be slowly phased out, because the use of renewables is being slowly phased in. The point of this study is not to justify or promote the prolonged use of oil, but rather to offer solutions to keep oil refineries under a carbon pricing scheme financially viable long enough to support the energy transition.

Abstract

In order to reach their greenhouse gas emission reduction goals, the State of Washington passed the Climate Commitment Act, which took effect in 2023. The Cap-and-Invest program rising from the Climate Commitment Act has placed increased regulatory requirements and financial burden on the oil refining sector in Washington State. The high costs and cost uncertainties refiners face from the Climate Commitment Act, and other climate related laws, as well as impacts from the geographical nearness of California's carbon market, have led to an uncertain future for the state's refineries. The following analysis outlines the challenges refineries are now confronted with, including the cost uncertainties associated with allowance auctions, the future of cost-free allowances, the impacts of carbon market fragmentation, and the additional financial burden of compliance with the Clean Fuel Standard. It then offers policy and business solutions such as linking Washington's program with California and Quebec's carbon market, and encourages refiners to make decarbonization a priority. The offered recommendations could allow oil refineries to remain financially viable long enough to support the energy transition, and be phased out slowly rather than shutting down prematurely, thereby avoiding carbon leakage.

Introduction

Washington state adopted a limit on greenhouse gas emissions in 2020, titled the Climate Pollution Limits bill. They did this in order to align with recommendations from the Intergovernmental Panel on Climate Change to limit global warming to no more than 1.5 degrees Celsius (Tempest et al., 2021). The Climate Commitment Act was signed into law in May 2021, and provides a pathway for the state to stay under the limit set by the Climate Pollution Limits Bill. The Climate Commitment Act is a market-based Cap-and-Trade program that sets a cap on emissions from entities that emit over 25,000 metric tons CO2e per year (*Climate Commitment Act - Washington State Department of Ecology*, n.d.-a). The cap is lowered over time, which essentially guarantees an overall reduction in emissions throughout the state. Washington's program was modeled off of California's program, but reduces emissions at a much more aggressive pace. According to the Washington Department of Ecology, it is "Only the second such program in the U.S., cap-and-invest uses the powers of supply and demand to incentivize businesses to cut their emissions, using whatever strategy they think is best" (*Climate Commitment Act - Washington State Department of Ecology*, n.d.-b).

The cost of emissions allowances has increased during each auction the state has held since the rule was implemented, and the costs far exceed those in California's market. This has created a lot of uncertainty around the future financial burden the cap-and-trade program will place on covered entities. The high and uncertain nature of the cost of compliance can increase the risk of leaving the oil refining sector in Washington exposed, and has the potential to reduce their ability to remain viable in a competitive market. The environmental benefits of implementing a carbon tax can be lost as a consequence of covered industries succumbing to their reduced ability to compete. When this happens, carbon leakage can occur. The emissions

are simply displaced rather than truly abated as a result of a consequential shift in market share to producers in other regions that have weak or non-existent carbon pricing policies (Parry et al., 2015).

The oil refining sector has played an important role in powering the country's transportation sector. While the United States is on a path to transition away from fossil fuels toward more renewable sources of energy, this transition is moving at a slow pace. This paper offers suggestions on steps that refiners and legislators can take to ensure that the state's refineries remain financially viable long enough to support the energy transition.

Research Objective

The purpose of this study is to conduct a rigorous analysis of the Climate Commitment Act and the impacts it has on the oil refining sector in Washington State. This research will review the compliance requirements that refineries are subject to due to the policy and will discuss the impacts and challenges they face. It will then offer possible solutions that both policy makers and refiners can implement that will allow the states refineries to stay financially viable during the energy transition. This paper contributes to a growing literature on the greenhouse gas emissions regulations and decarbonization steps of the petroleum industry in Washington State. There is ample evidence that emission reduction requirements and fuel content regulations under carbon pricing policies place an increased financial burden on oil refineries.

Methodology

This project uses an integrative literature review and policy guidelines approach. I compiled and analyzed research from various sources including government publications, such as reports conducted or commissioned by the Washington State Department of Ecology (DOE)

and the California Air Resources Board *(CARB)*; peer-reviewed journals including Climate Policy and Quarterly Journal of Economics; and various industry and consulting publications. I integrated and consolidated the information from these sources to explain the implications of the Climate Commitment Act (CCA) on oil Refining in Washington State. I outlined the background and legislative framework, including the goals, timelines, and key provisions of the rule. I then explained the financial challenges that refineries will face due to the CCA, and the implications of having a second carbon market (California) geographically close. Lastly, I used these sources, along with qualitative data analysis, to produce policy recommendations that would ensure that the state's refineries do not shut down prematurely due to carbon pricing imposed financial constraints and thereby avoid carbon leakage.

Policy History, Framework and Compliance Requirements

A thorough review of the Climate Commitment Act was conducted by researching the history, purpose, and reasons why the state passed the law. The states greenhouse gas reduction goals were researched by reading RCW 70A.45.020 (*RCW 70A.45.020: Greenhouse Gas Emissions reductions—Reporting Requirements.*, n.d.). The legislative framework for the CCA was researched by reading Washington Administrative Code Chapter 173-446 WAC- The Climate Commitment Act Program Rule (*Chapter 173-446 WAC,* n.d.). Industry and consultant publications were reviewed as well in order to explain the legislative framework and history of the rule.

The Goals, Timelines, Key Provisions, and compliance requirements of the cap-and-invest rule were found by researching various information, research, and data provided by the Washington State Department of Ecology on their website.

Impacts and Challenges

The impacts and challenges that refineries could face due to the Climate Commitment Act were determined by first looking at the costs associated with compliance so far. However, since the rule has been in effect for less than one year, so a throughout literature review of impacts of cap-and- trade programs in other regions was also conducted to determine factors that could impact Washington's covered entities. The impacts and challenges that were most common in the literature were:

- High Costs and Cost Uncertainties- Peer reviewed studies, industry consulting publications, and data provided by the Department of Ecology were compiled to demonstrate the uncertain nature of future high allowance costs.
- Energy Intensive, Trade Exposed Industry- Information on the no-cost allowances provided to refineries was found on the Department of Ecology website. The carbon leakage risks associated with EITE industries was determined by researching various studies and peer reviewed papers on carbon leakage in other regions.
- Baseline Emission Exceedances- The data for refinery baselines was found from emissions that were reported to the Department of Ecology's Greenhouse Gas Reporting Program by the states five oil refineries. The possibility and reasons for low-skewed baselines came from my own knowledge of the oil refining industry.
- Carbon Market Fragmentation- Various studies conducted in other regions with carbon markets were referenced to determine the consequences of carbon market fragmentation. That information was then applied to Washington and California/Quebec's markets were demonstrated by showing the impacts on gasoline prices.

- Clean Fuel Standard- The CFS requirements were found on the Department of Ecology website. The financial impacts to refineries were shown through the high cost of compliance from auction data provided by the Department of Ecology.

Conclusions and Recommendations

- Policy Recommendations- Policy recommendations were determined by conducting review of literature on regions with successful carbon markets to determine factors that make them successful. A common claim in the literature is that larger markets lead to more stable market liquidity and lower compliance costs. Policy recommendations on linking were then outlined, and the reasoning for each recommendation was given.
- Refinery Recommendations- Recommendations for actions refineries could take were determined by conducting a review of studies, peer reviewed journals, and industry and consultant publications. The research was analyzed qualitatively to determine the most impactful steps refiners could take to maintain financial viability through cap-and-invest.

Background

Washington State's five oil refineries turn imported crude oil into finished products such as gasoline, diesel, jet fuel, and various chemicals used in manufacturing (e.g. nonene, tetramer). Some of these fuels are exported to other countries, but much of it stays in the U.S. and is distributed and consumed up and down the West Coast. While up to 80% of fossil fuel derived emissions occur during the end-use phase of combustion in a vehicle, a significant portion of the remaining emissions occur during the refining production process. "There is a larger uncertainty associated with the GHGs emitted throughout the production of the fuels from Well-to-Tank

(WtT). Refinery emissions account for more than half of the WtT GHG emissions of petroleum fuels" (Abdul-Manan et al., 2017).

Legislative Framework

In 2020, Washington State passed the Climate Pollution Limits bill (RCW 70A.45.020) that updated the states greenhouse gas emission reduction goals and stated that it would limit anthropogenic GHG emissions in order to achieve its set targets. The statute stated that by 2050, greenhouse gas emissions in Washington must be reduced by 95% below 1990 levels. "The 2020 legislation was ambitious but did not enact any specific policies to achieve the mandated reductions or advance the state's leadership in the area of climate change" (Hupp & Carmody, 2023). In 2021, The Washington State Legislature passed a climate related bill that work to help the state reach these set Greenhouse Gas emission reduction goals: The Climate Commitment Act (Chapter 173-446 WAC). This policy has both direct and indirect financial and operational impacts on the oil refineries operating within the state.

Goals, Timelines, Key Provisions

The Climate Commitment Act was designed to focus on greenhouse gas emission reductions from stationary sources that emit over 25,000 metric tons of carbon dioxide equivalent (CO2e) or more per year. These sources include electricity generators, fuel suppliers, and refineries, among others. All combined, the covered entities account for approximately 75% of emissions statewide.

The Act required the state to implement a cap-and-invest program that covered entities must participate in. The "cap-and-invest" is a form of cap-and-trade that is meant to "put environmental justice an equity at the center of climate policy" (Climate Commitment Act -

Washington State Department of Ecology, n.d.). The program runs quarterly auction to sell the emissions allowances, which generate significant revenue for the state. The revenue is required to be invested back into climate programs that benefit the community.

As large source emitters, oil refineries are covered by the program and are required to abide by the emissions caps. In 2021, the five refineries accounted for around 6 million MTCO2e of the total 38,368,010 MTCO2e reported to the state's Greenhouse Gas Reporting Program (GHG Reporting Program PIE by Sector | Data.WA | State of Washington, 2023), making them significant contributors to emissions.

The CCA was signed into law in May of 2021, and enforceable emissions reduction requirements began in January of 2023. State law requires emissions to be reduced below 1990 levels at 45% by 2030, 70% by 2040, and 95% by 2050, while also achieving net-zero carbon emissions by 2050 (*Climate Commitment Act - Washington State Department of Ecology*, n.d.-a).

The Refineries

There are five oil refineries that operate within the state of Washington, which combined, emit over 6 million MTCO2e annually (GHG Reporting Program PIE by Sector | Data.WA | State of Washington, 2023). The largest one in the Pacific Northwest is the BP Cherry Point refinery which has a process capacity of approximately 250,000 barrels of crude oil per day (*Washington | Where We Operate | Home*, n.d.). HF Sinclair's Puget Sound Refinery (formerly owned by Shell) has an approximate process capacity of 149,000 barrels per day (*HF Sinclair Corporation | Operations - Facilities - U.S. - Anacortes, WA*, n.d.). Marathon Petroleum's Anacortes refinery has a total crude oil capacity of 119,000 barrels per day (*Anacortes Refinery*, 2023). Phillips 66 Ferndale refinery has a process capacity of

approximately 105,000 barrels of crude per day (Phillips 66, 2023). The smallest refinery, U.S. Oil & Refining has a total capacity of 42,000 barrels per day (Pacific, n.d.). The Energy Information Administration (EIA) expects total refining capacity in Washington to be approximately 648,200 barrels per day in 2023 (*Washington Refinery Operating Atmospheric Crude Oil Distillation Capacity as of January 1 (Barrels per Calendar Day)*, 2023). While some greenhouse gas emissions from refineries are from flaring or fugitive sources, the majority are from fuel gas combustion from stationary combustion units that occur during the refining process ("2013 GHGRP Industrial Profiles," 2013). Greenhouse gas emissions are calculated based on production rates.

Discussion of Impacts & Challenges Refineries Face

High Costs and Cost Uncertainties

Currently, under the Climate Commitment Acts Cap-and-Invest program, refineries, and other covered entities are experiencing high costs and cost uncertainties. While it is difficult to accurately predict, the Washington State Department of Ecology, the body responsible for implementing and enforcing the policy, estimated that the Climate Commitment Act would have an overall economic impact of 1%-3% (*Economic Impacts - Washington State Department of Ecology*, n.d.). However, the direct economic impact on oil refineries could vary greatly due to several factors, a significant one being the cost of carbon. An analysis performed by Chaumontet et al. indicated that a carbon price of $100 per ton would add between $2-$4 per barrel to refinery operating costs. They stated that given that refineries historically operate at low margins, this additional cost could have significant risks to the refinery's ability to stay competitive (2023). In a 2012 study, Mertens showed that "depending on carbon price and refinery footprint,

the impact on refinery margin can vary from a marginal 0.1$/bbl to a hefty 3$/bbl" (2012). The uncertainty of financial impacts was demonstrated in a report on the effects of carbon pricing on the oil refining industry in Spain by Linares and Santamaria. In their report, they showed that the complexity of the oil refining industry makes it difficult to accurately predict the full economic impacts of carbon pricing policies. They stated that …"it is difficult to draw conclusions for this sector. Prices of refined products are volatile and the profit margin is so thin that it is very difficult to predict future trends for this industry" (2012).

While the cost of allowances in Washington's market has not yet reached $100 per ton, economic modeling done in 2022 suggests that they are likely to reach that price point sometime between 2023-2030 (Washington State Department of Ecology, 2022). Allowance prices have steadily increased with each auction the state has held since the cap-and-invest rule was implemented. For the allowance auctions that took place in 2023, the Washington State Department of Ecology (DOE) set the allowance floor price at $22.20, but actual settlement prices have significantly exceeded this. According to Hupp "The settlement price for the February 2023 auction was $48.50, and auction proceeds totaled almost $300 million. The settlement price for current-year allowances at the May 2023 auction was $56.01, and the auction of current-year and future-vintage (2026) allowances totaled $557 million. The settlement price for the August 2023 auction of current-year allowances was $63.03" (2023).

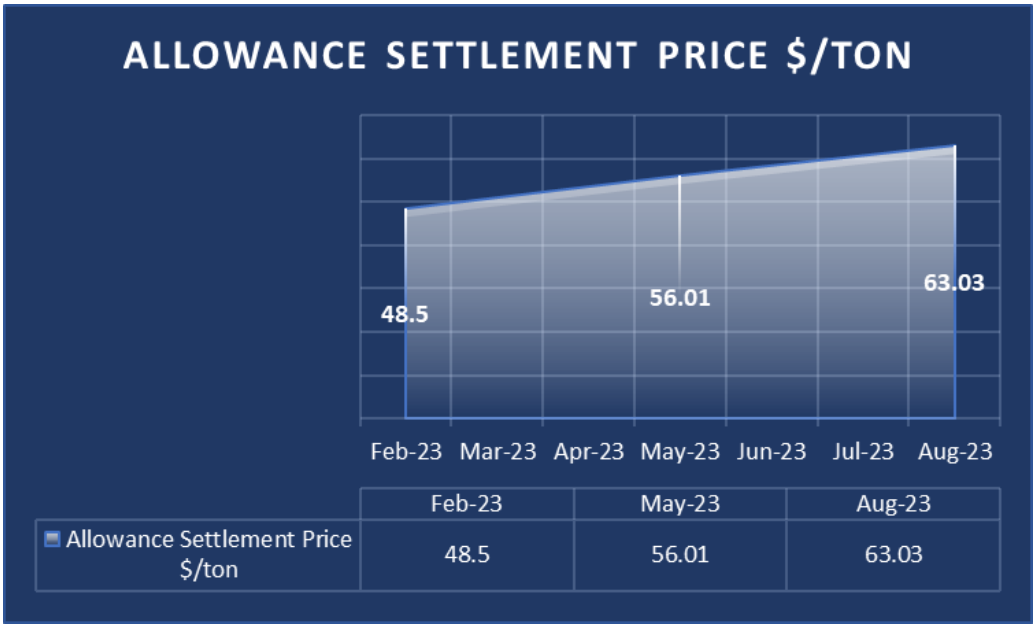

Figure 1:(Data from State of Washington Department of Ecology 2023 a,b,c)

Energy Intensive, Trade Exposed Industry

Kuik and Hofkes stated that "While in a textbook cap-and-trade system the modalities of the initial distribution of allowances should not matter for the final outcomes in terms of prices and activity levels (and therefore on competitiveness), in a real-world and imperfect system…the way of allocation of the allowances (free versus auctioned) might well matter to the extent that free allocation would give some relief to sectors that are particularly exposed to foreign competition" (2010). One of the main challenges of carbon pricing policies is the effect they can have on the competitiveness of businesses that are exposed to international or interregional trade. Carbon pricing, whether in the form of a straight carbon tax or a cap-and-trade program, increases costs for the entities that are subject to them, while those outside the jurisdiction of the policy do not face the same cost increases. When the covered entity is energy intensive, either due to the direct combustion of fossil fuels or high reliance on electricity, it is left particularly

vulnerable to market competitiveness and often unable to compete with outside sources. These entities are referred to as Energy Intensive, Trade Exposed (EITE) industries (or sometimes Emissions Intensive, Trade Exposed). The environmental benefits of implementing a carbon tax can be lost as a consequence of these industries succumbing to their reduced ability to compete. The emissions are simply displaced rather than truly abated as a result of a consequential shift in market share to producers in other regions that have weak or non-existent carbon pricing policies (Parry et al., 2015).

In order to avoid this displacement of emissions, known as carbon leakage, the Climate Commitment Act provides considerations for around 40 facilities in the State that it considers to be EITEs, including all five oil refineries. These facilities receive a certain portion of their emissions allowances for free through 2034. The amount they receive is based on a carbon intensity benchmark of their emissions for 2015-2019. The amount of emissions generated by producing a set volume of product determines the carbon intensity benchmark for each facility. If a facility increases their production volume, their emissions will also increase, and if they reduce production, their emissions will decrease.

From 2023, when the rule was first implemented, through 2034, has been broken up into three compliance periods. For the first compliance period, 2023-2026, EITEs will receive allowances equal to 100% of their carbon intensity benchmark or mass-based baseline, during the second compliance period, 2027-2030, they will receive 97%, and during the third compliance period, 2031-2034, they will receive 94% (*Emissions Intensive Trade Exposed Industries - Washington State Department of Ecology*, n.d.). There are currently no plans in place to offer allowances or assistance to EITE industries after the third compliance period ends. During the 2022 Legislative session, the Washington State Department of Ecology proposed

legislation (HB 1682) that would have created a pathway for EITE allowances for 2035-2050, however, the legislation did not pass (*Emissions Intensive Trade Exposed Industries - Washington State Department of Ecology*, n.d.-b).

Baseline Emission Exceedances

The baseline carbon intensity for emissions allowance allocations for oil refineries was determined using the historical data that they reported for 2015-2019. In determining the baseline, the Department of Ecology did not allow for adjustments of abnormal years. Oil refineries perform large projects every few years, called turnarounds, where they shut down multiple units for several weeks in order to perform maintenance that cannot be done under normal operating conditions. A refinery will report less emissions during a year with a large turnaround than during a normal operating year due to the significant decrease in run time and energy expenditure. Any refineries that went through turnarounds, or other significant periods of downtime during the 2015-2019 baseline years will have a carbon intensity benchmark that is skewed low due to the reduced production volume. Refiners will be forced to purchase allowances to make up the difference between its actual emissions and the no- cost allowances it is given from the state if it exceeds its baseline (*Emissions Intensive Trade Exposed Industries - Washington State Department of Ecology*, n.d.-b). The same applies to any emission increases resulting from operational upgrades or changes that have occurred since the baseline years.

Total Refinery Emissions (MTCO2e) 2015-2019					
Year	bp Cherry Point Refinery - Blaine	HollyFrontier Puget Sound Refinery LLC - Anacortes	Marathon Anacortes Refinery - Anacortes	Phillips 66 Ferndale Refinery - Ferndale	U.S. Oil & Refining Co.- Tacoma
2015	1,995,759	1,946,838	1,288,787	749,019	139,259
2016	2,130,008	1,980,495	1,359,988	767,579	146,049
2017	2,060,243	1,897,818	1,359,656	748,762	142,341
2018	1,987,668	1,989,609	1,234,174	798,454	139,445
2019	2,190,530	1,859,842	1,421,372	835,061	155,836
Average	**2,072,842**	**1,934,920**	**1,332,795**	**779,775**	**144,586**

Table 1:(Data from: State of Washington Department of Ecology, 2023)

There is no clear, publicly available data from the oil industry in Washington State on their exact baseline or how many no-cost allowances they receive. The Department of Ecology does not identify who participates in auctions or how many allowances participating entities purchase. However, data from EIA shows that total refinery capacity in Washington has increase from 631,700 barrels per day in 2015 up to 648,200 barrels per day in 2023 (*Washington Refinery Operating Atmospheric Crude Oil Distillation Capacity as of January 1 (Barrels per Calendar Day)*, 2023). As production rate and emissions are directly related, an increase in refinery capacity is a good indicator of an increase in emissions.

Between 2023-2034, refineries are receiving crucial financial assistance in the form of no- cost allowances, in order to meet their compliance requirements. The financial implications of purchasing allowances for emissions over their baseline still has the potential to be significant as the percentage of free allocations reduces with each compliance period. However, with no pathway for offering free allowances or assistance to EITE industries after the third compliance period, the cost burden of the cap-and-trade program, as it is now, could have devastating consequences for the oil refining industry in Washington.

Carbon Market Fragmentation

Stonestreet et al. noted that the full benefits of carbon trading cannot be realized when there is high market fragmentation. The fungibility of a market is impacted due to the lack of standardization, and widespread inconsistencies (2023). Arroyo-Currás et al. stated that:" Regionally fragmented climate policy regimes are prone to carbon leakage between regions" … and that "action on climate change mitigation is emerging in a fragmented manner. A fragmented climate regime is characterized by unequal carbon prices across regions and sectors. However, in the short- and medium-term, carbon leakage may impact the effectiveness of overall mitigation" (2015).

Washington's program is not the only cap-and-invest market on the west coast. California launched its program in 2013, and linked with Quebec's program in 2014. The combined California/ Quebec market is now the fourth largest emissions trading program in the world (Center for Climate and Energy Solutions, 2021).

Having two carbon markets with drastically different carbon prices geographically near to each other creates concerns around the competitiveness impacts of emissions trading systems. Historically, California's strict specification for CARB's reformulated gasoline has led to it being an insulate market (Scheyder, 2016). Very few refiners outside of the state are able or willing to produce the one-off blends that meet the States specs. These strict requirements have led to California having the highest retail cost of gasoline in the country. Data from the Energy Information Administration (see Appendix A for full data set) shows that Washington's retail gasoline prices for all grades and all formulations, tend to be just under California's (U.S. Energy Information Administration, 2023).

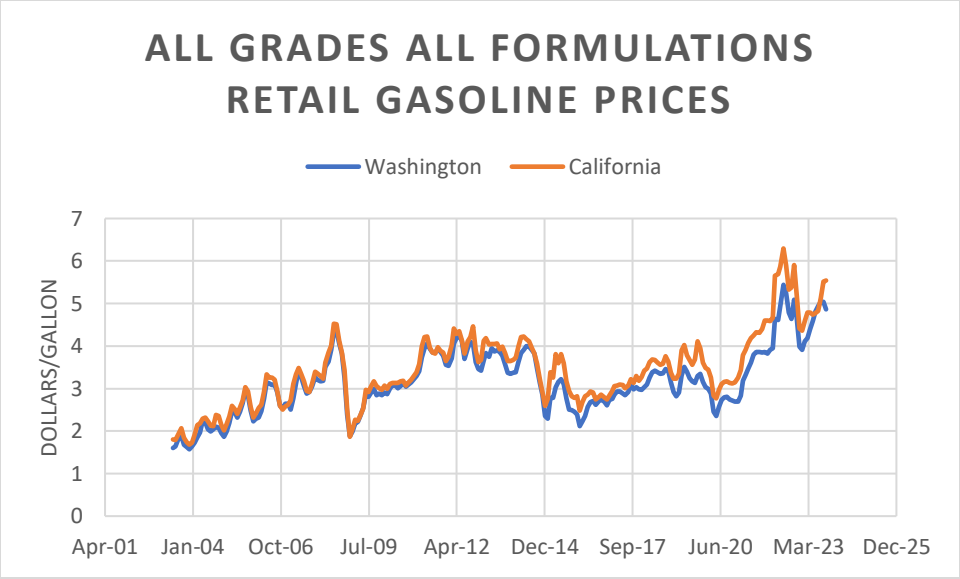

Figure 2:(Data from: U.S. Energy Information Administration, 2023)

During California's third quarter auction, in August of 2023, the allowance price reached its highest ever peak of $35.02 per ton (*Cap-and-Trade Program Data Dashboard | California Air Resources Board*, n.d.). Washington's first auction allowance price in February of 2023 was $48.50 (State of Washington Department of Ecology, 2023a), the second in May 2023 rose to $56.01 (State of Washington Department of Ecology, 2023b), and the state's third ever auction settlement price hit $63.03 (State of Washington Department of Ecology, 2023c). Gasoline prices in Washington overtook those in California for the first time ever in June 2023 (Santos, 2023). This increase in gasoline prices was credited my many to have occurred due to the state's high allowance costs as refiners and distributors pass on the costs of compliance to consumers. While there is little data to support these claims at present, it is possible that if the two markets continue to operate separately, the rising cost of Washington's allowances has the potential to lead to the state's gasoline prices outpacing California's gasoline prices permanently.

Historically, demand for refined products doesn't decrease significantly as prices rise. According to Hamilton, the price elasticity (the change in demand as a result of a change in price) of demand for oil products is low (2008). Consumers tend to continue to purchase the oil products they need, such as gasoline and diesel, regardless of cost. This means that demand for these products will not decrease while the transportation sector still depends on them. Consumers may look to outside markets in order to meet the demand of essential products at lower costs.

The unequal compliance costs for vulnerable sectors in similar markets in the same region can create high risk for shifting production and emissions from the higher compliance cost jurisdiction to one with lower compliance costs. Kuik and Hofkes noted that fragmented carbon emission reduction policies increase emissions in non-regulated regions due to their impact on energy commodity prices. They said that "By limiting CO_2 emissions in one sector in one region, changes in energy prices affect energy-related production and consumption decisions in all sectors in all other regions" (2010).

Clean Fuel Standard

In 2021, the Washington State Legislature passed a second climate related law that was meant to work along with the Climate Commitment Act to reduce greenhouse gas emissions. The Clean Fuel Standard is a market-based policy that requires transportation fuels to meet certain carbon intensity targets within a specified timeframe, and could arguably have greater economic impact to oil refiners in the short-term than the cap-and-invest program.

The carbon intensity targets are based on the average greenhouse gas emissions of the fuel being considered, and become stricter over time. In general, CFS policies give the regulated entities flexibility in determining the best method to comply with the set targets, usually based on

market conditions or ease/ cost of implementation (Bracmort, 2021). Washington's policy targets a total greenhouse gas emission reduction goal of 4.3 million metric tons per year by 2038. It aims to accomplish this by gradually reducing the carbon intensity of transportation fuels annually, down to 20% below 2017 levels by 2034 (*Clean Fuel Standard - Washington State Department of Ecology*, n.d.).

Under the rule, transportation fuels are assessed to determine the carbon intensity of their lifecycle based on a how they were manufactured and delivered to the state for end use (*Requirements - Washington State Department of Ecology*, n.d.). Producers of fuels that have a carbon intensity above the compliance period standard will generate deficits and will be required to purchase credits to make up the difference. Producers of fuels with a carbon intensity below the compliance period standard will generate credits that they can keep for later use or sell to other producers with higher carbon intensity fuels.

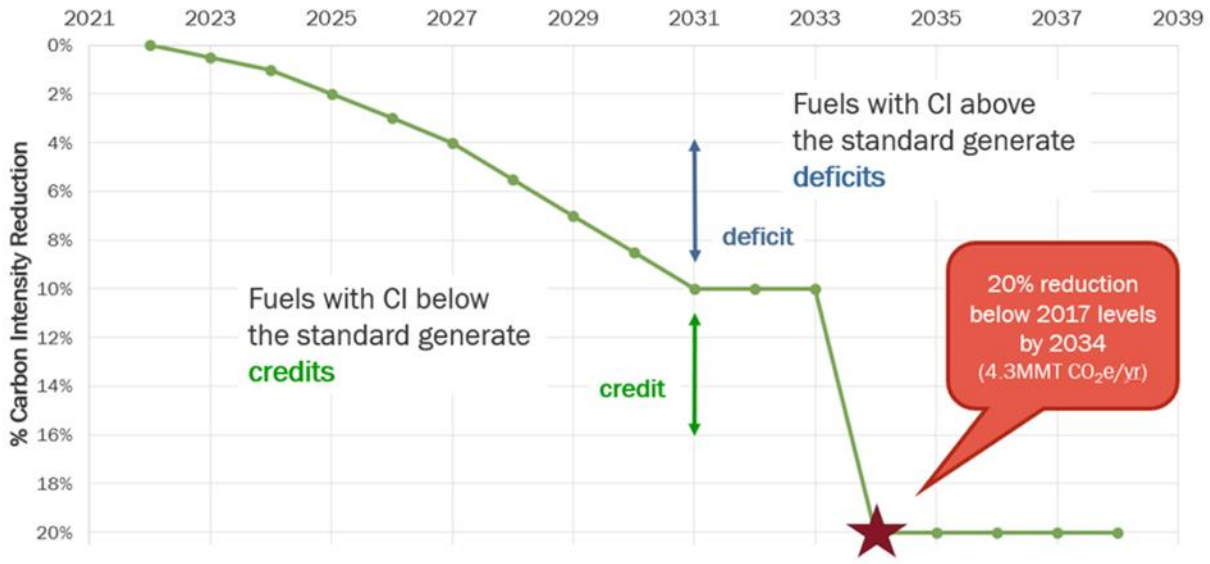

Figure 3:(Requirements- Washington State Department of Ecology, n.d.)

Refineries, as fuel producers, are considered to be EITE industries under the Cap-and-Invest program and are therefore granted a certain number of carbon allowances annually for the first three compliance periods. This allows them to avoid the worst economic impacts for some time. The Clean Fuel Standard, however, has economic impacts for fuel suppliers such as refineries beginning in the very first year of implementation. The state has implemented a participation fee that is separate and additional to the compliance costs. In the first year, 2023, entities that generate a deficit will pay 95% of the programs budget ($50,649 each), and entities that generate credits will pay the remaining 5% ($982 each) (*Requirements - Washington State Department of Ecology*, n.d.). For small entities, these fees could present economic challenges, however, for oil refineries, the impact will be minimal. The highest costs for refiners will be purchasing the credits required to cover the deficit between the carbon intensity of their fuels and the carbon intensity limits set by the state. The chart below outlines the total number of credits sold, their total value, and the average price per credit, as of October 2023:

Year	Month	Total Credits	Total Credit Value	Avg. Price per Credit
2023	September	51,322	$4,940,498.00	$96.26
	August	27,055	$2,885,775.00	$106.66
	July	-	-	-
	May	-	-	-
	2023 total	**78,377**	**$7,826,273.00**	**$99.85**
GRAND TOTAL			**$7,826,273.00**	**$99.85**

Figure 4: (Washington State Department of Ecology, 2023)

Every year, credit generators will generate fewer and fewer credits as the gap between the carbon intensity of their fuels and the standards set by the state closes. This will lead to a reduced number of credits available on the market for refiners and other fuel suppliers to purchase. The average cost per credit in 2023 was a little under $100, this will increase annually with dwindling

supplies if fuel producers do not take additional steps to reduce the carbon intensity of their fuels.

Conclusions and Recommendations

The oil refining industry has played an essential role in powering the country's transportation sector. While the United States is actively working at an aggressive pace to transition to electric vehicles and other electrified processes, demand for finished oil products will not turn off overnight. The over 287 million internal combustion vehicles on the road today will need to be phased out slowly, and finding viable substitutes for difficult-to-electrify vehicles, such as those used for trucking, shipping, and aviation, has not been simple (Dellesky et al., 2021). Shutting down Washington's oil refineries prematurely would have negative economic impacts on both the economy and the people living within the state. The refineries, and the products they provide, will continue to play an important role during the energy transition, and both the state and oil refiners need to take steps to ensure they remain financially competitive.

Policy Updates (What Can the State Do?)

- Linkage with California and Quebec

Linking carbon markets together means that they have a shared pool of allowances and conduct one auction covering both jurisdictions. Linking Washington's Cap-and-Invest program with California and Quebec's program could be beneficial for all three markets, and for covered entities. It could not only lead to lower compliance costs, but could also increase emission reductions, and increase the stability of the carbon markets.

High carbon allowance costs may lead policy makers to shy away from ambitious emission reduction targets. “When it costs less to reduce emissions, it becomes affordable to cut even more tons” (Jones, 2023). The lower cost of compliance can allow for more stringent and ambitious reduction targets, which can lead to deeper emissions reductions in the most cost-effective manner. This was seen when California and Quebec first linked their markets in 2014. They were able to achieve greater reductions at lower costs than either had been able to achieve independently (Jones, 2023). If refineries have to spend less on purchasing emissions allowances, they can feasibly spend more on technology that allows them to reduce emissions. “Research has shown that larger markets are more liquid, reduce price volatility, and result in lower cost emissions reductions. Studies have also suggested that entities operating in larger carbon markets rather than multiple smaller markets are more likely to invest in clean technologies, as afforded by a more standardized and stable regulatory environment. Joining the substantially larger combined California-Québec market will make it easier for Washington entities to reduce their compliance costs – both by reducing allowance prices and by expanding market demand for cleaner technologies and energy sources” (Climate Commitment Act Implementation Group, 2023).

- Linkage leads to reduced compliance costs

Marginal abatement costs are the amount that will be spent to reduce greenhouse gas emissions by one ton. For example, a refinery implementing a technological change that uses less energy will also reduce emissions, and will therefore be required to purchase fewer emissions allowances. The refinery will incur the upfront cost of the technological change, but will save money on long-term energy and compliance costs. The abatement cost, measured in dollars per ton of carbon not emitted, can be positive, or negative (as is likely the case with the

technological change example, given that the new technology is more energy-efficient), depending on the total additional cost (investment cost plus difference in operating costs) divided by the avoided emissions (World Bank Group, 2023). “Negative abatement costs correspond to opportunities to reduce emissions with a net economic gain. And the lowest abatement costs indicate opportunities to avoid emissions at low cost. If you have a budget of x million [dollars] to reduce emissions, then choosing the lowest abatement costs will [maximize] emissions reductions” (World Bank Group, 2023).

The marginal costs of abatement and compliance for businesses subject to an emissions trading system, as well as the government's administrative costs, are used to determine an emissions trading systems economic efficiency (Narassimhan et al., 2018). The balance between the supply, which is controlled by policymakers, and demand, which is dependent on a variety of broader economic and technological trends, determines the allowance price, which means that it can change significantly over time (PMR & ICAP, 2021). According to Belcher et al., “Washington’s Climate Commitment Act makes the state the country’s frontrunner on climate action, with the most ambitious enforceable limits on climate pollution of any state in the nation” (2023). California’s Cap and Trade Program, which started in 2013, requires a 2% reduction in emissions annually, whereas Washington’s program requires a much more aggressive 7% annual reduction. The states aggressive timeline can lead to higher costs.

The figure 4 illustrates a scenario indicative of the impact of linking on the marginal abatement costs (MAC) of two entities, as laid out by Erdmann and Zaklan (2018). The horizontal axis is the emissions reductions and the vertical axis shows the MAC per ton of emissions. Entity A and B start out in separate markets, with entity A’s market having a lower initial MAC than entity B’s, and both markets having the same reduction targets (q_{aut}). Under

independent markets, entity A's costs will be much lower (P^{A}_{aut}), than entity B's costs (P^{B}_{aut}), to reach the reduction target goal. The linking of the two markets entails a financial transfer from jurisdiction B to jurisdiction A. Once the link is established, entities in both jurisdictions may trade all certificates in the common market. Entity B gains access to less expensive carbon reduction options in jurisdiction A and shifts a portion of its abatement abroad, lowering their costs. The entity in jurisdiction A abates more than it did before the link, up to the point q_{link}, and sells its excess allowances to entities in jurisdiction B (Erdmann, 2018). After the markets link, the allowance price becomes equal for both entities, converging at P^{A}_{link} and $P^{B}_{link.}$ Total emissions remain the same, but jurisdiction B gains from a less costly abatement, while jurisdiction A gains from an influx of trading revenue. The blue and red areas represent the respective gains in cost effectiveness for the two jurisdictions (Erdmann, 2018).

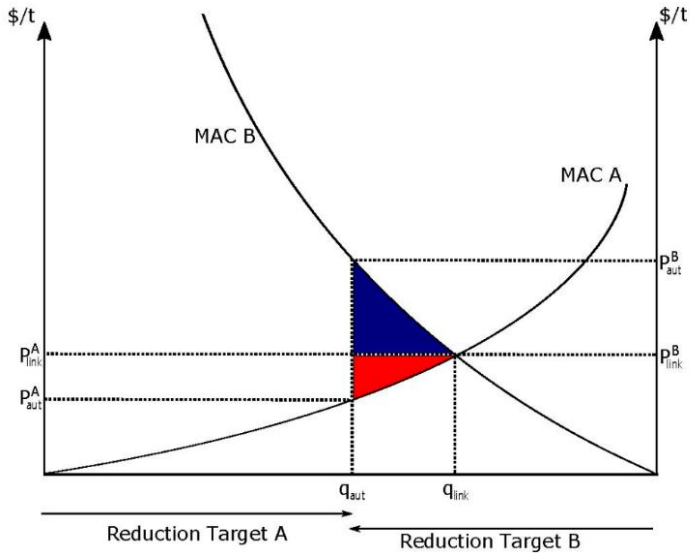

Figure 5:(Erdmann & Zaklan, 2018)

- Stability/ Liquidity of a Carbon Market

Linking markets can lead to increased stability and liquidity of the market. Individual participants can more easily buy and sell allowances in a stable market without significantly influencing prices. The cost effectiveness of allowance markets can benefit greatly from increased liquidity that reduces the influence of any single participant on the overall market (Hahn, 1984).

Larger markets, that result from linkage, have a larger number of participants both buying and selling allowances. According to Flachsland et al., this increase in participation can lead to increased liquidity, especially for smaller markets (2009). It can also lead to improved price predictability: "Another advantage of linking is that a larger, deeper market with a variety of participants from different sectors and geographies can reduce price volatility, as shocks to any one system are spread across the broader linked network. Larger, more diverse systems will be able to better absorb day-to-day, company-, industry-, or jurisdiction-specific shocks, as it is less likely that all actors in the linked market will be simultaneously hit by the same economic shock" (PMR & ICAP, 2021).

- Reduce Offset Prices

One optional tool available to Refineries is the use of offsets. Washington's Cap-and-Invest program allows for the limited use of offset projects that are "real, quantifiable, verifiable, enforceable, additional and demonstrate direct environmental benefits to the state" (*Washington Cap-and-invest Offsets - Climate Action Reserve*, 2023). Offset credits are compliance instruments used to give a covered entity a return for their investment in an offset project. The credits can then be used to cover emissions, saved for future compliance periods, or sold on the market (*Offsets - Washington State Department of Ecology*, n.d.).

Washington State allows for limited use of offsets to cover emissions. For the first compliance period (January 2023- December 2026), emitters may use offset credits to cover up to 8% of their emissions (5% from projects on non-federally recognized tribal lands, and 3% from projects on federally recognized tribal lands). Currently, all offset projects are required to provide direct environmental benefits (DEBs) to Washington. However, if the programs were to link, that requirement would be reduced and some offset projects located in the linked jurisdictions would be allowed. Even though the cost of offset projects in Washington State is currently unknown, the Climate Commitment Act Implementation Group believes linking with California and Quebec's programs would lead to lower project costs. In a report commissioned by the Washington State Department of Ecology, they said, "As of August 2023, no offset credits have yet been issued under the cap-and-invest program, so we do not currently have data on offset credit prices in Washington. However, we expect that the price of offset credits from projects that provide DEBs to Washington will be lower after linkage because covered entities will be able to meet a portion of their compliance obligation with non-DEBs offset credits" (Climate Commitment Act Implementation Group, 2023).

- APCR Auctions

Washington's Cap-and-Invest policy has an Allowance Price Containment Reserve build in to the program. It is a price containment mechanism that is used to increase price stability and predictability. The ACPR allowances are from the overall allowance budget, but are set aside for use if needed. In an attempt to stabilize the allowance market, the Department of Ecology offered 5 million allowances during a November 2023 APCR auction. They were offered at the lower price of $51.90 per allowance. The DOE is also working to contain compliance costs by clarifying the acceptable uses for APCR allowances. APCR allowances are intended to only be

used for compliance purposes, and not to be sold or traded on the secondary market. These clarifications are meant to help control the cost of compliance and ensure that covered entities can procure the necessary allowances needed at a reasonable price (Hupp, 2023).

Market Based Opportunity (What Can Refineries Do?)

"Similar to policy, business model and practices are an important lever for decarbonization" (Griffiths et al., 2022). Washington's refineries are facing significant compliance and administrative costs as a result of the States GHG emission reduction goals and the implementation of this and other climate related policies. However, the market-based nature of the cap-and-invest programs can lead to financial opportunities for businesses that achieve sufficient emissions reduction or carbon-intensity improvements. Even though the new policies, which are intended to allow the state to reach its emissions reduction goals, are still in the early stages and their future success is unclear, businesses should immediately begin to take meaningful steps to carefully plan strategies for long-term compliance

- ### Early Birds Get the Benefits

A facility covered by the Climate Commitment Act that has extra allowances may trade or sell them to a company that is unable to lower emissions due to financial or technological limitations, or they may bank the allowances for use in a later year (Hupp & Carmody, 2023). A study conducted by Sanderson and O'Neill, showed that "optimal simulations with abatement starting in the present day show a much more rapid rate of change in emissions than simulations starting in 1980,"and that "The difficulty and cost associated with delayed action towards meeting a…target are likely to increase over time" (2020). The cost of attempting to meet a specific emission reduction target by a specified date increases with delayed implementation

dates (Shadbegian et al., 2015). Companies that are ahead of the curve in decarbonization may be able to secure early contracts in expanding markets and generate revenue more quickly than their competitors; however, this advantage will decrease and disappear as competitors catch up (Crispeels et al., 2023). Therefore, refineries and other impacted entities should begin implementing emissions reduction measures as soon as possible in order to avoid increased costs and to maximize the benefits of their investments.

- Make Decarbonization a Priority

One of the main barriers of refinery decarbonization is the lack of organizational and managerial support. Reducing emissions has rarely been prioritized over profits. Oil refineries generally operate under very slim profit margins, and are sensitive to shifts in crude oil prices. This is especially true for smaller, independent refineries. Griffiths et al. stated that "given the impact of market circumstances, reducing emissions has taken a backseat to the goal of enacting cost-saving measures, with greater focus on minimizing overall costs and increasing product throughput…thus, the capacity of the oil refining industry to pursue decarbonization interventions beyond those that are purely profit-driven may be limited to the financial bandwidth that companies have to explore such technologies. Hence… management resistance to decarbonization would be expected" (2022).

Refiners have an opportunity to shift away from this immediate profit driven strategy and focus on long-term financial viability by making emission reductions a priority. Reducing emissions early can lead to the maximum benefit for their investment, as noted previously. It can also lead to increased cost savings from improved energy efficiency and reduced long-term compliance costs. Strong organization and managerial support are needed in order for this to occur. Investment in new technologies, feedstocks, and operating practices that reduce emissions

is an approach that refiners can take to help satisfy their compliance obligations (Griffiths et al., 2022).

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Appendix A

Data 1: Washington All Grades All Formulations Retail Gasoline Prices (Dollars per Gallon)

(Data from: U.S. Energy Information Administration, 2023)

Month	Washington All Grades All Formulations Retail Gasoline Prices Dollars per Gallon	California All Grades All Formulations Retail Gasoline Prices Dollars per Gallon
Oct-23	4.862	5.546
Sep-23	5.043	5.52
Aug-23	5.035	5.13
Jul-23	4.935	4.823
Jun-23	4.811	4.781
May-23	4.593	4.74
Apr-23	4.395	4.787
Mar-23	4.182	4.786
Feb-23	4.111	4.591
Jan-23	3.915	4.368
Dec-22	3.99	4.418
Nov-22	4.655	5.173
Oct-22	5.093	5.905
Sep-22	4.644	5.375
Aug-22	4.789	5.333
Jul-22	5.238	5.897
Jun-22	5.44	6.294
May-22	4.936	5.871
Apr-22	4.615	5.692
Mar-22	4.634	5.655
Feb-22	3.946	4.66
Jan-22	3.908	4.584
Dec-21	3.826	4.597
Nov-21	3.857	4.598
Oct-21	3.848	4.4

Sep-21	3.859	4.31
Aug-21	3.864	4.319
Jul-21	3.798	4.253
Jun-21	3.604	4.182
May-21	3.477	4.068
Apr-21	3.316	3.911
Mar-21	3.187	3.781
Feb-21	2.828	3.434
Jan-21	2.696	3.262
Dec-20	2.688	3.143
Nov-20	2.721	3.115
Oct-20	2.75	3.137
Sep-20	2.806	3.174
Aug-20	2.79	3.156
Jul-20	2.737	3.102
Jun-20	2.574	2.972
May-20	2.356	2.771
Apr-20	2.455	2.827
Mar-20	2.888	3.262
Feb-20	2.994	3.447
Jan-20	3.029	3.489
Dec-19	3.163	3.61
Nov-19	3.348	3.944
Oct-19	3.294	4.116
Sep-19	3.134	3.687
Aug-19	3.17	3.555
Jul-19	3.242	3.668
Jun-19	3.392	3.787
May-19	3.513	4.019
Apr-19	3.313	3.894
Mar-19	2.905	3.342

Feb-19	2.818	3.236
Jan-19	2.916	3.232
Dec-18	3.146	3.368
Nov-18	3.42	3.632
Oct-18	3.453	3.76
Sep-18	3.353	3.588
Aug-18	3.343	3.556
Jul-18	3.381	3.605
Jun-18	3.42	3.673
May-18	3.389	3.69
Apr-18	3.261	3.617
Mar-18	3.101	3.476
Feb-18	3.027	3.418
Jan-18	2.966	3.269
Dec-17	2.986	3.187
Nov-17	3.028	3.294
Oct-17	2.981	3.137
Sep-17	3.095	3.22
Aug-17	2.922	3.073
Jul-17	2.841	3.005
Jun-17	2.878	3.08
May-17	2.934	3.101
Apr-17	2.938	3.067
Mar-17	2.86	3.059
Feb-17	2.761	2.946
Jan-17	2.743	2.848
Dec-16	2.601	2.738
Nov-16	2.689	2.788
Oct-16	2.747	2.862
Sep-16	2.707	2.803
Aug-16	2.615	2.745

Jul-16	2.7	2.911
Jun-16	2.68	2.93
May-16	2.567	2.855
Apr-16	2.349	2.822
Mar-16	2.235	2.679
Feb-16	2.111	2.477
Jan-16	2.39	2.823
Dec-15	2.451	2.776
Nov-15	2.494	2.819
Oct-15	2.504	2.945
Sep-15	2.764	3.175
Aug-15	3.102	3.594
Jul-15	3.221	3.812
Jun-15	3.152	3.596
May-15	3.028	3.804
Apr-15	2.784	3.261
Mar-15	2.786	3.388
Feb-15	2.287	2.756
Jan-15	2.351	2.596
Dec-14	2.859	2.916
Nov-14	3.149	3.234
Oct-14	3.466	3.585
Sep-14	3.82	3.821
Aug-14	3.91	3.961
Jul-14	3.99	4.11
Jun-14	3.994	4.163
May-14	3.911	4.22
Apr-14	3.829	4.21
Mar-14	3.619	3.984
Feb-14	3.379	3.726
Jan-14	3.366	3.666

Dec-13	3.348	3.642
Nov-13	3.373	3.641
Oct-13	3.567	3.829
Sep-13	3.767	3.989
Aug-13	3.855	3.919
Jul-13	3.901	4.056
Jun-13	3.875	4.05
May-13	3.953	4.051
Apr-13	3.746	4.031
Mar-13	3.835	4.192
Feb-13	3.656	4.127
Jan-13	3.422	3.678
Dec-12	3.454	3.628
Nov-12	3.623	3.893
Oct-12	4.053	4.458
Sep-12	4.094	4.211
Aug-12	3.946	4.109
Jul-12	3.691	3.821
Jun-12	4.115	4.133
May-12	4.261	4.353
Apr-12	4.187	4.292
Mar-12	4.055	4.414
Feb-12	3.709	4.027
Jan-12	3.534	3.747
Dec-11	3.562	3.648
Nov-11	3.775	3.848
Oct-11	3.866	3.89
Sep-11	3.937	3.971
Aug-11	3.849	3.823
Jul-11	3.848	3.844
Jun-11	3.933	3.965

May-11	4.062	4.229
Apr-11	3.951	4.206
Mar-11	3.733	4.002
Feb-11	3.407	3.576
Jan-11	3.293	3.389
Dec-10	3.223	3.297
Nov-10	3.147	3.205
Oct-10	3.095	3.146
Sep-10	3.047	3.064
Aug-10	3.149	3.186
Jul-10	3.061	3.171
Jun-10	3.012	3.134
May-10	3.077	3.136
Apr-10	3.085	3.138
Mar-10	2.993	3.104
Feb-10	2.867	2.993
Jan-10	2.908	3.065
Dec-09	2.839	2.964
Nov-09	2.885	3.006
Oct-09	2.841	3.062
Sep-09	2.989	3.169
Aug-09	2.908	3.057
Jul-09	2.808	2.92
Jun-09	2.858	2.969
May-09	2.539	2.531
Apr-09	2.364	2.377
Mar-09	2.213	2.239
Feb-09	2.178	2.265
Jan-09	1.996	2.051
Dec-08	1.883	1.871
Nov-08	2.384	2.507

Oct-08	3.251	3.44
Sep-08	3.827	3.842
Aug-08	4.066	4.128
Jul-08	4.358	4.511
Jun-08	4.327	4.531
May-08	3.908	4.015
Apr-08	3.64	3.846
Mar-08	3.509	3.609
Feb-08	3.178	3.231
Jan-08	3.171	3.296
Dec-07	3.205	3.353
Nov-07	3.271	3.394
Oct-07	3.05	3.112
Sep-07	2.921	2.922
Aug-07	2.879	2.948
Jul-07	3.052	3.174
Jun-07	3.255	3.329
May-07	3.441	3.485
Apr-07	3.124	3.339
Mar-07	2.77	3.105
Feb-07	2.5	2.713
Jan-07	2.64	2.616
Dec-06	2.649	2.587
Nov-06	2.544	2.508
Oct-06	2.599	2.593
Sep-06	2.905	2.937
Aug-06	3.094	3.212
Jul-06	3.077	3.26
Jun-06	3.124	3.26
May-06	3.147	3.337
Apr-06	2.76	2.925

Mar-06	2.473	2.624
Feb-06	2.322	2.54
Jan-06	2.294	2.424
Dec-05	2.232	2.319
Nov-05	2.478	2.57
Oct-05	2.827	2.926
Sep-05	2.959	3.032
Aug-05	2.651	2.721
Jul-05	2.458	2.559
Jun-05	2.319	2.41
May-05	2.447	2.52
Apr-05	2.462	2.596
Mar-05	2.186	2.346
Feb-05	1.995	2.163
Jan-05	1.87	2.016
Dec-04	1.956	2.143
Nov-04	2.084	2.35
Oct-04	2.101	2.376
Sep-04	2.038	2.115
Aug-04	1.993	2.131
Jul-04	2.037	2.233
Jun-04	2.207	2.322
May-04	2.246	2.298
Apr-04	1.961	2.185
Mar-04	1.851	2.143
Feb-04	1.729	1.914
Jan-04	1.64	1.722
Dec-03	1.572	1.681
Nov-03	1.625	1.74
Oct-03	1.677	1.839
Sep-03	1.894	2.068

Aug-03	1.798	1.913
Jul-03	1.639	1.789
Jun-03	1.607	1.809