A Refining History of Washington State

Energy Transitions Laboratory
Western Washington University
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ABOUT THE ENERGY TRANSITIONS LABORATORY

The Energy Trans Lab at Western Washington University is a place where undergraduate and graduate student researchers and faculty work together to enhance our understandings of the energy transition. Our focus is on historical and contemporary changes to energy systems in Washington State and the Pacific Northwest.

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AUTHORS AND INVESTIGATORS

Will Smith

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ABSTRACT

Possessing over a quarter of the nation’s installed hydroelectric capacity, Washington State is often touted for is green electricity grid. Reliance of fossil fuels, specifically natural gas and coal, is relatively low as 70 percent of electricity consumed in state is hydroelectric generation. Washington (hereafter referring to Washington state) also boasts the seventh greatest installed wind capacity as of April 2015. But a comprehensive discussion of energy moves beyond the electricity grid; the greater energy landscape is a complex ensemble of infrastructure, investment and information, fueled by public perception, policy initiatives, economics and expectations, among others.

While Washington does not produce any oil, it is the refining capital of the Northwest with the fifth most refining capacity of any state in the nation. This industrial presence is sometimes overshadowed in energy discussions by Washington’s relatively renewable electricity grid. This paper seeks to elucidate the history of the petroleum industry’s downstream presence within the state, with a specific focus on refining. How did Washington’s energy landscape arrive at where it is today? Any discourse regarding Washington’s energy future lacks a publically available, comprehensive history of the oil refining industry, which inhibits informed, democratic dialogues regarding current and future energy policies and investments.

Washington sits strategically positioned between various production zones and export markets. A number of policy issues are currently up for debate at the state and municipal levels; chief among them are Clean Fuel Standards, Carbon Pricing, Fossil Fuel Exports, Oil Trains and various proposals for new investment in oil-related infrastructure. While a discussion of these policy initiatives is beyond the scope of this paper, detailing the landscape of fixed infrastructure and interests provides a foundation for assessing future decision paths.

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1. INTRODUCTION TO PETROLEUM REFINING IN WASHINGTON STATE

Washington is the oil refining capital of the Northwest and has the fifth highest refining capacity of any state in the nation. As of 2015, there are 5 refineries in the Washington with a joint capacity of 631,700 barrels per day.

Washington’s isolation from the country’s vast pipeline network (see Figures 8 and 9 on page 19) and its dependence on local petroleum markets ensures the refineries are crucial for providing energy that fuels the regional economy. The location of these facilities is strategically positioned to source crude from the Bakken shale play in North Dakota, Alberta’s oil sands, and Alaska’s North Slope to markets along the West Coast and the growing economies of Asia.

Canada, Alaska and foreign crude sources are the historic inputs for Washington’s refineries. In 2011, the last full year that crude import data is available, Alaska and Canada provided the majority of crude supply at 58 and 21.5 percent respectively. Russia was third at 8.5 percent with the remaining 12 percent received from a combination of unknown, Middle Eastern, South American and mixed origin sources in that order of significance. It should be noted that Washington’s refineries began receiving Bakken crude from North Dakota in 2012.

While total refining capacity comprises 3.5 percent of U.S. capacity, Washington accounts for only 2 percent of national petroleum consumption. This makes the state a net exporter of refined products as Washington’s refineries yield more products than the population consumes. Approximately 51 percent of end products are consumed in state with the remainder going out of state and abroad. In 2011, the last year full data is available, 35 percent of finished products were exported to domestic consumers, chiefly in Oregon and California. The remaining 14 percent of output was shipped abroad with the lion’s share to British Columbia.

1.1. Exports to Oregon

Oregon lacks any refining capacity and imports 100 percent of its petroleum products. Washington’s refineries supply upwards of 90 percent of Oregon’s petroleum product by way of the Olympic Pipeline (see Figure 11 on page 20) and barge. California and Utah refineries

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2 Behind Texas, Louisiana, California and Illinois, respectively.
3 “Table 1. Number and Capacity of Operable Petroleum refineries by PAD District and State as of January 1, 2014.”
4 Oil is purchased from the marginally cheapest source considering cost per barrel and cost to transport. All seagoing oil competes on the world market. Supply chains constantly fluctuate such that not all crude owned by producers will end up at a refinery operated by the same producer. “Crude traders will sometimes swap cargoes depending on the financials, says Richard Ranger, a senior policy analyst with the American Petroleum Institute.” Hollander, Zaz. Alaska Business Monthly. “Following North Slope Crude: From the ground to the gas station.”<http://www.akbizmag.com/Alaska-Business-Monthly/May-2012/Following-North-Slope-Crude-From-the-ground-to-the-gas-station/?utm> 1 May 2012.
7 Bonlender, Page 29.
8 Bonlender, Page 29.
contribute the remainder. Distribution through Oregon largely originates at Portland terminals that distribute product via tanker truck, Columbia River barge service and the Kinder Morgan Energy Partners pipeline. The pipeline is a quasi-extension of the Olympic Pipeline that travels 115 miles from Portland to Eugene.\(^\text{10}\) On average, the Kinder Morgan pipeline moves 42,000 barrels of refined product per day.\(^\text{11}\)

### 1.2. Exports to California

California has the third greatest refining capacity in the U.S. with 1,876,171 barrels per day.\(^\text{12}\) Supply and demand of refined product is tight with petroleum consumption accounting for 91 percent of refining capacity.\(^\text{13}\) Washington is the marginal supplier of refined product, providing cushion for any supply and demand imbalances in California markets.

The California Reformulated Gasoline Program requires the entire state to use gasoline with minimal oxygen content that burns cleaner than conventional fuel.\(^\text{14}\) A number of other states are either required or opt to use reformulated gasoline in an effort to reduce smog-forming and toxic pollutants.\(^\text{15}\) 30 percent of U.S. gasoline is reformulated, however California’s Reformulated Gasoline Program uses a proprietary blend that differs from the federal reformulated standard. While the East Coast features ample production capacity for federal reformulated gasoline, only Washington and Gulf Coast possess refineries outside California capable of producing the reformulated gasoline required by California state law.\(^\text{16}\) The Gulf Coast refineries haven’t produced reformulated gasoline since 2011\(^\text{17}\) leaving Washington as California’s only out-of-state gasoline source.

### 1.3. Exports to British Columbia

There are only two refineries in British Columbia. They have a combined refining capacity of 67,000 barrels per calendar day.\(^\text{18}\) Those refineries utilize domestically produced crude that travels from Edmonton to Vancouver via Kinder Morgan’s 300,000 b/d Trans


\(^{11}\) EIA. “Regional Goods Movement System.”

\(^{12}\) “Table 1. Number and Capacity of Operable Petroleum refineries by PAD District and State as of January 1, 2014.”


\(^{14}\) Air Resource Board. CA.gov. “California Reformulated Gasoline Program.”


\(^{16}\) Energy Almanac. CA.gov. “California’s Oil Refineries.” [http://energyalmanac.ca.gov/petroleum/refineries.html]

\(^{17}\) EIA. Refinery Net Production of Reformulated Gasoline. [http://www.eia.gov/dnav/pet/pet_pnp_refp2_a_epm0r_ypy_mbbl_m.htm] 30 March 2015

Mountain pipeline. The only petroleum pipeline that crosses the Rocky Mountains, the Trans Mountain is also the only North American line capable of moving both crude and refined product. Edmonton refineries supply 50 to 60 percent of product consumed in the greater Vancouver, B.C. market with the remainder sourced from the 55,000 b/d Burnaby refinery in Vancouver. Washington provides the marginal refined product supply following the refineries in British Columbia and Alberta. Washington’s refineries provide a supply cushion that allows Canadian refineries to move product to the eastern provinces to cover shut-in capacity or demand fluctuations that unbalance provincial supply. Canada is a net exporter of refined product with 92 percent of those exports consumed in the U.S.

1.4. The Refiners & Refineries

For ease of understanding, this paper assigns each of the five current refineries in Washington a number (Refinery 1, 2, etc.), which is used to reference that plant throughout the paper. Over the past sixty years these facilities have changed hands frequently, thus referencing via owner can be confusing. They are numbered in the order they were built. Table 1 (on page 7) below gives the refineries as of 2015 by number alongside current owner, past owners, year constructed and barrels per calendar day capacity.

The following subsections provide a brief description of both the company behind the operations and the refinery. Many of these companies have billions of dollars worth of assets spread across the country or the globe. Often their downstream presence in Washington goes beyond the refinery in question, extending to terminals that act as transportation hubs and pipelines that move either crude or refined product. This paper is written in the context of understanding each Washington refinery, rather than exploring the vertically integrated operations of a supermajor oil company.

1.4.1. Phillips 66 Company

Phillips 66 Company operates Refinery 1 outside of Ferndale along with eight other refineries throughout the nation. Phillips 66 is the fourth largest U.S. refiner with a total capacity of 1,611,200 barrels per day and possesses more capacity outside the country. As a multinational pure-play downstream company the operations of Phillips 66 include refining, marketing, transportation and petrochemicals. Traded on the New York Stock Exchange under the PSX ticker, the Houston-based oil company reported net income of $4.2 billion in fiscal year 2014.

Refinery 1 has 101,000 b/d capacity and produces predominantly transportation fuels consumed in local markets. Its secondary processing facilities include a fluid catalytic cracker,

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20 Owned by Chevron.
an alkylation unit, hydrotreating units and a naphtha reformer. The plant follows a 10-5-3-2 crack spread, meaning that for 10 barrels of crude feedstock the refinery produces 5 barrels of gasoline, 3 barrels of distillate and 2 barrels of fuel oil. A refinery’s crack spread is dependent on the characteristics of its crude feedstocks and the equipment it employs. Crack spreads are commonly used as a proxy for refinery profitability by subtracting the per barrel price of crude inputs from the per barrel price of combined product outputs.

1.4.2.  Tesoro Corporation

Tesoro Corporation is a pure-play midstream company owning seven refineries, 2,264 retail stations and a litany of other transportation assets across the nation. Although the nation’s seventh largest refining company is based in San Antonio, Texas, the majority of its 844,160 b/d capacity is on the West Coast (PADD V). Tesoro’s stock trades on the NYSE under the TSO ticker. While smaller than the multinationals, Tesoro is a Fortune 500 company with net income of $0.9 billion. Tesoro is currently involved in a proposed joint operation with Savage Companies to construct a 360,000 b/d oil-by-rail distribution facility at the Port of Vancouver, Washington. The project would connect tight oil-by-rail supply lines to more economic transportation via barge for delivery to refineries in Washington and California. The permitting process is currently underway.

Refinery 3 has a 120,000 b/d capacity and is operated under the parent corporation’s Tesoro West Coast subsidiary. The plant’s configuration is similar to Refinery 1 where the integral conversion unit (for secondary processing) is a fluid catalytic cracker. Hence the crack spread will be comparable to Refinery 1’s 10-5-3-2. Gasoline, jet and diesel fuel are the primary products, which are supplied to end users predominantly in Washington and Oregon.

1.4.3.  Royal Dutch Shell PLC

Royal Dutch Shell PLC is a vertically integrated, multinational company with operations in 70 countries, whose global refining capacity is second only to ExxonMobil. Headquartered in the Netherlands and incorporated in the United Kingdom, Shell’s shares are traded on the London Stock Exchange, Euronet Amsterdam and the New York Stock Exchange under the RDS ticker.24 2014 net income was a reported $14.8 billion25 and its $420.4 billion26 in revenues ranked third among global public companies as reported by Forbes. Shell operates two U.S.-based, wholly owned midstream subsidiaries, Shell Oil Products US and Shell Chemical LP, which account for a total of 426,400 b/d capacity, constituting the fourteenth largest U.S. refiner. Shell’s impact on the nation’s refining industry is understated without mention of Motiva Enterprises LLC, a 50-50 joint venture between Shell and Saudi Aramco (Saudi Arabia’s nationalized oil company and the top global producer of crude). Motiva is a downstream

24 Shell has class A and B common stock whose only difference is that class A is subject to a Dutch dividend withholding tax of 15%. Hence the price discount of class A on the NYSE. 
<http://www.shell.com/global/aboutshell/investor/share-price-information/difference-a-b.html>
company that operates three Gulf Coast refineries, including the country’s largest in Port Arthur, Texas.

Shell Oil Products US operates Refinery 3 outside of Anacortes as the greatest single employer and taxpayer in Skagit County. The plant has a 145,000 b/d capacity with facilities that include a delayed coker, fluid catalytic cracker, polymerization unit and alkylation units. Based on the secondary processing units in place Refinery 2 likely follows a 3-2-1 crack spread. Shell’s refinery produces three grades of gasoline, fuel oil, diesel fuel, propane and butane. Refinery 2 is currently the only plant in Washington absent a facility to accommodate tight oil via rail. The permitting process is currently underway for the proposed 60,000 b/d unloading capacity of the East Gate Rail Project.

1.4.4. **U.S. Oil & Refining Company**

The U.S. Oil & Refining Company is the only privately owned refiner in Washington. However the company is owned by the TrailStone Group, a commodities logistics and trading firm, which is in-turn owned by the non-listed, energy-based Riverstone Holdings LLC equity firm. Company income and revenues are thus unavailable for U.S. Oil and its layered holding companies.

Refinery 4 is by far the smallest and simplest of Washington’s facilities with a 40,700 b/d capacity. Located on the deep-water Port of Tacoma, the facility operates as a topping plant, that is, absent any conversion units to crack the heavier, less-economical hydrocarbon products into the lighter, more profitable ones. Its crack spread is assumed to be 3-1-1-1. Most products are supplied to local margins with in the form of gasoline, diesel, marine fuel, jet fuel and asphalt. A direct product pipeline transports jet fuel to the nearby McChord Air Force Base.

1.4.5. **BP PLC**

BP PLC, like Shell, is a vertically integrated supermajor with upstream and downstream assets spanning the globe. BP is a top five global refiner with wholly owned plants ranging from Australia to Germany and jointly owned plants ranging from South Africa to Malaysia. Its U.S. downstream operations account for 649,000 barrels of U.S. refining capacity (making it the ninth largest refiner), distributed amongst three wholly owned subsidiaries that each control one refinery. The London-based Corporation has stock traded on the London, Frankfurt and New York Stock Exchanges, under the BP ticker. Reported net income was $2.9 billion and its $353.6 billion in revenues were matched by only four other listed companies in 2014, according to Forbes.

Wholly owned BP West Coast Products LLC operates Refinery 5 outside of Ferndale with a 225,000 b/d capacity. This subsidiary is directly controlled by BP America Inc., itself a subsidiary of BP PLC. Refinery 5 is the third largest on the West Coast and is the most complex of Washington’s facilities with coker and hydrotreater units capable of significant bottoms upgrading. Additional conversion units increase a plant’s flexibility to alter its outputs to meant

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27 For 3 parts crude, 2 parts gasoline and 1 part diesel is produced. The crack spread assumption for Refinery 2 comes an IRB sanctioned interview with an anonymous process engineer at one of the Puget Sound refineries. All future crack spread assumptions are based on that interview.

demand and to source different crudes while keeping the output constant. Refinery 5’s additional complexity makes the crack spread more ambiguous, however its spread is either a 2-1-1 or 3-2-1. Refinery 5 is the largest supplier of calcined coke (a co-product of bottoms upgrading) to the global aluminum industry such that one out of six aluminum cans worldwide is made of coke that may be traced back to BP’s facility. Like most others, Refinery 5 deals primarily in transportation fuels. Its scale and specifications make the plant a producer of 20 percent of the gasoline market in Washington and Oregon, the majority supplier of jet fuel to Vancouver, Seattle and Portland international airports and largest West Coast supplier of jet fuel to the U.S. military.

Table 1: Washington Refineries in 2015 by assigned number

<table>
<thead>
<tr>
<th>Refinery Number</th>
<th>Current Owner</th>
<th>Past Owners</th>
<th>Year Constructed</th>
<th>Major Products 29</th>
<th>Current Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Phillips 66</td>
<td>ConocoPhillips, Tosco, BP, Mobil, General Petroleum</td>
<td>1954</td>
<td>Gasoline, diesel oil, jet fuel, liquid petroleum, residual fuel oil</td>
<td>101,000</td>
</tr>
<tr>
<td>2</td>
<td>Tesoro</td>
<td>Tesoro Northwest and Shell Oil</td>
<td>1955</td>
<td>Gasoline, diesel oil, turbine &amp; jet fuel, liquid petroleum gas, residual fuel oil</td>
<td>120,000</td>
</tr>
<tr>
<td>3</td>
<td>Royal Dutch Shell</td>
<td>Equilon Enterprises and Texaco</td>
<td>1957</td>
<td>Gasoline, diesel oil, jet fuel, propane, coke, sulfur</td>
<td>145,000</td>
</tr>
<tr>
<td>4</td>
<td>US Oil</td>
<td></td>
<td>1957</td>
<td>Gasoline, diesel oil, jet fuel, marine fuel, gas oils, emulsified &amp; road asphalt</td>
<td>40,700</td>
</tr>
<tr>
<td>5</td>
<td>BP</td>
<td>ARCO</td>
<td>1971</td>
<td>Gasoline, diesel oil, jet fuel, calcinated coke</td>
<td>225,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>631,700</td>
</tr>
</tbody>
</table>

2. PETROLEUM REFINING PRODUCTS AND PROCESS

Oil refineries utilize crude oil feedstocks to produce value-added products. The form value of a refined product is considerably higher than crude oil with the price difference being the source of refinery revenues. This is the difference between value of refinery inputs and outputs. A litany of outputs is produced in the form of gases, liquids, and solids. While gasoline, diesel, and jet fuel account for over 75 percent of refinery output, other products range from lubricants to waxes to asphalt. Most refineries have specifications to produce over 2,000 products. Figure 1 below illustrates the divergence of the various refined goods, beginning as petroleum, which comprises the tree’s trunk.

Figure 1: Oil products

Some products that leave the refinery are used in the construction of other goods. Of note are the petrochemical classes olefins and aromatics, which act as the foundation for plastics, resins, gels, fibers, and detergents, among others. A bevy of consumer goods utilize post-petroleum products, items that conveys how ensconced petroleum is the modern world, beyond the realm of transportation.


2.1. Refinery Yield

Figure 2 below shows U.S. refinery yield by major product as a percentage of total yield. Data is yearly from 1993 through 2014.

Motor gasoline is the dominant product, averaging 46 percent of total yield over the past 22 years. That share dipped in 2007-2008 as recession and skyrocketing gas prices reduced demand. Distillate fuel is diesel, which has increased steadily due to its higher profit margins and increased exports to consumers abroad. Distillates comprised 30 percent of yield in 2014, up from 22 percent in 1993. Its primary uses are transportation, space heating and electric generation. Residuals, petroleum coke and asphalt are combined to represent the heavier products that result from bottoms processing, whose percent yield has waned during the past decade. Residual fuel oil refers to the heavy oils remaining after distillates are removed. They are primarily used as fuel in steam-powered vessels (known as bunker fuel), as well as for electric power production, space heating and various other industrial applications.31

Petroleum coke (pet coke) is a coal-like co-product from refining heavy crude oil, and is high in carbon and sulfur. Its economic value stems from use in electricity generation, the creation of manufacturing materials in the smelting industry and as fuel for cement making.32 Roughly half of U.S. refineries have the coking capacity required to refine heavier crudes. In Washington State, only Shell’s Refinery 3 and BP’s Refinery 5 have coking units. Pet coke is seldom used in power generation in the U.S. as it emits more CO₂ and sulfur per metric ton than coal. However the co-product is shipped to Asian markets for power generation where environmental standards are usually less stringent. Pet coke, at 5.5 percent of refinery yield in 2014, is one of the largest net exports from US refineries, second only to distillates. The U.S. provides over half of petroleum coke traded on the global market.33 Asphalt is a cement-like material, high in bitumen that is used predominantly for road construction. It currently accounts for 2 percent of U.S. refinery yield. Yield of jet fuel has remained steady, at 10 percent over the past 22 years. Liquefied petroleum, consisting 4 percent of refinery yield, includes ethane, propane, normal butane and isobutene.34

Refined product output will vary by refinery and crude input type. Yields fluctuate on a monthly basis as refiners maximize profits by matching output to meet demand for varying end products.

While a barrel of crude is 42 gallons, refineries typically increase the volume of refined product by around 7 percent. Alterations of the molecular composition of crude inputs occur throughout the refining process. “Cracking” is the colloquial term for breaking down long chain hydrocarbons into the more profitable short chain hydrocarbons. This is the essence of petroleum refining. Doing so increases the volume of refined output, referred to as refinery processing gain. It should be noted that refinery gain describes volume only, rather than the energy of outputs versus the energy of inputs. The second law of thermodynamics provides that energy is lost in the conversion process; hence refined products always contain less energy than their corresponding crude inputs. Efficiency in the refining process is estimated to be between 91 and 88 percent.36

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2.2. The Refining Process

Central to the operation of any refinery is the fractional distillation column. This is the cylindrical tower seen extending above a refinery. The distillation column is the first unit that the crude oil enters where temperatures in excess of 700°F are applied to the feedstock, which isolates different hydrocarbon chains by their respective boiling points. The vaporized crude wafts upwards through collection trays that allow the gases to rise but catch the hydrocarbon chains as they condense into liquid form. The heavier distillate products such as residual and heavy gas oil collect near the bottom of the column (hence the “bottoms” moniker) while lighter distillates such as naphtha and kerosene accumulate towards the top. The lighter products have lower boiling points, and hence travel further up the distillation tower before condensing. Those derivatives that accumulate higher are smaller molecules characterized by higher volatilities with lower flashpoints and viscosities. Figure 3 below depicts a fractional distillation tower and the resulting intermediate and finished product streams via their boiling points.

Figure 3: Atmospheric Distillation Column and Resulting Outputs


After fractional distillation, the separated products are further refined with additional equipment to best minimize costs and match output to the products generating the greatest revenues. Any measures beyond fractional distillation are considered secondary processing units (also called conversion units). Secondary units are used for a variety of applications that include: chemical restructuring to enhance profitability, removal of impurities, increasing fuel octane and meeting environmental mandates.

2.3. **Refinery Configuration**

The refining process is incredibly complex and configuration varies uniquely by refinery. The aforementioned crack spreads provides some measure of assessing a refinery’s configuration (see section 1.4.1.). A plethora of considerations contribute to both the physical structure and operations of an individual refinery. For instance, the characteristics of a refinery’s typical crude feedstocks will influence its configuration. In turn, feedstock supply is determined by geography, transportation infrastructure (pipelines, railways, docks, terminals, etc.), spot prices (affected by government policies), upstream activities within the company (given a vertically integrated corporation) and innovations that bring new fields online. The types of crude oil that a refinery can profitably source as feedstock are based on the equipment already in place. For example, a simple refinery without a catalytic cracker or delayed coker cannot benefit from price discounts in heavier crudes: it lacks the equipment required to profitably refine them. Altering refinery configuration based on crude availability is far from an expedited process. The concept and construction of a coker unit is a five-year process, which elucidates the managerial foresight required to capitalize on sifting dynamics of crude supplies. In 2011 a new coker unit was added to Phillips 66’s Wood River refinery in Roxana, Ill, a project whose price tag was $3.8 billion. Access to crude supplies and the profitability of refined products are both dynamic with varying degrees of volatility. The capital intensive nature of the refining business fixes the majority of costs and technological capacities. Altering configuration is a costly and lag-filled process.

2.4. **Oil Characteristics**

Crude oil exhibits varying color, viscosity, density and sulfur properties due the structure of its hydrogen and carbon atoms. The market value of any crude stream is a reflection of its chemical characteristics. In particular, density and sulfur content impact the composition of refined product yielded and equipment required to generate that yield. For example, sulfur must be removed during the refining process to reduce pollutants in finished fuels. Hence the sulfur content of a crude feedstock influences refinery operation as removal requires additional equipment that increases the marginal refining cost per barrel. Sulfur content below 0.5 percent is considered “sweet” whereas sulfur content greater than 1.0 percent is generally “sour.”

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38 Interview with process engineer from a Puget Sound refinery who selected to remain anonymous. June 10, 2015.
41 Bordoff, Page 23.
Anything between is “medium.” Density is delineated by API gravity,\(^42\) which is an esoteric measure of density relative to water denominated in degrees. API gravity is inversely related to the density of crude. API gravity greater than 35 degrees is considered “light” crude whereas below 27 degrees is “heavy.” Anything between is “medium.” Figure 4 provides a sample of crude oil types plotted by their respective sulfur content on the y axis and API gravity on the x-axis. While not shown in Figure 4, Alaska North Slope is a medium grade crude with an API of 31.4 degrees and sulfur content of 0.96%\(^43\). Bakken is a light sweet crude with an API gravity between 40 and 43 degrees and a sulfur content of 0.2%\(^44\).

![Figure 4: Density and Sulfur Characteristics of Selected Crude Oil Types\(^45\)](source)


Figure 5 below gives the proportion of products yielded from atmospheric distillation for three crude types. That is, product yielded irrespective of any secondary processing such as coking, catalytic cracking, etc. The API gravity measure is given below each crude type. Maya is a heavy sour crude produced in Mexico. Complex refineries are required to produce profitable end products from Maya crude given the bottoms processing equipment required for converting the large amount of vacuum residual to lighter, less viscous product. Catalytic crackers and

\[^42\] Degrees API = \((141.5 / (\text{sp. gr. 60°F / 60°F}) - 131.5)\). EIA. “Petroleum & Other Liquids: Definitions Sources and Explanatory Notes.” <http://www.eia.gov/dnav/pet/tbldefs/pet_pri_wco_tbldef2.asp> 16 April 2015.


cokers are examples of the units needed to achieve profitable quantities of high value petroleum products like gasoline, diesel and jet fuel from heavy crude. Conversely, the light sweet grades yield highly profitable products in the relative absence of sophisticated technology and energy intensive processes. Bakken and Eagle Ford crudes are examples of light sweet grades, both produced in shale formations in the recent plays in North Dakota and Texas, respectively. They are called light tight crudes given the “tight” shale formations from which they are extracted and their light API gravity. However, the construction of an individual refinery will influence the profitability of even light sweet crudes. This issue is currently presenting itself in the Gulf Coast (PADD 3) where refineries equipped for processing heavy sour imports find light sweet crude less economical than the simpler refineries. Processing exclusively light crudes in a complex facility requires shutting in capacity associated with bottoms upgrading. Bottoms, vacuum residuals and vacuum gas oils, are represented in blue in below. As Figure 5 demonstrates, distillation of the light tight oil being extracted from shale plays in North Dakota in Texas results in considerably different yields than their foreign counterpart.

Figure 5: Proportional Yields from Three Crude Oil Types

Source: EIA. “Technical Options for Processing Additional Light Tight Oil Volumes within the United States.”
<http://www.eia.gov/analysis/studies/petroleum/lto/> April 2015. Figure 1.
3. THE UNITED STATES OIL REFINING INDUSTRY

Crude oil distillation capacity\(^{47}\) in the United States has remained relatively constant over the past three decades from 17,890 thousand barrels per calendar day\(^ {48}\) in 1982\(^ {49}\) to 17,925 in 2014,\(^ {50}\) the last year data is available. The U.S. consumes 18,541 thousand barrels of refined petroleum products per day, less than its refining capacity assuming a 7.1 percent refinery processing gain.\(^ {51}\) The U.S. is the currently largest refined petroleum exporter in the world.\(^ {52}\) The number of operable refineries dwindled from 301 in 1982 to 142 in 2014.\(^ {53}\) By way of comparison, there are 650 refineries across the globe. Market trends favor larger, more sophisticated refineries as smaller, independently run units have closed due to onerous emission restrictions and the increasing complexity required to remain profitable.\(^ {54}\) Economies of scale and scope dominate as fewer but larger refineries continue to add capacity. Varied technologies are required to accommodate changing sources of crude and shifting demand for end products.

As of May 2015, only two new refineries have been constructed since the turn of the century in the U.S.. Both are small refineries. In 2008 the Antelope Refinery came online in Douglas, WY with an initial capacity of 3,000 barrels per day. An additional 800 barrels of capacity have since been added. Dakota Prairie Refining, the most recently completed refinery, began operations in May outside Dickinson, ND. The 20,000 b/d plant’s capital cost was $400 million.\(^ {55}\) The Energy Information Administration (EIA) categorizes all refineries as either “simple” or “complex,” where the difference is delineated by existence of a coker unit.\(^ {56}\) Built to accommodate light tight oil extracted from the Bakken Shale Play, both aforementioned

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\(^{47}\) Atmospheric crude oil distillation capacity refers to the amount of “front end” crude that a refinery can accommodate.

\(^{48}\) Barrels per calendar day refers to the amount of crude inputs that an atmospheric crude distillation facility can process “under usual operating conditions.” This is expressed in a 24 hour period that accounts for production limitations due to types/grades of inputs, capabilities of downstream facilities to handle outputs, environmental constraints, scheduled and unscheduled downtime due to maintenance, repairs, inspection, mechanic problems, etc. Barrels per calendar day should not be confused with barrels per stream day that assumes input capacity that the distillation facility can process under optimal operating conditions within a 24 hour period. This report quotes all refining capacity in barrels per calendar day. For more information visit EIA Energy Glossary. [EIA](http://www.eia.gov/tools/glossary/index.cfm?id=petroleum)

\(^{49}\) Last year EIA data was available.

\(^{50}\) EIA. “Atmospheric Crude Oil Distillation Capacity.” [EIA](http://www.eia.gov/dnav/pet/pet_pnp_cap1_dcu_nus_a.htm) 25 June 2014.

\(^{51}\) Results in 19,198 barrels of refined product equivalent from the 17,935 barrels of crude feedstock.


\(^{53}\) “Atmospheric Crude Oil Distillation Capacity.”


\(^{56}\) Processing unit that converts heavy residual oils into profitable lighter products. Long hydrocarbon chain molecules are cracked into shorter chains, leaving petroleum coke behind as a co-product. A coker is required to economically process heavy crudes. The coking process is referred to in the industry as “bottoms upgrading” where the uneconomical residuals from the bottom of the distillation tower are converted into higher-value added products. See EIA. “Coking is a refinery process that produces 19% of finished petroleum product exports.” [EIA](http://www.eia.gov/todayinenergy/detail.cfm?id=9731)
refineries have no need for a coker and would be considered “simple.” The last complex refinery built in the USA was in 1977 in Garyville, LA with an initial capacity of 200,000 b/d. Its capacity has gradually been upgraded to 544,000 b/d as of 2015.

3.1. A Shifting Petroleum Industry

Historically, U.S. crude oil production peaked at 11.3 million b/d in 1970 and steadily declined to 6.8 million b/d in 2006.\(^{57}\) Demand grew by 6 million b/d over the same period.\(^ {58}\) Increased crude imports filled the widening gap between flagging domestic production and growing consumption. That trend has been reversed in less than a decade as U.S. crude production has dramatically rebounded. Since 2014, the U.S. has been the largest global producer of petroleum and other liquids\(^ {59}\) and is expected to reach all-time production highs later in 2015.\(^ {60}\) Saudi Arabia and Russia sit at second and third respectively.\(^ {61}\)

Widespread implementation of unforeseen industry innovations, namely horizontal drilling and hydraulic fracturing, have turned resources into reserves in tight oil formations. These innovations engendered the Bakken, Eagle Ford and Permian Basin shale plays in 2008, and are responsible for the production spike observed in Figure 6. North Dakota is now the second greatest oil producing state and production levels in Texas are at a 30-year high. Figure 6, which plots thousands of barrels produced per month against time, illustrates how drastically trends can be reversed in the petroleum industry. The recent production surge is of unmatched magnitude in the country’s history. Never before has production added 100 million barrels per month faster than the two and a half years from August 2012 to March 2015.

\(^{57}\) Bordoff and Houser. Page 19.
\(^{58}\) Bordoff and Houser. Page 19.
\(^{59}\) Other liquids are defined as carbon-based petroleum equivalents extracted from drill sites.
3.2. Petroleum Administration for Defense Districts and Downstream Infrastructure

The new sources of crude from the country’s interior shale plays are presenting technical and logistical challenges for downstream operations. For more information on these domestic challenges see item 1 in the appendix. The country’s refining and transportation infrastructure was constructed to predominantly accommodate oil from foreign sources and Texas, the domestic production juggernaut. Hence half of the country’s refining capacity is located in the Gulf of Mexico with a network of refined and crude pipelines branching to the interior states.

Figure 7 below provides an illustration of the breakdown of Petroleum Administration for Defense Districts (PADDs) across the country with the refineries per respective district. The five PADDs were created in 1942 during WWII as a means for gasoline rationing. Those districts remain for aggregating petroleum supply and movement data across regions. Figure 7 gives the total refining capacity per PADD by simple and complex refinery (a refinery without coking capacity is simple and depicted in beige whereas the complex refineries with coking units are depicted in brown).

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The Gulf Coast is located in PADD 3, which dominates U.S. refining capacity. Texas and Louisiana, PADD 3 states, possess the greatest refining capacities respectively. The country’s six largest refineries (by barrels per calendar day) are located amongst these two states. The majority of the country’s heavy and sour crude processing capacity is also located in this region. Hence, 80 percent of PADD 3 refiners (by capacity) have coking units. Notice Alaska, depicted in the bottom left of Figure 2, which has only simple refineries. The Alaskan North Slope oil has light, low sulfur characteristics allowing for economic refining without bottoms upgrading equipment.

Figure 8 illustrates U.S. and Canadian crude oil pipelines while Figure 9 shows U.S. and Canadian refined product pipelines.

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66 That is, crude with an API gravity rating below 27 degrees is heavy and sulfur content greater than 1.0% is sour. See page 13 for more information. EIA. “Regional refinery trends evolve to accommodate increased domestic crude oil production.”
Figure 8: US and Canadian Crude Pipeline Map


Figure 9: US and Canada Refined Pipeline Map

3.3 Petroleum Administration for Defense District 5 (PADD V)

Petroleum Administration for Defense District 5 (PADD V), accounting for 17 percent of U.S. capacity, comprises Alaska, Arizona, California, Hawaii, Nevada, Oregon and Washington. PADD V is shown in purple and labeled as “West Coast” in Figure 8 above. California refineries dominate PADD V consisting of 65 percent of capacity while Washington constitutes the second largest share at 21 percent of capacity.\(^{67}\) There are currently 32 operable refineries in the district in 2015, down from 59 in 1982.\(^{68}\) This follows the national trend.

There is no crude oil pipeline that crosses the Rocky Mountains in the U.S. As result, PADD V is noticeably isolated from the world’s largest pipeline network. Washington and California feature the only crude oil pipelines in PADD V, with California crude restricted to intrastate movement. This is partly due to California’s geologic endowment: the Golden State is currently the third largest oil producer in the nation, recently edging past Alaska. Washington refineries receive crude from the Puget Sound Leg of the Trans Mountain Pipeline via fields in Alberta (Figure 10). Due to the relative absence of crude pipeline to PADD V refineries, supply via tanker and barge is critical.

While there are no refined pipelines leaving PADD V, four separate pipelines deliver petroleum products to the district. The vast majority of Washington’s petroleum demand is met with product refined in state, yet eastern Washington markets receive product via the Yellowstone and Chevron pipelines (see Figure 9) from Montana and Utah respectively. This is a function of marginal transportation costs\(^{69}\) rather than in state product scarcity. Product pipeline throughout PADD V is lacking compared to the rest of the nation. As with crude oil, this increases the importance of movement via waterway. For instance, barges deliver finished product from Washington’s refineries to terminals in British Columbia, Seattle, Portland and California where the product is distributed to retail stations or moved to other markets. As of 2015, there are 19 separate oil terminals throughout Washington which serve as transportation hubs between supply lines and storage facilities that economically move crude to refineries and refined product to retail stations. BP’s Olympic line is a intra-PADD V pipeline that moves refined product from north to south on a pro rata basis from the Puget Sound refineries to Portland, Oregon with terminals en route (see Figure 11).

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\(^{67}\)“Table 1. Number and Capacity of Operable Petroleum refineries by PAD District and State as of January 1, 2014.”


\(^{69}\)Pipeline is the transportation method of lowest marginal cost.
4. A HISTORY OF PETROLEUM REFINING IN WASHINGTON STATE

The following section is a per decade breakdown of the history of the petroleum industry in Washington. This section details the 60-year period where the state transitioned from one without any refining capacity to that of the fifth greatest capacity in the nation. This history includes discovery and exploration of new oil fields, refinery construction, political events and the multitudes of mergers, acquisitions, spin offs and asset purchases within the oil industry, all with respect to the history being told.

4.1. 1950s

4 of the 5 currently operating refineries in Washington State were built in response to the 1950s Canadian oil boom. The Turner Valley oil and gas field, southwest of Calgary, established Canada’s geologic endowment but produced far less oil than the wildcatters who made the discovery in 1914 expected. Turner Valley production peaked in 1942 and was in rapid decline when a new discovery reshaped Canada’s energy industry. The Leduc Field, tapped in 1947, jumpstarted Canada’s postwar economy and made the country a significant exporter on the world stage. The first well, Leduc No. 1, produced 300,000 b/d and was one of a thousand drilled in the Leduc Formation. Geologists later uncovered hundreds more similar Devonian Reef formations.
across Alberta. The drastic uptick in crude production revealed Canada’s infrastructure was unequipped to bring the commodity to market: pipelines to both coasts was the answer.

The Trans Mountain Pipeline, in operation since 1953, brought Alberta’s crude oil to the Westridge Terminal in Burnaby, British Columbia. This opened crude supply lines to Washington as oil was delivered via tanker, which engendered construction of the first refineries. In 1956 the 65-mile Puget Sound spur off the Trans Mountain pipeline directly connected the Puget Sound refineries outside Ferndale and Anacortes to Canadian crude. The Puget Sound leg of Kinder Morgan’s Trans Mountain pipeline is illustrated above in Figure 10 and is still in operation today. As of 2015, the pipeline currently operates at its 180,000 b/d capacity.

General Petroleum Corp completed Washington’s first refinery in 1954 (Refinery 1, currently owned and operated by Phillips 66), just west of Ferndale, WA, in what is now known as the Cherry Point industrial zone. The original capacity was rated at 35,000 barrels per stream day. General Petroleum was a subsidiary of Socony (Standard Oil Company of New York) and was integrated into Mobil Chemical Co when the company formed in 1960.

On June 2, 1953 the entire front page of the Anacortes Bulletin daily newspaper featured nothing but the following four words: “Shell Picks Local Site.” Royal Dutch Shell announced the $75 million project on March Point, southeast of Anacortes, which promised the community 600 jobs. This came amidst various economic setbacks in the region, most notably the closure of the Morrison and Walton lumber mills as the Anacortes population decreased from the 1920s until the 1950s. Shell’s construction of the state’s second refinery (Refinery 2, currently owned and operated by Tesoro) began in 1954 as the 40,000 b/d capacity came online in 1955. A total of 3,115 workers aided the plant’s construction, this in a town of only 6,000. More positive employment news came in 1957 when Texaco began construction of a second refinery on March Point (Refinery 3, currently owned and operated by Shell). Its 45,000-barrel capacity came online in 1958. These plants accommodated crude sourced from Canadian fields, received by way of tanker and pipeline. The Shell and Texaco plants provided employment and economic stability in a community whose jobs were plagued by boom and bust cycles and historically revolved around the fishing and lumber industries.

Pacific Oil & Refining Co formed in 1952 with the purpose of constructing an oil refinery in the Pacific Northwest (Refinery 4, currently owned and operated by U.S. Oil, the same company). The site at the Tacoma Tideflats was purchased in 1954 and the company’s name was subsequently changed to U.S. Oil & Refining Co. The refinery was fully operational by the end of 1957 with 5,000 barrels per stream day capacity. A second unit capable of producing marketable products from heavy crude was completed in 1959.

While ostensibly trivial to Washington at the time, Shell and Standard Oil of New Jersey began Alaskan explorations in 1956. They suspended operations in 1959 after reportedly drilling what was then the world’s most expensive dry hole. Even after the initial failures, Alaska remained on the minds of corporations and governments seeking to diversify supplies

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70 Barrels per stream day being daily input capacity given optimal conditions.
71 Now ExxonMobil, the largest multinational oil company in the world.
73 Skagit Publishing.
74 U.S. Oil Trading LLC, U.S. Oil & Refining Co.
lines that depended on stability in the Middle East. Egypt’s nationalization of the Suez Canal in 1956 and the ensuing crisis was a reminder of the geopolitical risks associated with the region. The following year, BP, with backing from the British government, made a concerted effort to seek crude supplies in the Western Hemisphere.

By the end of the 1950s Washington had 125,000 barrels of capacity spread across four refineries, a far cry from the absence of refining ability a decade prior. All crude came via tanker or pipeline, with the preponderance being extracted from Canada’s Alberta fields. Refined product was delivered to markets and retail stations via truck and barge.

4.2. 1960s

The Olympic Pipeline Company was formed in 1961, headquartered in Renton, WA, to more efficiently transport refined product to Northwest markets. The pipeline, completed in 1964, runs 299 miles along a route that generally follows the I-5 corridor from Blaine, WA to Portland, OR, seen in Figure 11 above. This provides cost-effective transportation from the refineries to terminals throughout Washington and Oregon. Pipeline is the transportation method of lowest marginal cost. The majority of product delivered to Washington consumers still travels through this pipeline, which currently operates at its 315,000 b/d capacity.

Oil was discovered on Alaska’s North Slope in the Prudhoe Bay State Number 1 well during the final days of 1967. Original estimations put recoverable barrels at 10 billion, making it the largest field ever discovered in the United States. Prudhoe Bay later proved to be the largest field in North America. The three main players in Alaska were ARCO, BP and Jersey Standard Oil (which became Exxon in 1972). This discovery represented a distinct shift in future crude supplies for Washington’s refineries.

ARCO, BP and Humble Oil (a subsidiary of Standard Oil of New Jersey) formed the Trans Alaska Pipeline System (TAPS) where they announced plans in 1969 to construct an 800-mile crude pipeline from the Arctic Circle at Prudhoe Bay to the Port of Valdez, off the Prince William Sound. TAPS purchased $900 million worth of land in the Prudhoe Bay area and $100 million worth of steel pipe from Japan later that year in anticipation of quickly moving forward. But ensuing environmental concerns and litigation put the project on hold.

Not coincidentally, ARCO announced plans to build a refinery outside of Ferndale, WA in 1968 (Refinery 5, currently owned and operated by BP). The refinery was constructed on the small historic community of Whitehorn where the inhabitants were bought out and the town bulldozed to accommodate the 3,300-acre plant. ARCO’s plant was constructed for $150 million, $965 million when inflated to 2015 dollars.
Following the Alaska discovery, BP had a foothold in the U.S. market and 25 percent of global reserves, but was devoid of downstream infrastructure to refine, transport or market its oil in North America. BP merged with Sohio (Standard Oil of Ohio) whose portfolio was concentrated around downstream assets but faced dwindling prospects in exploration and production. In 1968, BP exchanged its Alaskan crude for a 25 percent controlling share of Sohio. This was BP’s entry into the U.S. refining and retail market (BP later purchased Refinery 1 via Sohio in 1988). The agreement stipulated that BP would assume majority ownership when Sohio’s Alaskan production eclipsed 600,000 b/d. This level was achieved in 1978 and BP received a 54 percent share of the Cleveland-based company. In 1987, BP purchased Sohio’s remaining equity, which established the company as a subsidiary of BP America.

Sound Refining opened in 1967 on the Tacoma Tideflats as an asphalt refinery that utilized crude oil inputs. Its crude capacity was less than 5,000 b/d, accounting for only a small portion of Washington’s refining. Due to its minute share of total capacity, this facility is afforded less attention in this report. It ceased to refine oil in 1998 and currently functions as an oil terminal with a tank farm and logistics center for transportation.

Canada continued to provide the majority of Washington’s oil throughout the 1960s but the refineries were preparing for incoming supplies of Alaskan crude. Downstream transportation was redefined by the creation of the Olympic Pipeline.

4.3. 1970s

ARCO’s Refinery 5 came online in 1972 with a capacity of 100,000 barrels per day. The refinery was built in what is now the Cherry Point Industrial Zone, just a few miles north of Refinery 1. This was and still is the biggest refinery in Washington, although its capacity has increased by nearly two and a half times since.

Oil was predicted to begin flowing from Alaska’s North Slope by 1972, but opposition galvanized by environmental concerns stalled extraction. The National Environmental Policy Act of 1970, which was catalyzed by the Santa Barbra spill of 1969, powered a Federal court injunction of the TAPS permitting process only 2 months after the pipeline’s route was proposed. The equipment, stockpiled along the North Slope in 1969, sat for the next 5 years. In 1973 the Senate ruled that the U.S. Department of the Interior environmental assessment met provisions set by the National Environmental Policy Act, a decision that sanctioned the project on environmental grounds.

94 Cowan, Edward. The New York Times. “Senate, 77-20, Votes For Alaska Pipeline; Court Test Barred, With 49-to-49 Tie Broken by Agnew Senate, 77 to 20.”
On October 6, 1973 the Yom-Kippur War erupted when the Egypt-Syria coalition launched invasions into the Israeli-occupied Sinai Peninsula and Golan Heights respectively. OPEC issued an oil embargo on the United States for resupplying Israel with arms during the conflict. The combined oil embargo and production cuts, both issued in 1973, engendered what is now considered the first oil shock. In early October, Arab crude supply totaled 20.8 million barrels per day. Due to rolling production cuts that increased 5 percent each month, that amount was reduced to 15.8 million barrels by December. Without any spare production capacity the U.S. was helpless to influence global prices by increasing supply as it did during the 1967 embargo. The consequence of rapid contractions in global supplies, a net reduction of 4.4 million barrels from the 50.8 million available 2 months prior, was magnified by yearly global consumption growth of 7.5 percent. As a direct result the posted price per barrel rose four-fold from $2.90 in mid-1973 to $11.65 by December, with spot prices that climbed above $20 a barrel in some instances. At the pump U.S. motorists observed a 40 percent jump in retail prices, an increase depressed by domestic price controls that lead to massive shortages and the infamous “gas lines.” In response to skyrocketing energy prices, President Nixon signed the Trans-Alaskan Pipeline Authorization Act in November 1973, which recognized the production of Alaska’s North Shore crude as a national priority. The Department of the Interior granted federal agreement and right-of-way permits in January 1974, allowing the Alyeska Pipeline Company to begin construction.

Alyeska, the pipeline service company formed in 1970 by BP, ARCO and Humble to plan, construct and maintain the Trans-Alaskan Pipeline System (TAPS), completed the first ever haul road to the Arctic Circle by October 1974. Construction of the Trans-Alaskan Pipeline began the following spring. The pipeline was completed in 1977 with a total cost of $8 billion, far beyond the 1970-estimated price tag of $900 million. North Slope oil production eclipsed 1 million barrels per day the following year in 1978. The pipeline has a capacity of 2.1 million barrels per day, which was reached when Alaskan production peaked in 1988. As of 2015, the pipeline operates at approximately 25 percent capacity. Figure 13 below illustrates the history of Alaskan field production of crude oil, measured in thousand barrels per day. Notice that Alaska was an oil producing state prior to the discovery of Prudhoe Bay. However Alaska’s aggregated
production never exceeded 250,000 barrels per day until the Trans-Alaskan Pipeline was completed in 1977.\textsuperscript{105}

\textbf{Figure 12: Alaska Field Production of Crude Oil}

![Alaska Field Production of Crude Oil](https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mcrfpak2&f=m)

Source: EIA. Petroleum and Other Liquids. “Alaska Field Production of Crude Oil.”

On June 9, 1979 an explosion and ensuing fire in Shell’s Anacortes Refinery 2 killed two men working on piping to a furnace when a gasket ruptured.\textsuperscript{106} Shell paid $1.8 million in claims to the families, but further damage settlements were discarded.

The influx of Alaskan oil reshaped Washington’s supply. An increasing proportion of crude arrived via tanker due to supply lines opening from Valdez. The new crude inputs mitigated reductions in Canadian crude imports caused by the oil shocks. As global oil demand escalated North American and European economies became increasingly dependent on imports despite major discoveries in Alaska and the North Sea. The oil shocks and gas lines of the decade remain burned into the memory of many American consumers. These events prompted the political championing of “Energy Independence” and cultural vilification of the global oil companies.

\textbf{4.4. 1980s}

BP acquired Sohio outright in 1987 and made the company a focal point of its new BP America operation.\textsuperscript{107} In the 1980s Sohio owned over 4,000 retail gasoline stations east of the Rockies,\textsuperscript{108} which BP inherited in the deal. BP acquired refining capacity in Washington when its newly acquired subsidiary purchased Refinery 1 outside of Ferndale from Mobil Oil in 1988.

\textsuperscript{105} EIA. “Alaska Field Production of Crude Oil.”

\textsuperscript{106} Spokane Chronicle. “High court tosses out Shell Oil’s $1.8 million explosion settlement.”

\textsuperscript{107} BP.com. “History of Sohio.”

\textsuperscript{108} Sohio was without a Northwest presence prior to the purchase of Refinery 1.
Sohio received the refinery in exchange for $152.5 million and crude oil inventories. In addition, Mobil swapped 240 Northwest retail stations and four product terminals in Washington, Oregon and California for 330 Sohio stations across Michigan, Florida and six other Atlantic States as well as one product terminal in Tampa, Florida. At that time Sohio owned a 50 percent share of the Trans Alaskan Pipeline.

Canada rescinded its National Energy Program, which banned crude exports in 1984, and resumed its supply to Washington’s refineries. This political decision followed the trend of unwinding price and export controls enacted in response to the oil shocks of the 1970s. Washington’s refineries sourced Alaskan and other foreign crudes to nullify the temporary absence in Canadian supply.

North Slope production peaked at over 2 million barrels per day in 1988 and has been in decline ever since.

4.5. 1990s

In 1993, Tosco Corp, a California-based downstream and marketing corporation, bought Refinery 1 from BP. The deal included BP’s retail stations and marketing assets across Washington and Oregon. BP left the Northwest refining market only five years after entry.

Shell and Texaco combined their refining and marketing operations, assets valued at $17 billion, in 1997. The joint business, Equilon Enterprises, subsequently co-owned Refineries 2 and 3 on March Point outside Anacortes. Antitrust legislation accepted the deal under the condition that Shell sold Refinery 2. Tesoro, an independent Texas-based midstream and downstream company, won bidding for Refinery 2 at $237 million, with an additional payment of $60 million for net working capital. Tesoro still owns and operates Refinery 2 as of 2015.

An explosion and fire at the Equilon Puget Sound Refinery, Refinery 2 operated by Tesoro, killed 6 workers on November 25, 1998. A storm knocked out the plant’s electricity for two hours on November 23, two days prior to the accident. When workers attempted to restart the delayed coking unit they found oil much hotter than expected, which immediately erupted in flames that raised several stories high.

In 1999 two ten-year old children and an 18-year old were killed when 277,000 gallons of gasoline spilled from the Olympic Pipeline and subsequently exploded in Bellingham’s Whatcom Falls Park.

4.6. The making of Supermajors: How BP and Phillips 66 came to own Refineries 1 & 5 at Cherry Point


In the 1950s the seven sisters (the world’s seven largest oil companies)\textsuperscript{114} held 85 percent of global reserves.\textsuperscript{115} Their collective share has since dwindled to less than 10 as nationalized oil companies now hold the preponderance of reserves. By way of comparison, 5 of the 6 largest oil producers in 2013 were state-owned or associated companies. ExxonMobil is the world’s largest multinational producer, ranking fourth.\textsuperscript{116} The largest state-owned companies are Saudi Aramco (Saudi Arabia), Gazprom (Russia), NIOC (Iran), PetroChina, and Kuwait Petroleum. These companies control the lion’s share of reserves after fields across the globe were nationalized in the 1970s. The listed companies\textsuperscript{117} have been elbowed out to unconventional fields where projects require greater capital expenditures and feature increased financial and environmental risks. The multinational companies seek strategies to compete with their nationalized counterparts.

World consumption rose nearly two million barrels per day from 71.8 million in 1996 to 73.5 million in 1997,\textsuperscript{118} an increase predominantly driven by economic growth throughout Asia. Oil producers expected these growth rates to continue. OPEC met in Jakarta, Indonesia in 1997 and left in agreement to raise their collective production quota by two million barrels per day.\textsuperscript{119} Simultaneously the “Tom Yum Goong” financial crisis erupted in Thailand as the baht collapsed, forcing the Thai monetary authority to sever the currency’s peg to the U.S. dollar.\textsuperscript{120} The crisis spread quickly throughout Southeast Asia, bankrupting multiple governments as GDP contracted across the region. Now dubbed the 1997 Asian Financial Crisis, the panic was global by years end. The downward demand shock, alongside swelling supplies reduced oil to $10 a barrel by the end of 1998.\textsuperscript{121} This was a 60 percent drop in prices from two years prior. Daniel Yergin, a leading voice in energy markets, wrote that the price collapse “set off the biggest reshaping of the structure of the petroleum industry since the breakup of Standard Oil Trust by the Supreme Court in 1911.”\textsuperscript{122}

At $10 per barrel, few fields outside Saudi Arabia can economically produce oil. The price shock hit the multinational companies especially hard. The upstream divisions if those companies operate in the world’s most technically challenging fields where economic production requires a relatively high price per barrel, prices absent in the late 1990s. The collective response of the multinationals was to chase greater economies of scale. The prevailing idea being that

\textsuperscript{114}Commonly known as the seven oil companies forming the Consortium for Iran in the 1950s. They were then Anglo-Persian Oil Company (BP), Gulf Oil (Chevron), SoCal (Chevron), Texaco, Royal Dutch Shell, Esso (Exxon) and Socony (Mobil).


\textsuperscript{116}The Economist. “Supermajordämmerung.”

\textsuperscript{117}That is the publicly owned companies, the multinationals.


\textsuperscript{119}This event is now referred to by OPEC as the “Jakarta Syndrome.” It exemplifies the repercussions of increasing demand while supply simultaneously falls. Yergin, Daniel. Page 85.


\textsuperscript{121}EIA. “Cushing, OK WTI Spot Price FOB.” <http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=D> 15 April 2015.

shareholders would value larger companies more favorably\textsuperscript{123} while combined experience and assets would produce more profitable endeavors.

Through a series of record-breaking mergers and acquisitions, BP ended up owning Refinery 5 at Cherry Point. The first occurred in August 1998 when BP purchased Amoco for $48.2 billion in what was the largest merger the oil industry’s history.\textsuperscript{124} BP Amoco (as it was known in 1999) subsequently purchased ARCO for $26.8 billion in April 1999.\textsuperscript{125} Antitrust litigations forced BP Amoco\textsuperscript{126} to sell $6 billion worth of ARCO’s Alaskan North Slope crude assets. This was the crown jewel of ARCO’s balance sheet, amounting to 1.53 billion barrels of proven reserves\textsuperscript{127} that were eventually purchased by Phillips Petroleum. This nonetheless made BP Amoco the second largest private oil company in the world. At the turn of the century, ARCO’s Refinery 5 was the only Puget Sound plant to remain under constant ownership. This changed in 2001, and BP still operates Refinery 5 as of 2015.

Chevron and Texaco finalized a merger in October 2000. The resulting supermajor, ChevronTexaco\textsuperscript{128} would be the world’s fourth largest multinational producer with over 50,000 retail stations worldwide.\textsuperscript{129} Antitrust rulings demanded the new entity sell Refinery 3 on March Point, due to Chevron’s already strong presence in West Coast markets. Shell bought Texaco’s share of their combined downstream entity, Equilon Enterprises, and acquired the plant, which the two companies previously co-owned and operated. Shell still owns and operates Refinery 3; it sits adjacent to Refinery 2, which Shell built in 1955 but is currently owned by Tesoro.

Phillips purchased Tosco for $7 billion in February 2001, assuming control of Refinery 1 also located at Cherry Point outside Ferndale.\textsuperscript{130} This merger was about downstream assets. With the deal’s close, Phillips became the second largest refiner in the U.S. and obtained refineries on both coasts. Even after the Tosco purchase, Phillips sought further expansion.

Phillips and Conoco announced a merger in November 2001, forming ConocoPhillips, the new controlling entity of Refinery 1. Conoco desired scale to diversify upstream assets and to discourage hostile takeovers.\textsuperscript{131} Despite the recent Tosco acquisition, Phillips was in a similar position. The two companies, who recently bid against each other for ARCO’s Alaskan assets, combined into a supermajor that boasted the nation’s largest downstream system.\textsuperscript{132}

4.7. Post-merger 2000s

\textsuperscript{123} Yergin, Page 89.
\textsuperscript{126} Which rebranded itself as simply “BP” in 2001.
\textsuperscript{127} As of 1998.
\textsuperscript{128} Reverted to the Chevron title in 2005.
\textsuperscript{131} DuPont came to own Conoco in 1981 as a white knight, preferable to the hostile takeover attempt of currently defunct Seagram Company Ltd.
\textsuperscript{132} That is the largest downstream system in 2012. See Yergin. The Quest. Page 105. As of 2015 Valero has the greatest refining capacity of in the US.
Seven refinery workers died in an industrial accident at Tesoro’s Refinery 2 on April 2, 2010. This was the Washington’s worst industrial accident in 50 years. The blast occurred when a 40-year old heat exchanger ruptured along welds later found to contain micro-fractures. Volatile hydrogen and naphtha were released at temperatures greater than 500°F, which exploded immediately. Two of the seven workers standing nearby died at the scene while the others died later of severe burns. That particular heat exchanger had a history of leaking and hadn’t been inspected since 1998, furthermore a scheduled test of the unit in 2008 never happened. The Washington Department of Labor and Industries embarked upon a six-month investigation that found 39 “willful” violations and five “serious” violations. The department concluded that the tragedy was entirely preventable and levied a $2.39 million fine, the largest for workplace safety violations in state history. That fine has since been whittled down to $658,500 as litigation continues. Tesoro and Shell, which owned the refinery as recently as 1998, settled out of court with the families afflicted, combining to pay them $39 million. The U.S. Department of Justice concluded a four-year criminal investigation in April 2014 by dropping criminal charges against Tesoro. This was the largest U.S. refinery accident since the 2005 BP Texas City incident that resulted in 15 fatalities and 180 injuries.

4.8. 2010s

In 2012 ConocoPhillips spun off its downstream assets as a new independent energy company, Phillips 66, which still operates Refinery 1. ConocoPhillips became the second company to abandon the vertically integrated model, following Marathon Oil Corporation’s decision to spin off its downstream assets in 2011.


136 Gilmore, Susan & Welch, Craig. “State declares Tesoro blast was preventable.” The Seattle Times. 5 October 2010. Retrieved from <http://www.seattletimes.com/seattle-news/state-declares-tesoro-blast-was-preventable/>


138 Defined as when an employer acts indifferently to a workplace hazard capable of causing an accident likely to result in death or grievous physical injury. See United States Department of Labor: “Federal Rights and Responsibilities Following an OSHA Inspection-1996.” <https://www.osha.gov/Publications/fedrites.html>


143 The downstream company is Marathon Petroleum Corp, trading under the MPC ticker.
The innovations in drilling technology and oil extraction that have engendered a recent resurgence in U.S. oil production (see Figure 7 on page 18) has a direct result on Washington’s refineries. Light tight Bakken crude is produced in a region without sufficient infrastructure required for transportation, refining and distribution. Pipeline is the most cost effective method of moving oil, that is, the transported at the lowest margin cost. But due to the unanticipated and unprecedented leap in production, investments in large downstream capital projects in the region were never considered. Absent pipelines and waterways, the transportation method of lowest marginal cost across long distances is railcar. The permitting, litigation and construction process required to build pipeline is lengthy and requires significant fixed, upfront costs, whereas the railway infrastructure is already in place.

A drastic uptick in transportation by rail is observed in Washington State and throughout the country as Bakken supply gropes its way toward refining and distribution systems. Washington’s refineries have responded with a bevy of projects to accommodate the crude by rail. In 2011 the state received crude only via tanker and pipeline. By 2013, the last year full data is available, the refineries received over eight percent of their collective oil by way of rail.\textsuperscript{145} That percentage has only increased since, with more rail facilities now online. As of May 2015, Washington’s refineries have a collective handling capacity of 191,400 barrels per day.

Refineries 1, 2, 4 and 5 are currently handing crude by rail with the permitting process still underway for Shell’s Refinery 3. Oil-by-rail is an increasingly hot button issue, largely owed to a recent series of high profile train derailments. These accidents have resulted in explosions and spills with consequences occasionally paid in human life and environmental damage. See Table 2 below for the handling capacity for oil by rail of Washington’s refineries.

\begin{table}[h]
\centering
\caption{Crude by Rail at Washington State Refineries}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
Refinery Number & Current Owner & Total Capacity & Rail Capacity & % of Total Capacity & Year Constructed \\
\hline
1 & Phillips 66 & 101,000 & 35,000 & 35\% & 2015 \\
\hline
2 & Tesoro & 120,000 & 50,000 & 42\% & 2012 \\
\hline
3 & Shell & 145,000 & 60,000 & 41\% & Proposed \\
\hline
4 & US Oil & 40,700 & 35,000 & 86\% & 2012 \\
\hline
5 & BP & 225,000 & 71,400 & 32\% & 2013 \\
\hline
Total Operational Capacity & & 631,700 & 191,400\textsuperscript{146} & 30\% \textsuperscript{147} & \\
\hline
\end{tabular}
\end{table}

\textsuperscript{145} Oil by Rail Transportation Study. Department of Ecology. Insert citation.
\textsuperscript{146} Doesn’t include 60,000 barrels per day of the proposed Shell rail facility.
\textsuperscript{147} Doesn’t include proposed Shell facility.
In April 2015, reports began surfacing of plans to construct a “micro-refinery” at the Port of Longview. The plant, proposed by the previously unknown firm Riverside Refining, would be a 45,000 b/d topping facility receiving two-thirds of its inputs via tight oil-by-rail and the remainder from renewable biofuels sourced overseas.\textsuperscript{148} The plant’s backers seek to capitalize on the State’s proposed Clean Fuel Standards legislation, which would mandate a reduction in transportation carbon fuel intensity of 10 percent from 2012 levels by 2026.\textsuperscript{149} The timeline for permitting and construction is currently unknown. Biorefineries have an auspicious past in the Northwest. A previous ethanol plant at Port Westward on the Columbia River, located near Clatskanie, Oregon, currently operates as an oil terminal and logistics facility. Another biofuels producer in Hoquiam, Washington, Imperium Terminals, is reported to be unprofitable and the firm is currently in the permitting process to shift operations to an oil terminal. This Port of Grays Harbor facility plans to build nine 80,000-gallon storage tanks and a 70,000 b/d oil-by-rail facility.

The following Table 3 is a visual summary of the History of Petroleum Refining in the State of Washington. It shows a per decade snapshot of the atmospheric distillation capacity per calendar day and owner of each refinery by assigned number during select years where data was available.