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Implications Of Lifting The Ban On The Export Of Alaskan Crude Oil

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ENERGY INFORMATION ADMINISTRATION
OFFICE OF ENERGY MARKETS AND END USE
U.S. DEPARTMENT OF ENERGY
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PREFACE

The Energy Issues group of the United States General Accounting Office requested that the Energy Information Administration (EIA) analyze the implications of lifting the ban on the export of Alaskan crude oil. This report is the EIA's response to that request. The main objective of the report is to estimate the potential impacts on crude oil and product prices and petroleum trade flows of lifting the ban.

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EXECUTIVE SUMMARY

A ban exists on the export of crude oil from the United States. It was imposed on Alaskan North Slope (ANS) crude oil in order to reduce U.S. dependence on imported crude and to assure that the Trans-Alaska pipeline would be used to benefit domestic consumers rather than to facilitate exports.

The export ban affects the distribution of ANS crude oil within the United States and its territories. Nearly three-fourths of that crude is currently shipped to refineries on the U.S. West Coast. Much of the remainder is shipped to the Gulf Coast. Shipments to the Gulf Coast are expected to fall sharply and be all but eliminated during the next few years as West Coast demand increases and ANS production continues to decline.

The elimination of the ban could, and probably would, result in substantial exports of ANS crude to Japan and, possibly, other Pacific Rim countries. This analysis indicates that in the absence of the ban, ANS crude would be valued from $1.35 to $3.39 per barrel more on the West Coast. This analysis indicates, therefore, that Alaskan crude oil is undervalued on the U.S. West Coast and that Japan would be a market for ANS crude. Much of this price change can be explained by the fact that Japan uses much more middle distillate than does the West Coast and that ANS crude is suited to this production.

There are important qualifications to these model-generated results. First, they are based on 1988 data; but this is not generally considered to be a serious limitation. Second, the model-generated prices are marginal prices for the first barrel of crude oil that would be exported. Additional ANS exports to Japan would revalue all crudes in both markets and ANS prices would probably rise by somewhere between $1.35 and $3.39 per barrel.

The potential export of ANS crude has additional implications for the U.S. economy. Product prices on the West Coast would increase, but the overall impact on consumers would be minimal. The economy would benefit from gains in economic efficiency since costs to transport crude from Alaska to Japan would be substantially reduced relative to costs incurred in shipping to the U.S. Gulf Coast. However, the maritime industry would be adversely affected since some part of the domestic tanker fleet used to transport ANS crude would be laid-up if exports to Japan were made in foreign bottoms. National security could be adversely affected to some extent for the same reason. However, the same effect would occur, albeit later in time, even if the ban remained in effect since ANS shipments to domestic outlets will drop sharply as the current forecasted decline in ANS production continues. The State of Alaska would benefit from higher wellhead prices. Alaska directly and indirectly derives a large share of its tax revenues from wellhead prices for ANS crude.

1. INTRODUCTION

Present legislation effectively bans the export of crude oil produced in the United States. The ban has been in effect for years and is particularly stringent with respect to crude oil produced in Alaska, particularly on the North Slope. The Alaska crude export ban is specifically provided for in the Trans-Alaska Pipeline Authorization Act of 1973 and in other legislation. It was imposed for two reasons. The first was to reduce U.S. dependence on imported crude oil. The Arab oil embargo had been imposed shortly before the Act was passed and a greater measure of energy independence was considered imperative at that time. The second reason was to assure that funds expended in building an Alaskan pipeline would benefit domestic users rather than simply employed to facilitate shipments to other countries.

The ban on exports of domestically produced crude oil is not total. Exceptions are permitted, but the conditions that must be met are stringent. Currently, only small quantities are exported. In 1988, for example, shipments from the United States and its territories amounted to only 13 thousand barrels per day and were destined only for Canada and China/Taiwan. Exports to the China/Taiwan area were from Alaska's Cook Inlet. Licenses to export crude oil from parts of Alaska's Cook Inlet have been issued since 1986.

The main objective of this report is to estimate the potential impacts on crude oil prices that would result from lifting the export ban on Alaskan crude oil. The report focuses on the Japanese market and the U.S. West Coast market.[1] Japan is the principal potential export market for Alaskan crude oil. Exports to that market would also affect the price of Alaskan crude oil as well as crude oil and product prices on the West Coast and the volume of petroleum imported in that area.

Section 2 of the report presents a perspective on Alaskan crude oil, production of which is decreasing as proven reserves become increasingly depleted. The bulk of the production is shipped to West Coast refineries and much of the remainder to the U.S. Gulf Coast. Shipments to the Gulf

[1] The term "West Coast," as used in this report, refers to Petroleum Administration for Defense District V (PADD V). PADD V consists of Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington.

Coast are expected to fall sharply during the next few years, a result of the expected continued decline in Alaskan production.

Section 3 describes the factors that would determine the trade flow of Alaskan crude oil if the export ban were abolished. These flows are determined by the demand for petroleum products in domestic and foreign markets, since the demand for crude oil is a derived demand. The ability of Alaskan crude oil to satisfy end-use demand, however, depends on the crude oil assay of that oil and refinery configurations in various regions, in this instance the U.S. West Coast and Japan.

Section 4 describes the methodology used in the analysis to generate values for Alaskan crude oil. The Energy Information Administration's (EIA's) Refinery Yield Model (RYM) is used to generate these values. RYM is a linear programming model whose objective function is to minimize refinery processing costs given a fixed set of demands for refined products. The model simulates the refining environment in both Japan and the U.S. West Coast and takes as given the 1988 values for product demand slates and refinery configurations in those areas and the characteristics of ANS crude oil.

Section 5 presents the model-generated results and related data. The 1988 value of ANS crude in a free market is estimated to be $14.85 per barrel if that crude were processed in a West Coast refinery to meet that refinery's demand slate. This is $1.35 more than the average spot price in Los Angeles of $13.50 per barrel for that year. However, if the crude were processed in Japan to meet product demand requirements in that country, the crude is projected to be valued at $16.56, and substantial exports of ANS crude to Japan would probably occur. When the value of the ANS crude to Japan is adjusted for transportation costs, it exceeds the $13.50 price of ANS crude on the West Coast by $3.39 per barrel. The $1.35 and $3.39 differentials are two measures of the potential increase in the price of ANS crude if the ban were removed. Prices for refined products on the West Coast would also increase. The increase for gasoline would likely be quite small with most of the price increases concentrated in the heavier refined products.

The imputed, or model-generated, values for ANS crude must be interpreted with caution. They are marginal prices. That is, they represent the values for the first barrel that would be exported. Additional barrels could cause those values to change with the actual price increase probably somewhere between the two price increase estimates.

Section 6 discusses, in qualitative terms, the broader implications of exports in terms of government revenues, the balance of trade, the maritime industry, employment, and national security. Although the maritime industry would be adversely affected, the overall effect on the U.S. economy could be favorable.

2. ALASKAN CRUDE OIL: A PERSPECTIVE

The discovery of North America's largest oil field at Prudhoe Bay on Alaska's North Slope in 1968 ushered in a new era for Alaska and the U.S. oil market. Major discoveries--in the hundred million barrel range--had previously been made on the Kenai Peninsula and in Cook Inlet in Alaska's Southeastern Region beginning in the 1950's. But these discoveries were dwarfed by the Prudhoe Bay field which added about 10 billion barrels to estimated U.S. proved reserves of crude oil, an increase of nearly one-third and all of it on State rather than Federal land. Alaska currently accounts for one-fourth of total U.S. proved reserves of crude oil, and Alaska and California combined account for nearly one-half (Table 1). Although much of the oil yet to be discovered in the United States is in Alaska, particularly in Federal areas, the discovery of additional fields approximating the Prudhoe Bay field in size is considered unlikely.

Table 1. United States Proved Reserves of Crude Oil at End of Year, 1977-1988
(Millions of Barrels)

Year	Alaska	California	Other United States	Total United States
1977	8,413	5,005	18,362	31,780
1978	9,384	4,974	16,997	31,355
1979	8,875	5,265	15,670	29,810
1980	8,751	5,470	15,584	29,805
1981	8,283	5,441	15,702	29,426
1982	7,406	5,405	15,047	27,858
1983	7,307	5,348	15,080	27,735
1984	7,563	5,707	15,176	28,446
1985	7,056	5,801	15,559	28,416
1986	6,875	5,708	14,306	26,889
1987	7,378	5,746	14,132	27,256
1988	6,959	5,903	13,965	26,825

Notes: o Includes both Federal and State offshore. o Sum of components may not equal total due to independent rounding.

Source: Energy Information Administration, U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves, 1988 Annual Report, DOE/EIA-0216(88) (Washington, DC, October 1989).

Alaska became a major energy supplier when the Trans-Alaska Pipeline System (TAPS) was opened in 1977. Production increased from 173 thousand barrels per day in 1976 to 2.0 million barrels per day in 1988, or nearly up to the line's capacity (Table 2). Well over 90 percent of the cumulative production during this period originated from the Prudhoe Bay field. Alaskan production declined in 1989 and is expected to continue to fall at a rapid rate for the foreseeable future even if the export ban is removed.

Alaska ships nearly all of its crude out of State for refining elsewhere. Nevertheless, it does refine about 11 percent of its own crude and the number of refineries in that State increased from four in 1985 to six in 1987 with a corresponding increase in crude distillation capacity (Table 3). Roughly one-half of the capacity is in Alaska's Interior Region near Fairbanks. Most of the remainder is refined in the Southeastern Region in Anchorage and the Kenai Peninsula. Only small volumes are refined in the Arctic Region, all of it at Prudhoe Bay.

The transport of Alaskan oil is an expensive process and is affected by law and regulations. North Slope crude is initially transported through the 800-mile TAPS pipeline to Valdez, Alaska. The need to amortize the costs of the pipeline, one of the most expensive construction projects ever undertaken, results in a high pipeline tariff. The regulated tariff for oil transported from Prudhoe Bay in early 1990 ranged from about $3.47 to $4.01 per barrel.

The natural market for Alaskan crude oil or a substantial part of it is the Pacific Rim, including Japan. However, the almost total ban on crude oil exports effectively restricts shipments to the United States and its territories. Further, the Jones Act requires that such shipments be in U.S. constructed vessels flying U.S. flags and manned by U.S. crews, which is substantially more costly than using foreign flag ships and foreign crews.

Because of the ban on exports, supply of crude oil on the U.S. West Coast has exceeded requirements in that area since shortly after the TAPS pipeline was completed in 1977. Alaskan crude oil in excess of West Coast requirements is shipped to markets on the U.S. Gulf and East Coasts and to the U.S. Virgin Islands. However, the share of Alaskan crude oil shipped beyond the West Coast has declined substantially since 1982. The particularly sharp decline from 33 percent in 1987 to 28 percent in 1988 reflects an increased utilization of Alaskan crude in West Coast refineries (Table 4). The trend is likely to continue as Alaskan production decreases over time.

The transport of Alaskan crude beyond the West Coast is lengthy and costly. Costs vary depending in part upon whether the crude oil is transported aboard ship from Valdez for an almost 5,000 nautical mile Pacific trip through the Panama Canal, or unloaded at one end of the Trans-Panama pipeline and reloaded at the other end on smaller U.S. flag vessels for shipment to the Gulf and East Coasts. Shipments to the U.S. Virgin Islands, however, are not subject to the Jones Act requirements and can be made in foreign bottoms around Cape Horn.

Table 2. United States Production of Crude Oil,[a] 1976-1995
(Thousands of Barrels per Day)

Year	Alaska	California	Other United States	Total United States
		A. History		
1976	173	891	7,068	8,132
1977	464	958	6,823	8,245
1978	1,229	951	6,527	8,707
1979	1,401	965	6,186	8,552
1980	1,617	975	6,005	8,597
1981	1,609	1,055	5,863	8,572
1982	1,696	1,100	5,853	8,649
1983	1,714	1,109	5,865	8,688
1984	1,722	1,126	6,031	8,879
1985	1,825	1,161	5,985	8,971
1986	1,867	1,114	5,699	8,680
1987	1,962	999[b]	5,388[c]	8,349
1988	2,017	969[b]	5,154[c]	8,140
1989	1,874	NA	NA	7,631
		B. Forecast[d]		
1990	1,840	NA	NA	7,370
1991	1,760	NA	NA	7,290
1992	1,630	NA	NA	7,010
1993	1,500	NA	NA	6,780
1994	1,380	NA	NA	6,580
1995	1,280	NA	NA	6,400

[a]Includes lease condensate.
[b]Excludes Federal offshore production.
[c]Includes California Federal offshore production.
[d]The forecast is from the Energy Information Administration's base case forecast in the source cited below. A range of forecasts is also presented in that source.

NA = Not available.

Sources: o History: Energy Information Administration, Monthly Energy Review, November 1989, DOE/EIA-0035(89/11) (Washington, DC); and Petroleum Supply Annual 1988, DOE/EIA-0340(88)/1 (Washington, DC, May 1989) and earlier issues. o Forecast: Energy Information Administration, Annual Energy Outlook 1990, DOE/EIA-0383(90) (Washington, DC, January 1990) and unpublished supporting documents.

Table 3. United States Refineries and Refining Capacity as of January 1, 1977-1989

Year	Operable Refineries[a]			Crude Distillation Capacity		
	Alaska	California	United States	Alaska	California	United States
	(Number)			(Thousand Barrels per Calendar Day)		
1977	2	40	282	60	2,326	16,398
1978	3	41	296	83	2,378	17,048
1979	4	42	308	106	2,440	17,441
1980	4	45	319	116	2,486	17,988
1981	4	45	324	123	2,475	18,621
1982	4	43	301	130	2,233	17,890
1983	4	41	258	136	2,513	16,859
1984	4	43	247	135	2,524	16,137
1985	4	37	223	139	2,081	15,659
1986	5	36	216	188	2,394	15,459
1987	6	37	219	225	2,431	15,566
1988	6	33	213	223	2,379	15,915
1989	6	32	204	215	2,235	15,655

[a]Includes operating refineries and refineries where distillation units are completely idle but not permanently shut down.

Source: Energy Information Administration, Petroleum Supply Annual 1988, DOE/EIA-0340(88)/1 (Washington, DC, May 1989) and earlier issues.

Table 4. Alaskan Crude Oil Receipts at U.S. Refineries,[a] 1981-1988 (Percent)

District[b]	1981	1982	1983	1984	1985	1986	1987	1988
PADD I	5	6	8	6	7	3	2	2
PADD II	3	4	3	2	1	1	2	3
PADD III	16	25	29	25	28	21	21	17
PADD IV	0	0	0	[c]	0	0	0	0
PADD V[d]	63	52	53	58	62	67	67	72
Other[e]	12	13	8	9	3	8	7	7
Total	100	100	100	100	100	100	100	100

[a]Receipts at refineries in the United States and its territories.

[b]Petroleum Administration for Defense Districts.

[c]Less than 0.5 percent.

[d]Hawaiian Free Trade Zone is included in PADD V beginning in 1987.

[e]Other includes the refineries in Puerto Rico, U.S. Virgin Islands and, through 1986, the Hawaiian Free Trade Zone.

NOTE: Sum of components may not equal total due to independent rounding.

Sources: 1986-1988: Energy Information Administration, Petroleum Supply Annual ... (1986-1988), DOE/EIA-0340(86-88)/1, Table 11 and unpublished data from Form EIA-810. 1981-1985: unpublished data from Form EIA-810.

The existence of Alaskan crude oil in excess of West Coast requirements and the need to ship that surplus to other domestic markets has given rise to a "West Coast discount."[2] Alaskan crude is sold on the West Coast at a price below that for the same crude delivered to the U.S. Gulf Coast.[3] The price of Alaskan crude oil to the Gulf Coast is determined by world oil prices in that market. The price of Alaskan crude on the West Coast, on the other hand, is theoretically bounded on the high side by the price of potentially competing world crudes and on the low side by the Gulf Coast average competing crude oil price minus the transportation costs between the two coasts. A price for Alaskan crude to the West Coast in excess of the upper bound would theoretically result in reduced sales (or no sales) of Alaskan crude to that area, and a price below the lower bound would result in increased sales (or all sales) being made to the Gulf Coast. In practice, different firms reportedly price Alaskan oil to the West Coast at different levels within these bounds and the magnitude of any discount is highly variable.

If the export ban on Alaskan crude were removed, the price of that crude on the West Coast could rise toward the upper bound (the world price) and the magnitude of any West Coast discount could diminish or disappear, since the world price to both the West and Gulf Coasts does not differ greatly. However, since the volume of Alaskan crude shipped to the Gulf Coast and to other Eastern U.S. markets is expected to decline sharply as Alaskan production declines as forecasted, any importance attached to the West Coast discount is likely to also diminish even if the export ban is retained.

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[2] Although the phrase "West Coast discount" is used in this report to refer to the price differential for Alaskan crude oil delivered to the Gulf and West Coasts, the phrase has been frequently used by others to describe the delivered price differential between West Coast produced and imported crude oil.

[3] The magnitude of the discount has been estimated by a number of individuals and groups, including estimates prepared for the Alaska Senate Finance Committee. See Institute of Social and Economic Research of the University of Alaska-Anchorage, Report on Alaska Benefits and Costs of Exporting Alaska North Slope Crude Oil (Anchorage, Alaska: University of Alaska, May 1987).

3. FACTORS DETERMINING THE TRADE FLOW OF ALASKAN CRUDE OIL

Crude oils differ in quality and price. In general, the sulfur content and API gravity of a specific type of crude oil affect its value. In addition, the first cut (crude oil assay) from a crude oil distillation unit also affects its value; crude oils which produce intermediate products that require less processing to match end-use demand generally command higher prices.

To determine the demand for Alaskan crude oil outside the United States requires that potential markets which would be willing to pay a price higher than that on the U.S. West Coast be identified. That is, if the ban on the export of Alaskan crude were lifted, Alaskan crude would flow to foreign refining regions only if the offering price for that crude in those regions were higher than on the U.S. West Coast.

Major factors that determine a particular region's demand for Alaskan crude oil are as follows:

- Demand for refined products
- Refinery configurations
- Crude oil mixes used in the refinery
- Characteristics of Alaskan crude oil

Potential major markets for Alaskan crude oil are in the Pacific Basin. Japan is the principal potential market in that area because of its distance to Alaska and the compatibility of its refinery configurations with Alaskan crude. For this reason, this analysis is restricted to the West Coast and Japan.

Demand for Refined Products

The composition of demand for end-use products in Japan differed sharply from that on the West Coast in 1988 (Table 5 and Figure 1). The gasoline share of the petroleum market was less than 15 percent in Japan, but exceeded 45 percent on the West Coast. The market share of residual fuel oil was about 18 percent in Japan, but less than 10 percent on the West Coast. And the market share of liquefied petroleum gases (LPG) in Japan was more than 11 percent, but only about 3 percent on the West Coast.

Table 5. Demand for Petroleum Products in Japan and the U.S. West Coast in 1988
(Demand in thousands of barrels per day; shares in percent)

	Japan		West Coast[a]	
Product	Demand	Market Share	Demand	Market Share
Motor gasoline	677	14.3	1,251	45.4
Jet fuel(kerosene)	541	11.4	341	12.4
Distillate fuel	970	20.5	423	15.3
Residual fuel	851	18.0	268	9.7
Other	783	16.5	348	12.6
Liquefied Petroleum Gases	536	11.3	68	2.5
Natural Gas Liquids	69	1.5	17	0.6
Crude Oil	305	6.4	40	1.5
Total	4,732	100.0	2,756	100.0

[a]West Coast refers to Petroleum Administration for Defense District V (PADD V).

Sources: Energy Information Administration, Petroleum Supply Annual 1988, DOE/EIA-0340(88/1) (Washington, DC, May 1989), and Organization for Economic Cooperation and Development, Quarterly Oil and Gas Statistics, selected issues.

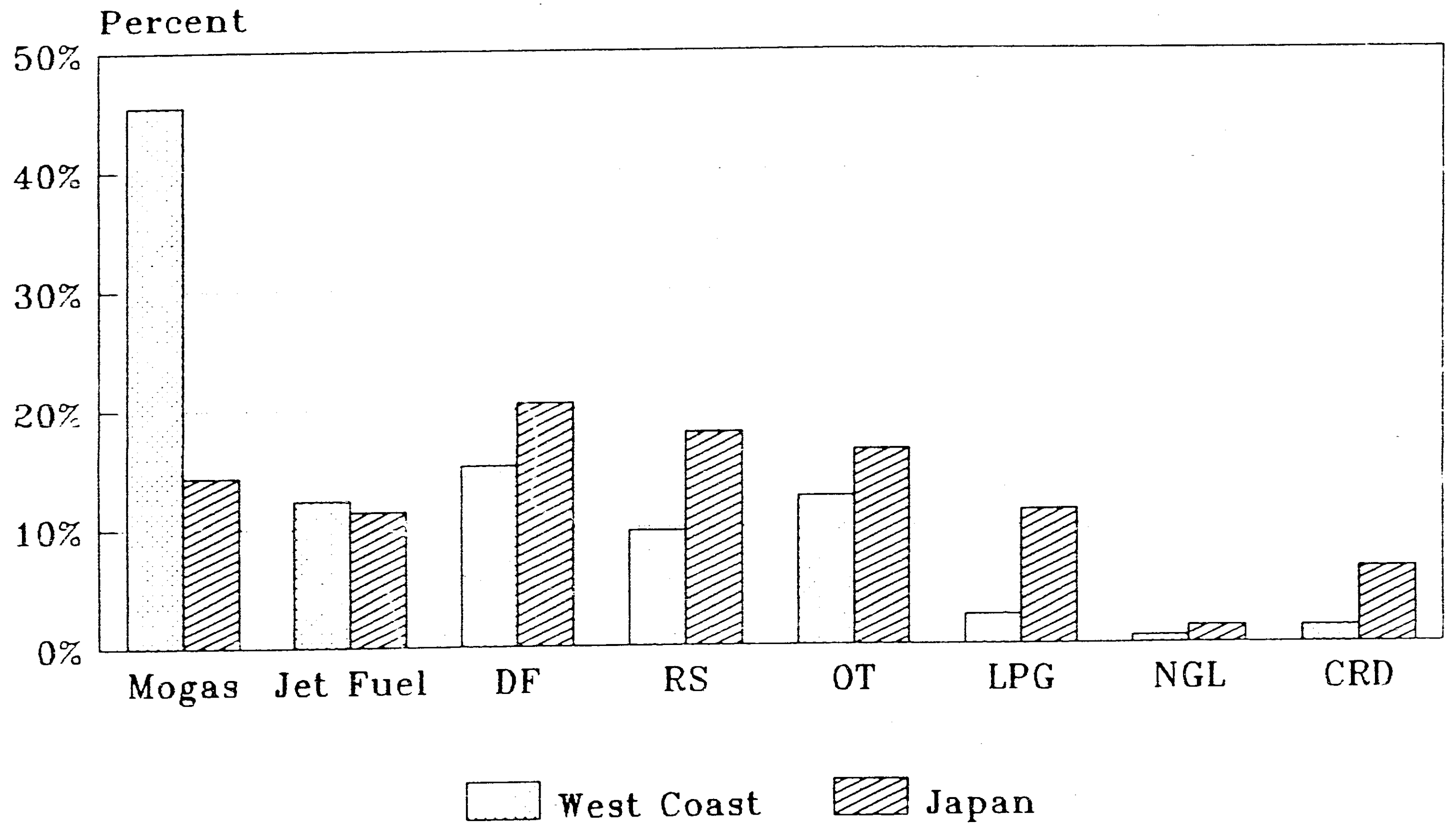
The significant differences in end-use product demand indicate that the demand for Alaskan crude oil may also be very different in these two regions.

Refinery Configurations

Table 6 and Figures 2 and 3 compare capacities for key refinery processing units on the West Coast and in Japan for 1988. The capacities reflect the need and requirement to meet end-use product demand. Two major categories of processing units stand out in the comparison. The first cracks the heavy-end of a barrel to lighter products and the second removes sulfur from the products.

On the West Coast, capacities for Coker, Hydrocracker, and Fluid Catalytic Cracker were 522 thousand barrels per day, 465 thousand barrels per day, and 773 thousand barrels per day, respectively, in 1988. A Coker converts asphalt or residual fuel oil to intermediate products to be processed in

Figure 1. Comparison of Market Share in 1988 Demand for Petroleum Products in Japan and the U.S. West Coast



Note: o West Coast refers to Petroleum Administration for Defense District V (PADD V). o See Table 5 for definition of mnemonics.
Source: Table 5.

either a Fluid Catalytic Cracker or a Hydrocracker. A Hydrocracker converts higher boiling petroleum materials such as aromatic cycle oils and coker distillates into gasoline and jet fuel. A Fluid Catalytic Cracker converts heavy oil into gasoline and lighter products. The capacities for these conversion units were substantially greater on the West Coast than in Japan in 1988. The differences in cracking capacity for these conversion units reflect the effect of a much greater market demand for gasoline on the West Coast with respect to the requirement to convert the heavy-end of a barrel into lighter products.

Table 6. Capacities for Key Refinery Processing Units in Japan and the U.S. West Coast in 1988
(In Thousands of Barrels)

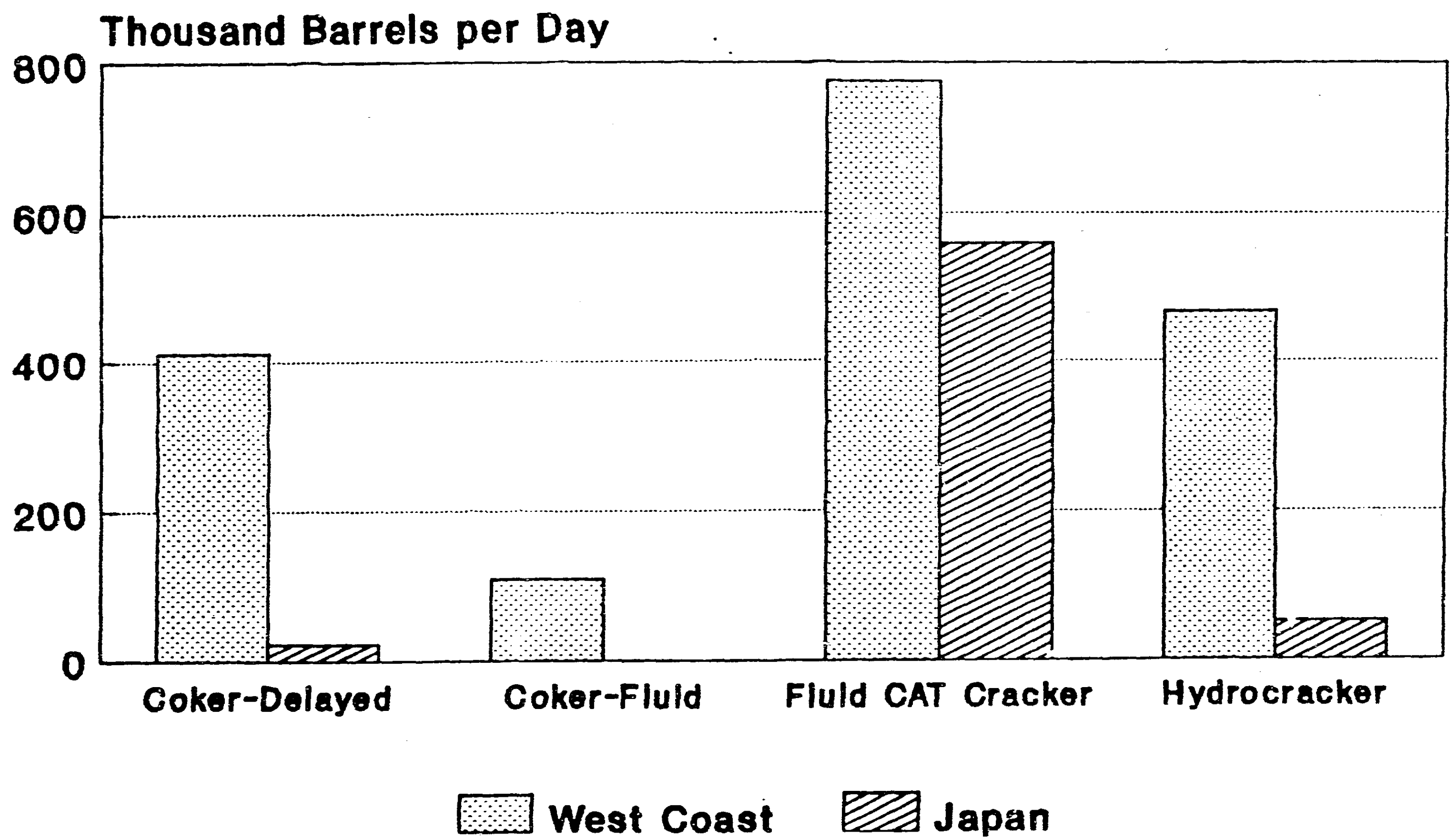
Processing Units	Japan	West Coast[a]
Crude Distillation	4,567	3,231
Vacuum Distillation	1,676	1,649
Coker-Delayed	23	412
Coker-Fluid	0	110
Viscbreaker	60	64
Naphtha Hydrotreater	850	573
Distillate HDS	1,377	373
FCC Feed Hydrofiner	208	490
Resid Desulfurizer	1,043	235
CAT Reformer High Pressure	476	384
CAT Reformer Low Pressure	58	322
Fluid CAT Cracker	557	773
Hydrocracker	51	465
Alkylation Plant	11	146

[a]West Coast refers to Petroleum Administration for Defense District V (PADD V).

Sources: Energy Information Administration, Petroelum Supply Annual 1988, DOE/EIA-0340(88/1) (Washington, DC, May 1989), and Oil and Gas Journal, December 28, 1987.

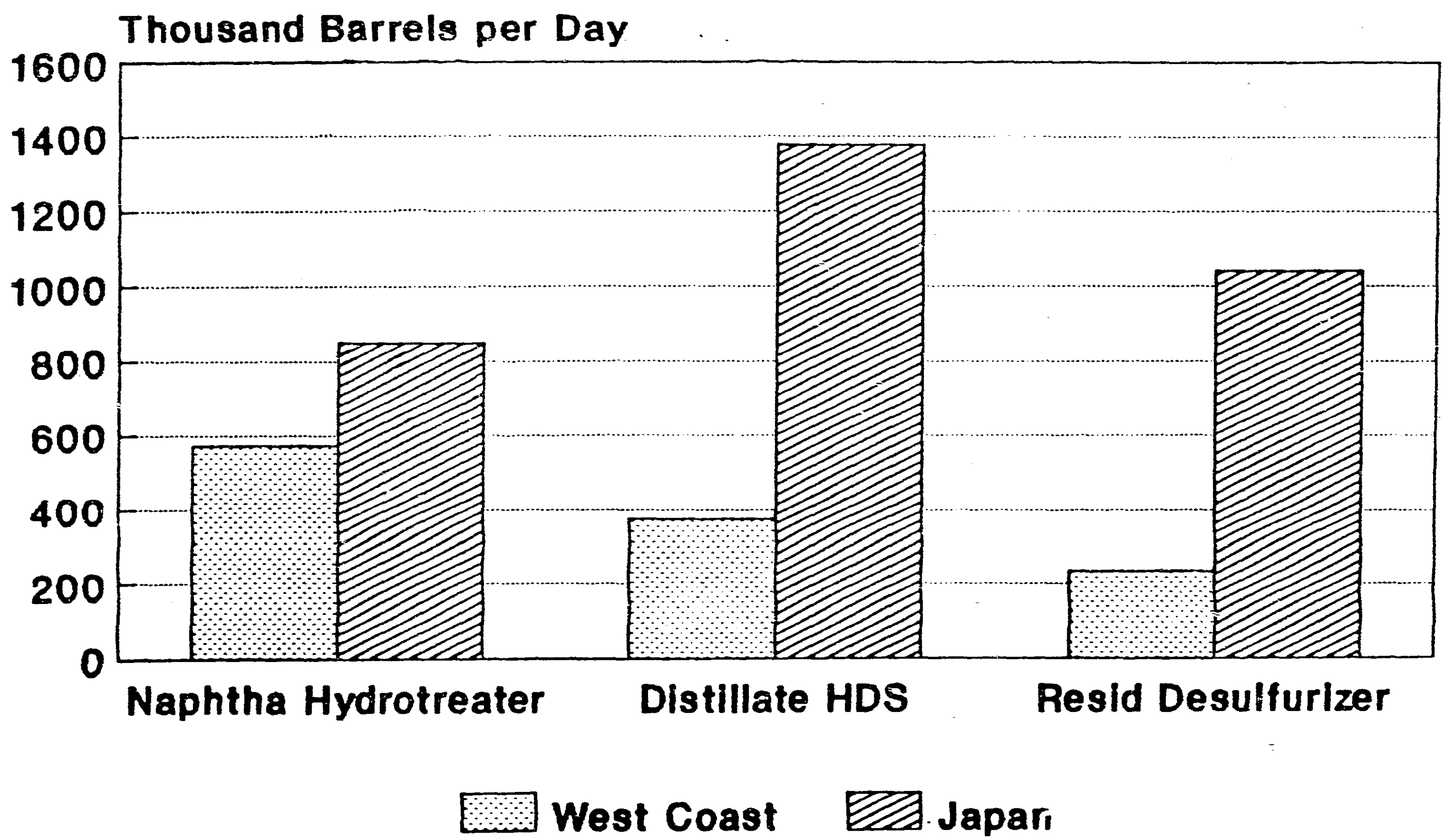
In contrast, hydrotreating units in Japan have a much greater capacity than those on the West Coast. In Japan, capacities for Naphtha Hydrotreater, Distillate Hydro-Desulfurizer, and Residual Fuel Desulfurizer were 850 thousand barrels per day, 1,377 thousand barrels per day, and 1,043 thousand barrels per day, respectively, in 1988. The differences in the capacities of desulfurization units reflect the much greater Japanese demand for naphtha, distillate fuel oil, and residual fuel oil, and environmental restrictions on the sulfur content of these fuels.

Figure 2. Comparison of Cracking Capacity in Japan and the U.S. West Coast in 1988



Note: West Coast refers to Petroleum Administration for Defense District V (PADD V).
Source: Table 6.

Figure 3. Comparison of Major Hydrotreating Capacity in Japan and the U.S. West Coast in 1988



Note: West Coast refers to Petroleum Administration for Defense District V (PADD V).
Source: Table 6.

Crude Oil Mix Used in the Refinery

Given the demand for end-use petroleum products and the refinery configurations, the output of refined products and the efficiency of refinery operations depend largely on the quality and volume of crude streams available to a refinery. The optimal crude oil mix would include crude oils with sulfur content, API gravity and crude oil assay that are best suited for processing in a given refinery and that minimize the cost of meeting a particular mix of petroleum product demand.

In 1988, Japan imported and processed the types of crude oils shown in the tabulation below. In general, the API gravity of these crudes are higher than 27°, and the sulfur content of most of them are greater than 1.5 percent by weight, except crude oils from China, Indonesia, and Malaysia.

1988 Japanese Oil Imports by Origin

Australia	Iran Light	Malaysia	Saudi Heavy
China	Iran Heavy	Mexico	USSR
Egypt	Iraq	Qatar	U.A.E.
Indonesia	Kuwait	Saudi Light	Venezuela

The West Coast imported about 200 thousand barrels of crude oil per day in 1988. The remaining crude oil used in that area was indigenous West Coast production, which included about 1.4 million barrels per day of crude from Alaska. The average API gravity of the crude used by the West Coast refineries was lower (heavier) than for crude oil used in Japan.

In a competitive oil market, a profit maximizing refiner would be continuously seeking that crude oil mix which minimizes operating costs and maximizes profits. In general, the optimal crude oil mix to a refinery changes as the demand slate for refinery products changes.

Characteristics of Alaskan North Slope Crude Oil

Alaskan North Slope crude oil has an API gravity of 26.4° and a sulfur content of 1.06 percent by weight. The assay of ANS crude indicates that it produces a very small fraction of gasoline range products (isobutane, light straight-run gasoline, and light naptha as gasoline blending components). The sum of these fractions is less than 8 percent (Table 7). In a market like the West Coast, which has very high gasoline demand, a great deal more processing is required to convert light gas oil, heavy gas oil, and residual

Table 7. Alaskan North Slope Crude Oil Assay

Intermediate Products	Crude Fraction
Gas	0.004
Propane	0.002
Isobutane	0.005
N. Butane	
Light Straight Run, LON (C5-175)	
Light Straight Run, ION (C5-175)	0.021
Light Straight Run, HON (C5-175)	0.013
Light Naphtha Paraffinic (175-250)	
Light Naphtha Intermediate (175-250)	0.038
Light Naphtha Naphthenic (175-250)	0.002
Naph P (250-325)	
Naph I (250-325)	0.050
Naph N (250-325)	0.006
Heavy Naph P (325-275)	
Heavy Naph I (325-375)	0.020
Heavy Naph N (325-375)	
Kero L. Flash P., LS/LM(375-500)	0.051
Kero H. Flash P., LS/LM(375-500)	0.099
Kero L. Flash P., HS/LM(375-500)	
Kero H. Flash P., LS/LM(375-500)	
Distillate LS/LM(500-620)	0.057
Distillate MS/LM(500-620)	0.072
Distillate HS/LM(500-620)	
Light Gas Oil, N. LS (620-800)	0.045
Light Gas Oil, N. MS (620-800)	0.130
Light Gas Oil, N. HS (620-800)	
Light Gas Oil, P. LS (620-800)	
Heavy Gas Oil N, LS (800-BTMS)	0.030
Heavy Gas Oil N, MS (800-BTMS)	0.155
Heavy Gas Oil N, HS (800-BTMS)	
Heavy Gas Oil P, LS (800-BTMS)	
Resid. Low Sulfur (.2)	
Resid. High Sulfur (2.1)	0.150
Resid. Very High Sulfur (3.2)	0.050
Asphalt Very High Sulfur (4.3)	
Total	1.000

Source: Energy Information Administration, Refinery Evaluation Modeling System (REMS) Model Documentation, DOE/EIA-0460 (Washington, DC, October 1984).

fuel to lighter products such as gasoline and jet fuel. The Fluid Catalytic Cracker and Hydrocracker would be used to convert gas oils to gasoline and jet fuel, and the coker process would be used to convert residual fuel to lighter products.

In Japan, the demand for distillate fuel and residual fuel is much greater than the demand for gasoline. Therefore, the processing required to convert the heavy-end of a barrel to lighter products is much less. In addition, the low sulfur content of ANS crude oil also implies a lower utilization of desulfurization units, which further reduces processing costs in Japan.

Would refineries in Japan outbid refineries on the West Coast for at least some portion of Alaskan crude oil? The answer depends on the savings in processing costs that could be achieved by substituting ANS crude oil for other, imported, crudes as well as on the relative prices of ANS and internationally traded crude oils.

4. METHODOLOGY

The economic feasibility of exporting ANS crude oil can be quantitatively evaluated by simulating market and refinery conditions that refiners face in both Japan and the West Coast. These conditions include demand for petroleum products, refinery configurations, and crude oil mixes. The Energy Information Administration's Refinery Yield Model (RYM) is suitable for performing such an analysis.[4]

The RYM model is capable of simulating refinery operations to meet the demand for petroleum products. Given the demand for end-use products and a particular refinery configuration, the RYM model can be solved to either maximize refinery profits or minimize refining costs. Solutions from the RYM model also provide an imputed price for each type of crude oil, based on processing costs which are used as inputs to the model simulations. These imputed prices reflect the combined effects of demand for refined products and refinery processing costs.

Historic 1988 data on petroleum markets for Japan and the West Coast are used as inputs to the RYM model to simulate refinery operations in these two regions. Specific assumptions and data sources used in the RYM model simulations are as follows.

Assumptions

1. The cost of refining for both the crude oil distillation units and the downstream conversion units are assumed to be identical in Japan and the U.S. West Coast.

2. Crude oil tanker rates from Valdez to Japan are based on a 175,000 deadweight ton foreign flag tanker.

3. The regional refining capacity for each type of conversion unit is the sum of the capacities for this type of conversion unit for each refinery in the region.

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[4] Energy Information Administration, Refinery Evaluation Modeling System (REMS) Model Documentation, DOE/EIA-0460 (Washington, DC, October 1984).

4. Demand for end-use products in each region is based on total 1988 oil demand.

5. Crude oil inputs to a regional refinery are based on regional aggregates for 1988.

6. Refinery output of products in each refinery region is based on regional aggregates for 1988.

7. The FOB price for Saudi Light crude oil is set at $14.15 per barrel. Prices of other crude oils are imputed by the model using the price of Saudi Light as a reference.

Data Sources

1. The Energy Information Administration's Petroleum Supply Annual 1988 is the primary data source for West Coast crude oil inputs to refineries, production of refined products, and capacity for all refining units.

2. The Organization for Economic Cooperation and Development's Quarterly Oil and Gas Statistics and computer printouts from the EIA's December 1989 International Petroleum Statistics Report data base provided data on crude oil imports and production of refined products for Japan.

3. Data on imported refinery acquisition costs in Japan were obtained from the International Energy Agency.

4. The 1988 annual average FOB price for Saudi Light is from Petroleum Intelligence Weekly, January 23, 1989.

5. Tanker rates were derived from Platt's Oilgram News, various issues published in 1988.

6. The 1988 spot price for ANS crude oil at Los Angeles was obtained from Telerate System, Inc.

Model Simulations

The actual historical 1988 data for petroleum markets in Japan and the West Coast reflect the effects of economic forces and institutional factors on these two markets. In particular, the data reflect the effects of interactions among demand for end-use petroleum products, supply of crude oil, and refinery configurations. Institutional factors such as the export ban on ANS crude oil cannot be modeled easily, but the impacts of such factors can be evaluated with use of the RYM model. The use of 1988 data in the model implicitly assumes that refinery operations in those two markets performed efficiently during that year, given the prevailing contractual and institutional constraints and practices.

Several steps are required to simulate refinery operations in Japan and to generate a value for ANS crude oil to that country. First, the demand for end-use refined products is fixed at the 1988 level and composition in the RYM model. Second, the volume of crude oil, except ANS crude, used by the Japanese refinery is upper-bounded. Third, the model is calibrated to match the 1988 imported refinery acquisition costs in Japan. Fixing both the product demand and the upper bound for crude oil inputs allows direct evaluation of processing costs related to each type of crude oil. It also assumes that the petroleum market in 1988 was in equilibrium.

To determine the relative price of ANS crude oil in the two refining regions, and to do so on a common basis, both regions used the CIF Saudi Light price as a reference price. The reference price was estimated using relevant tanker rates and the FOB Saudi Light price.

5. ANALYSIS OF RESULTS

Alaskan North Slope crude oil could be shipped to Japan and possibly other Pacific Rim countries if the ban on the export of such crude were eliminated. Because only independent simulations are made here for the two markets, the quantities traded cannot be estimated. However, the high value that Japan places on ANS crude virtually assures that such shipments would occur. Additionally, the price of ANS and other West Coast crude oils would likely increase relative to the price that would exist with a continuation of the ban. These are the direct implications of the results generated by the Refinery Yield Model (RYM). They are based on 1988 data. However, similar results would likely be generated for the early 1990's given recent and expected product demand slates and prices, refinery configurations and crude streams in Japanese and West Coast refineries. Although the RYM model does not generate data for petroleum products, some inferences can be made concerning them based on the RYM-generated data for crude oil prices and information extrinsic to that model.

Implications for Crude Oil Prices and Exports

Two different approaches were used to estimate the difference between the actual price of ANS crude oil and its value in an open, or unconstrained, market. The approaches basically differ according to the particular refinery model used to value ANS crude. The first approach asks what the imputed (or model-generated) CIF value of ANS crude would be if the Alaskan crude were processed in a West Coast refinery given that refinery's demand slate. The estimate is $14.85 per barrel, or $1.35 more than what ANS crude actually sold for to U.S. West Coast refiners in 1988 (Table 8, Part A).[5] Although this result implies that the market would value ANS crude more than

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[5]The $1.35 in Table 8, Part A is derived as follows: The FOB price of Saudi Light intended for Japan was $14.15 per barrel in 1988. This price translates to CIF prices of $14.82 and $15.01 in Japan and the West Coast, respectively, given the known transport costs from Saudi Arabia. Using $15.01 as a standard, the RYM model generates, or imputes, a lower ($14.85) value for ANS crude given the different characteristics of that crude and given the refinery configuration and product demand slate that exists on the West Coast. The $14.85 CIF value exceeds the actual average CIF price at which ANS crude sold for in 1988 by $1.35.

Table 8. Potential Price Differences for ANS Crude Oil on the U.S. West Coast in 1988

Method A. Potential Difference Using West Coast Refinery Model

Source/Type of Crude	Destination: Japan FOB	Destination: Japan CIF	Destination: U.S. West Coast CIF
Saudi Light	$14.15[a]	$14.82[b]	$15.01[b]
Alaska North Slope (ANS)			14.85
ANS Spot in Los Angeles			13.50[a]
Difference in ANS Prices			$ 1.35

Method B. Potential Difference Using Japan Refinery Model

Source/Type of Crude	Destination: Japan FOB	Destination: Japan CIF	Destination: U.S. West Coast CIF
Saudi Light	$14.15[a]	$14.82[b]	
Alaska North Slope (ANS)		$16.56	$16.89
ANS Spot in Los Angeles			13.50[a]
Difference in ANS Prices			$ 3.39

[a]Actual price (not imputed or estimated).
[b]FOB Saudi Arabia plus transportation cost.

Note: West Coast refers to Petroleum Administration for Defense District V (PADD V).

Sources: o FOB Saudi Light price: Petroleum Intelligence Weekly, January 23, 1989. o Transport Costs: Platt's Oilgram News, 1988, various issues. o ANS spot price in Los Angeles: Telerate Systems, Inc. o All other ANS prices: generated by the RYM model.

its recent actual price if the ban were lifted, it does not provide a basis for determining whether or not ANS crude would likely be exported to Japan or elsewhere in the Pacific Rim.

The second approach does provide a basis for resolving this issue. It estimates the difference between the actual price of ANS crude and its value using the Japanese refinery model and associated product demand slate to value the crude. This second approach asks the following question: What would the imputed CIF value of ANS crude be if it were processed in Japanese refineries? The estimate is $16.56 per barrel for ANS crude on a CIF basis to Japan (Table 8, Part B). The implication is that Japan would import crude oil from Alaska if the export ban were abolished. The $16.56 value that Japan places on ANS crude delivered to that country is equivalent to a $16.89 value on the West Coast when transportation costs are adjusted. The $16.89 price is $3.39 per barrel more than what ANS crude actually sold for on the West Coast in 1988. The differential is one measure of the magnitude of the increase that could occur in the price of ANS crude if the ban were removed.

The imputed values ($14.85, $16.56, and $16.89) for ANS crude in Table 8 are marginal values, whereas the $13.50 price for that crude is an actual average price. The imputed values represent the values for the first barrel that would be exported. Additional exports would cause the values of crude oils to change in both markets with the likely price increase of ANS crude somewhere between the values estimated here. The implication (from Table 8, Part B) is that some volumes would likely be exported if the ban were removed and that average prices for ANS crude would rise. Estimates of equilibrium volumes and prices, however, are beyond the scope of the RYM model. Nevertheless, it is very likely that, at a minimum, the 200,000 barrels per day of ANS crude that was recently (1989) shipped to the U.S. Gulf Coast would be exported to Japan.

Implications for Petroleum Products

An increase in the price of Alaskan crude oil on the U.S. West Coast would raise the value of other crude oils produced in that region. In addition, higher-priced imported crude oils would be used to replace exported ANS oil. As a result, the average acquisition cost of crude oils and the prices of refined products would increase.

Exporting ANS crude oil and importing gasoline-producing crude oils would free-up the utilization of downstream conversion units. The capacities freed from processing ANS crude oil could be used to process other indigenous West Coast heavy crude oils. This increased capability of processing heavy crude oils would enable refiners on the West Coast to produce additional volumes of lighter products and could raise the demand for and the prices of indigenous West Coast heavy crude oils.

Prices for refined products would also increase due to an increase in refinery acquisition costs. The magnitude of the price increase, however, would not be the same for all products. Price increases for lighter products such as gasoline and distillate fuel oil would be expected to be relatively small. First, the exportation of ANS crude oil and the importation of gasoline-producing crude oils would reduce refiners' processing costs, which could offset part of the increase in refiners' acquisition costs. Second, in a competitive international market, free trade in petroleum products assures that differences in product prices across international refining regions would not exceed transportation costs.

Price increases for residual fuel oils would probably be significantly greater than for lighter products. Historically, there is a general parity between the prices for crude oil and residual fuel; an increase in the price of crude oil inputs to West Coast refineries would certainly raise the price of residual fuel. Market forces would also ensure higher prices for residual fuel; production of residual fuel oil would decline because imported crude oils produce a smaller volume of residual fuel. In addition, the exportation of ANS crude oil would enable refiners to convert more heavy crude oil to produce lighter products.

Generally, lifting the export ban on ANS crude oil would likely have little impact on consumers. The economic impact on industrial users would not be very great because the share of residual fuel oil in total energy consumption in both industrial use and power generation is very small.

6. BROADER IMPLICATIONS OF LIFTING THE ANS CRUDE OIL EXPORT BAN

The elimination of the ban on ANS crude oil exports has implications for the economy that extend beyond the direct effects on petroleum prices and trade flows. These additional effects relate to petroleum producers and production, the domestic distribution of Alaskan crude, the shipping industry, government revenues, the balance of trade, and national security. This section qualitatively explores some of these additional effects. Quantitative estimates are beyond the scope of this report.[6]

The removal of the export ban on Alaskan crude oil would cause the volume of crude exported to foreign countries to rise substantially from its present negligible level. The so-called oil glut on the West Coast would diminish and wellhead prices in Alaska and elsewhere on the West Coast would increase. Wellhead activity in Alaska and in California would probably also increase relative to the level of activity with the ban in effect.

The removal of the ban would have favorable and unfavorable effects on the petroleum industry. The direct increase in export prices together with export shipments in foreign bottoms at lower rates would result in higher wellhead prices and profits for producers of crude oil, at least in Alaska. Conversely, some refiners on the West Coast could be adversely affected by the increase in ANS and, possibly, California crude oil prices. This adverse effect would be offset to only a minor extent by the expected small increase in average prices for products.

The U.S. tanker fleet would be adversely affected if the Alaska export ban were eliminated. However, adverse effects on that portion of the fleet used to ship ANS crude to the Gulf and East Coasts would be quite small since shipments to those areas would be all but eliminated by 1992 (and possibly earlier) even with the ban in effect, because of the expected continued

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[6] The most comprehensive published set of quantitative estimates of both the direct and broader effects of eliminating the export ban is in U.S. Department of Commerce, Report to Congress on Alaskan Oil (Washington, DC, June 1986). Also see Marshall Hoyler, "The Politics and Economics of Alaskan Oil Exports," U.S.-Japanese Energy Relations (Boulder, Colorado: Westview Press, 1984), pp. 83-137; and Institute of Social and Economic Research of the University of Alaska-Anchorage, Report on Alaska Benefits and Costs of Exporting Alaska North Slope Crude Oil (Anchorage, Alaska: University of Alaska, May 1987).

sharp decrease in ANS production. Removing the ban would simply accelerate the process somewhat. Tankers involved in the intercoastal trade on the West Coast, on the other hand, would be more adversely affected. Over a longer period, they would also be affected to the extent that exports to the Pacific Rim are made in foreign bottoms, which is likely. A large share of the deadweight tons of that fleet is used to transport ANS crude. The layed-up tonnage would adversely affect the profitability of owners of tankers, could cause some defaults on tanker loans, and result in layoffs of seamen for whom alternative employment is not readily available. Employment in the shipbuilding and repair industry would also be impacted. The Federal government could also be adversely affected by developments in the tanker industry, since some of the tanker loans which might go into default are Federally guaranteed.

The increase in the prices, and possibly volumes, of ANS crude oil production that would result from eliminating the export ban would have a favorable effect on State government revenues in Alaska. A large share of Alaska's revenues, and most of its tax revenues, are tied directly or indirectly to wellhead prices through severance taxes on oil and gas, conservation taxes, taxes on producing properties, and corporate income taxes. Severance taxes alone accounted for two-thirds of Alaska's State government tax revenues in fiscal 1988. The State government also collects lease royalties of 12.5 percent of the wellhead value of crude petroleum produced in the Prudhoe Bav field since that field is on State-owned land. Higher crude oil prices and increased production volumes would cause State tax and royalty revenues from all of these sources to increase over the near term relative to the revenues that would otherwise be generated. California tax and related revenues from its indigenous crude would also increase for similar reasons but to a lesser extent since it has only a negligible severance tax.

The effect on the U.S. balance of trade from eliminating the ANS crude oil export ban is uncertain. The net effect depends on many factors, including (1) whether exported crude would be replaced with imported crude on a barrel-for-barrel basis, (2) potential increases in the volume of product imports, (3) increases in West Coast crude oil production, and (4) the extent to which West Coast petroleum product consumption would decline as a result of higher production prices in that area. Although the net effect on the balance of trade is uncertain, the effect on only the balance of trade in services would clearly be unfavorable if both the ANS oil which is exported and the compensating volumes that are imported were all shipped in foreign bottoms.

The national security implications of lifting the ban on the export of ANS crude oil are complex. The additions to total ANS crude oil production from higher prices enhances security since it makes more domestic oil available to the world market. U.S. dependence on petroleum imports, measured as the ratio of net imports of crude oil and products to petroleum products supplied to the U.S. market from all sources, would decrease to the extent that the increase in import volumes from eliminating the ban is less than the export volume. Nevertheless, the U.S.'s net dependence on imports from members of the Organization of Petroleum Exporting Countries (OPEC) would increase to the extent that the increase in the volume of imports is from that group. Within a broader geographic framework, however, the dependence of Pacific Basin countries on OPEC would decrease as they diversify their sources of crude oil supply to include Alaska.

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