Appendix V

Supplemental Data Responses and Technical Reports

- **Referenced Responses to Data Requests**
- **EnSys Reports: Keystone XL Assessment; Keystone XL - No Expansion Review**
- **ICF Report: Life-Cycle Greenhouse Gas Emissions of Petroleum Products from WCSB Oil Sands Crudes Compared with Reference Crudes**
- **Keystone Response to PHMSA (relative to the Special Permit)**
- **DOE memo on the paper by Philip K. Verleger, “The Tar Sands Road to China**

Department of Energy
Washington, DC 20585

January 25, 2011

Dr. Kerri-Ann Jones
Assistant Secretary
Bureau of Oceans, Environment and Science
U.S. Department of State
2201 C St., NW
Washington, DC 20037

Dear Dr. Jones:

In support of the Department of State's environmental review of TransCanada's proposed Keystone XL pipeline, the Department of Energy is pleased to provide the attached contractor report assessing petroleum market impacts of the pipeline. The Department of Energy (DOE) Office of Policy & International Affairs contracted EnSys Energy and the Brookhaven National Laboratory to undertake an analysis to evaluate how the presence or absence of the Keystone XL pipeline would affect U.S. petroleum imports and other variables.

Because the status of future pipelines that could transport Canadian oil sands to U.S. refineries is uncertain, the contractors analyzed seven different scenarios, each representing a different combination of available pipelines. The analysis focused on the estimated import of Canadian oil sands to U.S. refineries, exports of Canadian oil sands to Asian markets, U.S. petroleum imports from other sources and greenhouse gas emissions. The estimates of imports of Canadian oil sands to the U.S. were specified for each of the five U.S. refinery regions (Petroleum Administration for Defense Districts). The greenhouse gas emission estimates included those from U.S. refineries and world-wide full fuel-cycle emissions. These analyses were estimated with two different projections of U.S. oil demand: the Energy Information Administration's *2010 Annual Energy Outlook* Reference Case and a low-demand scenario that was suggested by the Environmental Protection Agency.

I believe that the enclosed assessment of the petroleum market impacts of the proposed Keystone XL pipeline can be a useful resource for the Department of State's environmental review of the project. If you have questions about this study, please contact Dr. Carmine Difiglio on my staff (202-586-8426; carmine.difiglio@hq.doe.gov).

Sincerely,

David B. Sandalow
Assistant Secretary
Office of Policy and International Affairs

Enclosures: Keystone XL Assessment Final Report and Keystone XL Assessment Final Report Appendix

Keystone XL Assessment

Prepared by Ensys Energy

For the U.S. Department of Energy Office of Policy & International Affairs

Final Report

December 23 2010

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Abbreviations & Acronyms Used in this Report

bbl	barrel
bpd	barrels per day
mbd	million barrels per day
tpa	tonnes per annum
mtpa	million tonnes per annum
DOE	Department of Energy
DOS	Department of State
EPA	Environmental Protection Agency
PADD	Petroleum Administration for Defense Districts
BC	British Columbia
CAPP	Canadian Association of Petroleum Producers
NEB	Canadian National Energy Board
WC	Western Canada
WCSB	Western Canadian Sedimentary Basin
ETP	Department of Energy's Energy Technology Perspectives Model
WORLD	EnSys' World Oil Refining Logistics & Demand Model

1 Executive Summary

In June 2010, EnSys Energy was contracted by the Department of Energy Office of Policy & International Affairs to conduct an evaluation of the impacts on U.S. and global refining, trade and oil markets of the Keystone XL project to bring additional Canadian crudes, including oil sands, into the U.S. The study was conducted in close collaboration with and also with significant inputs from the Department of Energy. Those included assessments of global life-cycle GHG impacts of scenarios evaluated.

This report presents the assumptions used to perform the analyses and the findings developed via integrated global modeling and under a range of potential scenarios. The central focus of the report is the proposed project by the Canadian company TransCanada to build a pipeline known as Keystone XL (or simply KXL) from Hardisty Alberta to Steele City Nebraska and then on to the U.S. Gulf Coast via Cushing Oklahoma. The line would carry crude oil streams from the Western Canadian Sedimentary Basin (WCSB) to U.S. Midwestern (PADD2) and Gulf Coast (PADD3) oil refineries. Transit of Bakken and Cushing /West Texas area crudes on KXL may also be added. The project was approved by the Canadian National Energy Board in March 2010, and TransCanada has applied for a Presidential Permit from the U.S. Department of State. The Department of Energy commissioned this analysis in support of the Department of State as a component of its environmental review of the KXL pipeline and its review of the request for a Presidential Permit.

The first two phases of the Keystone pipeline system, intended to carry crude from Hardisty into central PADD2 and then on down to Cushing Oklahoma, are under start-up or construction, with full operation early 2011. Total system capacity after these phases is stated as 591,000 bpd. The Keystone XL expansion comprises two new lines, one to run from Hardisty, cross-border via Montana and South Dakota, to PADD2 and the other from Cushing to the U.S. Gulf Coast. TransCanada projects start-up operations in the first quarter of 2013, subject to permits. Completion of KXL would increase total Keystone pipeline capacity by 700,000 bpd to 1.29 mbd, with the ability to move 591,000 bpd of crude from Hardisty to PADD2 refineries (Keystone Mainline) and another 700,000 bpd from Hardisty to the Gulf Coast (Keystone XL).). A potential tie-in TransCanada is considering would enable Bakken crudes to feed into the Keystone XL line, taking up part of the 700,000 bpd capacity. Keystone XL would be designed to support future capacity of 900,000 bpd by increasing pumping capability[1]. Maximum capacity for the total Keystone system after expansion would be 1.5 mbd. Associated capacity to the Gulf Coast has not been set but would likely be 900,000 bpd[2]. Current commitments on KXL, if built,

[1] A permit waiver would be required for any future expansion of KXL but is not being requested by TransCanada at this time.

[2] Future capacity to the Gulf Coast could be lower than 900,000 bpd as the co-location of the Keystone XL and Mainline pipelines at Steele City, Nebraska, allows for the possibility that crudes in future traveling on KXL to Steele City could be diverted there onto the Keystone Mainline running east to Wood River/Patoka, i.e. could stay in PADD2 rather than go south to PADD3.

are for 535,000 bpd of volume from Hardisty to Cushing and for 380,000 bpd on the segment from Cushing to the Gulf coast (out of 700,000 bpd capacity)[3].

EnSys employed its World Oil Refining Logistics & Demand (WORLD) model to address the potential impacts on U.S. refining, crude and product import dependency and cost, and on Canadian crude oil market destinations, of constructing or not constructing Keystone XL. The model provides integrated analysis and projection of the global petroleum industry, combining top down scenarios for projected oil price/supply and demand over the next twenty years with bottom up detail on crude oils, non-crudes, (NGL's, biofuels, etc.), refining, transportation, product demand and quality[4].

[3] These commitments are for WCSB crudes only. Additional volume commitments for (a) Bakken crude that would be fed into KXL in Montana and/or (b) MidContinent crudes that would be fed in at Cushing could result should TransCanada determine to proceed with these options based on the results of two "open seasons" that closed in November.

[4] Although a 50 year life for a pipeline is a common base for assessment of potential impacts, (thus to 2063 for Keystone XL if it were to start up in 2013 as currently targeted by TransCanada), this WORLD model based study evaluated outlooks only through 2030. Firstly, the WORLD version available for the study extended only to 2030. Secondly, the horizons that could be modeled were constrained by those in available global outlooks. The projections available in the 2010 EIA Annual Energy Outlook went only to 2035, similarly those in the 2010 EIA International Energy Outlook . In general, high levels of uncertainty at very long term horizons tend to lead to studies modeling the detail of oil supply, refining and demand being limited to a maximum horizon 20 to 25 years out. In addition, the Keystone XL project is but one potential element in a complex, global petroleum supply system. The effects of such a project can be identified in a near to mid-term (10 to 20 years) assessment but are likely to be subsumed by assumptions concerning other changes in the global petroleum supply infrastructure over the longer term.

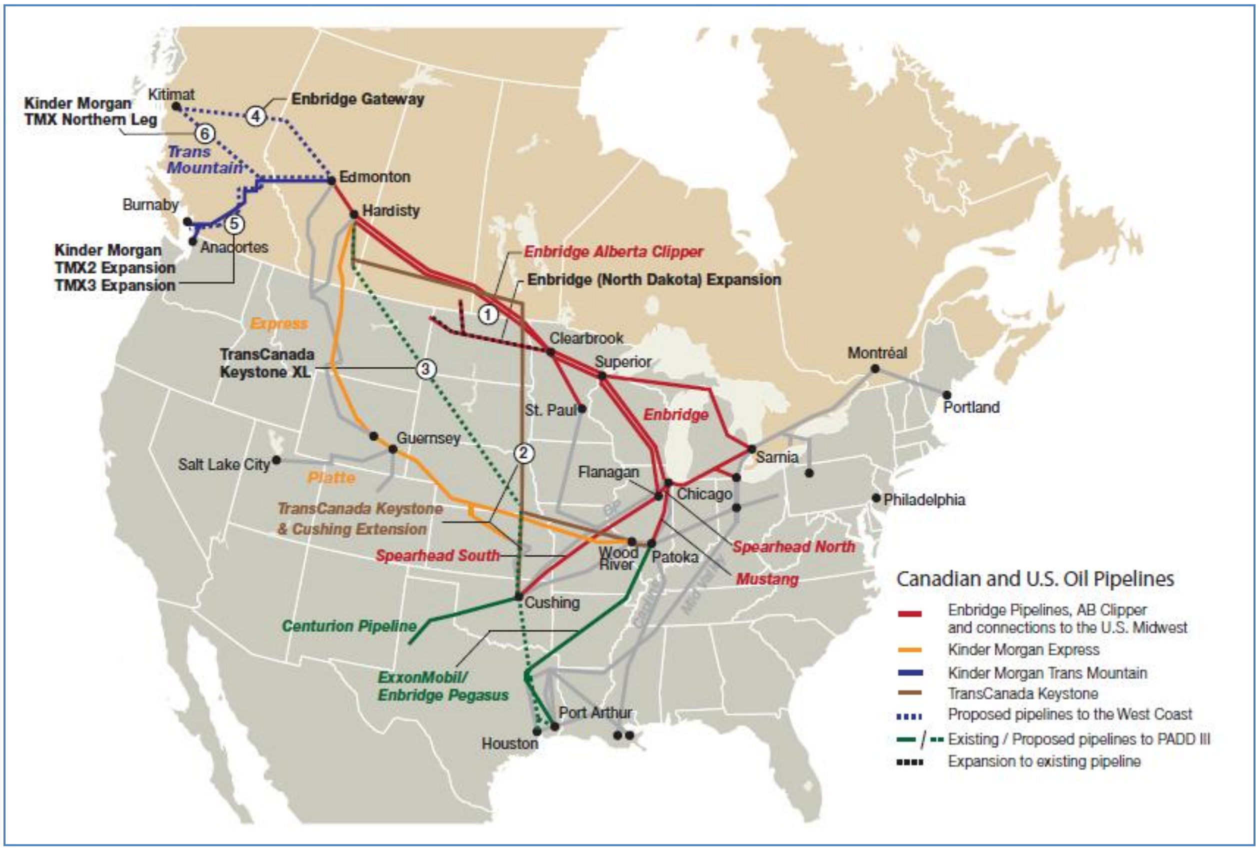

Figure 1-1

The impact of adding the KXL pipeline to the North American crude oil transport system depends on the other pipeline paths available to carry heavy crude out of the West Canadian Sedimentary Basin. Figure 1-1 illustrates both existing and proposed pipelines that could deliver WCSB crude to export markets.

To address uncertainties in the outlook for WCSB pipeline export projects, a set of scenarios was developed and analyzed using WORLD to explore the potential impact of KXL being built, of No KXL (not built) and of No Expansion in pipeline capacity. Variants were applied for each of these pipeline availability scenarios as set out in Tables 1-1 and Table 1-2.

Base Scenario		**Variant**
KXL (is built)	KXL	Transmountain TMX 2 and 3 expansions go ahead
	KXL+Gateway	TMX 2 and 3 and Northern Gateway go ahead
	KXL No TMX	No TMX 2 and 3 or Northern Gateway i.e. no expansion to west coast of Canada
No KXL (not built)	No KXL	Transmountain TMX 2 and 3 expansions go ahead
	No KXL HiAsia	High level of expansion to Asia: TMX 2,3, Northern Gateway, Northern Leg
No Expansion	No Exp	No expansion of pipelines at all beyond current projects under construction
	No Exp + P2P3	No expansion except TMX 2,3 and U.S. domestic PADD2 to U.S. Gulf Coast

Table 1-1

Basic Scenarios	Scenario WORLD Model Cases	Scenario Assumptions: USA Pipelines			Scenario Assumptions: Asia Pipelines		
		Keystone XL Allowed	WCSB to PADD2 EXP	PADD2 to PADD3 EXP	TMX Expansion	Northern Gateway	Nothern Leg
KXL	KXL	Y	Y	Y	Y	N	N
KXL	KXL+Gway	Y	Y	Y	Y	Y	N
KXL	KXL No TMX	Y	Y	Y	N	N	N
No KXL	No KXL	N	Y	Y	Y	N	N
No KXL	No KXL Hi Asia	N	Y	Y	Y	Y	Y
No Expansion	No Exp	N	N	N	N	N	N
No Expansion	NoExp+P2P3	N	N	Y	Y	N	N

Table 1-2

All scenarios were assessed using two different demand outlooks: the EIA Annual Energy Outlook 2010 for reference global and U.S. petroleum supply and demand projections and a low-demand outlook[5], which leads to 4 mbd lower U.S. petroleum product demand by 2030. The study therefore presents 14 scenarios resulting from two different demand outlooks and 7 scenarios for different combinations of pipeline availability. The study uses the 2010 Growth Outlook from the Canadian Association of Petroleum Producers (CAPP) for crude oil supply to market from the WCSB. This projection, with extrapolation from 2025 to 2030 by EnSys and DOE, leads to WCSB supply growing from 2.49 mbd in 2009 to 4.85 mbd in 2030, with the fraction of crude produced from oil sands rising from 65% to 91% over the same time period.

Key findings and conclusions from the study covered U.S., Canadian and global refining and supply impacts. General findings are summarized first to set a context for findings that are specific to KXL.

General Findings Not Specific to KXL

A. Inadequate WCSB export capacity from 2005 through 2008 led to production shut-ins, crude revenue losses, and to a number of export pipeline projects, notably Enbridge Alberta Clipper and TransCanada Keystone Mainline and Keystone Extension. These are now coming on-line, adding over 1 mbd of export capability. Consequently, there is now surplus capacity for moving WCSB crudes cross-border into the USA. However, capacity to move WCSB crudes via pipeline to the U.S. Gulf Coast remains limited to less than 100,000 bpd.

B. Given the base projection for WCSB supply to nearly double by 2030, WCSB imports into the USA rise over time under all scenarios evaluated, including those where WCSB crude oil production growth rates are constrained by a total lack of pipeline expansion.

C. Refineries in western and eastern Canada, and U.S. PADDs I, IV and V (with California Law AB32 in place) are projected to have limited ability to process incremental volumes of WCSB crudes. PADD2 is projected to be able to economically absorb approximately an additional 0.5 - 0.8 mbd. PADD3 represents the major U.S. growth market, with the potential to process up to 2 mbd of WCSB crudes by 2030 from less than 0.1 mbd today. The region's large existing capacity geared to processing heavy crudes (over 5 mbd) is a major factor.

D. WORLD model scenario results indicate a market opportunity exists short term (2010 – 2015) as well as longer term for pipeline capacity to deliver heavy WCSB crudes to U.S. Gulf Coast refiners[6]; this to fill a gap being created by declining supply from traditional heavy crude

[5] This low-demand outlook was provided to staff of the Department of Energy by staff of the Environmental Protection Agency.

[6]. Also, U.S. Gulf Coast refiners have committed to take 380,000 bpd of WCSB crude oils via KXL if the pipeline is built.

suppliers, notably Mexico and Venezuela, a gap it is projected would otherwise be filled by increases in other foreign supplies, notably from the Middle East.

E. Future level of U.S. refining activity is projected as relatively insensitive to the combination of pipelines available to carry crude out of the Edmonton/Hardisty area.

F. However, WCSB crude routings and future level of WCSB imports into the U.S. will be sensitive to the combination of pipelines available to carry crude out of the Edmonton/Hardisty area. Figures 1-2 and 1-3 illustrate modeling results that project cross-border WCSB deliveries rising from 1.2 mbd today to between 2.6 mbd and 3.6 mbd in 2030, depending on the combination of pipelines assumed to be available.

G. Over the next twenty years, the principal choice for WCSB exporters is between moving increasing crude oil volumes to the USA or to Asia. Led by China, which has already bought heavily into oil sands production, Asia constitutes the major region for future petroleum product demand and refining capacity growth and offers Canada diversification of markets. In addition, costs for transporting WCSB crudes to major markets in northeast Asia (China, Japan, South Korea, Taiwan) via pipeline and tanker are lower than to transport the same crudes via pipeline to the U.S. Gulf Coast. Projections from this study, which are supported by third party information, indicate that Asian markets are attractive and, if the access routes are developed, could absorb at least 1 mbd of WCSB crudes, potentially significantly more; this versus the less than 50,000 bpd of WCSB crude that moves to Asia today.

H. Variations in WCSB import volumes into the U.S. will lead to equivalent offsetting variations in crude oil imports from other foreign sources. Model projections are that, when increased volumes of WCSB crudes move to Asia instead of the U.S., the "gap" would be filled by offsetting increases in crude oil imports from other foreign sources, especially the Middle East (as the primary balancing supplier).

I. In all scenarios considered, increases of Canadian crude oil imports into the U.S. correspondingly reduce U.S. imports of foreign oil from sources outside of North America and the scale of "wealth transfers" to those sources for the import costs of the crude oils.

J. Under any given pipeline scenario, reducing U.S. oil demand would result in reduction of oil imports from non-Canadian foreign sources, especially the Middle East, with no material reduction in imports of WCSB crude.

K. Together, growing Canadian oil sands imports and U.S. demand reduction have the potential to very substantially reduce U.S. dependency on non-Canadian foreign oil, including from the Middle East.

L. Canadian oil sands imports do not change significantly under the low-demand outlook.

M. The only scenario studied that resulted in a significant reduction of WCSB oil sands production assumed (a) a total moratorium on WCSB pipeline expansions in Canada to any destination and (b) no expansion of pipeline capacity between PADD2 and PADD3, and (c) restriction of rail/barge modes. Even then, existing available pipeline capacity (up to and including Keystone Mainline and Extension – but not KXL) is such that any reduction in WCSB production would not occur until after 2020 (Figures 1-4 and 1-5).

Findings Specific to KXL

N. KXL would add to the cross-border surplus of crude oil pipeline capacity observed in Finding A. In every scenario studied, with or without KXL, the excess cross-border pipeline capacity persists until after 2020. In scenarios where high pipeline capacity to the British Columbia coast – and thence Asia – is assumed built, the excess cross-border capacity into the U.S.A. is projected as continuing until 2025 or even 2030.

O. If KXL were not built, the scenario analyses show there is a demand for alternative projects to be implemented that would lead, over time, to crude flows from WCSB to PADD2 and thence from PADD2 to the PADD3 Gulf Coast broadly similar to those that would be provided by KXL.

P. These crude flows include indicated demand to take over 1.4 mbd of WCSB crude to the U.S. Gulf Coast by 2030 (on the basis the Transmountain TMX 2 and 3 pipeline expansions to the BC coast go ahead[7]). KXL represents a high capacity supply option that could meet early as well as longer term market demand for crude oil at Gulf Coast refineries as discussed in Finding D[8].

Q. KXL would provide increased redundancy for WCSB supply routes into the USA. Potentially, it could also add capacity to bring U.S. Bakken crudes to market and/or to reduce congestion at Cushing by increasing capability to take domestic U.S. crudes to the Gulf Coast.

R. The WORLD and DOE Energy Technologies Perspective (ETP) model analyses[9] results show no significant change in total U.S. refining activity, total crude and product import volumes and costs, in global refinery CO_2 and total life-cycle GHG emissions whether KXL is built or not.

The detailed premises and analyses underpinning these conclusions are set out in the body of the report and in an accompanying Appendix.

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[7] If TMX 2 and 3 were not built, scenario projections are that WCSB volumes to PADD3 could reach 1.8 mbd by 2030; if Northern Gateway and/or Northern Leg are built as well as TMX 2 and 3, WCSB flows to PADD3 could drop to 1 mbd or lower.

[8] At 700,000 bpd, KXL capacity is roughly twice that of the recently proposed Enbridge Monarch project. Reversal of the Seaway line, which is stated by its owners as constituting only a possibility and not a project at this time, would add around 200,000 bpd of capacity to transport heavy crudes to the Gulf Coast.

[9] The WORLD model analysis was performed by EnSys Energy. Supplemental analysis of greenhouse gas emissions was performed by Brookhaven National Laboratory (BNL) using DOE's ETP global energy model.

Reference Outlook

Low Demand Outlook

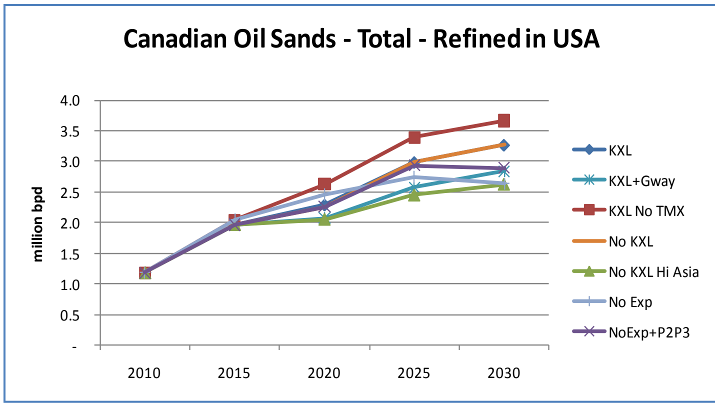

Figure 1-2

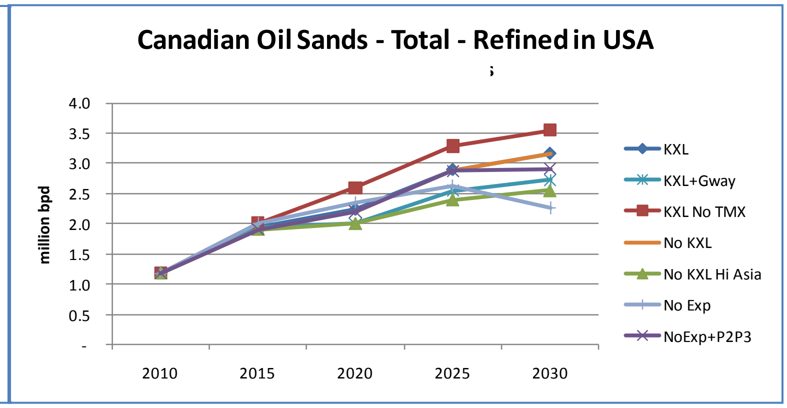

Figure 1-3

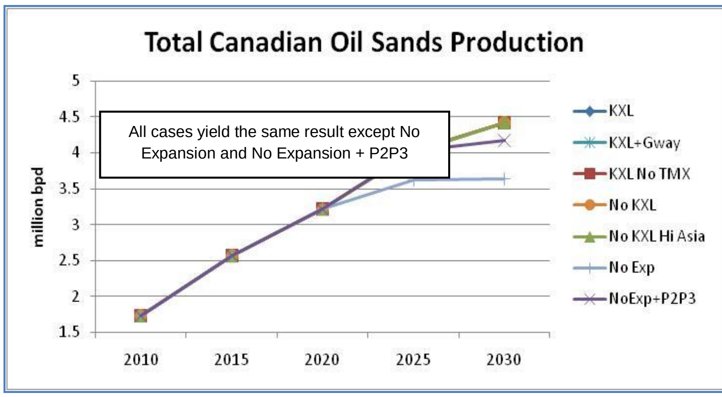

Figure 1-4

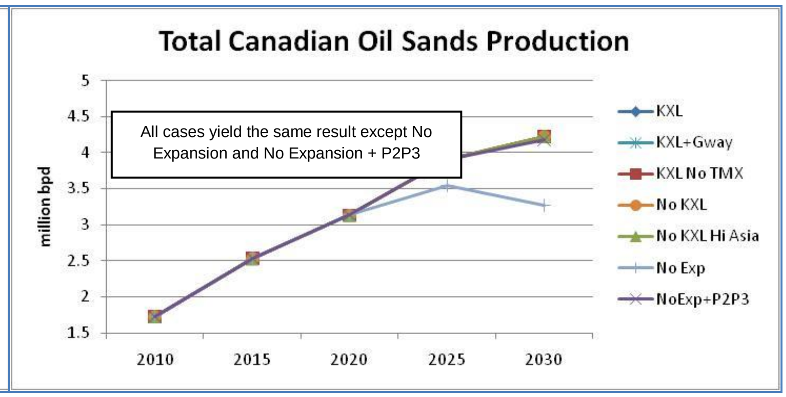

Figure 1-5

2 Introduction

2.1 Keystone XL Project and Status

The central focus of this report is the proposed project by the Canadian company TransCanada to build a pipeline known as Keystone XL (or simply KXL) from Western Canada to Cushing, Oklahoma, via Nebraska and then on to the U.S. Gulf Coast. As proposed, the line would carry crude oil streams from the Western Canadian Sedimentary Basin (WCSB) to refineries in the Cushing Oklahoma area of PADD2 and the PADD3 Gulf Coast. KXL may also incorporate shipping of Bakken and of Oklahoma/West Texas crude oils. The project was approved by the Canadian National Energy Board in March 2010. TransCanada has also applied for a Presidential Permit from the U.S. Department of State. The Department of Energy commissioned this analysis in support of the Department of State as a component of its revised Environmental Impact Statement for the KXL pipeline[10].

As further described under Section 3.2.3, the first two phases of the Keystone pipeline system, carrying crude into central PADD2 and then on down to Cushing, Oklahoma, are under start-up or construction, with full operation early 2011. Total system capacity after these phases is stated as 591,000 bpd. The third and fourth phases fall under the aegis of Keystone XL and comprise two additional lines. One line would run from Hardisty, cross-border via Montana and South Dakota, to PADD2 and the other from Cushing to the U.S. Gulf Coast. TransCanada projects start-up of operations in the first quarter of 2013, subject to permits. Completion of KXL would increase total Keystone pipeline capacity by 700,000 bpd to 1.29 mbd, with the ability to move 591,000 bpd of crude from Hardisty to PADD2 refineries (Keystone Mainline) and another 700,000 bpd from Hardisty to the Gulf Coast via Cushing (Keystone XL). Keystone XL would be designed to support an eventual capacity of 900,000 bpd by increasing pumping capability. Maximum capacity for the system after the expansion would be 1.5 mbd. Associated capacity to the Gulf Coast has not been set but would likely be 900,000 bpd.

TransCanada has closed two recent “open season” bidding rounds for use of transport capacity on the proposed KXL pipeline. The Cushing Marketlink open season gauges interest in bringing U.S. Mid-

[10] “TransCanada Keystone Pipeline, L.P. has applied to the United States Department of State (DOS) for a Presidential Permit at the border of the United States for the proposed construction, connection, operation, and maintenance, of facilities for the importation of crude oil from Canada. DOS determined that the issuance of the Presidential Permit would constitute a major federal action that may have a significant impact upon the environment within the context of the National Environmental Policy Act of 1969 (NEPA), and on January 28, 2009 issued a Notice of Intent (NOI) to prepare an environmental impact statement (EIS) to address reasonably foreseeable impacts from the proposed action and alternatives.” United States Department of State, Scoping Summary for the Keystone XL Project, Environmental Impact Statement, May 2009.

Continent crudes into Keystone XL at Cushing and thence on to the Gulf Coast. The second open season, Bakken MarketLink, assesses interest in Bakken producers feeding into the northern KXL line at Baker, Montana, already a Bakken storage and transmission hub. Final decisions by TransCanada on these projects are expected in early 2011.

2.2 Department of Energy Study Request

The Department of Energy (DOE) Office of Policy & International Affairs contracted EnSys Energy to undertake an analysis to evaluate different scenarios through 2030 focused on the Keystone XL project. The DOE sought to better understand the potential impacts of the presence or absence of the KXL pipeline on U.S. refining and petroleum imports and also on international markets. Because the availability of other pipelines is a key uncertainty, the analysis examined key metrics under seven different scenarios each representing a different combination of available pipelines. Market dynamics for each pipeline combination were explored for two different projections of U.S. oil demand.

In each of the resulting 14 scenarios requested, the objective of EnSys' analysis was to assess the U.S. petroleum refining, supply and price impacts of incremental Canadian oil sand crudes into the U.S. using a detailed refinery model embodying global downstream petroleum product and crude oil market activity. DOE sought an analysis that could evaluate oil flows into each of the PADD regions into which U.S. petroleum infrastructure is divided and which would also project market destinations for Western Canadian crudes.

The questions DOE requested EnSys to address included:

- What is the outlook for the U.S. refining industry's competitive position - as measured by U.S. refinery throughputs, utilizations, investments, CO_2 emissions, product import dependency and oil import costs?
- How does the level and composition of crude oil imports into the U.S. change with and without the incremental Canadian oil sands crude transport capacity proposed by the Keystone XL project?
- What are the changes in crude oils that would supply PADD3 refineries with and without incremental oil sand crudes into PADD3?
- What are the changes in world regional demands for incremental Canadian oil sand crudes with and without the incremental pipeline capacity to U.S. refineries?
- What are the U.S. petroleum product supply and price impacts, and also U.S. oil import bill impacts, with and without the incremental imports of Canadian oil sand crudes to the U.S.?

- What impacts, if any, would disallowing the Keystone XL pipeline have *per se* on Canadian crude oil flows into the U.S.?
- What would be the impacts of much lower U.S. product demand outlook on U.S. refining, Canadian and other oil imports and the implications for Canadian crude oil export capacity?

2.3 EnSys' Approach to Study

To address these questions, EnSys employed its World Oil Refining Logistics & Demand (WORLD) model. This provides integrated analysis and projection of the global petroleum industry, encompasses total liquids, captures the effects of developments and changes and of interactions between regions, and projects the economics and activities of refining, crude oils and products. WORLD works by combining top down scenarios for projected oil price/supply and demand over the next twenty years with bottom up detail on crudes oils, non-crudes, refining, transportation, product demand and quality. Used for the Department of Energy Office of Strategic Petroleum Reserve since 1987, WORLD has been applied in many analyses for organizations ranging from the EIA and EPA to the American Petroleum Institute, World Bank, OPEC Secretariat, International Maritime Organisation, Bloomberg, major and specialty oil and chemical companies.

Further information on EnSys and WORLD is provided in Appendix Section 1.

2.4 Content of Report

Section 3 below sets the context for this analysis by reviewing the recent history of and current projections for Canadian oil production, including oil sands, and of the pipeline systems and associated projects that exist or are planned to move crude oils out of Canada to the U.S. and elsewhere. Keystone / Keystone XL and other active projects are described.

Section 4 summarizes the basis and key premises for the analysis, outlines the methodology and describes the specific scenarios developed and evaluated.

Section 5 presents key results and Section 6 presents conclusions.

Supporting appendices provide additional detail on pipeline projects, the EnSys WORLD model, its set up and use for this analysis, including detailed premises and results; also information on the DOE ETP model and its use in this study.

3 Background to Study

3.1 Recent WCSB Production and Export History

A factor in this study is the potential for the Keystone XL project to add to the excess of capacity to bring WCSB crudes into the U.S. However, it was concern in Canada over shortages of export pipeline capacity in the 2006 to 2008 period which, combined with anticipated rapid increases in WCSB crude supply, led to a series of pipeline projects including Keystone.

By 2005, WCSB total crude oil supply had reached nearly 2.2 mbd. Oil sands streams to market comprised over 50% and were rising rapidly. In 2007, the Canadian Association of Petroleum Producers (CAPP) projected that WCSB crude supply could rise to between 4.6 and 5.3 mbd by 2020. (By way of comparison, the CAPP 2010 supply projection – which is being used in this report - is for 3.8 mbd of total WCSB supply by 2020 of which 3.2 mbd is oil sands streams.)

At the time, it was evident that the then existing export pipelines were operating at or close to capacity. There had been instances of capacity restrictions and "allocations" with associated shut-ins of crude production. The bottlenecks were also causing reductions in the prices obtained for Western Canadian crudes, especially the heavy grades. Figure 3-1 illustrates how discounts for Canadian Lloydminster heavy crude widened in 2005 through 2007 versus other marker heavy crude grades, to as much as $20/bbl versus Mayan and $15/bbl versus Saudi Heavy, far exceeding historical levels in the $0-5/bbl range[11]. As a consequence, Canadian producers, shippers and government agencies deriving revenue from production were all being adversely affected economically. The chart also shows that differentials returned to the $0-5/bbl range in 2009 but then widened again in mid 2010 driven by shutdowns in the Enbridge Mainline pipeline system due to leaks. Thus the chart reinforces how sensitive WCSB heavy crude discounts are to having sufficient export pipeline capacity in operation and the consequences in lost revenue of periods when capacity is inadequate.

[11] The Figure 3-1 chart is based on pricing data taken from the EIA online Petroleum Navigator, World Crude Oil Prices.

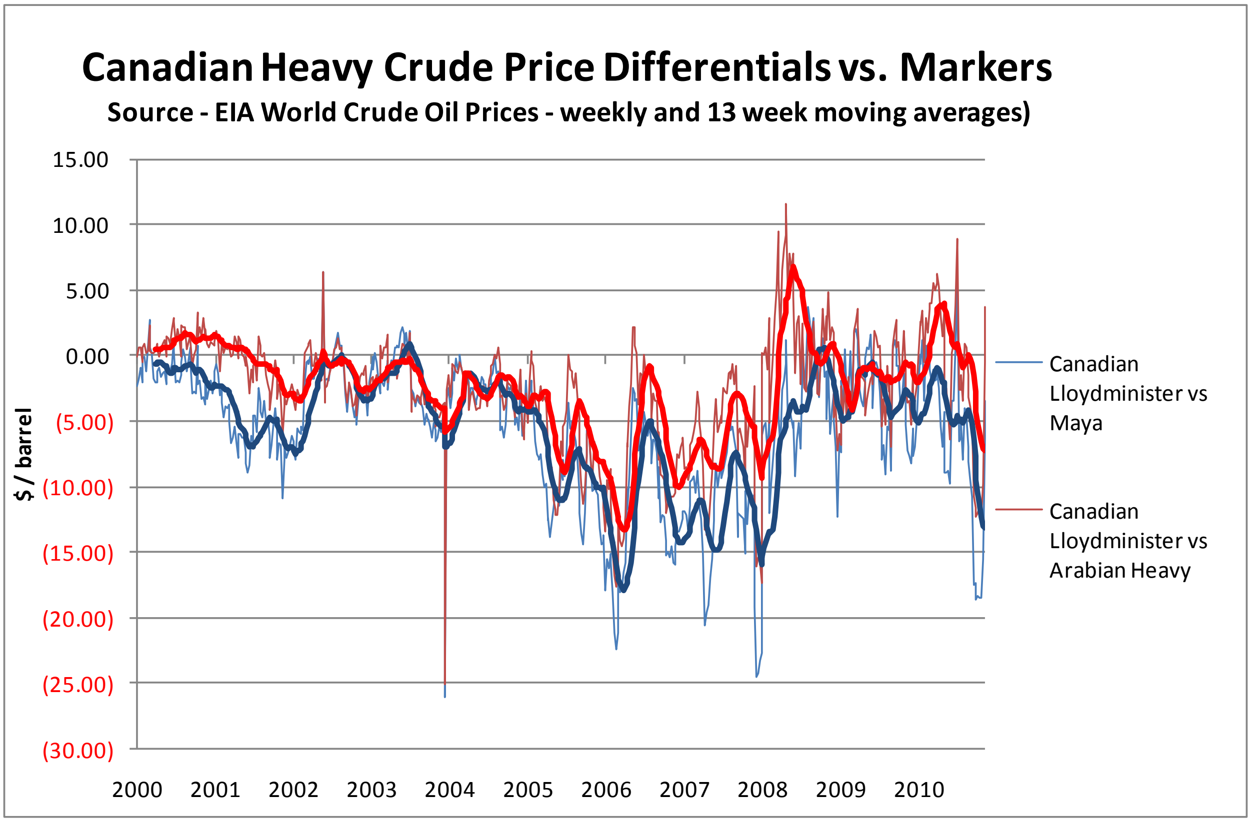

Figure 3-1

The undesirable situation in 2005 through 2008, combined with the prospect of swiftly growing WCSB production, led to the perception that significant export pipeline expansions were required. As of early 2008, one analyst estimated 1.1 mbd of new capacity would be needed by 2011, 1.9 mbd by 2015 and 2.7 mbd by 2020[12]. Despite the recession slowing their pace, a number of major projects have materialized, including the Enbridge Alberta Clipper, TransCanada Keystone and the proposed Keystone XL and also a first phase of expansion of the Kinder Morgan Transmountain line to Vancouver. In addition, further projects have been or are being actively considered, as discussed in Section 3.2.3.

The recent history of pipeline capacity bottlenecks, shut-ins and losses of revenue sets a context for the recent expansion of pipeline capacity and resulting cross-border surplus. Producers, shippers and government agencies in Canada arguably have no desire to see any repetition of the past restrictions and are thus predisposed to establishing export capacity that provides redundancy, flexibility, security and also diversification of markets.

[12] “Canadian Oil Imports”, Jeannie Stell, from Oil & Gas Investor, January 2008.

3.2 The WCSB Crude Oil Export System and Projects

3.2.1 Current Flows

In 2009, the WCSB region produced approximately 2.5 mbd of crude oil, of which 65% came from oil sands and 35% from conventional extraction[13]. Figure 3-2 illustrates the destination of the Canadian supply in 2009, with the sum of all exports to Asia and the U.S. being equal to WCSB production minus consumption within Canada.

As shown in Figure 3-2, 709,000 bpd were processed within Canada, 65% in Western Canada and the remaining 35% in Eastern Canadian refineries in the Sarnia area. The U.S. PADD2 comprised the major market at over 1.2 mbd. Smaller volumes flowed to PADD4, 238,000 bpd, PADD5, 148,000 bpd, and PADD1, 62,000 bpd. The flows to PADD5 were predominantly to refineries at Ferndale and Anacortes in Washington state; those to PADD1 to a single refinery in Warren, western Pennsylvania. Flow to PADD3 was relatively small at 107,000 bpd. Significantly, only 14,000 bpd was exported in 2009 to destinations outside the USA, although this figure has been rising in 2010.

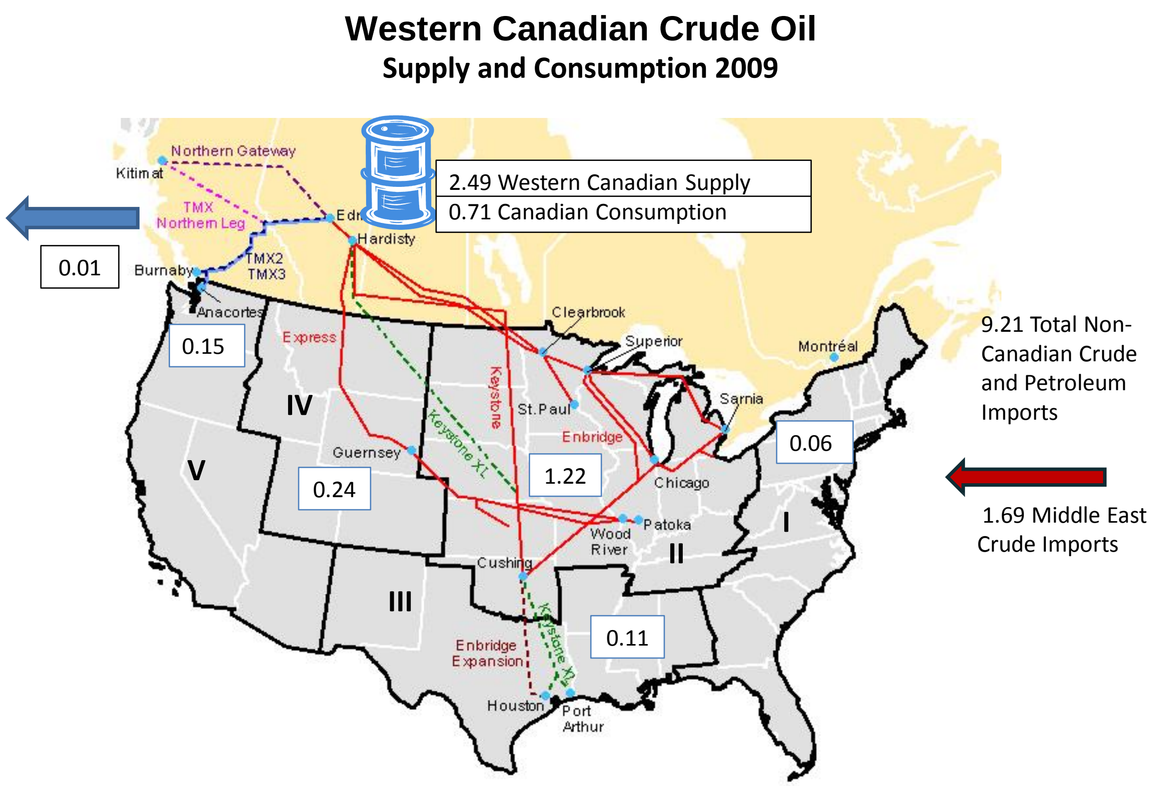

Figure 3-2

[13] Canada also produces conventional crude oils offshore Newfoundland. This eastern Canadian production totaled 0.27 mbd in 2009 and is projected by CAPP to slowly decline to 0.11 mbd by 2030.

3.2.2 Current Export Routes

For such a major producing region, the WCSB crude export system is highly unusual in that it is currently overwhelmingly land-locked. Domestic and export flows are almost entirely via pipeline, and to the USA and eastern Canada, as illustrated in Figure 3-2. Waterborne exports are minor and through only one marine terminal, the Westridge dock, near Vancouver.

Figure 3-3, taken from the CAPP 2010 Outlook, depicts the extensive network of both existing and planned major crude pipelines feeding U.S. and Canadian refineries. The solid lines indicate *existing* pipelines discussed in this section while the dotted lines indicate *proposed* pipelines described in the next section. Essentially all these pipelines can carry heavy crude oil[14].

WCSB crudes feed the western Canadian refineries. These are mainly in the Edmonton area, local to the main sources of WCSB supply in Alberta and neighboring Saskatchewan. The Transmountain pipeline takes WCSB crudes west from Edmonton to the 55,000 bpd Chevron refinery at Burnaby and a dock at Westridge, both near Vancouver. The Puget Sound Pipeline is a spur that connects the Transmountain pipeline to four refineries at Ferndale, Anacortes, and Cherry Point in Washington state. Crude oil can also be shipped via the Westridge dock by barge or tanker to U.S. refineries in Washington State but, historically, has mainly been moved to California or even the Gulf Coast and also to Asia. The Transmountain line also ships refined products from Edmonton refineries to points west in British Columbia, including the Vancouver area.

Deliveries of crude to the Burnaby refinery have remained stable at around 45,000 bpd while those for product have slowly declined in recent years, dropping below 50,000 bpd in 2010. Crude deliveries to the Washington state refineries have slowly increased over time and currently run at just under 130,000 bpd. Crude oil deliveries over the Westridge dock have risen from 25,000 bpd in 2006 to 80,000 bpd in 2010[15]. Of these, volumes moving to Asia have reportedly risen to 20,000 bpd[16]. The Transmountain line was reported as operating above its 300,000 bpd rated capacity and over-committed at the time of this report, indicating strong market demand even with excess pipeline capacity available across the border to the U.S.

WCSB crudes move to PADD4 in the U.S. via three lines with total capacity of around 485,000 bpd. Of these, the Express is the largest and has an onward extension, the Platte, into PADD2.

[14] The stated capacity of a pipeline is generally rated on an assumed "design basis" proportion of light versus heavy crude moving through the line, e.g. 100,000 bpd with 20% heavy, 80% light crude. Essentially all pipelines can take (additional) heavy crude but at a debit to throughput because of the generally higher viscosity and therefore increased pumping horsepower requirement for the heavy crude. Major new lines out of WCSB, including Alberta Clipper and Keystone (Mainline and XL) are designed for essentially total transport of heavy grades. In the modeling study, account was taken of the higher effective capacity consumption of heavy crudes moving especially through older pipelines that were originally designed for a lighter crude mix.

[15] "Firm Service Capacity on the Trans Mountain Pipeline System", Purvin & Gertz, November 2010.

[16] "Oil Patch Sets Course for China", The Globe and Mail, Toronto, Ontario, July 24, 2010.

The main export route from WCSB to the U.S. is via the Enbridge Mainline system into PADD2 (2,055,000 bpd rated capacity). The Mainline system has recently been expanded via the addition of the Alberta Clipper line (450,000 bpd rated capacity). North Dakota crude oil can flow into the Mainline at Clearbrook, Minnesota. Enbridge has recently expanded its line from Minot North Dakota to Clearbrook to 161,500 bpd. The Enbridge/ExxonMobil Pegasus line can take WCSB crude from Patoka Illinois to Port Arthur in the Gulf Coast but current capacity is less than 100,000 bpd. Pegasus constitutes the only pipeline that today can take WCSB crudes into the Gulf Coast. Small WCSB volumes currently also move to Gulf Coast refineries via barge from PADD2 and via tanker from the Westridge dock; both relatively high cost movements.

Eastern Canadian refineries at Sarnia receive WCSB crude via the Line 5 and 6 extensions of the Enbridge Mainline system. Total listed capacity to Sarnia via these routes is 680,000 bpd. However, this includes ability to ship NGLs and condensates as well as light, medium and heavy crudes. Sarnia refineries are also able to receive foreign crude from a terminal in Portland, Maine, via a pipeline system which runs west to Sarnia via Montreal[17]. This comprises two lines, the Portland Montreal Pipeline (PMPL), rated at 525,000 bpd which feeds into the 240,000 bpd Enbridge Line 9 from Montreal to Sarnia[18]. The PADD1 Warren, PA, refinery receives approximately 60,000 bpd of WCSB crude, fed via a spur (Line 7) off the Sarnia end of the Mainline system.

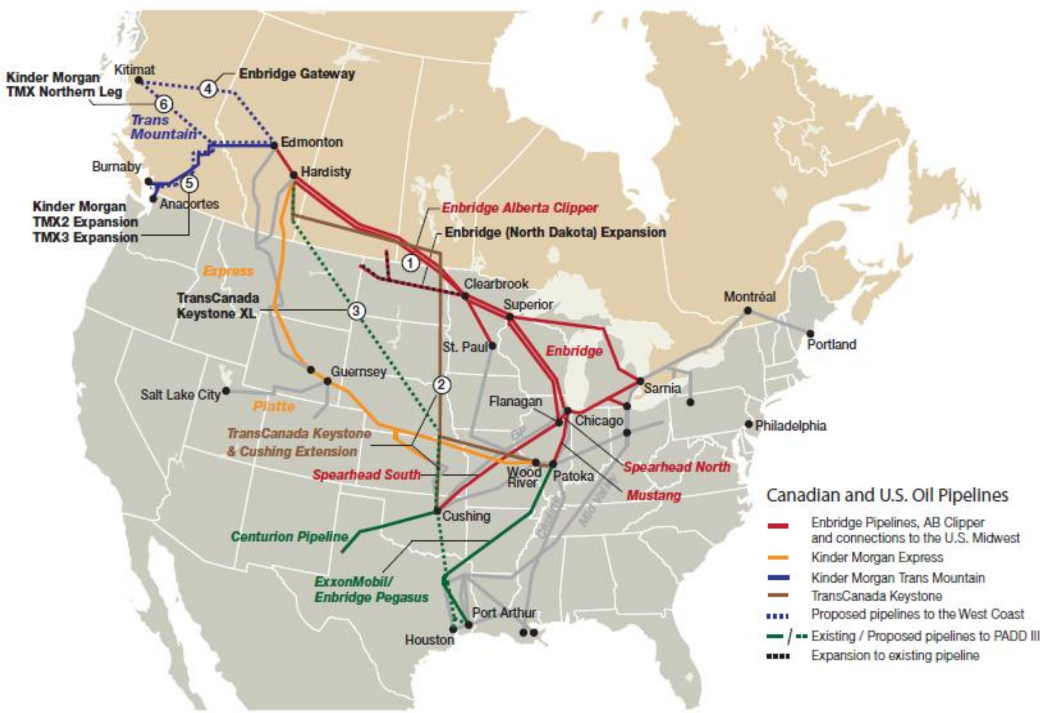

Figure 3-3

[17] The sole Montreal refinery still operating, Valero at Saint-Romuald, Quebec, can receive crude via tanker.
[18] The high rated capacity on the PMPL stems from its construction in World War II to bring crude oils more safely into eastern Canada.

3.2.3 Current and Proposed Export Projects

WCSB oil sands growth and the recent history of shut-ins and price discounts have led to a series of projects to expand export capacity out of western Canada and to access additional markets. These projects are summarized below, and all are listed with data on size, proposed start date, and project status in Table 3-3 in Section 3.2.3.5. The sections below cover both future projects (including Keystone XL) and projects that have come on stream during the course of this study by EnSys or which are under construction at the time of this report. Specifically included under current projects are the Alberta Clipper pipeline and Keystone Mainline, both of which have recently started up, and Keystone Cushing extension which is under construction and due for start-up first quarter 2011.

3.2.3.1 West to British Columbia Coast and Asia

There is considerable interest in Canada in establishing volume water-borne exports, with their attendant flexibility to diversify markets and to access growth areas, notably in Asia. Nautical distances from the British Columbia coast to Asian ports are relatively short and a recent study has estimated that refineries in four north Asian countries, (China, Japan, South Korea, Taiwan), could today process up to 1.75 mbd of Western Canadian (mainly heavy) crudes[19]. These drivers have led to a series of projects to expand capacity to move WCSB crudes west to marine terminals in British Columbia.

3.2.3.1.1 TMX 2, 3 and Northern Leg

Kinder Morgan expanded the Transmountain line to 300,000 bpd in 2008 via its TMX1 project. The company has plans to further expand to first 380,000 (TMX2) and then 700,000 bpd (TMX3). No decision to go ahead has been taken on either of these projects. This will depend upon level of commercial interest. But Kinder Morgan indicates potential timing as being in the 2015 to 2020 time frame. Plans also include upgrading of the Westridge dock and associated work with the Port of Vancouver so that the facility can load larger tankers and thus take advantage of lower freight rates[20]. In addition, in late November 2010, Kinder Morgan applied to the Canadian National Energy Board to establish longer term "firm service" contracts for WCSB crude oil shipments across the Westridge Dock[21]. This reflects the current growing interest in exporting WCSB crudes from Westridge and, arguably, could comprise a first step toward establishing a commercial basis for later expansion of the Transmountain line via the TMX 2 and 3 projects. According to a press announcement in late October 2010, the Transmountain pipeline is running at 316,000 bpd, i.e. above nameplate capacity, and is 32%

[19] Market Prospects and Benefits Analysis for the Northern Gateway Project, Muse Stancil, January 2010.
[20] The Westridge facility can today take AFRAMAX tankers, capacity approx 650,000 bbls. Kinder Morgan's plan is to enable 1,000,000 bbl SUEZMAX tankers to use the facility. Enabling safe passage of larger tankers under the Lion's Gate Bridge is one key issue.
[21] https://www.neb-one.gc.ca/ll-eng/livelink.exe?func=ll&objId=654331&objAction=browse.

over-subscribed for the month of November as of the time of this report[22]. This tends to reinforce that there is growing demand for the line's capacity.

The TMX 2 and 3 expansions would use existing facilities and right of way[23]. Extensive work would be required with various organizations, including the NEB, Port Metro Vancouver and First Nation groups before the projects could go ahead. Permits would be required for expansion. In addition, agreements with landowners along the route may have to be renegotiated. These requirements could possibly delay or stop the projects but the view was taken in this study that TMX 2 and 3 may be the most likely to go ahead of any of the West Coast projects.

Kinder Morgan has further proposed a Northern Leg expansion of the Transmountain line. This would use the existing Transmountain route part way from Edmonton west and then require construction of a new spur line running northwest to the port of Kitimat mid-way up the British Columbia coast. Proposed capacity on the Northern Leg line is 400,000 bpd. It would increase the total Transmountain system capacity to 1.1 mbd for (i.e. existing Transmountain pipeline + TMX 2 + TMX 3 + Northern Leg). The Northern Leg expansion is considered by Kinder Morgan to be a longer term project. It also faces strong opposition from First Nations and environmental groups. An advantage of building a pipeline to Kitimat is that the port can take VLCC crude tankers, with attendant lower freight rates. The port is also modestly nearer northeast Asia than is Vancouver.

3.2.3.1.2 Northern Gateway

Enbridge has proposed a 525,000 bpd (initial) capacity line named the Northern Gateway to run from Edmonton to Kitimat. This would be an entirely new facility, potentially expandable to 800,000 bpd[24]. Enbridge's May 2010 filing to the Canadian National Energy Board (NEB) stated 2016 as the target start-up year. However, the project is encountering strong resistance from First Nations and environmental groups, which renders its timing uncertain.

3.2.3.1.3 CN Rail / Altex

CN Rail currently imports condensate, for blending with oil sands bitumen to make DilBit, through Kitimat. The company has partnered with the Altex group to offer a PipelineOnRail service that would ship DilBit or other WCSB streams via rail from the Edmonton/Hardisty area to terminals that Altex would operate and, if required, ship diluent back to Western Canada. PipelineOnRail has the benefit that it avoids the large fixed investments associated with major pipelines. CN Rail indicates potential capacity to move "as many as 200,000 bpd or more"[25]. However, the economics of the system do appear to hinge partly on claimed diluent valuation benefits for shippers.

[22] http://www.reuters.com/article/idAFN2834277720101028?rpc=44.
[23] If both TMX 2 and 3 were completed, the resulting system would comprise two lines running parallel.
[24] The Northern Gateway proposal also potentially includes a 193,000 bpd diluent import line.
[25] http://www.cn.ca/en/shipping-north-america-alberta-pipeline-on-rail.htm.

This study did not allow for the expansion of the PipelineOnRail capacity in any scenario because tariffs for rail are generally not considered attractive relative to pipelines. However, during a period of constrained pipeline capacity, the PipelineOnRail could compete as an alternative. The potential role of rail among WCSB export options would require further analysis.

3.2.3.1.4 The China Factor

Chinese oil companies have to date invested several billion dollars buying partial stakes in existing and planned WCSB oil sands production facilities. Crude oil exports to China via Transmountain are reported to have been increasing and to have reached 20,000 bpd in 2010[26]. This may represent a small proportion of potential future equity crude accruing to Petrochina, CNOOC and other Chinese companies. If these companies follow patterns seen elsewhere, they will aim to repatriate their crude oil for processing in China, rather than allow it to be sold elsewhere. This could add to pressure for pipeline expansion to the British Columbia coast.

3.2.3.2 South to PADD4 & Bakken Exports

Currently, no major projects have been identified that would expand pipelines from WCSB into PADD4. The main activities in the region relate to expanding pipeline and rail capacity to ship out growing volumes of Bakken crude from North Dakota and secondarily Montana and Saskatchewan. Growing North Dakota Bakken production surpassed the 200,000 bpd level in mid 2010, and comprised the major reason total crude production in North Dakota passed the 300,000 bpd mark in June 2010[27] and exceeded 340,000 bpd in September 2010[28]. (Eastern Montana crude production stood at 65,000 bpd.) According to industry reports[29], projections by the North Dakota Pipeline Authority are that North Dakota Bakken production alone could reach 400,000 – 500,000 bpd, implying total in the state of possibly 500,000 - 600,000 bpd. Some estimates put the potential for total Bakken production (North and South Dakota, Montana, Saskatchewan[30]) at 800,000 – 1 million bpd by 2015[31],[32].

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[26] "Oil Patch Sets Course for China", The Globe and Mail, Toronto, Ontario, July 24, 2010.
[27] EIA Petroleum Navigator, http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbblpd_m.htm.
[28] https://www.dmr.nd.gov/pipeline/production.asp.
[29] Platt's Plans First Price Assessments of Bakken Shale Fields Crude, April 6, 2010.
[30] As stated elsewhere in the report, the study used the 2010 CAPP Growth Outlook for Canadian crudes. This incorporated the projection that Bakken/Cardium formation crude oils in Saskatchewan would contribute over time to WCSB production of conventional light crude oil. According to one source, total Saskatchewan Bakken/Cardium production could peak at 100,000 bpd. http://www.packersplus.com/pdfs/Canadian%20Business%20Making%20Bakken.pdf
[31] "Rockin' the Bakken" While Reducing the Oil's Logistical Limitations, The Barrel, Nov 22, 2010.
[32] In addition, there is growing interest in the potential of the Tyler formation which lies on top of the Bakken and extends into South Dakota. Current estimates are that the Tyler is one third to one half the size of the Bakken and so could further expand future regional oil and gas output. Source: Officials Find North Dakota's Tyler Oil Formation Similar to Bakken, Lisa Anne Call, Forum Communications Co. Nov 18, 2010.

Table 3-1 summarizes existing capacity and potential projects to take crude away from the Bakken region. Existing pipeline plus rail capacity totals approximately 450,000 bpd. This includes some very recent start ups and capacity expansions, including the EOG and Dakota Transport rail projects and expansions to the Enbridge North Dakota and Butte pipelines. Because of recent limited takeaway capacity, up to 25,000 bpd of Bakken crude has been moving via truck. Future pipeline and rail expansions are expected to eliminate truck movements, however.

Several companies, notably Enbridge, Plains All American, Butte Pipeline and TransCanada, have proposed pipeline solutions for bringing additional Bakken crude to market. In addition, Hess has a project to increase rail "takeaway" capacity. Again these are summarized in Table 3-1[33]. If all listed projects were to be implemented, combined Bakken pipeline and rail takeaway capacity would double to over 900,000 bpd. Pipeline capacity alone would total approximately 740,000 bpd.

Enbridge has recently expanded to 161,500 bpd its existing line that runs east from Berthold, North Dakota, to the Mainline at Clearbrook, Minnesota. Enbridge may also cease routing sour crudes through the line, increasing effective capacity by 28,500 bpd, and is proposing the reversal of its Portal line so that it runs north to join the Mainline system at Cromer, Manitoba. In addition, an expansion of the Butte line south and west to PADD4 refineries has been put forward. These three projects would add a total of 85,500 bpd of capacity by early 2011. A further Butte expansion, and the Hess Tioga rail project, would add 110,000 bpd more capacity by early 2012.

In early November, Plains All American, L.P. (PAA) announced a Bakken North project with two pipeline legs. The first leg would take 55,000 bpd of Bakken crudes, expandable to 75,000 bpd, from Trenton, North Dakota, to the Canadian border where it would feed in to the second leg, the Wascana line that would be reversed to run north to Regina, Saskatchewan. There the system could connect into either Keystone or Enbridge lines to take the crudes to PADD2. Subject to permits, PAA anticipates placing the Bakken North project into service in late 2012.

The Enbridge Bakken expansion would add a parallel line north along its Portal route to join the Mainline at Cromer in Manitoba (and thence re-cross the border back into the US). Initial capacity for the line to Cromer is indicated at 120,000 bpd with start-up first quarter 2013.

In addition, TransCanada is currently assessing market interest in tying Bakken crude into the planned Keystone XL line that would cut through Montana and South Dakota. The tie-in point would be at Baker, Montana, directly on the proposed KXL line. Baker is already a hub for Bakken crudes. Third party gathering and pipeline facilities[34] would deliver to three tanks at Baker. Two tanks would also be added at Cushing. The additional tankage would enable segregated accumulation and delivery of Bakken

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[33] A number of the projects listed in Table 3-1 have been presented under the name "Bakken 300". See, *inter alia*, Rocky Mountain Crude Oil Market Dynamics, Tad True, Belle Fourche & Bridger Pipelines, Wyoming Pipeline Authority, October 26, 2010.

[34] The Bakken Marketlink would lift crudes from existing facilities for Bakken crude at Baker, which could be augmented by the development of a third party (Quintana) pipeline system that will gather Bakken crudes in western North Dakota.

crude, which is a light, sweet crude with a higher value. The Bakken open season closed November 19th 2010, and a final decision from TransCanada on whether to go ahead with integration of Bakken crude into the KXL project is not expected until early 2011. TransCanada is targeting a first quarter 2013 start-up. Especially if the related Quintana project to gather Bakken crude into the KXL at Baker goes ahead, volumes of Bakken crudes placed into KXL could exceed 100,000 bpd.

Announcements on Bakken production and takeaway projects have been evolving rapidly during the period in which this study was undertaken. In addition, the status of the various projects varies from firm to indeterminate. Consequently, some – but not all – of the projects were accounted for in the modeling analysis. Specifically, capacity approximately equivalent to the Enbridge and Butte projects was allowed for whereas the potential Bakken MarketLink into Keystone XL was not incorporated. Thus, in the study cases conducted, Bakken crudes flowed through other lines but not through KXL.

Overall, sufficient capacity was allowed to move projected Bakken production volumes to market. However, even though EnSys adjusted upward EIA's AEO projections for Rocky Mountain crude oil production (which includes the Dakotas and Montana) to better allow for Bakken developments, the resulting projections used were still conservative considering information now to hand. In addition, more account could arguably be taken of the rail projects to move Bakken crudes. The assumption implicit in the study was that, over the longer term, volumes of Bakken crude shipped long distances would move predominantly via pipelines as these are generally lower cost than rail.

In summary, further analysis could be warranted to evaluate latest available assumptions and projections relating to the Bakken. A decision by TransCanada to go ahead with the Bakken MarketLink could raise total crude volumes moving through the KXL pipeline, alter the mix between WCSB and Bakken crudes with their different characteristics, and/or alter the market destinations for Bakken and other crude oils.

Bakken Crude Takeaway Capacity - Current & Projects

Current		capacity bpd
Tesoro Mandan refinery		58,000
Pipeline		
Butte pipeline (to PADD4 refineries)		118,000
Enbridge North Dakota line to Clearbrook and PADD2 refineries		161,500
Rail		
EOG, Stanley ND to Cushing OK, (started up Dec 2009)	Dec 2009	65,000
Dakota Transport Systems, New Town ND to St. James LA	Dec 2010	20,000
Smaller facilities in ND		30,000
Total Current Takeaway Capacity from North Dakota & Eastern Montana (1)		**452,500**
Projects	**Planned in Service Date**	
Pipeline		
Enbridge Portal Reversal, Berthold ND to Enbridge Mainline at Cromer, Manitoba	Q1 2011	25,000
Enbridge Sour Service Cancellation on North Dakota line to Mainline at Clearbrook MN	Q1 2011	28,500
Butte Expansion (to PADD4)	Q1 2011	32,000
Butte Loop (to PADD4)	Q1 2012	50,000
Plains North American Bakken North Project, Trenton ND to Enbridge Mainline and/or Keystone Mainline at Regina Saskatchewan	Q4 2012	50,000
Enbridge Bakken Expansion, Berthold ND to Enbridge Mainline at Cromer, Manitoba (3)	Q1 2013	120,000
Keystone XL Bakken Interconnect, Baker MT (4)	Q1 2013	100,000
Rail		
Hess, Tioga ND (5)	Q1 2012	60,000
Total Potential Additions		**465,500**
Total Current Plus Potential Additions		**918,000**
Total Current Plus Potential Additions - Pipelines Only		**743,000**

Notes:

1. Excludes variable truck takeaway that currently ranges from 0 to 25,000 bpd.

2. Project entails construction of a new line from Trenton ND, 50,000 bpd capacity expandable to 75,000 bpd, tieing in to the PAA 77,000 bpd Wascana pipeline that would be reversed to run north to Regina Saskatchewan. Sources: PAA website and Downstream Today.com. Project announced November 2010.

3. Ultimate 300,000 bpd capacity.

4. Estimate of tie-in capacity. Could be higher. Related Quintana BakkenLink project would of itself have 100,000 bpd capacity for gathering Bakken crudes and moving to Baker ND for tie-in to KXL line. Quintana projected start-up date is Q1 2013.

5. 120,000 bpd stated ultimate capacity.

6. Primary source for above data: North Dakota Pipeline Authority, North Dakota Petroleum Council Annual Meeting, Justin J. Kringstad, Sept 23, 2010, Minot, ND

Table 3-1

3.2.3.3 East and South to PADD2, PADD3

The development of additional pipeline capacity from Western Canada to PADD2 and then on to PADD3 comprises the main area of current project activity.

3.2.3.3.1 Alberta Clipper

The Enbridge Alberta Clipper line came on stream in October 2010. It is designed to carry heavy WCSB crude oils from Hardisty, Alberta, to Clearbrook, Minnesota, and on to Superior, Wisconsin. Line capacity is 450,000 bpd, expandable to 800,000 bpd through the addition of pumping facilities[35].

Alberta Clipper is being built in conjunction with the Southern Lights pipeline. This runs parallel to Alberta Clipper but in the opposite direction, taking diluent streams from Manhattan, Illinois, near Chicago, via northern PADD2 back to Hardisty and Edmonton. Southern Lights initial capacity is 180,000 bpd, expandable to 330,000 bpd. Its purpose is to gather, and to some degree recycle, diluent streams to be used at Hardisty and Edmonton for blending WCSB bitumen into DilBit.

3.2.3.3.2 Keystone Mainline & Keystone XL

The Keystone XL project that is the primary focus of this report constitutes a major segment of two phased projects being undertaken by TransCanada under the Keystone/Keystone XL name. The projects are designed to bring WCSB crudes, including oil sands, from Hardisty, Alberta, to PADD2 and then, via Cushing to the U.S. Gulf Coast; also, potentially, to transport Bakken and Oklahoma/West Texas crudes to Gulf Coast markets. Table 3-2 summarizes the phases of Keystone based on information from and discussion with TransCanada as of mid November 2010. Figure 3-4 illustrates the detail of the pipeline segments and routings.

Keystone Mainline[36], or Phase I, (denoted by the number 2 in Figure 3-3, and the blue line in Figure 3-4), comprises a pipeline with 30” then 34” then 30” sections that runs east from Hardisty, Alberta, crosses the border at Haskett, Manitoba, then runs south to Steele City, Nebraska, and from Steele City east to Wood River and Patoka, Illinois. At Wood River, the line links to the ConocoPhillips/Cenovus WRB joint venture refinery and at the Patoka terminal to the Plains All American pipeline. This in turn enables onward delivery to additional refineries in the region[37]. The WRB Wood River refinery is being revamped to raise its intake of heavy Canadian crudes from the 164,000 bpd level that obtained in 2009[38] to

[35] Enbridge to Assist Enbridge Energy Partners with U.S. Alberta Clipper Funding, July 20, 2009.
[36] TransCanada refers to the “Base” system as “Mainline”.
[37] Patoka is also the terminus for the 1.1 mbd Capline crude oil pipeline which originates in St. James, Louisiana and is a hub for other crude oil pipelines. Capline moves imported crudes from the Gulf Coast to the Midwest (PADD2). It includes two docks capable of handling 600,000 bbl tankers and has access to the Louisiana Offshore Oil Port (LOOP) for crude oil supplies.
[38] Source: EIA 2009 crude imports data.

approximately 240,000 bpd[39] from 2011 onward. Keystone Mainline Phase I initial pipeline capacity from Hardisty to Wood River/Patoka is 435,000 bpd. Phase I started commercial operations in July 2010.

The Keystone Cushing Extension, or Phase II, both raises the capacity of each of the Hardisty to Steele City and the Steele City to Patoka pipeline legs to 591,000 bpd and adds an extension from Steele City south to Cushing, Oklahoma (the orange line in Figure 3-4). The leg to Cushing also has a capacity of 591,000 bpd. However, under Phase II, the system will be run in batch mode such that crude shipping from Steele City will, at any one time, be either east to Wood River/Patoka or south to Cushing. Thus the upper section of the line down to Steele City will operate continuously while the eastern and southern legs below Steele City will operate on an either/or basis, depending on where a given batch is routed. Either or both of these two legs will thus operate, on a monthly average basis, below their rated capacity. Phase II is completing construction with commercial operation expected in the first quarter of 2011.

The Keystone XL expansion comprises two distinct segments. The segments consist of the new Northern KXL line which would cut diagonally cross-border from Hardisty to Steele City via Montana and South Dakota (the green line in Figure 3-4) and a further extension south (the purple line in Figure 3-4) in the form of a new pipeline from Cushing to the Gulf Coast at Nederland/Port Arthur. Both segments have stated commercial start dates of first quarter 2013, subject to permits. However, the Cushing to Gulf Coast extension is being described as Phase III (the "Gulf Coast segment") and the Northern KXL line as Phase IV (the "Steele City segment") since TransCanada anticipates the former may go ahead first.

The scope of coverage of the Presidential Permits TransCanada is seeking is limited to the facilities at the border up to the first shut-off valve, although the environmental analysis and mitigation measures apply to the whole pipeline in the U.S. Thus the Presidential Permit does not cover the Cushing to Gulf Coast segment. It is included in the project description because of National Environmental Policy Act (NEPA) requirements, not because of the Presidential Permit.

Both pipelines would have a diameter of 36". Stated initial capacity for both the Northern KXL line (Steele City Segment) and the Cushing to Gulf Coast segment is 700,000 bpd. The capacity of the Steele City to Cushing segment would be expanded to deliver 700,000 bpd of capacity from Hardisty to the U.S. Gulf Coast. The resulting aggregate capacity of the Keystone Mainline and XL lines would be 1.29 mbd.

Unlike under Phase II, the expanded system would run the Steele City to Wood River/Patoka and the Steele City to Cushing/Gulf Coast segments simultaneously in order to absorb the full inflow from Hardisty. Following the completion of Phase IV, the Phase II Cushing leg would no longer connect to the Phase I (Mainline) system. In other words, and referring to Figure 3-4, the blue line from Hardisty to Wood River/Patoka and the green-orange-purple line from Hardisty to Cushing and the Gulf Coast would operate separately (even though they both pass through Steele City, Nebraska).

[39] http://www.cenovus.com/operations/refineries/wood-river-and-borger.html

TransCanada states that it has secured 910,000 bpd of commercial contracts for transit on the Keystone Mainline and XL pipelines. Of the 910,000 bpd, 375,000 bpd are committed to Wood River/Patoka, Illinois, 155,000 bpd to (for take-out at) Cushing and 380,000 bpd to the Gulf Coast. Commitments to Wood River/Patoka and to Cushing are covered by Keystone capacity either started up or under construction. Commitments to the Gulf Coast are subject to Keystone XL permitting and construction. The total 910,000 bpd commitment equates to 70% of the 1.29 mbd total Keystone capacity that would be in operation were KXL built. Committed throughput is 375,000 bpd out of 591,000 bpd capacity (63.5%) on the Keystone Mainline system from Hardisty through to Wood River/Patoka. On the KXL segments from Hardisty to Steele City, Nebraska, and on to Cushing, the committed throughput would be 155,000 bpd for take-out volume at Cushing + 380,000 bpd on to the Gulf Coast = 535,000 bpd out of 700,000 bpd capacity (76.4%). On the segment from Cushing to the Gulf Coast, the committed throughput would be 380,000 bpd out of 700,000 bpd capacity (54.3%)[40].

In designing the Keystone pipeline system, TransCanada has allowed for future increases in pumping capacity such that eventual capacity across the U.S. border is indicated at 1.5 mbd. Expansion is expected to be on the green-orange-purple XL line in Figure 3-4, with capacity to the Gulf Coast potentially increasing from 700,000 to 900,000 bpd.

In addition to the two KXL Phases described above, TransCanada has been running two "open seasons" labeled Cushing MarketLink and Bakken MarketLink. The purpose of the open seasons is to assess shipper interest in signing up for contracted shipments on either of these projects, and both open seasons were offered for operation starting first quarter 2013. The open seasons closed on November 19, 2010. Their results – and consequently whether TransCanada will decide to go ahead with either or both - will not be known until early 2011.

Cushing Marketlink is a proposed project that would serve market demand for more pipeline exit capacity from Cushing; this by enabling West Texas/Mid-Continent crudes to feed into KXL at Cushing and so be routed south to the Gulf Coast. It would use facilities that form part of the Phase III Gulf Coast Segment. Bakken Marketlink would serve market demand for more pipeline exit capacity from the Bakken region in Montana and North Dakota. It would constitute a tie-in to the Phase IV northern KXL line at Baker, Montana, as discussed in Section 3.2.3.2. TransCanada has stated that neither the Bakken Marketlink nor the Cushing Marketlink are part of the KXL pipeline project, though both are dependent upon it.

[40] Based on information from TransCanada, 100% of the initial capacity of 435,000 bpd on the Keystone Mainline system was offered commercially. The resulting 375,000 bpd of contracts equated to an 86% contracted capacity percentage. The commitment for 155,000 bpd of take-out volume at Cushing provided the incentive to raise the capacity on the Mainline system (to 591,000 bpd) as well as to proceed with the line segment from Steele City to Cushing. On Keystone XL, the intended physical capacity has always been 700,000 bpd. However, in the open season, only 500,000 of the 700,000 bpd total was offered commercially – and led to 380,000 bpd of contracts. 200,000 bpd of capacity was held back to leave room for future operational flexibility and as a reserve to cover presumed growth.

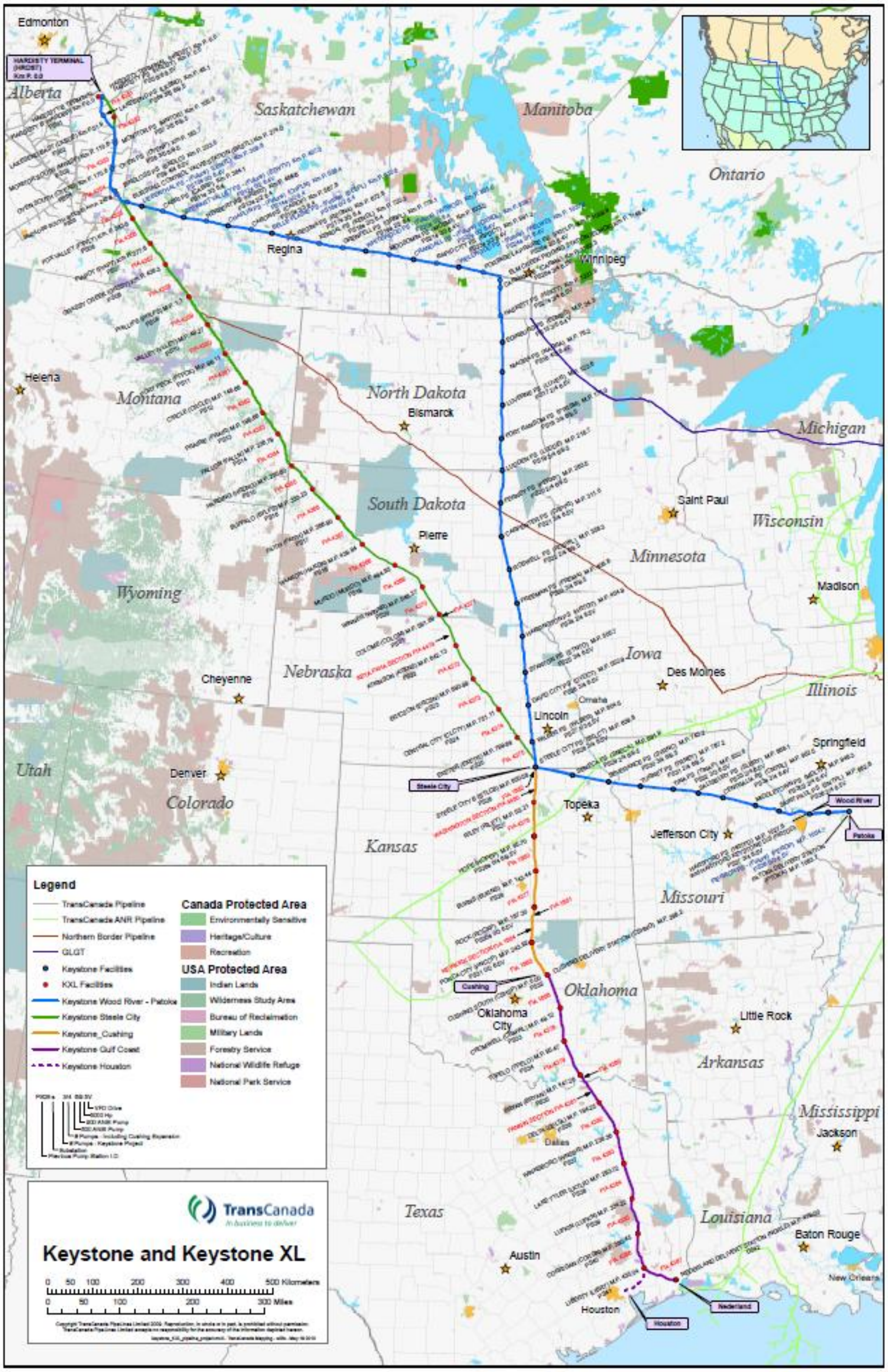
Keystone and Keystone XL
TransCanada
Legend
Canada Protected Area
USA Protected Area
Edmonton
Alberta
Saskatchewan
Manitoba
Ontario
Regina
Winnipeg
Helena
Montana
North Dakota
Bismarck
Michigan
South Dakota
Pierre
Saint Paul
Wisconsin
Minnesota
Wyoming
Madison
Iowa
Nebraska
Cheyenne
Des Moines
Illinois
Lincoln
Utah
Denver
Colorado
Springfield
Topeka
Kansas
Jefferson City
Missouri
Oklahoma
Oklahoma City
Little Rock
Arkansas
Mississippi
Jackson
Dallas
Texas
Louisiana
Baton Rouge
Austin
New Orleans
Houston

Figure 3-4

Keystone / XL Capacities & Phasing

	Phase I	Phase II	Phase III	Phase IV	
	Base / Mainline(1)	Cushing Extension	Gulf Coast Segment	Steele City Segment (Northern Line)	
Part of KXL	no	no	**yes**	**yes**	
Keystone Pipeline Segment	Capacity in thousand bpd				Line Diameter
Hardisty to Steele City (MainLine)	435	591	591	591	30"/34"/30" (2)
Hardisty to Steele City (KXL)				700	36"
TOTAL Hardisty to Steele City (3)	**435**	**591**	**591**	**1291**	
Steele City to Wood River/Patoka	435	591	591	591	30"
Steele City to Cushing	0	591	591	700	36"
TOTAL out of Steele City	**435**	**591**	**591**	**1291**	
Lines operate		either/or batch	either/or batch	simultaneous	
Cushing to Gulf Coast					
Cushing to Nederland/(Houston spur)	**0**	**0**	**700**	**700**	36"
Commercial Operations Start Date	July 2010	Q1 2011	Q1 2013	Q1 2013	
Ability to Drop off Crudes at Cushing	no	yes	yes	yes	
Ability to Pick up Crudes at Cushing	no	(4)	(4)	(4)	
Ability to Pick up Bakken Crudes	no	no	no	(5)	
Net Totals					
WCSB to PADD2	435	591	591	1291	
PADD2 to PADD3 (USGC)	0	0	700	700	

Notes:

1. TransCanada use the term "Mainline" to describe the initial ("Base") Keystone system
2. 30" then 34" line in Canada, 30" in USA.
3. Potential eventual total Keystone capacity is stated as 1.5 mbd with likely 900,000 bpd to Gulf Coast.
4. Interest in picking up crudes at Cushing to move to GC being assessed under Cushing Market Link open season. Being offered for Q1 2013.
5. Interest in picking up Bakken crudes as XL line passes through Montana/Dakotas being assessed under Bakken Market Link open season. Being offered for Q1 2013.
6. The Bakken and Cushing Marketlink proposals are stated by TransCanada as not being part of KXL per se.

Table 3-2

3.2.3.3.3 Other Gulf Coast Projects

As stated in earlier in this Section, pipeline routes for moving crude from PADD2 to the U.S. Gulf Coast are currently limited to the ExxonMobil Pegasus system, which has a capacity of less than 100,000 bpd. Small volumes of WCSB crudes have been moving to the Gulf Coast by tanker via the Panama Canal from the Vancouver Westridge dock and by barge from PADD2.

Pipeline companies other than TransCanada have announced a number of pipeline projects from PADD2 to the U.S. Gulf Coast. Enbridge has previously listed potential projects with both ExxonMobil and BP. Its latest announcement, in September/October 2010, is referred to as the Monarch project. This would move light and/or heavy crudes from PADD2 to the Gulf Coast through a new 24" line from Cushing to the Houston area. Initial stated capacity would be 370,000 bpd of light sweet (or 250,000 bpd of 22 degrees API heavy crude), expandable to 480,000 bpd light, or 325,000 bpd heavy[41].

In addition, the 30" Seaway crude oil pipeline runs north from Freeport, Texas, to Cushing. The line is owned by a 50:50 joint venture of Enterprise Products Partners and ConocoPhillips[42]. It is rated at 350,000 bpd but is currently reported as underutilized. The partners have reportedly examined the feasibility and cost of reversing the line such that it would run from north to south. On the basis of running heavy crudes, and recognizing pipeline wall thickness limitations, the north to south capacity could be nearer to 200,000 bpd. As of the date of this report, no decision has been taken on the reversal. A continuing need to move crude volumes north is a factor, although any reduction in the future in that need could release the line for reversal.

3.2.3.4 Eastern Canada Line 9 Reversal

As crude oil availability from WCSB has grown, refineries at Sarnia have taken in greater volumes from western Canada. Consequently, throughputs on the Portland Montreal Pipe Line (PMPL)/ Line 9 system from Portland, Maine to Sarnia have been dropping. Enbridge, the operator of Line 9, has considered the option of reversing Line 9 and PMPL so that they would carry WCSB crudes east to the New England coast and thence to markets on the U.S. East Coast, Gulf Coast and potentially elsewhere. This project, labeled Trailbreaker, was reported as shelved by Enbridge in early 2009[43].

[41] "Infrastructure Solutions for the Bakken and Three Forks", Mike Moeller, Enbridge Pipelines (North Dakota) LLC, North Dakota Petroleum Council Annual Meeting, Minot, North Dakota, September 23, 2010.
[42] ConocoPhillips also owns 100% of the Seaway products line. This 20" line also runs from south to north.
[43] PMPL/Line 9 reversal was included as a project in early WORLD model cases. However, the capacity was not utilized, tending to support the view that such a line would be uneconomic. It would constitute a very lengthy and roundabout route to market.

3.2.3.5 *Summary of Export Projects*

Table 3-3 provides a summary of pipelines that would support export and delivery of WCSB crude oils. Projects to increase takeaway capacity for Bakken crude, which could impact on the effective capacity of pipelines listed in Table 3-3 to carry WCSB crudes, are discussed in Section 3.2.3.2.

Summary of Recently Completed and Proposed Projects Supporting WCSB Exports

Pipeline Project	Destination	Capacity bpd	Expansion Possible to	Completion as Listed by Operator	Status
WCSB West to BC					
Kinder Morgan Transmountain TMX1 expansion	Vancouver, BC	300,000		Nov 2008	Operational
Kinder Morgan Transmountain TMX2 Expansion	Vancouver, BC	80,000		2015/16	On hold pending commercial interest
Kinder Morgan Transmountain TMX3 Expansion	Vancouver, BC	320,000		2016/18	On hold pending commercial interest
Kinder Morgan Northern Leg	Kitimat, BC	400,000			On hold, longer term proposal
Enbridge Northern Gateway (1)	Kitimat, BC	525,000	800,000	2016/17	Proposal submitted to NEB Joint Review Panel May, 2010 - In Review
WCSB Cross Border to US PADD-2					
Enbridge Alberta Clipper	Clearbrook, MN	450,000	800,000	Oct 2010	Operational Oct 2010
Transcanada Keystone MainLine (Base)	Wood River/Patoka, IL	435,000	(2)	Jun 2010	Operational July 2010
Transcanada Keystone MainLine (Expansion)	Wood River/Patoka, IL	156,000	(2)	Q1-2011	Completing pumping upgrades
Transcanada Keystone Cushing Extension	Cushing, OK	591,000	(2)	Q1-2011	Completing construction
Transcanada Keystone XL - Phase IV (Steele City Segment)	Steele City, NE	700,000	(2)	Q1-2013	NEB Approved March 2010 -Pending Presidential Permit
Domestic Pipelines PADD-2 to PADD-3					
TransCanada Keystone XL - Phase III (Gulf Coast Segment)	Port Arthur/Houston, TX	700,000	(2)	Q1-2013	NEB Approved March 2010 -Pending Presidential Permit
Enbridge Monarch Cushing to Gulf (3)	Houston, TX	370,000	480,000	2014	Proposed mid 2010
Non-Pipeline Projects					
CN Rail/Altex "PipelineOnRail"	Rail routes to Kitimat, BC, and to US Gulf Coast being offered - status uncertain				

Notes

1. Northern Gateway Project also includes a 193,000 bpd pipeline to import condensate (diluent) from Kitimat to Edmonton
2. Total Keystone/XL system listed as expandable from 1.29 to 1.5 mbd. Resulting total capacity to Gulf Coast expected to be 900,000 bpd
3. Listed capacities are for light sweet crude. For 22 API heavy crude, stated capacities are 250,000 bpd initial and 325,000 eventual

Table 3-3

3.2.4 WCSB Production versus Export Capacity Outlook

Table 3-4 summarizes nominal or nameplate export capacity for WCSB crude oils and compares this with estimated WCSB crude supply based on the 2010 Growth projection issued by the Canadian Association of Petroleum Producers (CAPP)[44]. Approximately 460,000 bpd of WCSB crude oils are processed local to their source in refineries mainly near Edmonton. Apart from volumes processed there, all other WCSB crudes must move via pipeline (or rail) to either the British Columbia coast, PADD4 or PADD2, the latter with onward connections to PADD3, eastern Canada and PADD1. Table 3-4 includes existing pipelines, those under construction or start-up and Keystone XL. Possible additional projects, such as Transmountain TMX 2 and 3 are not included.

WCSB Crude Pipeline Export Capacity Outlook - Existing Pipelines plus Keystone XL

		2008	2010	2011	2013	2015	2020	2025	2030
Vancouver BC Transmountain (1)		0.225	0.300	0.300	0.300	0.300	0.300	0.300	0.300
PADD4 Express/Milk River/Rangeland		0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485
PADD2 Enbridge Mainline		1.870	2.055	2.055	2.055	2.055	2.055	2.055	2.055
PADD2 Enbridge Alberta Clipper (2)	**NEW**		0.110	0.450	0.450	0.450	0.450	0.450	0.450
PADD2 Transcanada Keystone Base (3)	**NEW**		0.218	0.435	0.435	0.435	0.435	0.435	0.435
PADD2 Transcanada Keystone Extension	**NEW**			0.156	0.156	0.156	0.156	0.156	0.156
PADD2 Transcanada Keystone XL (4)	**Permitting**				0.700	0.700	0.700	0.700	0.700
Total WCSB Pipeline Export Capacity (5)		**2.580**	**3.168**	**3.881**	**4.581**	**4.581**	**4.581**	**4.581**	**4.581**
Total WCSB Crude Supply (6)		**2.436**	**2.565**	**2.755**	**3.082**	**3.275**	**3.811**	**4.528**	**4.848**
less WCSB crude processed at Edmonton refineries (7)		(0.450)	(0.462)	(0.462)	(0.462)	(0.462)	(0.462)	(0.462)	(0.462)
Net WCSB Supply to be Moved by Pipeline out of Alberta (8)		**1.986**	**2.103**	**2.293**	**2.620**	**2.813**	**3.349**	**4.066**	**4.386**
Total Surplus Capacity with Keystone XL		0.594	1.065	1.588	1.961	1.768	1.232	0.515	0.195
Total Surplus Capacity without Keystone XL		0.594	1.065	1.588	1.261	1.068	0.532	(0.185)	(0.505)

Notes:

1. Line capacity is 300,000 bpd but approximately 50,000 bpd is currently used to transport products
2. Fractional 2010 capacity shown as start up October 2010
3. Fractional 2010 capacity shown as start up July 2010
4. 700,000 bpd capacity from Hardisty to Steele City, NB, and on via Cushing to USGC
5. WCSB export capacity does not take into account any potential that could be added by non-pipeline modes, e,g, CN Rail / Altex
6. WCSB supply from CAPP data, comprises streams to market downstream of upgraders and blending
7. Estimated from CAPP data. Edmonton refinery throughputs assumed in this calaculation to remain constant at 2010 levels although the reality may well be different.
8. Includes WCSB crude sent on Transmountain pipeline to refinery at Burnaby near Vancouver, BC

Table 3-4

[44] This study uses the CAPP data specific to WCSB "supply to trunk lines and markets" downstream of upgraders and blending. Gross production of "raw" oil sands from the WCSB is also projected by CAPP as a separate data series. While total CAPP figures for WCSB production and supply are essentially identical for 2010, over time, the CAPP projection for supply becomes gradually higher than that for production such that, by 2025, their total WCSB supply figure is some 8%, 337,000 bpd, above their production projection. The reason for this is that the CAPP projection assumes most incremental oil sands bitumen will be delivered to market as DilBit, i.e. as a blend of raw bitumen with condensate type diluent. Therefore, built in to the CAPP projection is a steadily increasing intake from non-Canadian sources of diluent streams that are blended with WSCB bitumen into DilBit that is then counted as supply to market. This rising intake of diluent from outside WCSB is the reason for "supply" becoming gradually larger than raw production. In the WORLD modeling analysis, the need for growing diluent volumes to blend with bitumen was taken into account.

Figure 3-5 includes the data from Table 3-4, i.e. the figure is based on nameplate line capacities. The graph shows that, if no further projects were built between now and 2030 beyond those listed in Table 3-4, then surplus export capacity would exist until around 2024 assuming (a) all pipelines being used at full "nameplate" capacity and (b) growth in Canadian oil sands production matching the 2010 CAPP projection. However, it is unrealistic to assume or plan on the basis that all lines would at all times (be able to) run full. Figure 3-6 illustrates the effect of applying a more conservative long run average system-wide utilization rate of 90%[45]. On this basis, additional export capacity would be needed soon after 2020, still assuming that no other pipeline project is built in the next decade. The implication is that, while Keystone XL, coming on line in 2013, would add to the excess in export capacity through 2020, its capacity - or an alternative (i.e. other projects in Section 3.2) - would be needed soon after 2020 to sustain WCSB production at the levels projected by CAPP. Figure 3-7 illustrates the net WCSB export capacity surpluses/deficits assuming both nameplate and effective pipeline capacities.

Any increase in WCSB output versus the CAPP projection would bring that date nearer and *vice-versa*. Equally, other pipeline projects coming on-stream in the 2015-2020 time frame, (e.g. TMX 2 and 3, which would add a total of 400,000 bpd), would push back the date when Keystone XL or other equivalent export capacity would be needed to avoid shutting in WCSB production.

It is thus clear that recent and current projects (excluding KXL) have led to a surplus in cross-border export capacity into the USA that would take around ten years to eliminate, assuming (a) the 2010 CAPP projection for production is realized and (b) no new pipelines from the WCSB to the West Coast are opened.

However, cross-border capacity alone and associated excess is not the whole story. Key questions also relate to the onward delivery of WCSB crude oils to refineries within U.S. regions other than PADD2 and to the potential for export routes that would diversify WCSB destinations outside the U.S. A central goal of the analysis was to address these and their implications.

[45] Recent issues with the Enbridge Mainline system and associated WCSB production shut-ins including into December 2010, (Devon Trims Oil Output, Cites Pipeline Problems, Ryan Dezember, Dow Jones Newswires, Dec 10, 2010), indicate that, even with Alberta Clipper and Keystone Mainline (initial capacity) under start-up, the total system for transporting WCSB crudes into the U.S. is still tight, i.e. that effective capacity may be below nominal. The issues highlight the necessity for redundant nominal capacity.

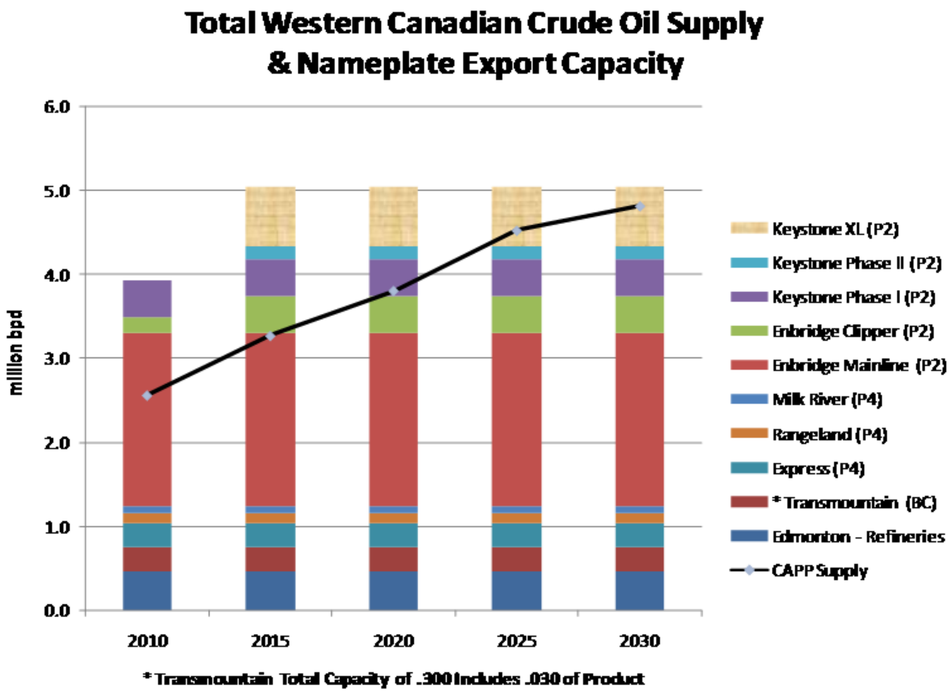

Figure 3-5

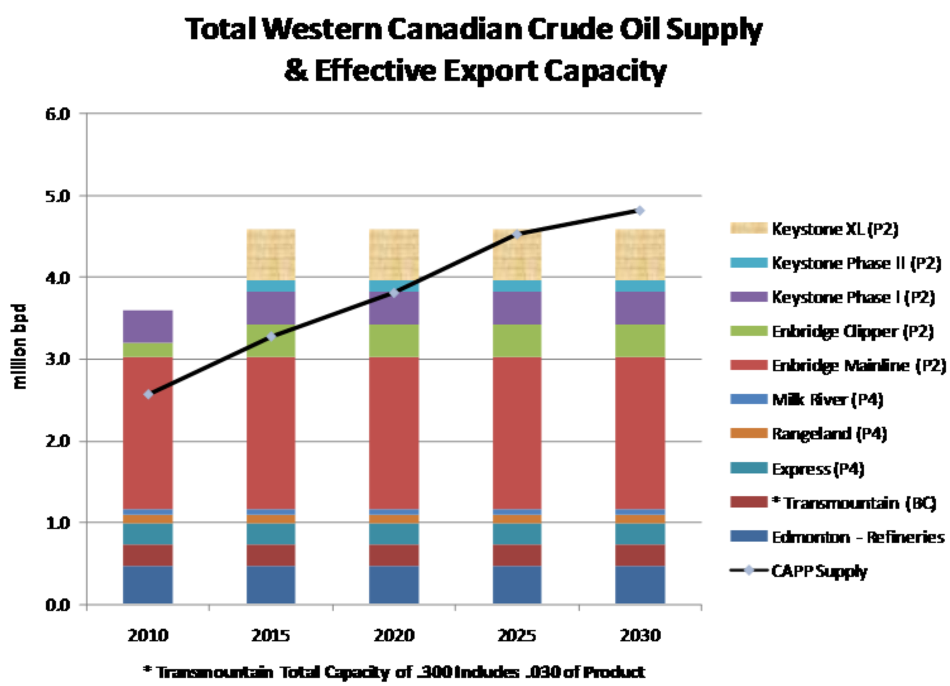

Figure 3-6

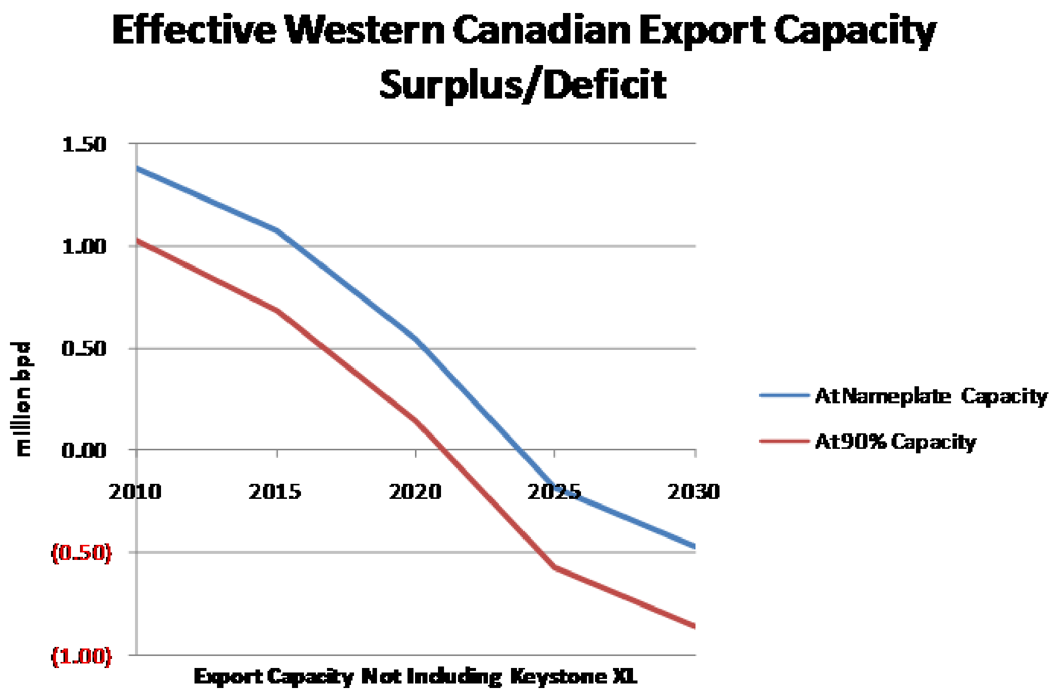
Effective Western Canadian Export Capacity
Surplus/Deficit
1.50
1.00
0.50
0.00
(0.50)
(1.00)
million bpd
2010
2015
2020
2025
2030
Export Capacity Not Including Keystone XL
At Nameplate Capacity
At 90% Capacity

Figure 3-7

4 Scope & Basis of Analysis

The scope of this analysis centers on addressing the questions set out in Section 2.2 above, exploring the impacts on the U.S., Canadian and global crude oil and refining systems and markets of (a) building and (b) not building the Keystone XL pipeline. Because the combination of other available pipelines is a key uncertainty, the study took the form of scenario analysis, examining seven different pipeline scenarios, (see Section 4.4), each applied used two different outlooks for U.S. oil demand (see Section 4.3.1). All scenarios are based on the assumption that Canadian oil production capacity realizes the CAPP 2010 Growth projection (see Section 0). This section also provides a basic overview of the models that generate results for each scenario and associated calculation of greenhouse gas emissions.

4.1 Methodology/Approach

The study design employed EIA and EPA outlooks for U.S. and global oil supply, demand - and world oil price - to which were applied sets of assumptions about available pipelines, together with refining and other bottom up detail. These cases were modeled to gauge crude oil flows, refining activities, market prices and other parameters under each scenario. The results provided insights into the impacts of the Keystone XL pipeline on key aspects of the U.S., Canadian and global petroleum sectors.

The methodology centered on the use of EnSys' WORLD model. This provides an integrated approach encompassing the U.S., Canadian and global supply systems that:

- Encompasses total oil liquids (non-crudes as well as crudes and all petroleum products) worldwide
- Characterizes petroleum market dynamics for 22 world regions with U.S. breakdown by PADD with sub-PADD refining detail
- Provides simulation and projection of the U.S. and Canadian petroleum supply and refining systems operating within the total global competitive system and market
- Integrates "top down" oil supply/demand/world oil price scenarios with "bottom up" detail on crudes and non-crudes supply, refining, product type and quality, transportation and economics
- Captures the interactions between regions and the effects of developments in supply, transportation, refining capacity, product demand and quality on trade, refining and market activity and economics.

WORLD results generated in this study encompassed the key parameters of the industry with U.S. and Canadian detail plus other world regions in aggregate, including:

- Refining throughputs, utilizations, investments
- Crude flows into the U.S., from Canada and from other origins; and in aggregate globally
- Product flows into and out of the U.S. and in aggregate globally
- Supply costs of crude oil and products imports to the US
- Refinery CO_2 emissions U.S. and non-U.S.

For more information on WORLD and parameters used for this study, see the Appendix.

To undertake the study, cases were first developed based on the Reference case for the U.S. Energy Information Administration's 2010 Annual Energy Outlook (AEO). This comprises an outlook for world oil price and for global oil supply and demand with regional breakdown, including U.S. detail. . Base WORLD model cases were established for 2010, 2015, 2020, 2025 and 2030, thereby allowing the broad U.S. and global evolution of refining, trade and related activities and economics to be examined and understood. Seven specific scenarios regarding KXL and other potential pipeline developments (or restrictions) were then applied across the model horizons to examine the impacts of different assumptions regarding available pipeline capacity.

Outputs from WORLD cases include U.S. and non-U.S. refinery CO2 emissions but not emissions associated with production of crude oil upstream of the refinery. Using WORLD results as input for the Energy Technology Perspectives model, the U.S. Department of Energy generated estimates of global life-cycle GHG emissions for the seven scenarios.

Changes in lifecycle GHG emissions were calculated with the models and methodology used in deriving indirect impacts of petroleum consumption for the RFS2 program[46]. Lifecycle GHG emissions for transportation fuels may be grouped into five general areas: raw material acquisition, raw material transport, liquid fuel production, product transport and vehicle operation.[47] Changes in upstream emissions (comprising the first two categories listed above) were calculated across scenarios using the modeled feedstock production changes from ETP and emissions factors for various crude oils as established by EPA. More information may be found in the Appendix Section 4.

The AEO oil demand outlook was then replaced with a projection of lower U.S. demand for refined products. The DOE ETP model was used to estimate the impacts that a reduction in U.S. petroleum demand could be expected to have on world oil price and hence non-U.S. supply and demand, including WCSB oil sands production. With world oil price, U.S. and non-U.S. supply and demand adjustments in place, the WORLD model was then rerun for the full suite of seven pipeline scenarios. The DOE ETP model was then used to generate associated estimates of global life-cycle GHG emissions impacts.

Key premises and results for each scenario are summarized here in the main body of the report and are detailed in the Appendices.

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[46] Petroleum Indirect Impacts Analysis (February 1, 2010), EPA-HQ-OAR-2005-0161-3156.

[47] DOE/NETL, An Evaluation of the Extraction, Transport and Refining of Imported Crude Oils and the Impact on Life Cycle Greenhouse Gas Emissions, March 27, 2009, DOE/NETL-2009/1362.

4.2 Study Exclusions

The study did not explore the sensitivity of results to changes in the initial assumption of Canadian crude oil production through 2030. In addition, the study limited or excluded the following.

4.2.1 U.S. Climate Policy

Although federal U.S. climate legislation or regulatory action could be enacted during the timeframe of the study, this assignment excluded consideration of any potential U.S. Federal, regional or state regulatory or legislative action on climate change. The study did include California's Law AB32 since this is in force, but only in so far as the law discourages California refineries from buying Canadian oil sands crudes. The EU climate regime was incorporated and was projected as moving forward with moderately increasing carbon costs over time. Potential U.S. policy actions are implicitly assumed in the lower U.S. demand outlook for refined oil products. EPA described the analysis in which it developed its low demand outlooks as focused on "the GHG reductions that could be derived directly from the transportation sector if effective drivers were in place"[48].

4.2.2 Oil Sands Upgrading Emissions and Life-Cycle Analysis

The analysis used features built into WORLD to project refinery CO_2 emissions by region, U.S. and non-U.S., by scenario. The WORLD modeling excluded any computation or consideration of carbon footprints of crude oils and non-crude supply streams, (including the life-cycle/LCFS carbon footprint of Canadian oil sands), or of the CO_2 emissions associated with transportation of oil streams and combustion of oil products. Specifically, the EnSys analysis did not consider or model oil sands upgrading processes and technologies but began from and used as inputs oil sands streams as delivered to market, i.e. those grades and volumes available after blending with diluent and or upgrading. Further, the study did not consider any variations in the mix of oil sands streams to market, e.g. variations in the proportions of DilBit, SynBit and fully upgraded synthetic crude oil (SCO). As described in Section 4.3.2, the latest CAPP projection was used to create a single "reference" outlook for Canadian crude supply volumes and mix.

Global life-cycle GHG emissions impacts were, however, estimated by the Department of Energy using results from WORLD and other data in their ETP model. Those results are included in this report.

[48] EPA Analysis of the Transportation Sector Greenhouse Gas and Oil Reduction Scenarios, February 10, 2010. http://www.epa.gov/oms/climate/GHGtransportation-analysis03-18-2010.pdf.

4.2.3 Alberta Oil Sands Vision

The Alberta government has recently altered its royalty strategy such that this now includes taking royalty in kind. Thus the government will have available to it a growing stream of oil sands bitumen. Northwest Upgrading has been awarded a contract to process and upgrade royalty bitumen. Upgrading configuration has been evaluated. Announced plans are to focus on hydrocracking (rather than coking), on distillates production and on gasification with recovery of CO_2 for use in EOR projects. Initial capacity is indicated as 50,000 bpd with subsequent growth phases. Overall, this is seen as a first step by the Alberta government in realizing a vision under which major, latest technology oil sands facilities produce both fuels products and petrochemicals, including – potentially - for sale into the USA. Again, EnSys did not attempt to include or evaluate such developments. As described in Section 4.3.2, the study used CAPP projections for WCSB oil sands supply and mix of blended/upgraded streams.

4.2.4 Time Period After 2030

Although the project life for a major pipeline such as Keystone XL is generally taken as fifty years, this study covers the time frame from 2010 to 2030. The EnSys WORLD model is currently configured to project only 20 years ahead[49]. The underlying reason is that the level of uncertainty in any longer term analysis of the details of global refining activity, trade, market economics etc. is generally considered too great to yield meaningful results. In addition, the time frame for projections in the EIA Annual Energy Outlook used for this study reached only to 2035.

4.2.5 Corporate Strategy Effects

Under this study, scenarios were developed across time that were driven by refining and supply economics as simulated in the EnSys WORLD model. The crude destination and other impacts projected are a result of those drivers.

The WORLD modeling approach does not attempt to endogenously model commercial or corporate strategies that might affect pipeline construction. Therefore, the study makes no judgment on whether, for instance, early construction of one pipeline could deter or otherwise modify investor interests in other projects. Similarly, the study neither assumes nor models the extent to which producers, shippers and/or refiners might seek specific commercial terms that reflect factors such as the value of securing long term supply or sales. In that respect, the study did not "lock in" WCSB or other crude oil dispositions established in earlier study horizons, including existing long-term contracts for existing routes. Rather, dispositions were allowed to change over time to reflect changes in scenario pipeline capacities and refining economics factors. However, such corporate strategies as described above could be considered as being incorporated in the assumptions that underlie each scenario, especially as regards those that set the extent and timing of pipeline capacity expansions.

[49] EnSys has conducted numerous WORLD projects in the last five years for the EPA, American Petroleum Institute, World Bank, International Maritime Organisation, OPEC Secretariat and others. To date in these studies, the latest horizon evaluated has been 2030. Current EnSys plans are to extend to 2035 during 2011.

4.3 Study Basis and Outlooks

4.3.1 Demand Outlooks

The study applied two different outlooks for U.S. petroleum product demand.

The primary study basis was the Reference Case from the 2010 U.S. Energy Information Administration Annual Energy ("**AEO**" or "Reference") Outlook[50]. Under the 2010 AEO outlook, world oil price rises from an estimated $67.40/bbl in 2010 to $111.49/bbl in 2030 ($2008). Global oil demand rises from 85.9 mbd in 2010 to 95.6 in 2020 and 105.9 in 2030, an increase of essentially 1 mbd each year totaling 20 mbd over the period. (See Table 4-1.) Of this 20 mbd, growth is dominated by China at 7.3 mbd, plus India/rest of non-OECD Asia at 4.8 mbd and the Middle East/Africa at 3.3 mbd. In total, non-OECD regions account for 82.5% of the demand growth and OECD regions 17.5% through 2030. Of the projected 3.6 mbd growth in OECD, the USA (50 states plus insular properties) accounts for 2.3 mbd. Growth in Australasia and Mexico is projected as moderate and that in Europe, Japan, South Korea and Canada as minimal.

A second "**Low Demand**" outlook was also applied to each of the seven pipeline availability cases to assess the impacts of reduced consumption of transport fuels in the U.S. This outlook was based on a February/March 2010 study by the EPA[51] which examined "more aggressive fuel economy standards and policies to address vehicle miles traveled". Projections were used from the EPA's Scenario A, leading to reductions in U.S. petroleum product consumption versus the AEO 2010 outlook starting post 2015 and reaching 1.2 mbd by 2020 and 4.0 mbd by 2030.

The AEO and Low Demand outlooks for U.S. demand are compared in Figures 4-1 and 4-2. As can be seen, the differences lie predominantly in the projections for transport fuels demand, led by a 2.8 mbd reduction in 2030 gasoline consumption in the Low Demand scenario relative to the AEO. Under the AEO outlook, U.S. petroleum demand continues to slowly increase, although associated growth in supply of biofuels under the RFS-2 mandate means projected ex-refinery demand for products is essentially flat. Under the Low Demand outlook, a marked reduction in U.S. demand begins to take hold after 2015 and continues through 2030.

Since WORLD comprises an integrated global approach, the impacts of the projected reduction in U.S. demand on the global supply system were estimated by Brookhaven National Laboratory using the Energy Technology Perspectives (ETP) model. In the ETP results, U.S. demand reduction cut world oil price which in turn led to small increases in oil demand in non-U.S. regions. The effects of the U.S. Low Demand outlook on global demand, global supply and world oil price are summarized in Table 4-1.

[50] Considerable additional detail covering U.S. and global crude oil and non-crudes supplies, refining, transport, demand and product quality was also applied to develop the full WORLD modeling analysis.

[51] EPA Analysis of the Transportation Sector, Greenhouse Gas and Oil Reduction Scenarios, February 10, 2010, last updated March 18, 2010, in response to September 2009 request from Senator Kerry.

Demand reductions in the U.S. were projected to lead to reductions in world oil price which in turn encouraged (small) petroleum product demand increases outside the USA. The resulting Low Demand world oil price was projected by 2030 to be close to $4.50/bbl below that in the AEO outlook. The net global oil demand reduction in 2030 was 3.7 mbd, comprised of small demand increases totaling 0.3 mbd in regions outside the U.S. partially offsetting the U.S. product demand reduction of 4.0 mbd. On the supply side, ETP results indicate the reduction of 3.7 mbd would be met primarily by cuts in OPEC crude production, notably from the Middle East. ETP results also indicate that there would be small reductions in U.S., Canadian and other non-OPEC supplies, including those for WCSB conventional and oil sands crudes. As indicated in Table 4-1, total Canadian oil production was projected to be cut by 0.2 mbd by 2030. This reduction was taken as being entirely in oil sands output.

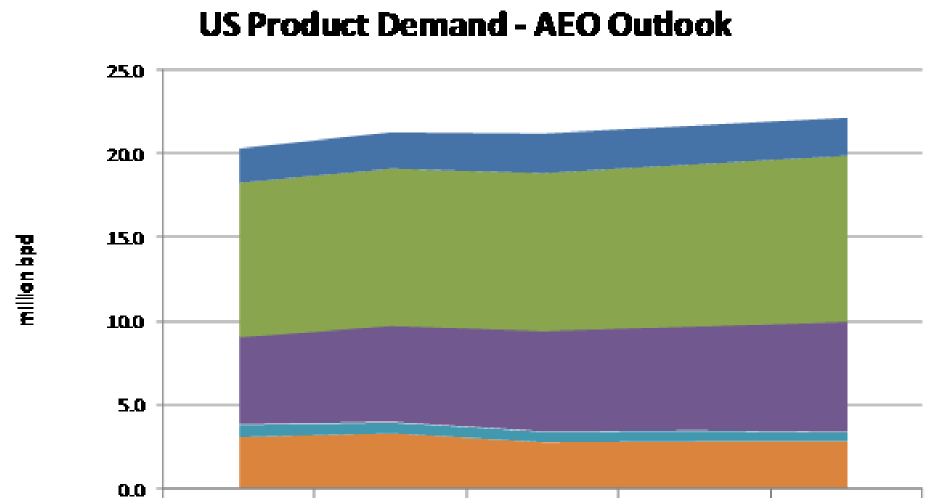
Summary of AEO and Low Demand Projections

	AEO Outlook (6)			**Low Demand Outlook** (7)		
	2010	2020	2030	2010	2020	2030
World oil price $/bbl (1)	$ 67.40	$ 98.14	$ 111.49	$ 67.40	$ 96.80	$ 107.00
Liquids demand						
million bpd						
USA (50 states)	19.2	20.6	21.5	19.2	19.4	17.5
Canada	2.3	2.4	2.5	2.3	2.4	2.6
other OECD (2)	24.8	25.7	25.8	24.8	25.7	25.9
China	8.5	12.4	15.8	8.5	12.4	15.8
other non-OECD	31.0	34.6	40.3	31.0	34.7	40.4
Global	85.9	95.6	105.9	85.9	94.5	102.2
Canada crude oil supply (3)						
Conventional (4)	1.10	0.82	0.54	1.10	0.80	0.51
Oil Sands (5)	1.73	3.22	4.42	1.73	3.15	4.25
Total	2.83	4.04	4.96	2.83	3.95	4.76

Notes:

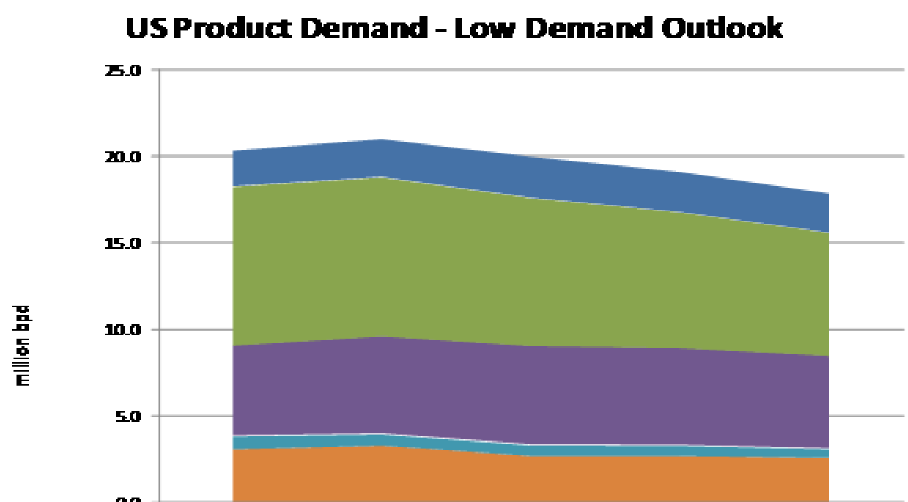
1. World oil price taken as price of US imported crude oil. Values are constant dollars $ 2008
2. Comprises: Mexico, Europe, Japan, South Korea, Australia, New Zealand
3. Projections to 2025 taken from CAPP 2010 Report Growth projection, 2030 estimates via extrapolation
4. Include both Western and Eastern Canada
5. Comprises blended / upgraded supply streams to market not raw production
6. Basis EIA Annual Energy Outlook 2010 Reference Case
7. Basis EPA Analysis of the Transportation Sector, Greenhouse Gas and Oil Reduction Scenarios, February 10, 2010, last updated March 18, 2010

Table 4-1



	2010	2015	2020	2025	2030
LPG	2.0	2.2	2.4	2.3	2.3
Gasoline/E85	9.2	9.3	9.4	9.6	9.9
Jet/ Distillate	5.2	5.8	6.0	6.2	6.6
Residual Fuel	0.8	0.7	0.6	0.6	0.6
Other	3.1	3.3	2.8	2.8	2.8

Figure 4-1



	2010	2015	2020	2025	2030
LPG	2.0	2.2	2.3	2.3	2.3
Gasoline/E85	9.2	9.2	8.6	7.8	7.1
Jet/ Distillate	5.2	5.7	5.7	5.7	5.4
Residual Fuel	0.8	0.7	0.6	0.6	0.5
Other	3.1	3.3	2.7	2.7	2.6

Figure 4-2

4.3.2 Canadian Oil Production Outlook

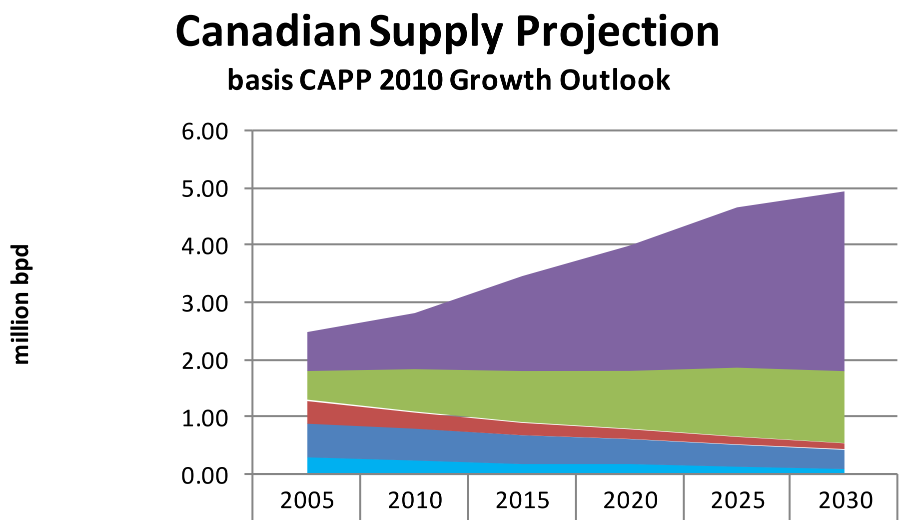
This study used the Canadian Association of Petroleum Producers (CAPP) 2010 Growth Outlook for Canadian crude oil production. The CAPP 2010 Growth outlook was used verbatim in all AEO demand outlook cases and with small adjustments, as described in Section 4.3.1, in the Low Demand cases. The 2010 AEO contained projections only for "North America non-conventional" supply which includes Canadian oil sands but also other streams. The CAPP projection is both more recent, having been issued in June 2010, and provides an explicit production outlook by major Canadian crude type including oil sands. It is also taken to comprise the Canadian oil industry's own view of their production outlook. Further, the 2010 CAPP Growth projection is very similar to the explicit Canadian oil sands projection in the July 2010 EIA International Energy Outlook.

As noted in Section 4.2.2, EnSys did not model oil sands production or upgrading; rather the analysis used as inputs the volumes and mix of oil sands streams delivered to market, i.e. downstream of upgraders and blending[52]. Since substantial volumes of DilBit are included in the projection, EnSys accounted for the associated diluents requirements in each time period[53]. This entailed netting off production of raw condensate in western Canada and in other regions which it was estimated would be sources of condensate supply used for DilBit blending. Also, in the longer term, the analysis allowed for some measure of diluent recycling.

Figure 4-3 summarizes the reference supply projection used. The CAPP projection extends to 2025. Supply levels for 2030 were developed via extrapolation of production trends. The outlook embodies gradual declines in conventional Canadian crude supplies in Atlantic Canada and in Western Canadian conventional light/medium and heavy grades. These declines are more than offset by increases in supply of oil sands streams such that total Canadian supply rises from 2.8 mbd in 2010 to 4.0 mbd in 2020 and 4.95 mbd in 2030. Of this, oil sands streams sent to market rise from 1.7 mbd in 2010 to 4.4 mbd in 2030, i.e. from 61% of total Canadian supply in 2010, (65% of WCSB), to 89%, (91% of WCSB), by 2030.

The "bitumen blends" category comprises both DilBits and SynBits as well as the Western Canadian Select (WCS) stream, which is a SynDilBit blend plus some conventional. Of the total bitumen blends, SynBits are projected as comprising only a minority, around 7% in 2010 rising to somewhat over 10% by 2030. WCS is projected to comprise 21-33% depending on the horizon and DilBit the balance[54].

[52] The CAPP 2010 projections distinguish between (raw) WCSB production and streams to market.
[53] DilBit blends typically contain around 75% bitumen and 25% diluent.
[54] Projections made several years ago typically included much higher proportions of SynBit, driven by concerns over limited diluent availability once WCSB condensates streams had been fully used and therefore an expectation that synthetic crude oil would have to be blended with oil sands bitumen. Current outlooks reflect a realization of growing diluent availability, notably through the Southern Lights pipeline project, imports from Asia via Kitimat, and eventually through an ability to recycle. Consequently, DilBits are now projected to comprise the bulk of the future bitumen blends.



	2005	2010	2015	2020	2025	2030
Bitumen Blends	0.69	0.99	1.67	2.20	2.82	3.16
SCO	0.51	0.75	0.90	1.01	1.21	1.26
Conv Heavy	0.41	0.29	0.22	0.17	0.13	0.10
Conv Lt & Medium	0.58	0.55	0.49	0.42	0.37	0.33
Atlantic Canada	0.30	0.25	0.19	0.19	0.15	0.11

Figure 4-3

4.4 Study Scenarios

In this study, a set of alternative pipeline expansion scenarios explore how different developments could impact U.S. refining and crude slate, Canadian oil exports and other parameters. First, three basic pipeline expansion scenarios were defined and then, within those, selected variants were examined. The resulting seven specific scenarios are set out in Table 4-2.

Each scenario variant assumed a specific combination of pipelines coming on stream over time, including whether Keystone XL was built or not. The **No Exp**ansion scenario was the one scenario wherein no new pipeline capacity at all was allowed beyond lines already operating. In addition, in all **KXL** and **No KXL** cases, the model was given flexibility to add pipeline capacity if justified, on two routes, namely WCSB to PADD2 and PADD2 to PADD3 U.S. Gulf Coast. This flexibility was allowed for to recognize the various alternatives to KXL that are evident as potential projects, as described in Section 3.2.3.3[55]. Again, the **No Exp**ansion scenario was the single cases in which the model was not given this

[55] The underlying premise was that other lines may be built if Keystone XL is not, i.e. that – if warranted by demand – industry would go ahead with alternative capacity. In the specific case of WCSB to PADD2 expansion potential,

flexibility. Under the **No Exp + P2P3** scenario, expansion of U.S. domestic pipeline capacity from PADD2 to PADD3 was allowed (and the scenario also assumed go-ahead of the Transmountain TMX 2 and 3 expansions). Table 4-3 summarizes for each scenario whether KXL was or was not assumed built, whether model expansion of lines from WCSB to PADD2 and/or from PADD2 to PADD3 was allowed, and which pipelines west from Alberta to the British Columbia coast (and thus with onward shipping to Asia and elsewhere) were assumed to be built. Section 4.4.1 describes the scenarios in detail.

Base Scenario		**Variant**
KXL (is built)	KXL	Transmountain TMX 2 and 3 expansions go ahead
	KXL+Gateway	TMX 2 and 3 and Northern Gateway go ahead
	KXL No TMX	No TMX 2 and 3 or Northern Gateway i.e. no expansion to west coast of Canada
No KXL (not built)	No KXL	Transmountain TMX 2 and 3 expansions go ahead
	No KXL HiAsia	High level of expansion to Asia: TMX 2,3, Northern Gateway, Northern Leg
No Expansion	No Exp	No expansion at all beyond current projects under construction
	No Exp + P2P3	No expansion except TMX 2,3 and U.S. domestic PADD2 to U.S. Gulf Coast

Table 4-2

the new Alberta Clipper line was built to be expandable by a further 350,000 bpd. Also, there could be some potential within the existing Enbridge Mainline system. As discussed in Section 3.2.3, various options could potentially be employed to bring crude oil from PADD2 to the Gulf Coast if Keystone XL does not go ahead. These include the Enbridge Monarch proposal and/or reversal of the Seaway crude line. It is assumed that internal domestic line projects or cross-border expansions of existing facilities would not be subject to the same level of permitting requirements or hurdles as is the case for Keystone XL, i.e. that such projects could go ahead under any "business as usual" scenario.

Basic Scenarios	Scenario WORLD Model Cases	Scenario Assumptions: USA Pipelines			Asia Pipelines		
		Keystone XL Allowed	WCSB to PADD2 EXP	PADD2 to PADD3 EXP	TMX Expansion	Northern Gateway	Nothern Leg
KXL	KXL	Y	Y	Y	Y	N	N
KXL	KXL+Gway	Y	Y	Y	Y	Y	N
KXL	KXL No TMX	Y	Y	Y	N	N	N
No KXL	No KXL	N	Y	Y	Y	N	N
No KXL	No KXL Hi Asia	N	Y	Y	Y	Y	Y
No Expansion	No Exp	N	N	N	N	N	N
No Expansion	NoExp+P2P3	N	N	Y	Y	N	N

Table 4-3

All scenarios included the following specific assumptions:

- Capacities used for Alberta Clipper, Keystone Mainline and XL, Transmountain TMX 2 and 3, Northern Gateway and Northern Leg were as set out in Table 3-3[56]
- No further expansions were made up to potential eventual capacity levels, including for KXL and Alberta Clipper. (Opportunity for further expansion was handled by allowing model selection of additional WCSB to PADD2 and/or PADD2 to PADD3 capacity.)
- The Enbridge Monarch project from Cushing to the Gulf Coast was not included in the modeling cases. (It was announced too late to be included and its status is uncertain.)
- The Keystone XL Bakken MarketLink and Cushing MarketLink options were not included in the modeling. (They were identified after modeling had been completed.)
- Similarly, some of the other Bakken takeaway projects were allowed for - but not all. As discussed in Section 3.2.3.2, the Bakken situation is rapidly evolving. Several new announcements have been made since the modeling analysis was undertaken.

[56] The one exception was that WORLD modeling cases used a capacity for KXL of 500,000 bpd in 2015 and 700,000 bpd thereafter, whereas actual 2015 capacity would be 700,000 bpd. 500,000 bpd was used based on information at the time that total Keystone system capacity would be 1.09 (not 1.29) mbd. Also TransCanada was offering 500,000 bpd of capacity for commercial contracts to the Gulf Coast. (See Section 3.2.3.3.2.) This was interpreted at the time as meaning total capacity to the Gulf Coast would be 500,000 bpd. The authors do not believe the discrepancy between 500,000 and 700,000 bpd for 2015 KXL capacity had a significant impact on results.

4.4.1 KXL Scenario & Variants

Under this scenario, the KXL pipeline is built. In addition further expansions, to be selected by WORLD if warranted, are allowed from WCSB to PADD2 and from PADD2 to PADD3 (U.S. Gulf Coast).

Three scenario variants were undertaken in order to assess the impact of different levels of pipeline expansion from WCSB west to the coast of British Columbia and thus by ship to the Asian market[57].

KXL

- Assumes the Transmountain TMX 2 and 3 expansions are built and are operational by 2020. This assumption is consistent with the intent of various entities in Canada to expand and diversify export routes, and specifically, to access growth markets in Asia, i.e. it reflects a view that the combination of growing Asian refining capacity, increasing Asian equity interests in oil sands production and rising WCSB volumes currently being shipped to Asia would be likely to lead to some degree of pipeline expansion to the BC coast
- Assumes that, among all of the proposed projects to the West Coast, TMX 2 and 3 would be the most likely to be built. The Transmountain line constitutes an existing facility and right of way, rendering permits for capacity expansions for TMX 2 and 3 easier to obtain and potentially reducing challenges to completion. The Transmountain line was already reported as operating above capacity and over-committed at the time of this report, indicating strong market demand even with excess pipeline capacity available across the border to the U.S.
- Although this scenario explicitly assumes it is the TMX 2 and 3 expansions that are built, they also act as a more general “proxy” to represent a moderate level of expansion from WCSB. (Overall delivery costs to north Asia are not that different whichever pipeline route to the BC coast is assumed.)
- The scenario also assumes that “business as usual” obtains in that other pipeline expansions are able to be realized when justified by economics and where data indicate that options to expand exist. Reflecting these conditions, the options allowed within the WORLD model were to expand pipelines cross-border from WCSB to PADD2 and/or from PADD2 to PADD3 (U.S. Gulf Coast)

KXL + Northern Gateway

- Same assumptions as KXL case above except this variant also assumes that either the Enbridge Northern Gateway or the Kinder Morgan Northern Leg goes ahead by 2025. Although the Northern Gateway project was specifically selected for this scenario, the primary purpose was to

[57] WCSB crudes can also be shipped by tanker from British Columbia to the U.S. west and Gulf coasts. In the EnSys study, movements to the Washington state refineries were allowed but movements of oil sands streams to California were not; this reflecting the existence of California Law AB 32.

represent a higher level of export capacity west from WCSB beyond the expansion of TMX 2 and 3 already in the KXL case.

KXL – No TMX

- Same assumptions as KXL case above except assumes that there is no TMX 2, 3 or other expansion in lines from WCSB west across the period through 2030. The purpose of this scenario was to examine the effects of capacity to BC and Asia remaining at present day levels.

In the presentation of results, the **KXL** scenario is used in the study as a “central” or “reference” case against which the results of all other scenarios are compared.

4.4.2 No KXL Scenario & Variants

Under this scenario, the KXL pipeline is not built. However, the assumption is that, as in the KXL case, the situation is otherwise “business as usual”; notably, further expansions are allowed from WCSB to PADD2 and from PADD2 to PADD3 (U.S. Gulf Coast). Also, the TMX 2 and 3 projects are assumed to be on-line by 2020.

Two No KXL scenario variants were analyzed, with focus on the effects of different levels of WCSB expansion to BC and thence Asian markets.

No KXL

- Scenario is the same as the KXL “reference” scenario except KXL is assumed not built. TMX 2 and 3 expansions go ahead but no other lines from WCSB west.

No KXL High Asia

- TMX 2 and 3, Northern Gateway and Northern Leg are all built with staggered timing that places them onstream respectively by 2020, 2025 and 2030. This raises the capacity to move WCSB crudes to and out of British Columbia to 700,000 bpd by 2020 (from 300,000 bpd today), to 1.225 mbd by 2025 and to 1.625 mbd by 2030. Note that the firms proposing these projects have stated target dates for completion that would bring them on stream earlier than allowed for in the scenario. A more conservative approach was taken on timing in the analysis to reflect the potential for opposition to the Northern Gateway and Northern Leg projects in particular to significantly extend timetables for implementation

- A primary purpose of this scenario was to examine whether commercial incentives would be sufficient to fill substantially larger capacity to move WCSB crudes west – and thus to markets outside the USA – if it were available.

4.4.3 No Expansion Scenario & Variants

This scenario examines a future in which a widespread movement prevents essentially any expansion beyond existing line capacity. Two scenario variants were analyzed to explore the effects of different levels of constraint on pipeline expansion.

No Expansion

- No expansion is allowed beyond lines that are in operation as of 2010. Thus Alberta Clipper, Keystone Mainline and Keystone Extension to Cushing are allowed but otherwise there are no further expansions:
  - No KXL
  - No PADD2 to PADD3 line expansions
  - No TMX 2,3 or other lines WCSB to BC.

No Expansion + TMX 2,3 and PADD2 to PADD3 Allowed

- As No Expansion case, except TMX 2 and 3 expansions are assumed to go ahead and domestic U.S. line expansions from PADD2 to PADD3 are allowed.

4.4.4 Discussion of Scenarios

The scenarios span a range that enables assessment of the need for KXL and other lines under different circumstances. The KXL and No KXL scenarios enable assessment of the extent and timing for pipeline capacity needed to support full production of oil sands as projected by CAPP, notably from WCSB to PADD2 and from PADD2 to PADD3/Gulf Coast refineries. In parallel, the scenarios shed light on the extent of market incentives for shipping WCSB heavy crudes to Gulf Coast refiners. The KXL vs. No KXL comparisons also highlight the potential effects of differing levels of WCSB pipeline expansions west, and thus of the potential competition for WCSB crudes between the USA and Asia.

The KXL and No KXL scenarios enable sufficient pipeline capacity to be built such that production of WCSB crudes including oil sands streams is always at reference outlook levels. There is no shut-in of production relative to the 2010 CAPP production outlook used. Conversely, the No Expansion scenarios examines *inter alia* the extent to which a total or near-total elimination of pipeline expansion could lead to shutting in as well as re-distribution of WCSB production.

All scenarios enable examination of the implications for U.S. dependency on crude oil imports from the Middle East and other sources outside Canada; also U.S. refinery throughputs and product imports and exports. In addition, all seven pipeline scenarios were run against both the AEO Reference outlook and the Low Demand outlook for U.S. petroleum product consumption to assess the impact of U.S. demand level on U.S. refinery runs, crude oil import levels and sources, etc.

Outputs from WORLD cases were also used (a) to report U.S. and non-U.S. refinery CO2 emissions and (b) as inputs to the Department of Energy ETP model which then generated estimates of global life-cycle GHG emissions, again enabling the effects of different scenarios to be compared.

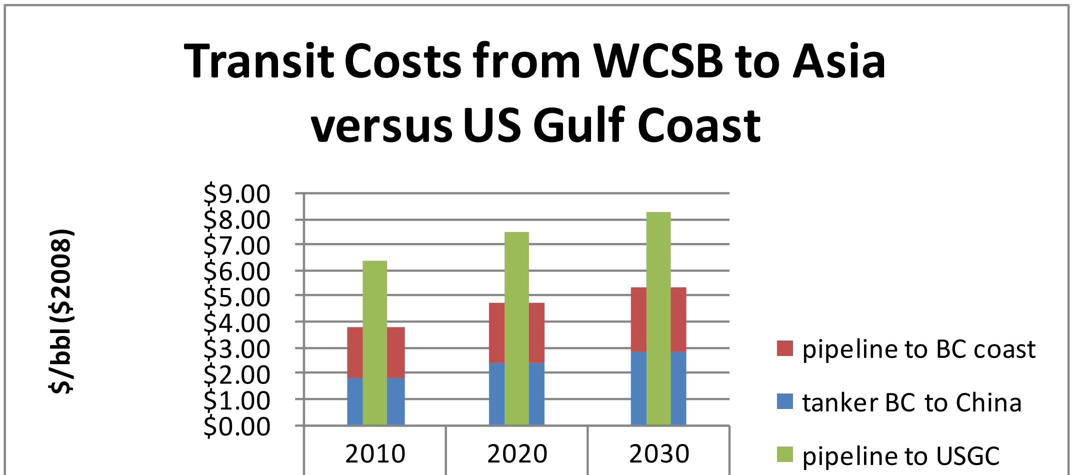
4.5 Economics of Moving WCSB Crudes to U.S. Gulf Coast versus Asia

A key factor in the analysis is the comparative transport economics of moving WCSB crudes into the U.S., especially PADD3 Gulf Coast, versus to Asia. Possibly not immediately apparent is that freight costs for WCSB crudes to northeast Asia (encompassing the markets of China, Japan, South Korea and Taiwan) are lower than those to the U.S. Gulf Coast. Figure 4-4 compares freight rates used in the WORLD cases[58]. The rates are for transporting a heavy WCSB oil sands stream such as DilBit or WCS. The pipeline plus tanker cost is via the Transmountain pipeline and then tanker to China[59]. The difference in freight cost is estimated at around a \$2.50 to \$3 per barrel advantage to moving WCSB to Asia rather than to the Gulf Coast[60].

[58] As further discussed in Appendix Section 2.3, EnSys escalated both pipeline and tanker (real) freight rates over time. The escalation was driven by the fact that both modes use fuels whose real costs are projected in the EIA AEO to rise over time. Tanker rates are impacted more by crude oil costs (marine bunker fuels) and pipeline costs more by natural gas, electricity and thus also coal prices. With crude oil prices projected to rise more rapidly than those for natural gas, coal or electricity in the AEO, tanker rates were projected to rise in real terms faster than pipeline rates, around 2.2% p.a. and 1.3% p.a. respectively through 2030.

[59] Costs for transport via the prospective Northern Gateway line to Kitimat and thence to China are projected to be similar. Broadly, it is expected the Northern Gateway route would have a higher pipeline tariff but a lower tanker freight cost, the latter because of the ability to move VLCC's out of Kitimat and the port's slightly shorter nautical distance to China.

[60] This difference is in line with recent press articles including a report that Enbridge believes "it can earn \$2 to \$3 more on every barrel it sells" to Asia, moving crude via Northern Gateway if built. Source: Oil Patch Sets Course for Asia", Toronto Globe and Mail, July 24th, 2010.



	2010	2020	2030
pipeline to BC coast	$1.93	$2.26	$2.48
tanker BC to China	$1.84	$2.44	$2.86
pipeline to USGC	$6.41	$7.51	$8.23

Figure 4-4

5 Results & Key Findings

The sections below focus on key results from first the WORLD modeling analysis of the U.S., Canadian and global downstream and second, the assessments of global life-cycle GHG emissions using the DOE ETP model. Details of WORLD model set up for this study and detailed results are contained in Appendix Sections 2 and 3. Corresponding detail on the ETP study is in Appendix Section 4.

5.1 AEO Reference and Low Demand Global Results for Refinery Expansion

The starting point for this study was the AEO 2010 Reference outlook. This was used, together with CAPP projections for Canadian crude supply and a series of other data sources, plus the extensive detail already built into WORLD, to develop a base case outlook. This comprised a WORLD 2010 case and then forward cases at 5 year intervals through 2030. These "Reference" cases used the KXL scenario.

Results from the AEO Reference outlook (KXL scenario) set out a projected global context for then focusing on specific pipeline scenarios. Of key significance is the contrast between the industrialized and the developing regions of the world as was summarized in Section 4.3.1. With the bulk of anticipated petroleum demand growth going to Asia, led by China, and with demand in the USA, Canada, Europe and Japan essentially flat, WORLD model results project some 75% of total global refinery capacity additions through 2030 being in Asia, 11.6 out of a total of 15.5 mbd of refinery distillation capacity over and above 2010 levels. (See Figure 5-1.)

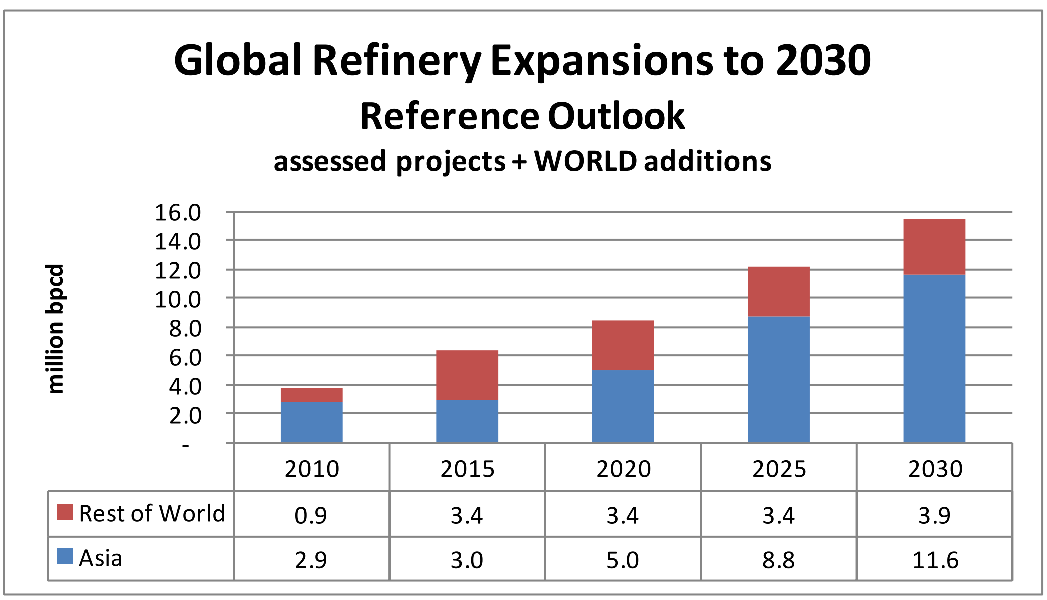
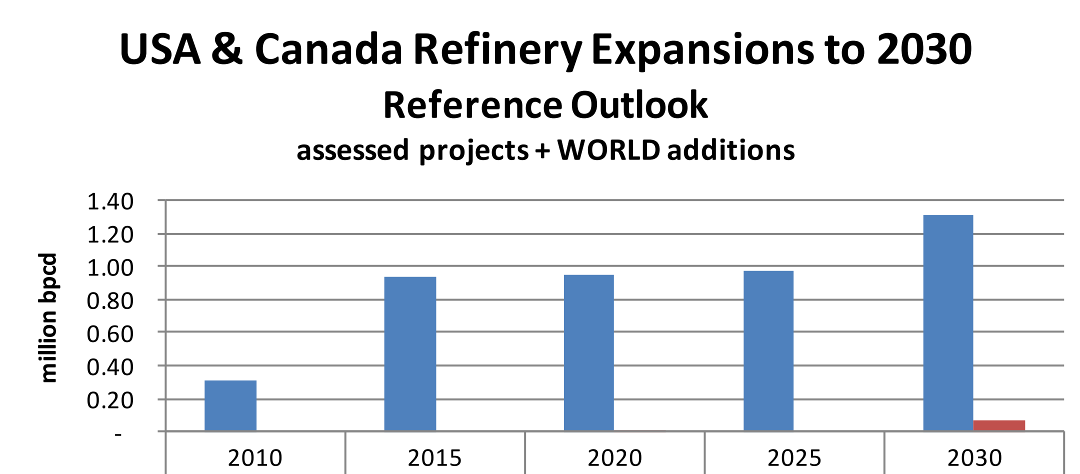


Figure 5-1



	2010	2015	2020	2025	2030
USA	0.32	0.93	0.95	0.97	1.32
Canada	-	-	0.01	-	0.07

Figure 5-2

In contrast, U.S. refinery capacity additions are projected to be minor (Figure 5-2). WORLD model output indicates essentially no capacity additions over and above current projects under construction until post 2025. A moderate expansion in the 2026-2030 timeframe is driven partly by exports, so whether it is actually realized would depend on several factors including the evolution of actual demand and refinery capacity in other world regions. Any need for further U.S. refinery expansions would also depend on U.S. demand level. Because these factors are highly uncertain, so is the expansion indicated for 2026-2030. Under the Low Demand scenario, U.S. refinery expansions beyond current projects are essentially nil.

As indicated in Table 4-1, petroleum product demand in Canada is projected under the AEO outlook to grow only minimally by 2030. The near absence of refinery capacity additions in WORLD model results reflects this.

These WORLD results highlight a key point that substantial refining growth in Asia means that Asia also necessarily represents a (the) major growth market for crude oils.

5.2 Scenario Results

5.2.1 Overview

Clearly evident from the suite of WORLD model scenario cases was that the differences between the pipeline scenarios materially impacted certain aspects of the U.S., Canadian and global refining systems and crude and product markets but had little effect on other aspects. This is to be expected considering what was and was not changed from scenario to scenario.

As discussed in Section 4.3.1, the differences between the 2010 AEO demand outlook and the Low Demand outlook are significant in terms of U.S. product demand but small in terms of effects on non-U.S. demand, world oil price, OPEC and non-OPEC supply, including that of Canadian oil sands streams. However, within each set of seven AEO and Low Demand scenario cases, the only input assumptions changed were those relating to US/Canadian pipeline projects and expansion options. Not changed within each set were:

- U.S. and global product demand and quality
- Crudes and non-crudes supply – other than Canadian oil sands supply in the No Expansion cases
- Refining base capacities, operating costs (e.g. prices for natural gas, electric power and other purchased utilities) and the costs of investing in new plant
- Transport costs.

There are three primary dimensions of comparison for the scenarios that were evaluated:

1. How results change over time for a single pipeline scenario
2. How results differ between different pipeline scenarios under the same demand outlook
3. How results differ for a given pipeline scenario but under different demand outlooks.

Section 5.2.2 presents observations on results for which little difference was detected in the second dimension above (i.e. a comparison between pipeline scenarios for a single demand outlook). For example, the scenario results indicate that industry parameters such as U.S. refinery crude throughputs or product imports are essentially unaffected by changes in assumptions about pipeline availability. However, these same results and exhibits still yield valuable insights regarding both developments over time within a single scenario and the effects of different demand outlooks.

Section 5.2.3 focuses on those aspects of the results where pipeline scenario (the second dimension above) led to significant differences. The impacts of changes in pipeline availability assumptions are primarily evident in data for U.S. foreign crude sources and destinations for Canadian crude. Those changes in scenario results primarily indicate how crude oil was rerouted in WORLD, but all within a global system with a global demand unaffected by changes to pipeline availability in North America.

5.2.2 Minor Scenario Impacts

Overall, the WORLD and ETP analyses projected that – within each demand outlook - all seven pipeline scenarios result in very similar U.S. refinery investments, expansions, throughputs, and thus total crude import levels, U.S. product import and export levels, U.S. import costs, U.S. and global refinery CO_2 emissions and global life-cycle GHG emissions. Impacts of changing pipeline assumptions on overall U.S. crude slate quality, U.S. Gulf Coast (PADD3) crude slate and refining activity were also limited. Figures below summarize the results obtained across all scenarios for both the AEO and Low Demand outlooks.

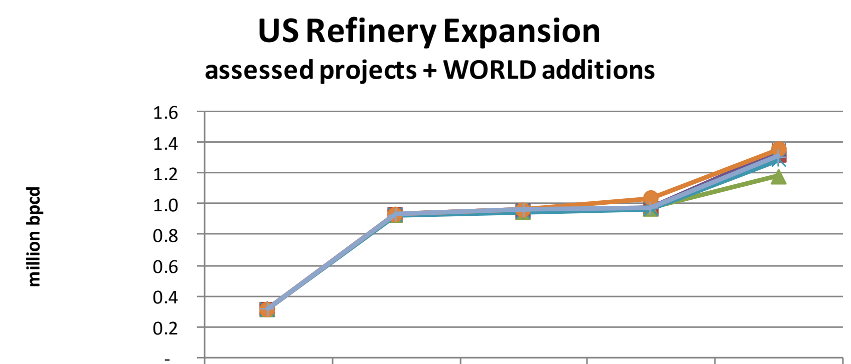
5.2.2.1 U.S. Refinery Investments and Expansions

Changes in pipeline availability for WCSB crude oil exports have minimal impact on either total U.S. refinery expansions or investments, as illustrated in Figures 5-3 through Figure 5-10. Under all pipeline scenarios, the only significant U.S. refinery expansion that occurs, over and above current projects under construction (described as "assessed" projects in the charts), is approximately 0.3 mbd in the 2025 to 2030 time frame, and then only under the AEO demand outlook. In all pipeline scenarios except No Expansion, this refinery expansion occurs in PADD3[61]. Under the No Expansion pipeline scenario, the refinery expansion occurs instead in PADD2, at approximately the same level of around 0.3 mbd by 2030, as that region maximizes its intake of WCSB crudes to take maximum advantage of available pipeline capacity. Capacity expansion does not occur in PADD3. Since the capacity expansion "switches" from PADD3 to PADD2, overall U.S. refinery expansions and investments are little altered. The switching of investment from PADD3 to in PADD2 is evident in Figure 5-7 and Figure 5-9. Under the Low Demand outlook, no significant capacity expansion occurs in either PADD2 or PADD3 under any pipeline scenario. U.S. total refinery investments are also substantially lower under the Low Demand outlook[62].

[61] Product exports are a driver but whether the expansions would actually occur is uncertain, depending on factors including actual demand and refinery investment levels in different countries.

[62] The main investments projected as occurring in the U.S. in the WORLD cases are for hydro-cracking, desulfurization and supporting units, as the industry deals with a continuing projected demand shift toward distillates and a continuing tightening in product sulfur standards worldwide, for both inland and marine fuels.

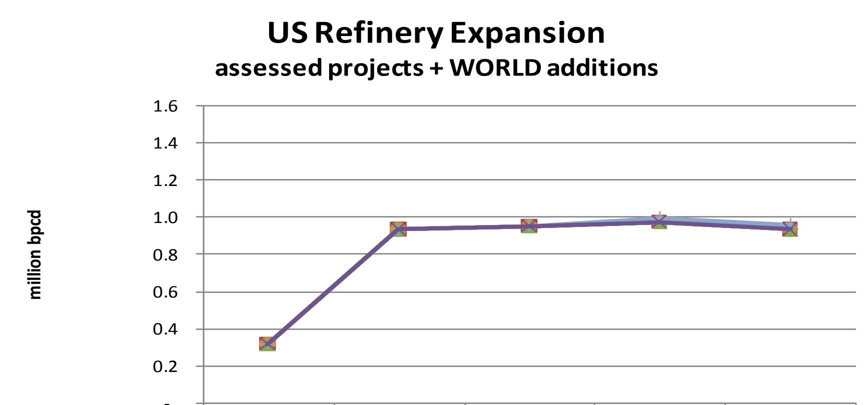
Reference Outlook



	2010	2015	2020	2025	2030
KXL	0.3	0.9	1.0	1.0	1.3
KXL+Gway	0.3	0.9	1.0	1.0	1.3
KXL No TMX	0.3	0.9	1.0	1.0	1.2
No KXL	0.3	0.9	1.0	1.0	1.3
No KXL Hi Asia	0.3	0.9	1.0	1.0	1.3
No Exp	0.3	0.9	1.0	1.0	1.4
NoExp+P2P3	0.3	0.9	1.0	1.0	1.3

Figure 5-3

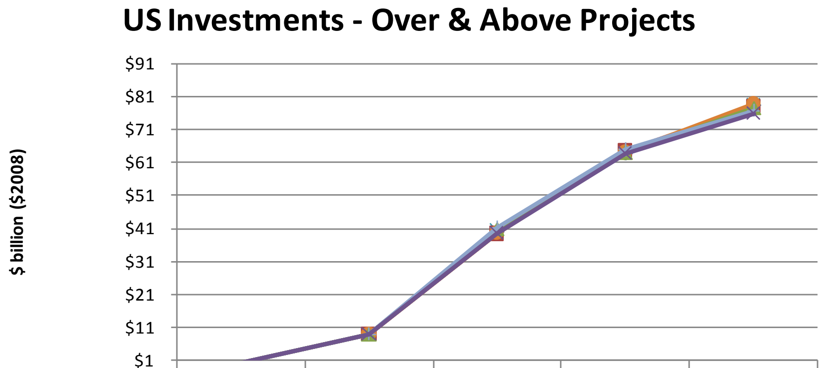
Low Demand Outlook



	2010	2015	2020	2025	2030
KXL	0.3	0.9	1.0	1.0	0.9
KXL+Gway	0.3	0.9	1.0	1.0	0.9
KXL No TMX	0.3	0.9	1.0	1.0	0.9
No KXL	0.3	0.9	1.0	1.0	0.9
No KXL Hi Asia	0.3	0.9	1.0	1.0	0.9
No Exp	0.3	0.9	1.0	1.0	1.0
NoExp+P2P3	0.3	0.9	1.0	1.0	0.9

Figure 5-4

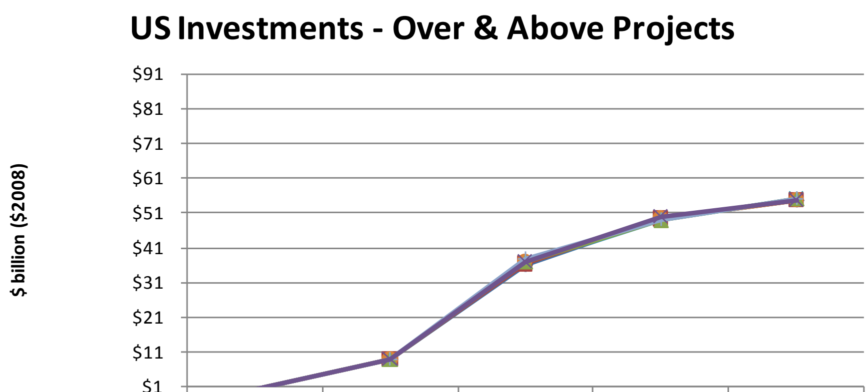
Reference Outlook



	2010	2015	2020	2025	2030
KXL	$0	$9	$40	$64	$78
KXL+Gway	$0	$9	$40	$64	$78
KXL No TMX	$0	$9	$39	$65	$78
No KXL	$0	$9	$39	$64	$79
No KXL Hi Asia	$0	$9	$41	$64	$77
No Exp	$0	$9	$41	$65	$77
NoExp+P2P3	$0	$9	$39	$64	$76

Figure 5-5

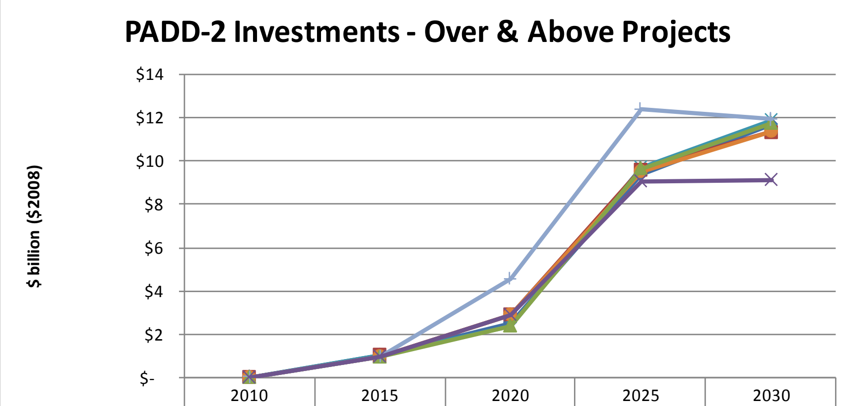
Low Demand Outlook



	2010	2015	2020	2025	2030
KXL	$0	$9	$36	$49	$55
KXL+Gway	$0	$9	$37	$49	$55
KXL No TMX	$0	$9	$36	$49	$54
No KXL	$0	$9	$37	$49	$55
No KXL Hi Asia	$0	$9	$37	$49	$55
No Exp	$0	$9	$38	$49	$55
NoExp+P2P3	$0	$9	$37	$50	$54

Figure 5-6

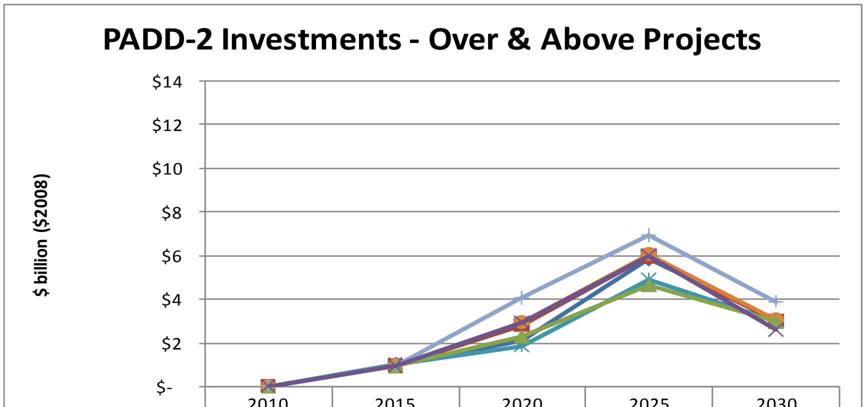
Reference Outlook



	2010	2015	2020	2025	2030
KXL	$0	$1	$3	$9	$12
KXL+Gway	$0	$1	$2	$10	$12
KXL No TMX	$0	$1	$3	$10	$11
No KXL	$0	$1	$3	$10	$11
No KXL Hi Asia	$0	$1	$2	$10	$12
No Exp	$0	$1	$5	$12	$12
NoExp+P2P3	$0	$1	$3	$9	$9

Figure 5-7

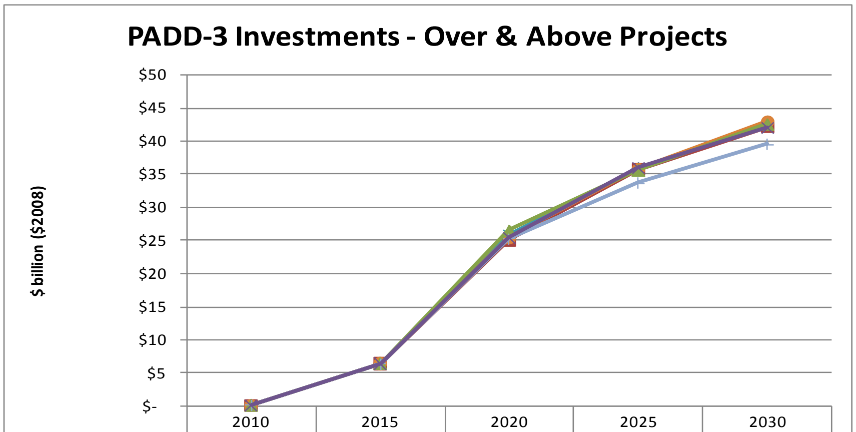
Low Demand Outlook



	2010	2015	2020	2025	2030
KXL	$0	$1	$2	$6	$3
KXL+Gway	$0	$1	$2	$5	$3
KXL No TMX	$0	$1	$3	$6	$3
No KXL	$0	$1	$3	$6	$3
No KXL Hi Asia	$0	$1	$2	$5	$3
No Exp	$0	$1	$4	$7	$4
NoExp+P2P3	$0	$1	$3	$6	$3

Figure 5-8

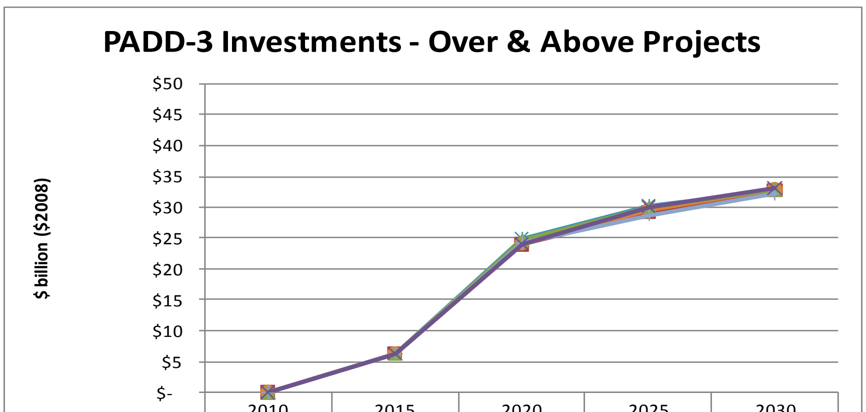
Reference Outlook



	2010	2015	2020	2025	2030
KXL	$0	$6	$25	$36	$43
KXL+Gway	$0	$6	$26	$36	$42
KXL No TMX	$0	$6	$25	$36	$42
No KXL	$0	$6	$25	$36	$43
No KXL Hi Asia	$0	$6	$26	$36	$42
No Exp	$0	$6	$25	$34	$39
NoExp+P2P3	$0	$6	$25	$36	$42

Figure 5-9

Low Demand Outlook



	2010	2015	2020	2025	2030
KXL	$0	$6	$24	$30	$33
KXL+Gway	$0	$6	$25	$30	$33
KXL No TMX	$0	$6	$24	$29	$33
No KXL	$0	$6	$24	$29	$33
No KXL Hi Asia	$0	$6	$25	$30	$33
No Exp	$0	$6	$24	$29	$32
NoExp+P2P3	$0	$6	$24	$30	$33

Figure 5-10

5.2.2.2 U.S. Refinery Crude Throughputs

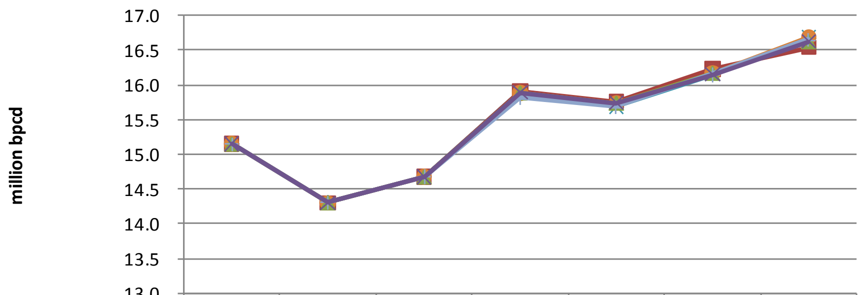
Overall U.S. refinery crude throughputs projections are very similar for all seven pipeline scenarios for each demand outlook (Figure 5-11 and Figure 5-12). Although U.S. refinery throughput appears insensitive to assumptions about available pipelines for WCSB export, the figures do illustrate the potential divergence in level of U.S. refining throughput depending on the outlook for U.S. demand. Under both the AEO and Low Demand outlooks, U.S. refinery throughputs recover post-recession through 2015. Under the AEO outlook, they gradually rise post 2020 driven largely by growth in net product exports (although, as stated in Section 5.1, there is uncertainty as to whether that growth for exports would actually occur). In contrast, under the Low Demand outlook, U.S. refinery throughputs peak around 2015 and then steadily decline. By 2030, they are projected to be some 2.5 mbd (15%) lower than under the AEO outlook. Given the associated U.S. demand reduction by 2030 is 4 mbd, the implication is that around 60% of the demand reduction would be absorbed by reductions in U.S. refinery runs and around 40% (1.5 mbd) by reductions in foreign refinery runs and U.S. product imports. (See Section 5.2.2.5.)

Figure 5-13 and Figure 5-14 show refinery crude throughput for PADD3 only, indicating limited sensitivity to variation in the combination of pipelines available to export WCSB crude oil. Figure 5-15 and Figure 5-16 show that changes to PADD3 throughput volumes are offset by comparable changes to throughput in PADD2. Under scenarios with high WCSB volume to Asia, PADD2 refinery throughput tends to drop but PADD3 throughput increase. Under the No Expansion scenario, PADD2 throughput rises as it absorbs maximum WCSB crude to utilize existing pipeline capacity – and PADD3 throughputs drop.

Again, the difference in input assumption about U.S. demand has a much greater impact on U.S. refinery throughput than any variation in the combination of pipelines available to export WCSB crude oil.

Reference Outlook

US Refinery Crude Throughputs to 2030

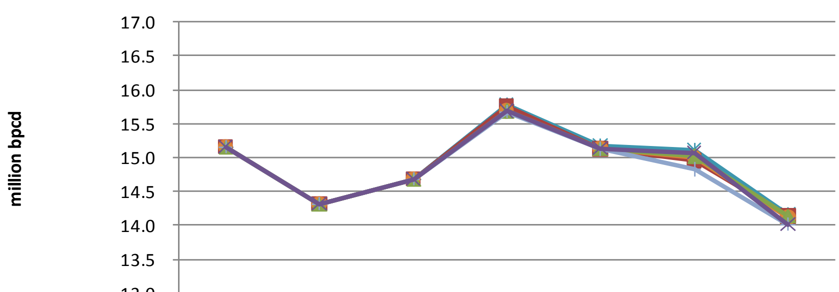


	2007	2009	2010	2015	2020	2025	2030
KXL	15.2	14.3	14.7	15.9	15.7	16.2	16.7
KXL+Gway	15.2	14.3	14.7	15.9	15.7	16.2	16.7
KXL No TMX	15.2	14.3	14.7	15.9	15.8	16.2	16.5
No KXL	15.2	14.3	14.7	15.9	15.7	16.2	16.7
No KXL Hi Asia	15.2	14.3	14.7	15.9	15.7	16.2	16.6
No Exp	15.2	14.3	14.7	15.8	15.7	16.2	16.7
NoExp+P2P3	15.2	14.3	14.7	15.9	15.7	16.2	16.6

Figure 5-11

Low Demand Outlook

US Refinery Crude Throughputs to 2030

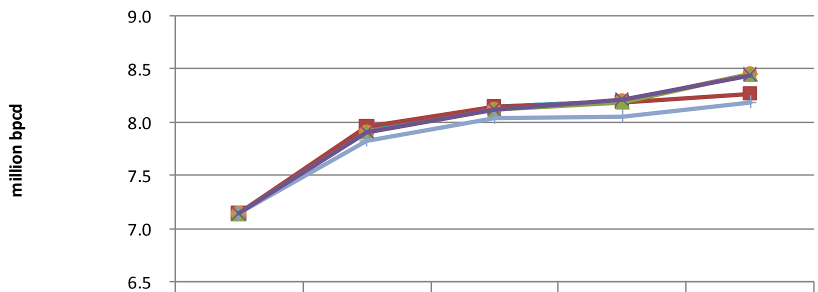


	2007	2009	2010	2015	2020	2025	2030
KXL	15.2	14.3	14.7	15.8	15.2	15.0	14.1
KXL+Gway	15.2	14.3	14.7	15.8	15.2	15.1	14.2
KXL No TMX	15.2	14.3	14.7	15.8	15.1	14.9	14.1
No KXL	15.2	14.3	14.7	15.7	15.1	15.0	14.1
No KXL Hi Asia	15.2	14.3	14.7	15.7	15.1	15.0	14.1
No Exp	15.2	14.3	14.7	15.7	15.1	14.8	14.0
NoExp+P2P3	15.2	14.3	14.7	15.7	15.1	15.1	14.0

Figure 5-12

Reference Outlook

US PADD-3 Refinery Crude Throughputs to 2030

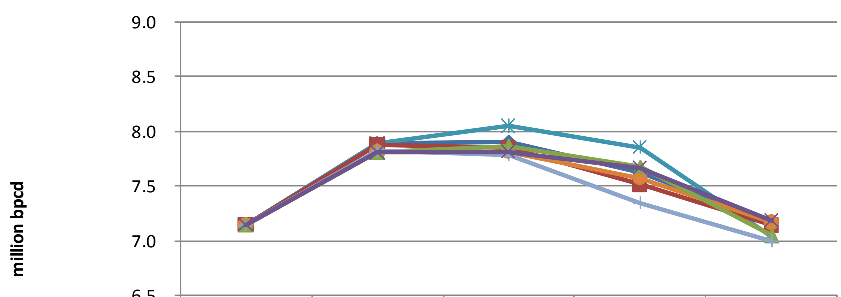


	2010	2015	2020	2025	2030
KXL	7.1	7.9	8.1	8.2	8.5
KXL+Gway	7.1	7.9	8.1	8.2	8.5
KXL No TMX	7.1	8.0	8.2	8.2	8.3
No KXL	7.1	7.9	8.1	8.2	8.5
No KXL Hi Asia	7.1	7.9	8.1	8.2	8.4
No Exp	7.1	7.8	8.0	8.1	8.2
NoExp+P2P3	7.1	7.9	8.1	8.2	8.4

Figure 5-13

Low Demand Outlook

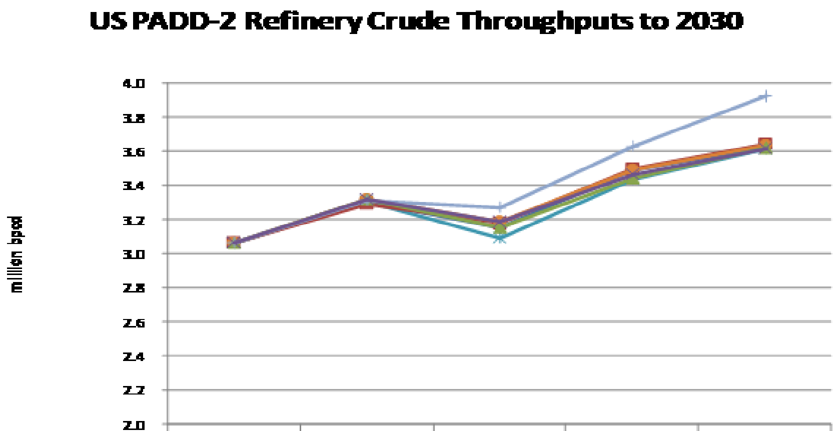
US PADD-3 Refinery Crude Throughputs to 2030



	2010	2015	2020	2025	2030
KXL	7.1	7.9	7.9	7.6	7.2
KXL+Gway	7.1	7.9	8.0	7.9	7.0
KXL No TMX	7.1	7.9	7.9	7.5	7.1
No KXL	7.1	7.8	7.8	7.6	7.2
No KXL Hi Asia	7.1	7.8	7.9	7.7	7.0
No Exp	7.1	7.8	7.8	7.3	7.0
NoExp+P2P3	7.1	7.8	7.8	7.7	7.2

Figure 5-14

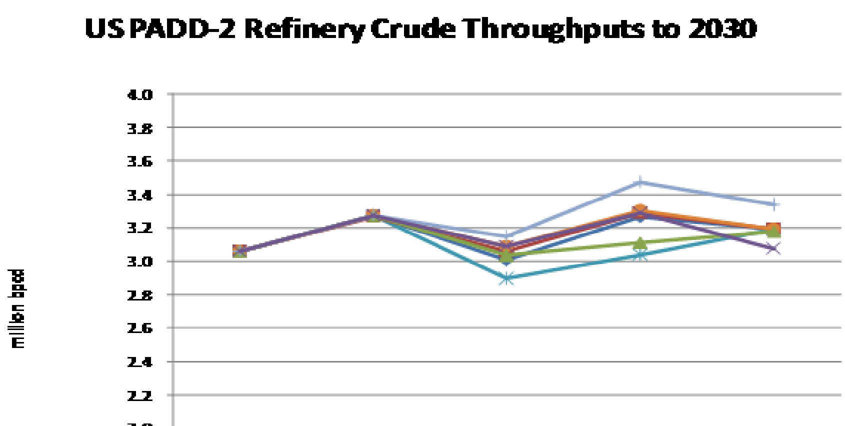
Reference Outlook



	2010	2015	2020	2025	2030
KXL	3.1	3.3	3.2	3.5	3.6
KXL+Gway	3.1	3.3	3.1	3.4	3.6
KXL No TMX	3.1	3.3	3.2	3.5	3.6
No KXL	3.1	3.3	3.2	3.5	3.6
No KXL Hi Asia	3.1	3.3	3.2	3.4	3.6
No Exp	3.1	3.3	3.3	3.6	3.9
NoExp+P2P3	3.1	3.3	3.2	3.5	3.6

Figure 5-15

Low Demand Outlook



	2010	2015	2020	2025	2030
KXL	3.1	3.3	3.0	3.3	3.2
KXL+Gway	3.1	3.3	2.9	3.0	3.2
KXL No TMX	3.1	3.3	3.1	3.3	3.2
No KXL	3.1	3.3	3.1	3.3	3.2
No KXL Hi Asia	3.1	3.3	3.0	3.1	3.2
No Exp	3.1	3.3	3.1	3.5	3.3
NoExp+P2P3	3.1	3.3	3.1	3.3	3.1

Figure 5-16

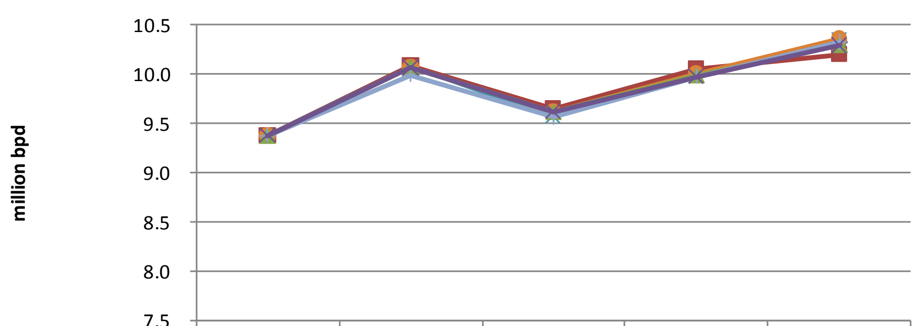
5.2.2.3 U.S. Total Crude Imports

Consistent with the relatively small impacts of pipeline assumptions on total U.S. refinery throughputs, changes in available pipelines to export WCSB crude oil have minimal impact on <u>total</u> U.S. crude imports and thus level of U.S. dependence on foreign oil for either demand outlook.

U.S. total crude imports are essentially the same in the scenario in which Canadian exports to the U.S. are the highest and the lowest. U.S. oil demand and domestic production were not changed between pipeline scenarios and, therefore, total crude imports remained unchanged. However, reducing U.S. oil demand below the AEO 2010 level to the Low Demand level would lead to a major reduction in crude oil imports and associated dependence on foreign oil. The scenario results indicate that crude oil imports would continue to grow slowly under the AEO outlook but decline appreciably after 2015 under the Low Demand outlook.

Reference Outlook

US Total Crude Imports



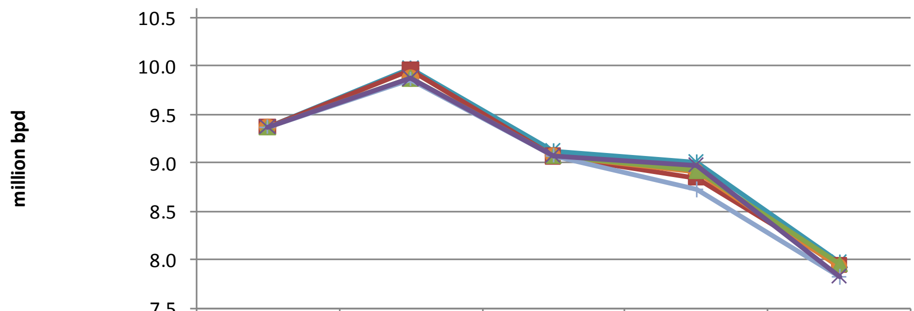
	2010	2015	2020	2025	2030
KXL	9.37	10.08	9.62	10.00	10.34
KXL+Gway	9.37	10.08	9.57	9.97	10.35
KXL No TMX	9.37	10.09	9.64	10.06	10.21
No KXL	9.37	10.06	9.62	10.00	10.36
No KXL Hi Asia	9.37	10.06	9.62	9.99	10.29
No Exp	9.37	9.99	9.56	9.97	10.32
NoExp+P2P3	9.37	10.06	9.62	9.97	10.29

Figure 5-17

Low Demand Outlook

US Total Crude Imports

Reference & Scenarios



	2010	2015	2020	2025	2030
KXL	9.37	9.98	9.10	8.92	7.92
KXL+Gway	9.37	9.98	9.12	9.01	7.97
KXL No TMX	9.37	9.96	9.07	8.85	7.94
No KXL	9.37	9.88	9.08	8.91	7.92
No KXL Hi Asia	9.37	9.88	9.08	8.92	7.95
No Exp	9.37	9.86	9.07	8.72	7.82
NoExp+P2P3	9.37	9.88	9.08	8.97	7.82

Figure 5-18

5.2.2.4 U.S. Crude Slate Quality

Figure 5-19 and Figure 5-20 indicate that U.S. crude slate quality[63] would be modestly impacted by changes in the combination of pipelines assumed to be available for WCSB export. The maximum difference in any time period across a whole range of scenarios is 0.5 degrees API. Outside the No Expansion scenarios, U.S. crude slate is projected as lightest in those pipeline scenarios that assume major pipeline expansions to the BC coast and thence Asia and heaviest when there is limited or no expansion west. Generally, these two extremes are represented by the No KXL High Asia and the KXL No TMX scenarios. High volumes of (heavy) WCSB crudes flowing to Asia mean less to the USA which replaces them with somewhat lighter crudes. When pipeline expansions west are limited, the opposite occurs; higher volumes of heavy WCSB crudes flow to U.S. refineries.

The results for PADD3 indicate the same effect, namely that lower assumed pipeline availability west to Asia leads to more WCSB heavy crudes coming into PADD3, hence a heavier crude slate, and *vice versa*.

[63] The portfolio of crude oils refined in a single refinery or the U.S. as a whole is described as the crude slate, and its quality is commonly expressed in terms of API gravity and secondarily sulfur content.

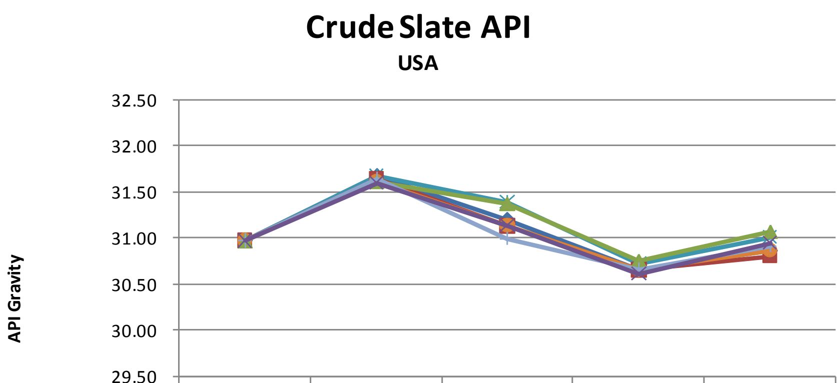
(Higher WCSB crude volumes to Asia have the opposite effect though for PADD2, leading to a lightening in the PADD2 crude slate and *vice versa*.)

The PADD3 crude slate quality would be highest (lightest) in the No Expansion case, which delivers the least WCSB crude to PADD3 among all seven pipeline combinations. With supply from WCSB effectively limited, PADD3 refineries turn to lighter crudes. Conversely, No Expansion is the scenario that leads to the heaviest crude slate for PADD2 which absorbs maximum volumes of heavy WCSB crude to take advantage of available pipeline capacity. The effects in the two PADDs tend to offset each other. The result is little change in crude slate quality at the national level under the AEO demand outlook. The lowest crude slate quality observed occurs in the No Expansion case with a Low Demand outlook. This is also the case with the highest proportion of U.S. oil supply coming from the Canadian oil sands.

Also evident in the results is that lower U.S. product demand leads to a heavier U.S. crude slate. This is because – under any one pipeline scenario – U.S. demand reduction backs out non-Canadian crude oil imports which, overall, are lighter than the Canadian grades. The heavier WCSB crudes still flow into the U.S. with volumes little affected under any given pipeline scenario by U.S. demand level. Thus the proportion of these heavy WCSB streams in the total U.S. crude slate is higher and the slate becomes heavier.

In line with limited changes in API, any particular pipeline scenario has little impact on either USA or PADD3 crude sulfur levels, with the exception of the No Expansion scenario. In this scenario, PADD3 refineries have extremely limited access to WCSB crudes and take in imported crude oils that are somewhat lighter and lower sulfur. (See Figure 5-21 and Figure 5-22 and Figure 5-25 and Figure 5-26.)

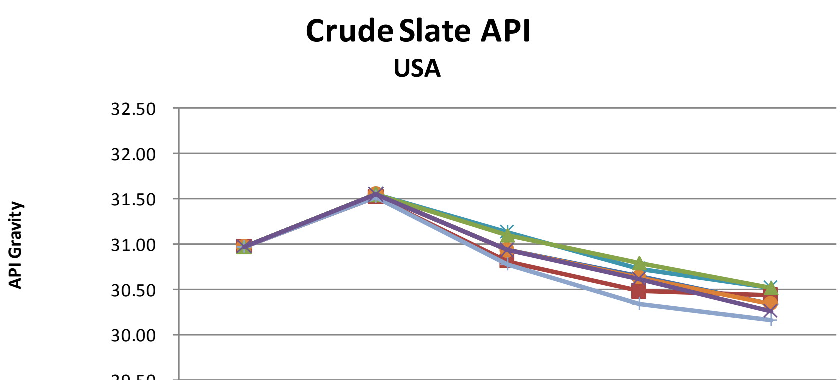
Reference Outlook



	2010	2015	2020	2025	2030
KXL	30.97	31.67	31.19	30.65	30.87
KXL+Gway	30.97	31.67	31.39	30.72	31.01
KXL No TMX	30.97	31.64	31.13	30.65	30.80
No KXL	30.97	31.61	31.14	30.66	30.86
No KXL Hi Asia	30.97	31.61	31.37	30.75	31.08
No Exp	30.97	31.65	31.00	30.65	30.92
NoExp+P2P3	30.97	31.60	31.14	30.61	30.95

Figure 5-19

Low Demand Outlook

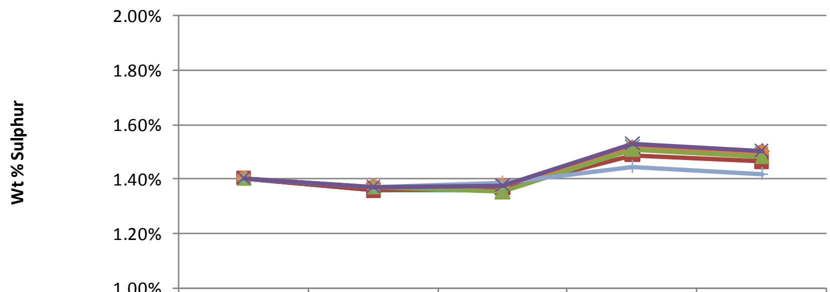


	2010	2015	2020	2025	2030
KXL	30.97	31.56	30.93	30.65	30.34
KXL+Gway	30.97	31.56	31.13	30.72	30.52
KXL No TMX	30.97	31.52	30.81	30.48	30.43
No KXL	30.97	31.55	30.93	30.63	30.34
No KXL Hi Asia	30.97	31.55	31.10	30.79	30.51
No Exp	30.97	31.52	30.78	30.34	30.16
NoExp+P2P3	30.97	31.55	30.93	30.61	30.26

Figure 5-20

Reference Outlook

Crude Slate Sulphur
USA

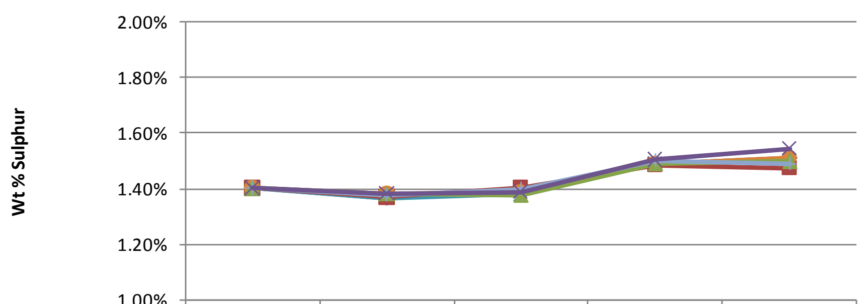


	2010	2015	2020	2025	2030
KXL	1.40%	1.36%	1.37%	1.51%	1.50%
KXL+Gway	1.40%	1.36%	1.36%	1.52%	1.49%
KXL No TMX	1.40%	1.36%	1.36%	1.49%	1.46%
No KXL	1.40%	1.37%	1.38%	1.51%	1.50%
No KXL Hi Asia	1.40%	1.37%	1.35%	1.51%	1.48%
No Exp	1.40%	1.37%	1.38%	1.44%	1.42%
NoExp+P2P3	1.40%	1.37%	1.38%	1.53%	1.50%

Figure 5-21

Low Demand Outlook

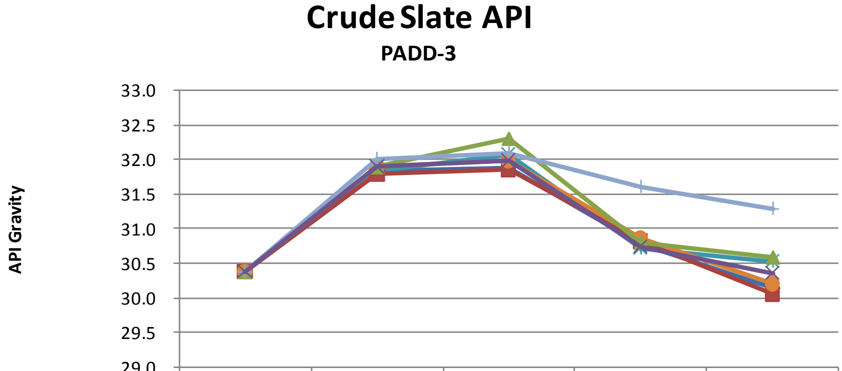
Crude Slate Sulphur
USA



	2010	2015	2020	2025	2030
KXL	1.40%	1.36%	1.40%	1.49%	1.51%
KXL+Gway	1.40%	1.36%	1.38%	1.49%	1.50%
KXL No TMX	1.40%	1.37%	1.40%	1.48%	1.47%
No KXL	1.40%	1.38%	1.39%	1.49%	1.51%
No KXL Hi Asia	1.40%	1.38%	1.38%	1.49%	1.50%
No Exp	1.40%	1.38%	1.40%	1.50%	1.49%
NoExp+P2P3	1.40%	1.38%	1.39%	1.50%	1.55%

Figure 5-22

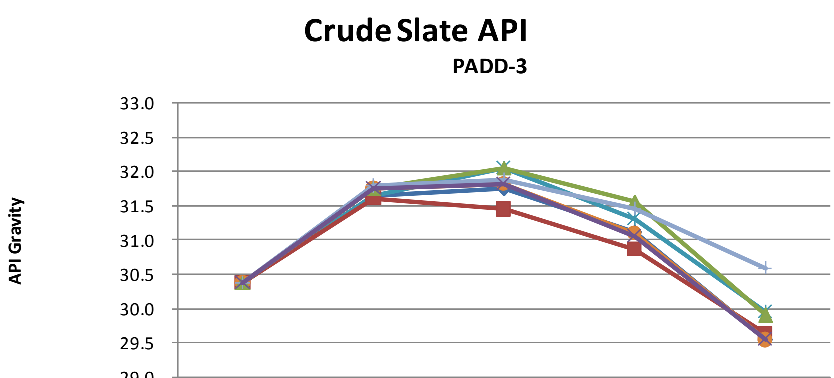
Reference Outlook



	2010	2015	2020	2025	2030
KXL	30.38	31.84	31.89	30.77	30.15
KXL+Gway	30.38	31.84	32.08	30.71	30.52
KXL No TMX	30.38	31.79	31.85	30.81	30.04
No KXL	30.38	31.89	31.98	30.86	30.20
No KXL Hi Asia	30.38	31.89	32.30	30.79	30.59
No Exp	30.38	32.01	32.08	31.60	31.29
NoExp+P2P3	30.38	31.89	31.98	30.74	30.36

Figure 5-23

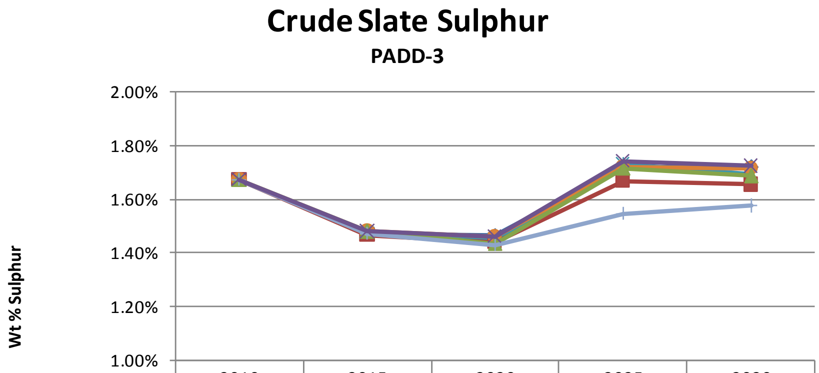
Low Demand Outlook



	2010	2015	2020	2025	2030
KXL	30.38	31.64	31.75	31.12	29.54
KXL+Gway	30.38	31.64	32.05	31.30	29.95
KXL No TMX	30.38	31.60	31.45	30.86	29.62
No KXL	30.38	31.75	31.81	31.10	29.54
No KXL Hi Asia	30.38	31.75	32.05	31.57	29.90
No Exp	30.38	31.79	31.88	31.45	30.58
NoExp+P2P3	30.38	31.75	31.81	31.05	29.55

Figure 5-24

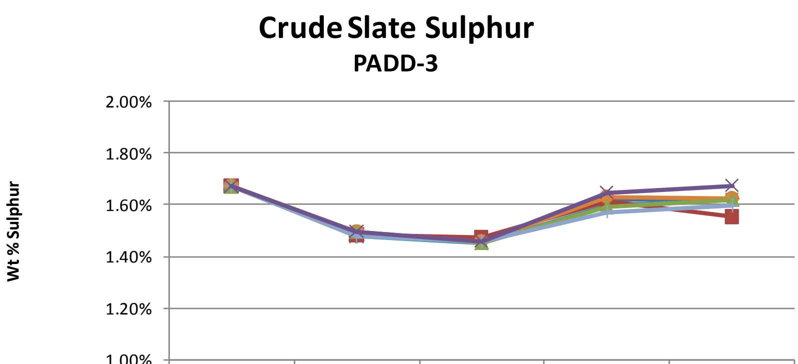
Reference Outlook



	2010	2015	2020	2025	2030
KXL	1.67%	1.47%	1.47%	1.72%	1.72%
KXL+Gway	1.67%	1.47%	1.45%	1.73%	1.69%
KXL No TMX	1.67%	1.47%	1.44%	1.67%	1.65%
No KXL	1.67%	1.48%	1.46%	1.72%	1.72%
No KXL Hi Asia	1.67%	1.48%	1.43%	1.72%	1.69%
No Exp	1.67%	1.47%	1.43%	1.55%	1.58%
NoExp+P2P3	1.67%	1.48%	1.46%	1.74%	1.72%

Figure 5-25

Low Demand Outlook



	2010	2015	2020	2025	2030
KXL	1.67%	1.48%	1.47%	1.62%	1.63%
KXL+Gway	1.67%	1.48%	1.45%	1.60%	1.62%
KXL No TMX	1.67%	1.48%	1.48%	1.61%	1.55%
No KXL	1.67%	1.50%	1.46%	1.63%	1.63%
No KXL Hi Asia	1.67%	1.50%	1.45%	1.59%	1.62%
No Exp	1.67%	1.48%	1.46%	1.57%	1.59%
NoExp+P2P3	1.67%	1.50%	1.46%	1.65%	1.67%

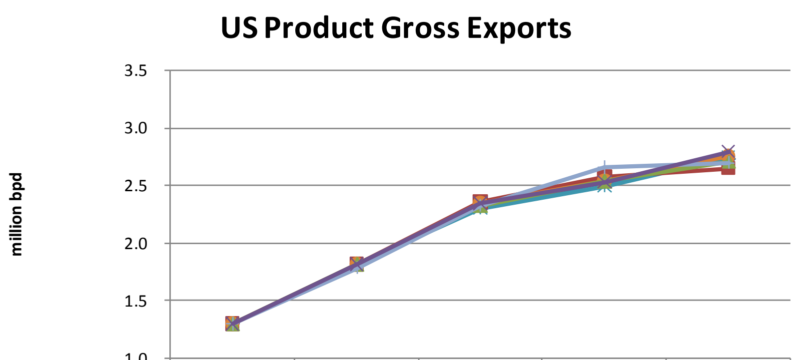
Figure 5-26

5.2.2.5 U.S. Product Imports and Exports

U.S. product exports, gross and net product imports are insensitive to changes in the combination of pipelines available to export WCSB crude.

Gross exports of refined products from the U.S. are essentially the same in the scenarios with both the most and least WCSB crude moving into the U.S. Again, it is the evolution of U.S. product demand that has the major impact on gross product exports from the U.S. Under both AEO and Low Demand outlooks, U.S. gross product exports are projected via WORLD to continue to grow[64], consistent with recent trends. However, gross product exports grow faster in the Low Demand cases compared to the cases under the AEO demand outlook, reaching a level in 2030 that is approximately 300,000 bpd higher than the AEO demand cases. This effect is small in the context of 2030 gross product exports projected to total of the order of 3 mbd but does indicate that declining U.S. demand for refined products could make more refinery capacity available to serve export markets. (See Figure 5-27 and Figure 5-28.)

Reference Outlook

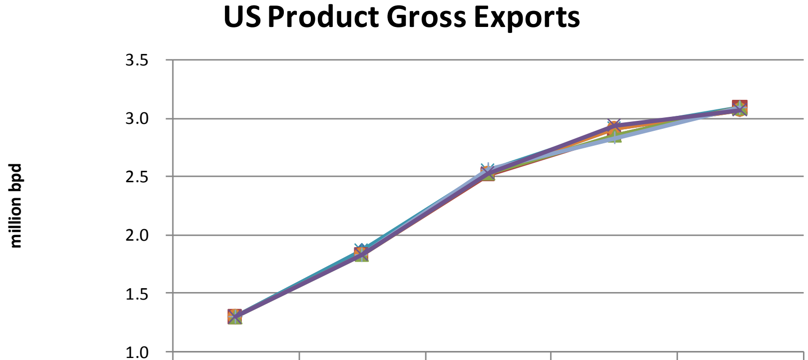


	2010	2015	2020	2025	2030
KXL	1.29	1.81	2.32	2.53	2.73
KXL+Gway	1.29	1.81	2.29	2.49	2.73
KXL No TMX	1.29	1.81	2.35	2.57	2.64
No KXL	1.29	1.81	2.34	2.54	2.75
No KXL Hi Asia	1.29	1.81	2.32	2.53	2.71
No Exp	1.29	1.78	2.32	2.65	2.69
NoExp+P2P3	1.29	1.81	2.34	2.52	2.79

Figure 5-27

[64] WORLD model product exports trade includes liquids and high grade petroleum coke but excludes fuel grade coke volumes.

Low Demand Outlook



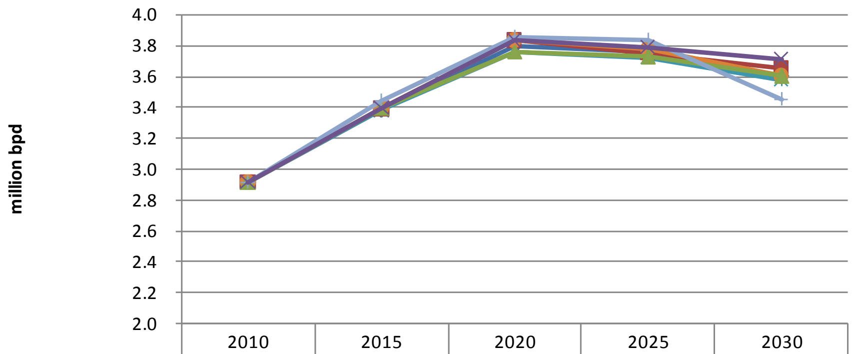
	2010	2015	2020	2025	2030
KXL	1.29	1.86	2.52	2.91	3.06
KXL+Gway	1.29	1.86	2.54	2.91	3.09
KXL No TMX	1.29	1.83	2.51	2.85	3.08
No KXL	1.29	1.83	2.52	2.90	3.06
No KXL Hi Asia	1.29	1.83	2.52	2.85	3.08
No Exp	1.29	1.82	2.56	2.83	3.08
NoExp+P2P3	1.29	1.83	2.52	2.93	3.06

Figure 5-28

Similar to gross product exports, gross product *imports* to the U.S. are not sensitive to changes in the combination of pipelines available to export WCSB oil from Canada. For all scenarios under the AEO outlook, gross product imports (Figure 5-29) continue to rise through 2020 and then flatten and decline very slightly. Under Low Demand (Figure 5-30), gross product imports flatten from 2015 to 2020 and then sharply decline through 2030 as the effects of declining U.S. demand are felt.

Reference Outlook

US Product Gross Imports

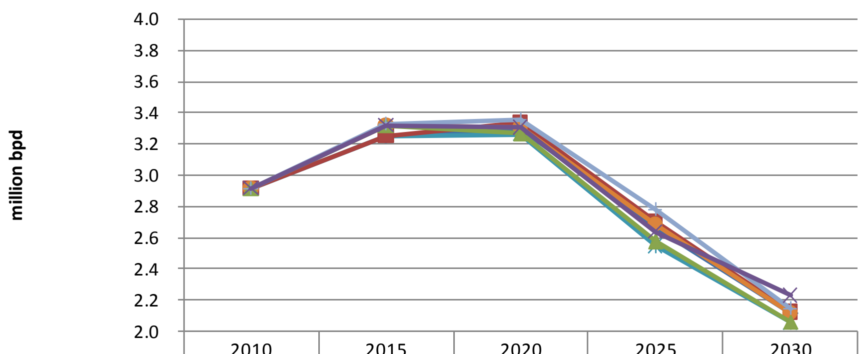


	2010	2015	2020	2025	2030
KXL	2.91	3.38	3.80	3.76	3.60
KXL+Gway	2.91	3.38	3.76	3.72	3.58
KXL No TMX	2.91	3.39	3.83	3.75	3.65
No KXL	2.91	3.39	3.83	3.77	3.60
No KXL Hi Asia	2.91	3.39	3.76	3.72	3.60
No Exp	2.91	3.44	3.85	3.83	3.45
NoExp+P2P3	2.91	3.39	3.83	3.79	3.71

Figure 5-29

Low Demand Outlook

US Product Gross Imports



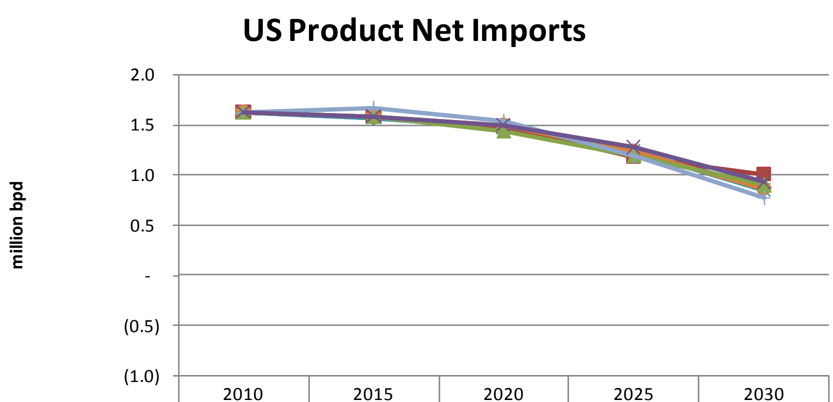
	2010	2015	2020	2025	2030
KXL	2.91	3.25	3.29	2.67	2.11
KXL+Gway	2.91	3.25	3.26	2.54	2.05
KXL No TMX	2.91	3.25	3.34	2.70	2.12
No KXL	2.91	3.31	3.30	2.68	2.11
No KXL Hi Asia	2.91	3.31	3.26	2.57	2.06
No Exp	2.91	3.32	3.35	2.78	2.14
NoExp+P2P3	2.91	3.31	3.30	2.63	2.22

Figure 5-30

Net product imports is the difference between gross product imports and gross product exports. With neither of these factors being sensitive to changes in the combination of pipelines available to carry WCSB crude oil, it is to be expected that net product imports would also be insensitive. As with the observations on the gross figures, U.S. net import level is sensitive to assumptions about U.S. domestic demand for oil. Figure 5-31 and Figure 5-32 present net product imports, the difference between the respective graphs for gross product imports and gross product exports. In all scenarios under the AEO outlook, the U.S. would remain a net product importer, whereas in all scenarios under the Low Demand outlook, the U.S. would become a net exporter in the 2020s.

The insensitivity of U.S. product imports and exports to WCSB pipeline scenario, demonstrates that the competitive position of U.S. refineries with respect to international markets for refined products is neither improved nor diminished by changes to the combination of pipelines available for WCSB export.

Reference Outlook

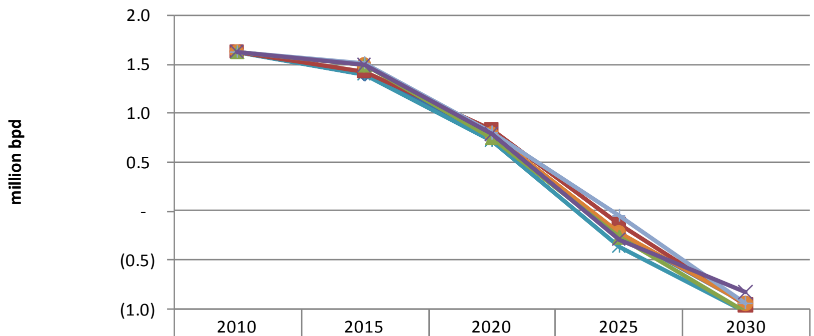


	2010	2015	2020	2025	2030
KXL	1.62	1.57	1.48	1.23	0.87
KXL+Gway	1.62	1.57	1.47	1.23	0.85
KXL No TMX	1.62	1.58	1.48	1.18	1.01
No KXL	1.62	1.58	1.49	1.23	0.85
No KXL Hi Asia	1.62	1.58	1.44	1.19	0.89
No Exp	1.62	1.66	1.53	1.18	0.76
NoExp+P2P3	1.62	1.58	1.49	1.27	0.92

Figure 5-31

Low Demand Outlook

US Product Net Imports



	2010	2015	2020	2025	2030
KXL	1.62	1.39	0.77	(0.24)	(0.95)
KXL+Gway	1.62	1.39	0.71	(0.37)	(1.04)
KXL No TMX	1.62	1.42	0.83	(0.14)	(0.96)
No KXL	1.62	1.48	0.78	(0.22)	(0.95)
No KXL Hi Asia	1.62	1.48	0.74	(0.28)	(1.03)
No Exp	1.62	1.50	0.79	(0.05)	(0.94)
NoExp+P2P3	1.62	1.48	0.78	(0.30)	(0.84)

Figure 5-32

5.2.2.6 U.S. Product Supply and Oil Import Costs

Within each demand outlook, AEO or Low Demand, U.S. total oil import costs are projected to be only slightly affected by pipeline scenario. Total crude oil import cost varies between the KXL No TMX and No KXL High Asia scenarios (which represent the maximum swing on WCSB volumes into the US) by at most 1.2%, (with No KXL High Asia having the higher cost), but then only post 2025 with lesser differences in earlier years. (The sources of the crude imports and thus associated wealth transfers would, however, vary substantially with pipeline scenario as discussed in Section 5.2.3.7.) When product imports cost are added in, to arrive at total U.S. oil import cost, the incremental cost associated with the High Asia scenario drops to at most 0.3% above the KXL No TMX scenario. Under the No Expansion scenario, total U.S. oil import costs are projected at 1.5% lower in 2030 than under other scenarios. The reduction is driven in part by increased discounts on WCSB crudes due to pipeline and thus production constraints but does not begin to be felt until 2020 and then increases, reaching the 1.5% level by 2030.

Similarly, within each demand outlook, U.S. total product supply costs[65] are insensitive to pipeline scenario, varying by less than 0.1% in any scenario where normal pipeline expansion is allowed. Under

[65] The term “supply costs” is commonly used to describe the costs of products that have been refined and delivered to major distribution centers. These costs are computed in WORLD for products at each regional center such as New York Harbor, product supply center for PADD1, Los Angeles, product supply center for PADD5, etc.

the No Expansion scenario, in 2030, reductions in crude prices stemming from shut in of WCSB heavy crudes lead to a reduction in U.S. product supply cost of 0.6% versus the 2030 KXL scenario.

5.2.2.7 WCSB Delivered Crude Prices

Pipeline scenario is projected to have small impacts on crude and product prices. The KXL pipeline would have the effect of adding short term capacity to move WCSB crudes to the U.S. Gulf Coast – and thereby also reduce pressure to absorb WCSB crudes in PADD2. Comparison of KXL versus No KXL WORLD model results reflects this. Under the KXL scenario, delivered prices for WCSB SCO and DilBit into PADD3 Gulf Coast are lower than under the No KXL case and those for PADD2, higher. The effect is limited, no more than around $0.70/bbl. It is more marked in the 2015-2020 period than in later horizons (reflecting the modeling results that the U.S. system would tend to add capacity over time if KXL were not built that would lead to crude routings similar to those that would obtain were KXL built). Small reductions in PADD3 product supply costs, of less than $0.10/bbl are evident in the KXL cases. (PADD2 product supply costs would, however, be higher and estimated net change in U.S. total product supply cost is projected to be minimal between the two scenarios.) Comparison of pairs of scenarios illustrates that level of WCSB capacity to the BC coast and thence Asia impacts delivered prices for WCSB crudes in the U.S.; broadly higher capacity to Asia moderately raises WCSB delivered prices and *vice versa*. Under the KXL No TMX scenario, projected PADD2 prices for DilBit are up to $0.60/bbl lower than those under the KXL scenario (which contains higher capacity to the BC coast in the form of the TMX 2 and 3 expansions). Under the KXL plus Gateway scenario, PADD2 DilBit prices are projected at up to $0.86/bbl above those under KXL. Under No KXL High Asia, PADD2 DilBit prices are up to $1/bbl higher than those under No KXL. Results for PADD3 delivered DilBit prices show directionally the same impacts but smaller.

5.2.2.8 U.S. Refining Margins

To examine how profit margins for refineries may be sensitive to assumptions about which combination of pipelines are available to carry WCSB crude,

Figure 5-33 and

Supply costs thus correspond to product spot prices at major centers within each region. Total U.S. product supply cost in WORLD is arrived at by multiplying supply cost in $/bbl for each product by demand for that product for each of the five PADDs and then summing to arrive at the U.S. total.

Figure 5-34 compare respectively 3-2-1 and 2-1-1 crack spreads[66] for U.S. Gulf Coast refineries for KXL, No KXL High Asia and No Expansion scenarios under both AEO and Low Demand outlooks. The differences between the projections for the KXL and the No KXL High Asia cases are small, i.e. refining crack spreads are projected to be only minimally affected by the extent to which WCSB crudes move to the USA versus to Asia. As previously explained, this is not surprising since, under the "business as usual" pipeline scenarios, industry is allowed to adapt and total supply and product demand are not altered. Therefore, the main effect is partial reallocation of WCSB crude between Asia and the USA, with attendant re-balancing in movement of Middle East and other crudes. The volume of WCSB crude being reallocated depending in the pipeline scenario would be at most 7% of the total U.S. crude run[67].

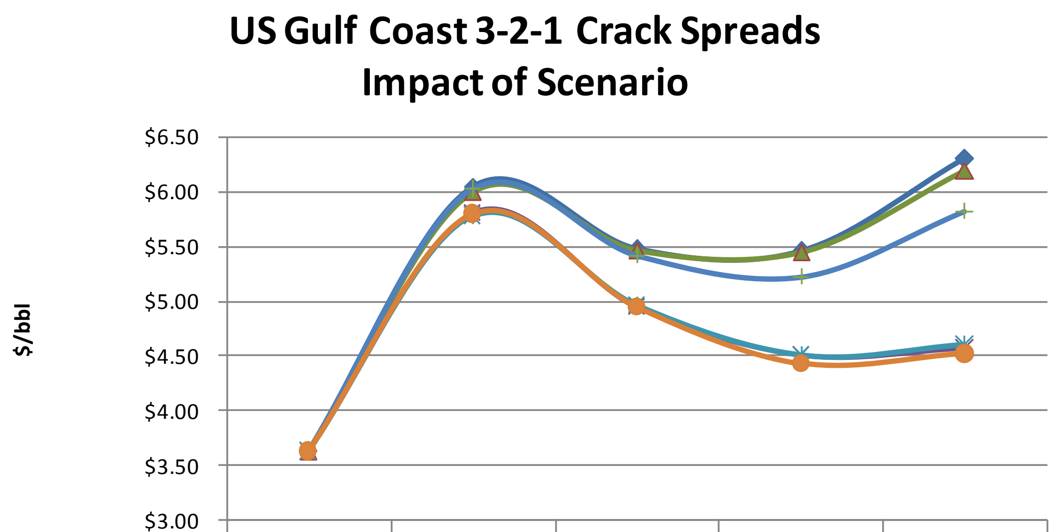
The No Expansion scenario, however, does adversely affect margins (by around 10 c/bbl) post 2020, notably under the AEO demand outlook. This stems from U.S. regions, particularly PADDs 2 and 3, having to accept non-optimal crude slates under the No Expansion scenario.

The projections do show that demand outlook is likely to have a primary impact on refining margins. Versus AEO, the Low Demand outlook cuts 3-2-1 (i.e. gasoline oriented) crack spreads by around $0.50/bbl by 2020, $1/bbl by 2025 and close to $1.75 by 2030 as competition intensifies for the remaining demand. The projected impact on evenly gasoline/distillate balanced 2-1-1 crack spreads is somewhat less: around $0.30/bbl by 2020, $0.60/bbl by 2025 and $1.20/bbl by 2030. This is because gasoline demand is more heavily cut back than distillate demand (diesel, jet fuel) in the Low Demand outlook. Even in the AEO outlook, gasoline oriented margins are projected to be appreciably lower than those (for refineries) oriented more toward distillate[68].

[66] "Crack spreads" are a commonly used set of fairly simple measures of refinery profitability. The 3-2-1 crack spread cited here refers to the difference or margin between the USGC value of 2 barrels of gasoline plus 1 of diesel minus the cost of 3 barrels of WTI crude. It is an approximate measure of the margin that could be expected in a cracking refinery which is heavily oriented to producing gasoline (as are most U.S. refineries). The 2-1-1 crack spread provides a comparison by presenting the margin for 1 barrel of gasoline plus 1 of diesel minus 2 of WTI, i.e. of a refinery oriented to more even yields of gasoline and distillate.

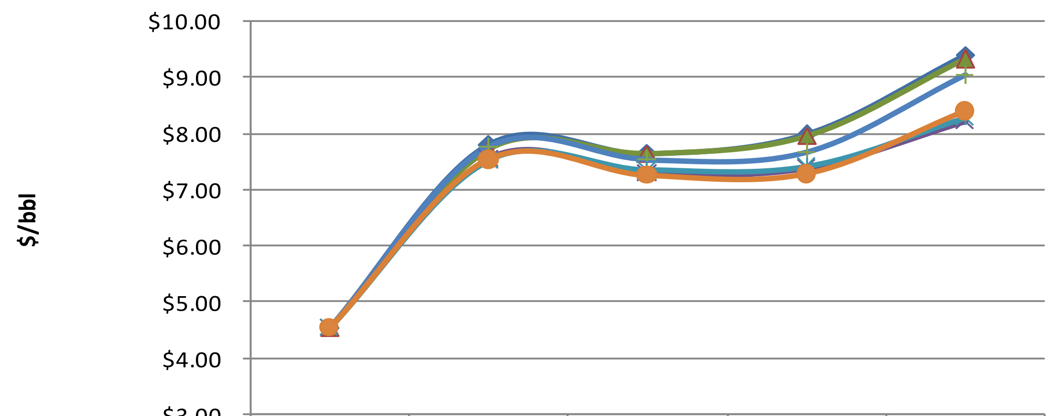
[67] Under the KXL No TMX and the No KXL High Asia cases, the difference in WCSB imports in 2030 is 1.0 mbd on a total U.S. crude run of 14 mbd.

[68] This reflects the relative U.S. and global gasoline/naptha surplus projected for the future in parallel with distillates representing the primary growth products.



	2010	2015	2020	2025	2030
AEO KXL	$3.63	$6.04	$5.47	$5.45	$6.30
AEO Hi Asia	$3.63	$5.99	$5.46	$5.44	$6.19
AEO No Exp	$3.63	$6.02	$5.42	$5.22	$5.81
Lo Dmd KXL	$3.63	$5.80	$4.95	$4.50	$4.56
Lo Dmd Hi Asia	$3.63	$5.78	$4.96	$4.51	$4.60
Lo Dmd No Exp	$3.63	$5.80	$4.94	$4.43	$4.51

Figure 5-33



	2010	2015	2020	2025	2030
AEO KXL	$4.56	$7.79	$7.63	$7.98	$9.41
AEO Hi Asia	$4.56	$7.72	$7.65	$7.97	$9.33
AEO No Exp	$4.56	$7.76	$7.54	$7.68	$9.04
Lo Dmd KXL	$4.56	$7.56	$7.30	$7.39	$8.23
Lo Dmd Hi Asia	$4.56	$7.52	$7.35	$7.41	$8.29
Lo Dmd No Exp	$4.56	$7.53	$7.26	$7.29	$8.40

Figure 5-34

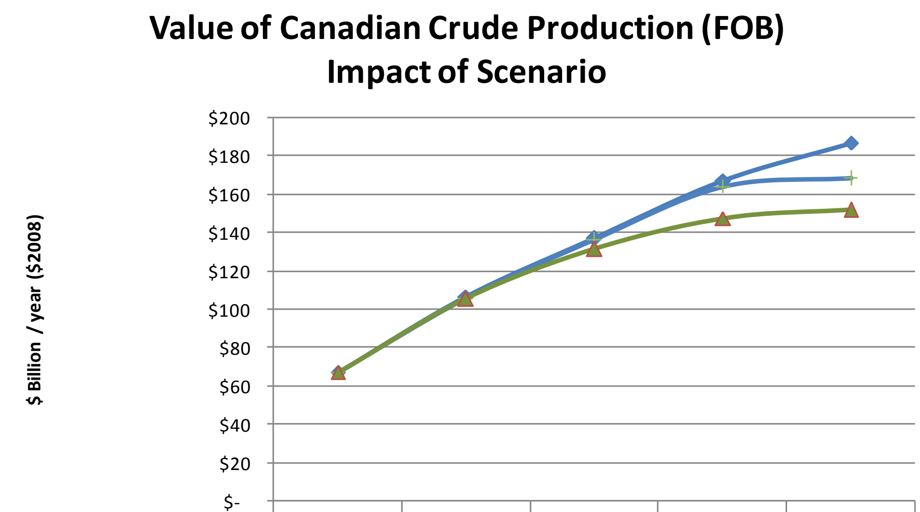
5.2.2.9 Crude Production Value

The value of US crude production is projected as little impacted across any scenario[69]. Similarly, the total value of WCSB production is projected to vary little based on whether WCSB production goes more to the USA or to Asia. However, the No Expansion scenarios lead to lower WCSB production and pricing discounts – and hence to an appreciable reduction in the value of WCSB crudes to Canadian producers. Around 2020, No Expansion would result in lower production volume and lower value of WCSB oil sands crudes. The lack of export pipeline expansion would start to shut in WCSB supply. A glut of heavy crude would develop in PADD2 as the only region with the pipeline capacity to accept WCSB crudes. In addition, PADD2 refiners would have to invest in additional equipment to process the WCSB heavy grades and this would be reflected back in the form of reduced WCSB heavy crude values. In this scenario, WCSB producer revenue would be 19% less in 2030 in the No Expansion scenario, compared to any of the KXL or No KXL scenarios, under the AEO demand outlook (Figure 5-35). (As stated above, the value of WCSB production is minimally impacted by pipeline scenario, i.e. KXL or No KXL and variants, other than in the No Expansion cases[70].) Under the Low Demand outlook (Figure 5-36), the difference between producer revenue in the No Expansion scenario compared to the KXL scenario would be 24%.

[69] The FOB value of total US crude oil production is projected to vary by less than 0.1% between pipeline scenarios that allow pipeline expansion. Under the No Expansion scenario, the 2030 value of US crude production is projected to be around 0.75% below that in the KXL scenario. US crude production was not altered under No Expansion but the value of US crude drops slightly due to competition with WCSB crudes whose prices are discounted because of production capacity being shut in.

[70] For that reason, only the KXL and the two No Expansion scenarios are shown in Figure 5-35 and Figure 5-36.

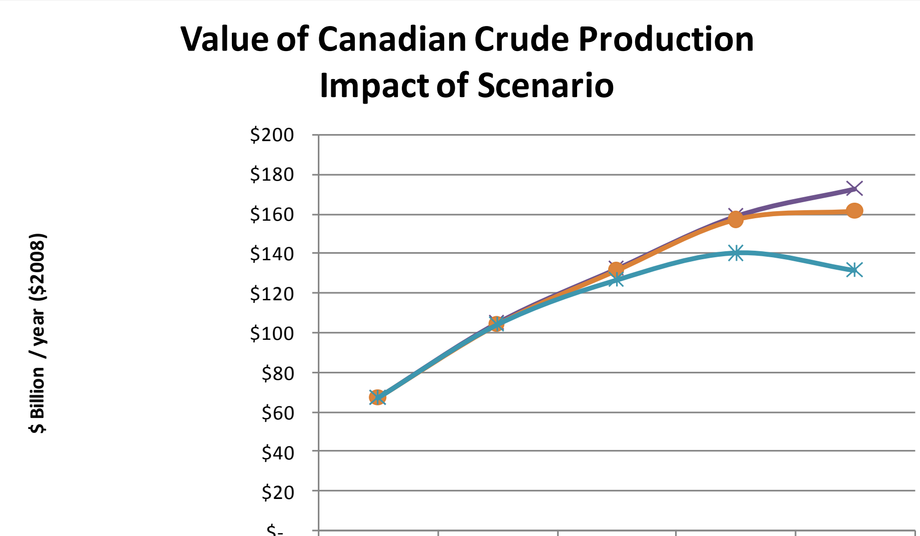
Reference Outlook



	2010	2015	2020	2025	2030
AEO KXL	$67	$107	$137	$167	$187
AEO No Exp + P23 TMX	$67	$106	$136	$164	$168
AEO No Exp	$67	$105	$131	$148	$152

Figure 5-35

Low Demand Outlook



	2010	2015	2020	2025	2030
Lo Dmd KXL	$67	$105	$132	$159	$172
Lo Dmd No Exp + P23 TMX	$67	$104	$132	$157	$161
Lo Dmd No Exp	$67	$104	$127	$140	$131

Figure 5-36

5.2.2.10 Global GHG Emissions

5.2.2.10.1 Refinery CO_2 Emissions

WORLD model results indicate changes in assumptions about pipeline availability have only minor impacts on U.S. and global refinery CO_2 emissions. (See Figure 5-37 and Figure 5-38.) The reason for this is that global and national demand for oil is not sensitive to the availability of pipelines to export crude oil from WCSB. Also, in the analysis, WCSB production volumes were not affected by changes in assumptions about pipelines for all scenarios except the No Expansion case. In all scenarios except No Expansion, the same products were required to be produced from the same crude oil and non-crudes feedstocks, i.e. on a global scale essentially the same extent of refinery processing needed to be undertaken. Under the No Expansion scenarios, WCSB oil sands production was impacted in the later horizons but global demand was not reduced and any “lost” WCSB oil sands (DilBit) were replaced by OPEC Middle East crude. The limited volumes of DilBit “lost” in the No Expansion cases and the limited crude quality differences (API, sulfur, yield) between “lost” WCSB DilBit and replacement Middle East sour grades were such as to lead to only a small impact on global refinery CO_2 emissions[71].

[71] In the WORLD model cases, Middle East sour crudes were taken to be the balancing grades for world crude oil supplies. (The widely accepted paradigm, as evidenced in reports and projections from the EIA, International Energy Agency, OPEC Secretariat and others, is that OPEC crude oils in general and – within those - Middle East OPEC crudes in particular comprise the crude oil supplies that balance up world oil supply so that it matches world oil demand. In the WORLD model, this role is reflected in that Middle East sour crude (generally Saudi Light) is taken to be the marginal or marker crude grade.) Thus, in the No Expansion cases, any loss in WCSB supply was replaced by Middle East sour grades. It is the authors’ view that production levels of Venezuelan, Mexican or other heavy crude grades would not alter based on whether or not WCSB oil sands production was constrained by pipeline limits. Mexican and Venezuelan production levels are being determined by other factors, including declining reserves.

Reference Outlook

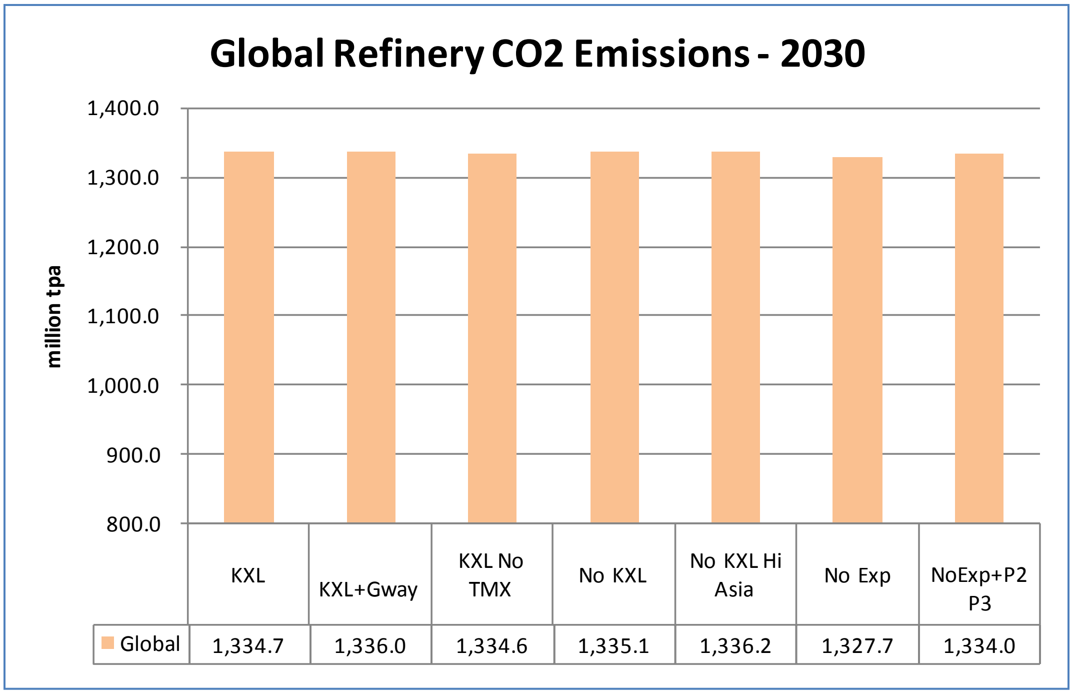


Figure 5-37

Low Demand Outlook

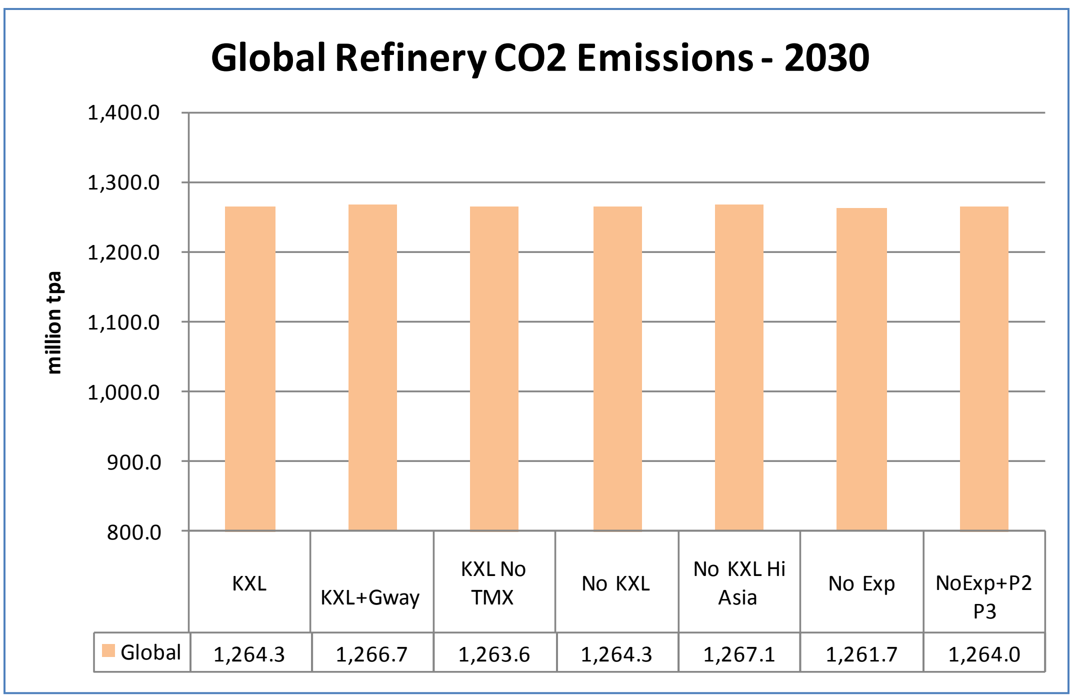


Figure 5-38

5.2.2.10.2 Life-cycle GHG Emissions

Evaluation of global life-cycle GHG emissions using the DOE ETP model leads to similar results.

As with refinery CO_2 emissions, the absolute level of global life-cycle GHG emissions is impacted by the demand outlook, but it is not very sensitive to changes in assumptions about available pipelines. The difference in 2030 global oil demand between AEO and Low Demand was 3.7 mbd out of 105.9 mbd, a reduction of 3.5%.

Annual global transportation GHG emissions would be approximately 11,000 million tons of CO_2e in 2030 under the AEO outlook and a little over 10,400 million tons of CO_2e under Low Demand, a reduction of just over 600 million tons of CO_2e. In contrast, the difference in emissions between pipeline scenarios in 2030 would be at most 26 +/- million tons of CO_2e, i.e. around 0.25% of GHG emissions from the global transportation sector[72]. (See Figure 5-39 through Figure 5-42. Additional detailed results are contained in the Appendix Section 4.)

[72] In the No Expansion scenario, 2030 global refinery CO_2 emissions were 7 million tons of CO_2e lower than under the KXL scenario, based on WORLD results; i.e. accounted for approximately 27% of the total life-cycle reduction of 26 million tons of CO_2e generated by the ETP model. Under all pipeline scenarios other than No Expansion, the variations in 2030 global refinery CO_2 emissions versus the KXL scenario were at most 1.6 million tons of CO_2e, or a little over 0.1% of the global level of refinery CO_2 emissions of around 1,335 million tons of CO_2e.

Reference Outlook

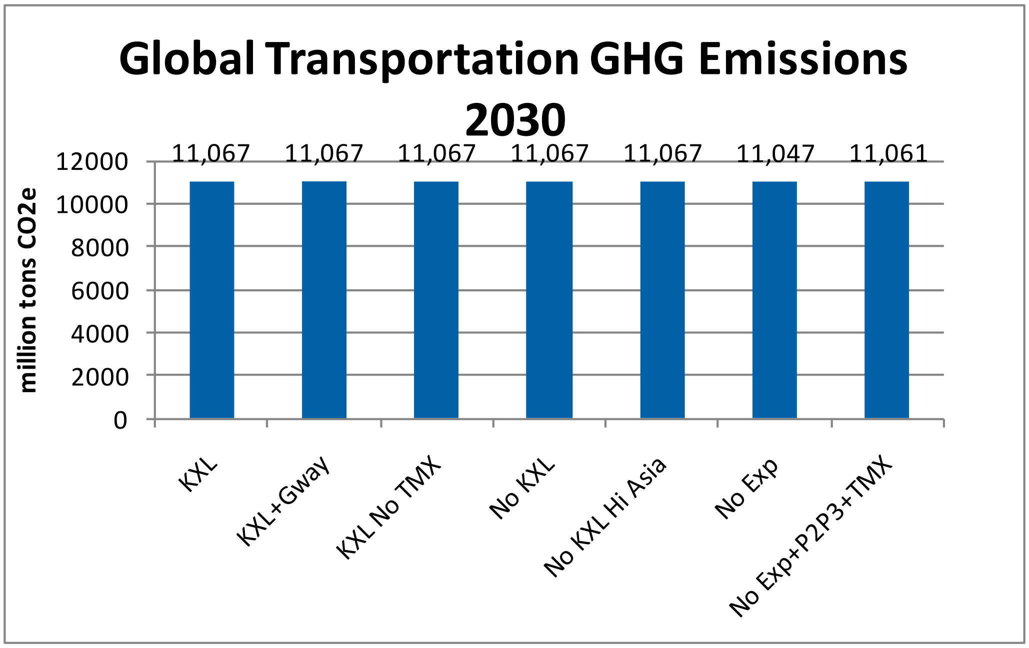


Figure 5-39

Low Demand Outlook

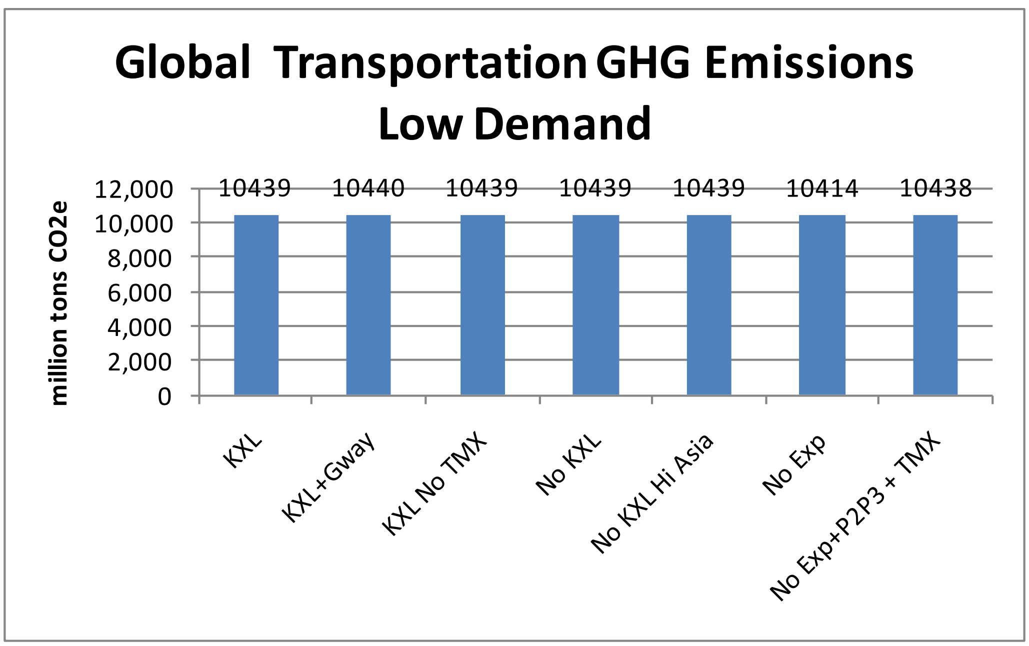
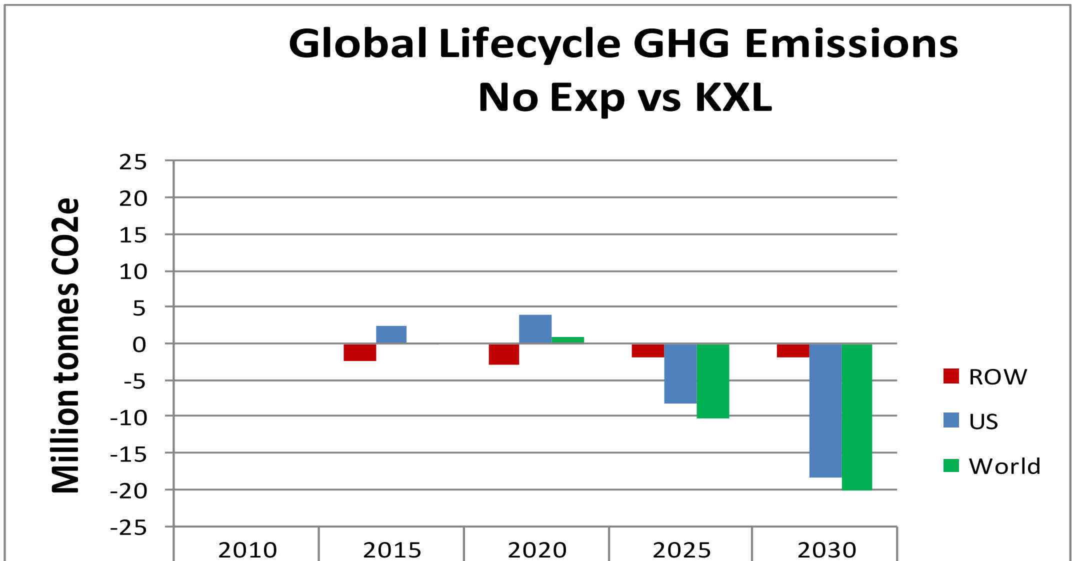


Figure 5-40

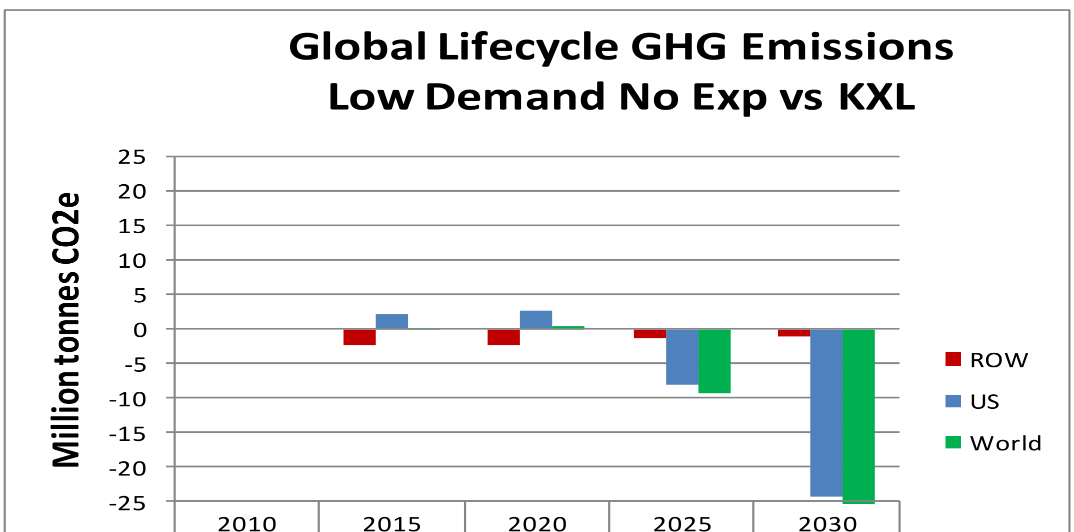
Reference Outlook



	2010	2015	2020	2025	2030
ROW	0.0	(2.5)	(2.9)	(1.9)	(1.8)
US	0.0	2.5	3.8	(8.3)	(18.4)
World	0.0	0.0	0.9	(10.2)	(20.2)

Figure 5-41

Low Demand Outlook



	2010	2015	2020	2025	2030
ROW	0.0	(2.2)	(2.3)	(1.4)	(1.1)
US	0.0	2.2	2.8	(7.9)	(24.3)
World	0.0	0.0	0.5	(9.3)	(25.4)

Figure 5-42

5.2.3 Major Scenario Impacts

In 2009, the USA imported 1.9 mbd of total Canadian crude oil supply. Of this, approximately 0.13 mbd was from eastern Canada and the rest, 1.77 mbd, from the Western Canadian Sedimentary Basin (WCSB). Of the WCSB imports, around 0.95 mbd, i.e. over half, was oil sands streams.

Figure 5-43 uses an annotated map to provide 2009 actual data for total Western Canadian crude oil flows including both conventional and oil sands streams. Figure 5-44 provides projections for Canadian oil sands flows for 2010 based on the WORLD 2010 case. Figure 5-45 through Figure 5-48 summarize key crude movements under the KXL and No KXL scenarios, by depicting WORLD model results showing projected WCSB oil sands streams flows for 2030. Additional figures, covering all the pipeline scenarios and both AEO and Low Demand outlooks are contained in Appendix Section 3. Circles and arrows on the figures highlight changes versus the AEO outlook 2030 KXL case (which includes the TMX 2 and 3 expansion projects).

Recalling the three dimensions of scenario comparison presented in Section 5.2.1, (time, pipeline scenario, demand outlook), Figure 5-43 and Figure 5-45 illustrate the first dimension – *how crude oil flows for a single scenario change over time* - here from 2009 to 2030[73]. The figures highlight relatively small changes for flows of WCSB oil sands streams into PADDs 1, 4 and 5 but significant potential for increases to PADD2, PADD3 and also to Asia via pipelines to the coast of British Columbia.

The pairs of figures, Figure 5-45/Figure 5-47 and Figure 5-46/Figure 5-48, use an annotated map to illustrate the second dimension of comparison – *how crude flows in a single time period under the same demand outlook can differ as a result of differences in assumptions about pipeline availability.* In each map:

> Canadian WCSB oil sands exports = WCSB oil sands Supply – Canadian oil sands Consumption
>
> Canadian WCSB oil sands exports = U.S. imports of WCSB oil sands crudes + Canadian WCSB oil sands exports from the West Coast
>
> U.S. imports of WCSB oil sands crude = PADD1 + PADD2 + PADD3 + PADD4 + PADD5 consumption
>
> Total U.S. oil imports = U.S. imports of WCSB oil sands crude + Total non-oil sands crude and product Imports.

Figure 5-45 and Figure 5-47 present the core "KXL" vs "No KXL" pipeline scenarios for the AEO 2010 demand outlook. Observations on the data for this pair (as well as the same pair under the Low Demand outlook) lead to the finding that results between the two are similar – that building or not building KXL *per se* has little impact on total U.S. imports of WCSB crudes over time, this because

[73] Because these changes are best observed in line graphs of time series data, many factors are presented in this report in that format. However, graphs like those featured in the previous section do not illustrate well the insights available when observing data about geographic crude oil flows.

sufficient alternative pipeline capacity is projected to be deliverable over time to lead to similar WCSB pipeline flows.

Figure 5-45 and Figure 5-46 (as well as Figure 5-47 and Figure 5-48) illustrate the third dimension of comparison – *how crude oil flows for a single set of pipeline availability assumptions are affected by different assumptions about future oil demand (AEO 2010 vs Low Demand).* Here, the results indicate that Low versus AEO demand would have little impact on WCSB import levels into the U.S. (other factors being equal) but would substantially cut U.S. Middle East and total oil imports. Appendix Section 3 provides a full set of these 2030 results covering all scenarios.

The following subsections discuss differences along all three dimensions, (time, pipeline scenario, demand outlook), with focus on those parameters where major impacts are evident. The purpose of each subsection is to highlight results relevant to the key study questions presented in Section 2.2.

Western Canadian Crude Oil
Supply and Consumption 2009

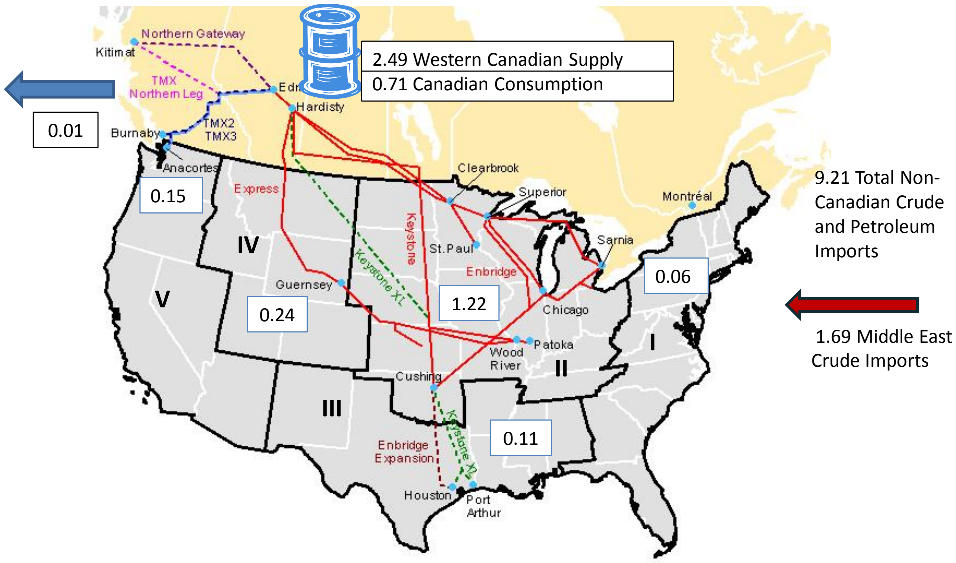
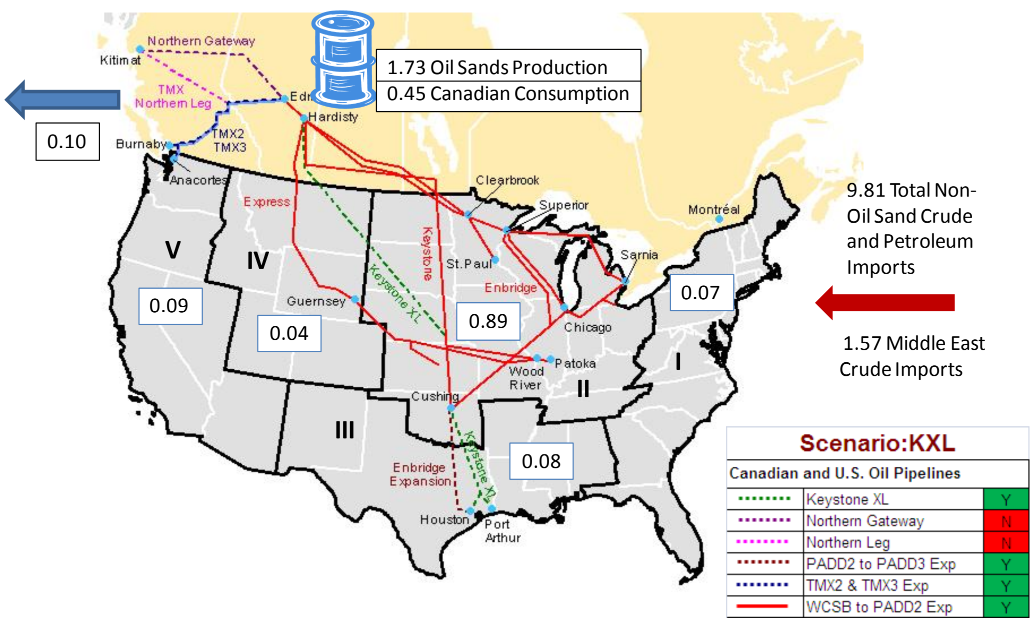


Figure 5-43

Western Canadian Oil Sands
Supply and Consumption 2010



Source: EnSys Analysis for 2010. All units in millions of barrels per day.

Figure 5-44

Reference Outlook

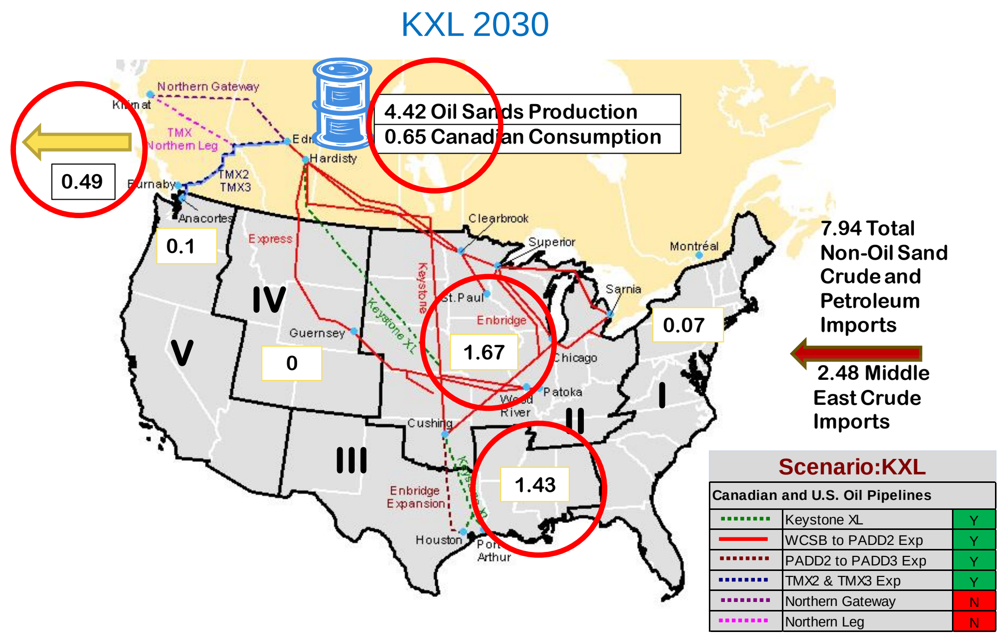


Figure 5-45

Low Demand Outlook

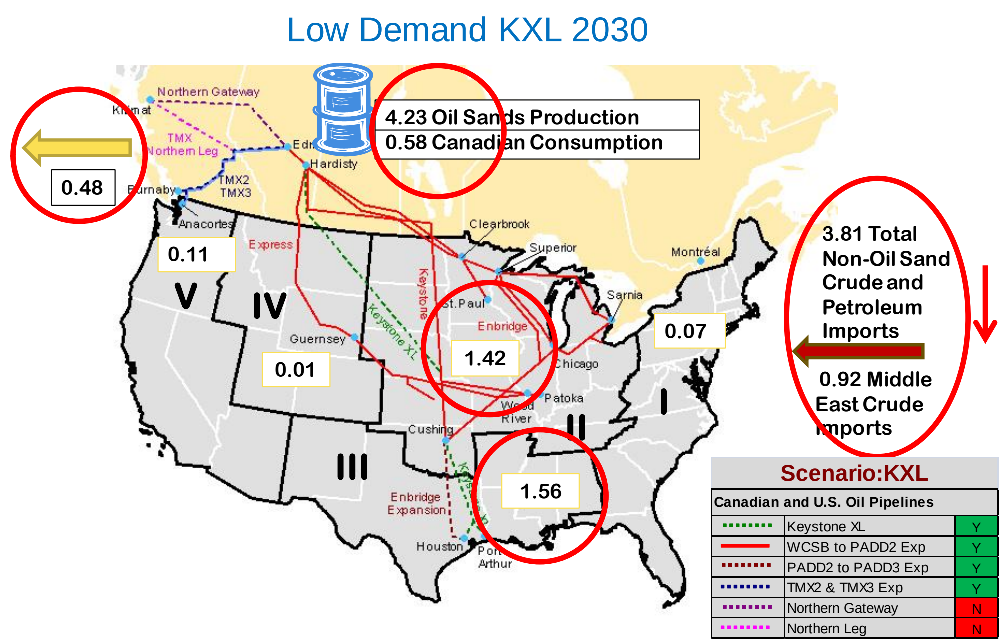


Figure 5-46

Reference Outlook

No KXL 2030

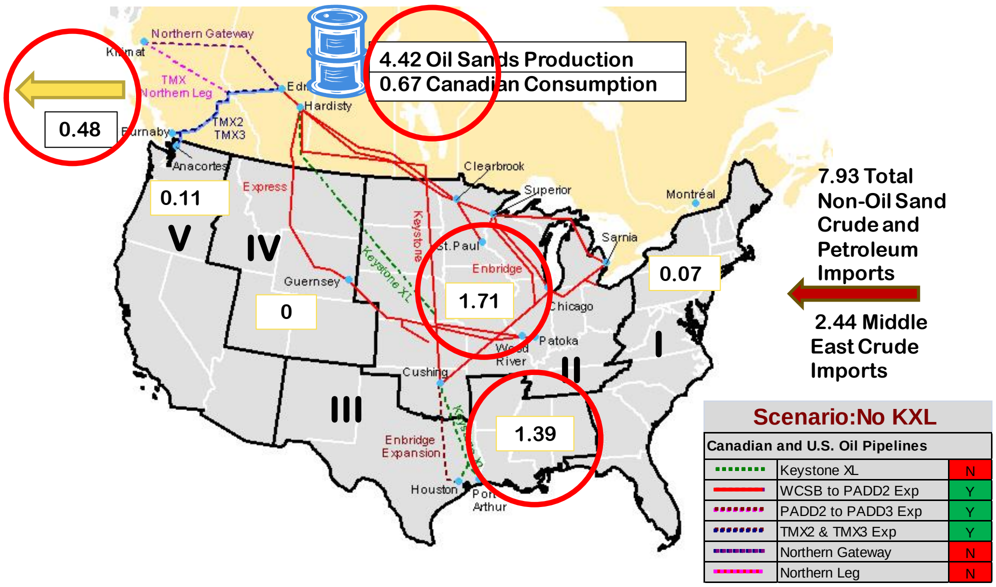


Figure 5-47

Low Demand Outlook

Low Demand No KXL 2030

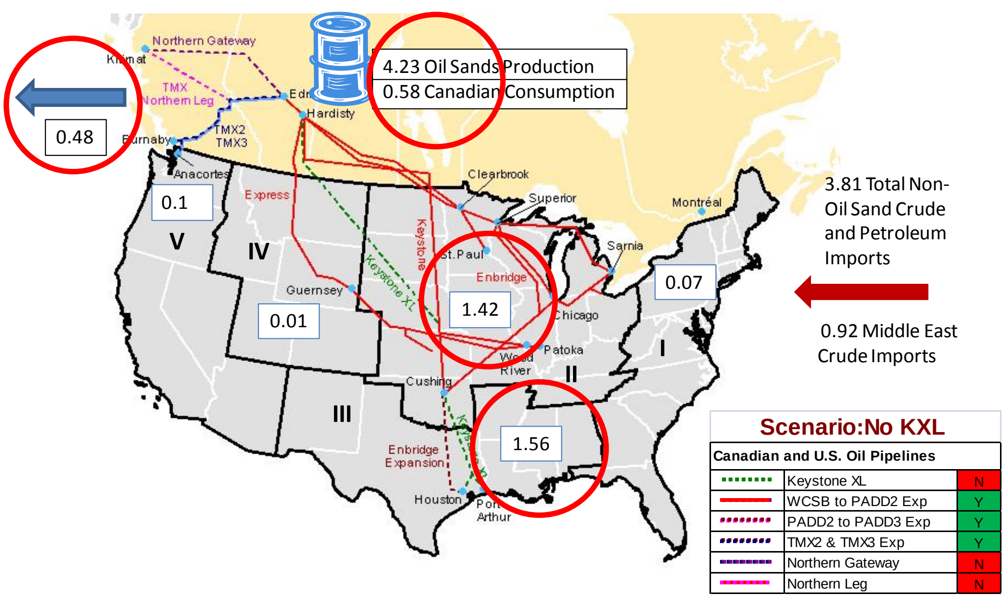


Figure 5-48

5.2.3.1 Canadian Imports Growth

All pipeline scenario results indicate a clear potential for a sustained increase in U.S. imports of Canadian crudes. (See Figures 5-49 and 5-50[74] [75].) This observation holds under both the AEO 2010 demand outlook and the Low Demand outlook. For all scenarios, the proportion of WCSB oil sands streams in U.S. WCSB crude oil imports is projected to steadily increase, from somewhat over 50% in 2009 to around 90% by 2030.

Under the KXL case, (which also allows for 400,000 bpd of expansion in the Transmountain line to Vancouver and Asia), total Canadian crude oil imports to the USA are projected to grow from 1.9 mbd in 2009 to 2.7 mbd by 2020 and 3.6 mbd by 2030[76]. The results for the No KXL case are almost identical[77].

Sections below further discuss the impacts of KXL versus No KXL, of assumed WCSB capacity to Asia, of No Expansion of pipelines and of Low Demand on U.S. crude oil imports and WCSB crude oil export destinations and production level.

---

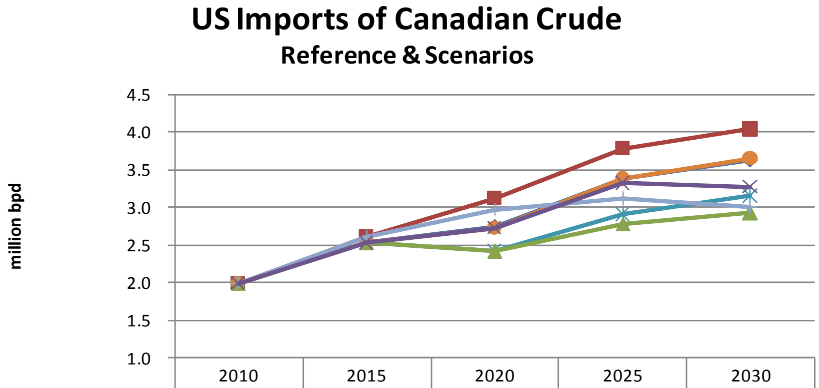
[74] The pipeline scenario reference "No Exp +P2P3" in fact denotes No Expansion except for allowed expansion of pipelines from PADD2 to PADD3 plus Transmountain TMX 2 and 3 expansions assumed in operation by 2020.

[75] These figures show projected volumes of imported WCSB crudes processed in U.S. refineries. In addition, WCSB crudes destined for the Sarnia area will also cross into the U.S. before later exiting to eastern Canada. Total cross-border movements into the USA will therefore be higher than the volumes refined in the U.S. Volumes of WCSB crude processed in Sarnia area refineries are projected at approximately 200,000 bpd. This figure should be added to arrive at total cross-border WCSB crude flows into the U.S.

[76] Total Canadian crude oil imports include a little over 0.1 mbd of eastern Canadian. The rest is all from WCSB.

[77] The plot line for the KXL case cannot be readily seen in Figures 5-48 and 5-49 because it is directly beneath the No KXL plot line.

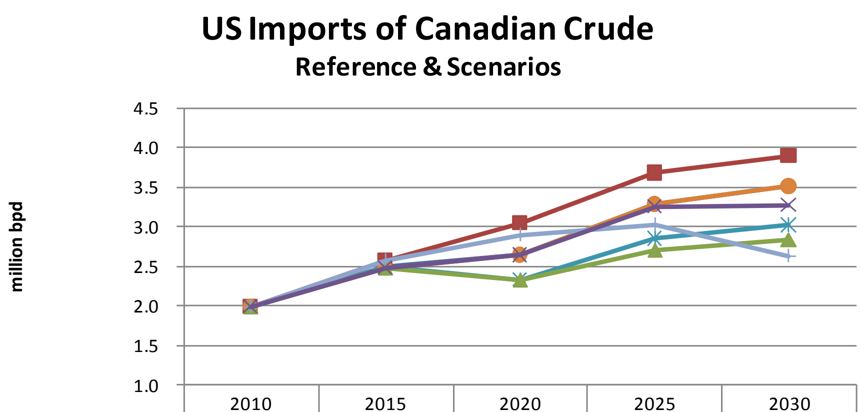
Reference Outlook



	2010	2015	2020	2025	2030
KXL	1.98	2.53	2.73	3.37	3.63
KXL+Gway	1.98	2.53	2.41	2.90	3.15
KXL No TMX	1.98	2.61	3.13	3.78	4.04
No KXL	1.98	2.52	2.73	3.37	3.64
No KXL Hi Asia	1.98	2.52	2.41	2.78	2.92
No Exp	1.98	2.61	2.97	3.11	3.00
NoExp+P2P3	1.98	2.52	2.73	3.32	3.27

Figure 5-49

Low Demand Outlook



	2010	2015	2020	2025	2030
KXL	1.98	2.49	2.65	3.28	3.50
KXL+Gway	1.98	2.49	2.33	2.84	3.01
KXL No TMX	1.98	2.57	3.04	3.68	3.90
No KXL	1.98	2.48	2.64	3.28	3.50
No KXL Hi Asia	1.98	2.48	2.33	2.71	2.84
No Exp	1.98	2.56	2.89	3.02	2.62
NoExp+P2P3	1.98	2.48	2.64	3.25	3.27

Figure 5-50

5.2.3.2 *Effect of Low U.S. Demand*

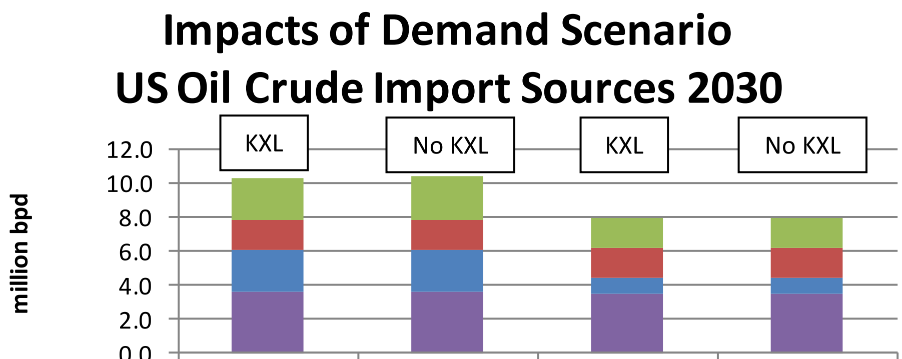
Significant reduction in U.S. demand for refined products, explored by shifting the assumed demand outlook from AEO 2010 to Low Demand (see Section 4.3.1),would have little impact on U.S. imports of Canadian crudes. The Low Demand outlook contained 2030 WCSB production 0.2 mbd below that under the AEO outlook. This generally led in the WORLD analyses to approximately 0.07 mbd less WCSB crude being processed within Canada and 0.13 mbd less in the USA than under the AEO 2010 demand outlook [78]. This result can be attributed to the limited options for Canadian exports. The WCSB export system is largely land-locked, and western and eastern Canada have little potential to absorb additional volumes. Therefore, WCSB streams must move to the U.S. unless additional pipeline capacity is made available to the BC coast and thus Asian markets.

Because U.S. demand for refined products would be essentially insensitive to U.S. domestic production and Canadian imports of crude oil, the primary effect of lower U.S. demand would be a direct reduction in U.S. dependency on imports from countries *other* than Canada. The Low Demand outlook assumes a 4.0 mbd reduction in U.S. demand by 2030, relative to the AEO outlook, which translates into essentially the same reduction in U.S. petroleum imports[79]. Figure 5-51 shows the make-up of total crude oil imports into the USA for 2030 under AEO and Low Demand outlooks for KXL and No KXL pipeline scenarios.

First these model results demonstrate the insensitivity of U.S. crude oil imports to whether or not KXL is built. There are only minimal differences between the KXL and No KXL cases for each demand outlook. Second, the results project total U.S. crude oil imports drop from close to 10.4 mbd under the AEO outlook to 7.9 mbd under Low Demand, a reduction of 2.5 mbd. The remaining 1.5 mbd of the 4.0 mbd demand reduction under the Low Demand outlook comes from declines in net product imports. Third, of the total reduction in crude oil imports of 2.5 mbd, approximately 1.5 mbd would come out of imports from the Middle East and 0.75 mbd from other regions.

[78] In the No Expansion scenario, lower U.S. demand (compared to the No Expansion scenario under AEO 2010) would reduce WCSB oil sands movements into the U.S. by over 0.3 mbd in 2030 with an attendant reduction in WCSB production. However, in all other scenarios, ranging from KXL to No Expansion + PADD2 to 3 + TMX, the impact of Low Demand is to cut WCSB oil sands movements into the U.S. by generally around 0.13 mbd by 2030, by less at earlier horizons.

[79] U.S. domestic supplies of crude oils and biofuels are approximately the same under Low Demand versus AEO.



	AEO	AEO	LowD	LowD
Other	2.55	2.53	1.76	1.76
Africa	1.70	1.77	1.73	1.73
Middle East	2.46	2.42	0.93	0.93
Canada	3.63	3.64	3.50	3.50

Figure 5-51

5.2.3.3 Effect of No Pipeline Expansion on Canadian Production and U.S. Processing

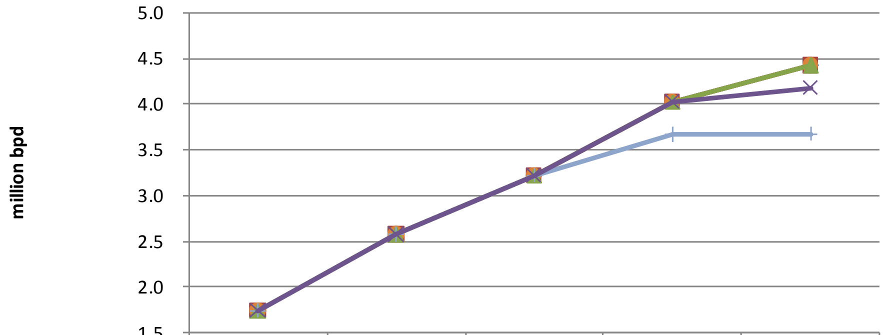
Under every scenario where pipeline expansion is not restricted, WCSB crude supply is projected to be maintained at the levels projected in 2010 by the Canadian Association of Petroleum Producers. Figure 5-52 and Figure 5-53 indicate that current pipeline capacity would be sufficient to deliver projected WCSB production to market at least until 2020 even with no expansion.

WCSB crude production would only be curtailed in the No Expansion scenario, and only after 2020. The No Expansion scenario would not allow any pipeline expansion at all over and above current installed capacity (i.e. Keystone Mainline and Cushing Extension included, KXL excluded).

A No Expansion scenario would have significant impacts on the disposition of WCSB crudes. Outlets to Asia and to PADD3 would be limited to their current levels of around 100,000 bpd each. Existing pipeline capacities would be utilized to the maximum. This would mean, especially, maximizing WCSB volumes processed in PADD2 and eastern Canada to fully utilize available pipeline capacity from WCSB to PADD2 and also onward from PADD2 to the Sarnia area. WCSB crudes would be sold at discounts that would not apply in normal market conditions. Figure 5-54 illustrates the sharp differences in WCSB crude dispositions between the KXL and No Expansion cases under both AEO and Low Demand outlooks.

Reference Outlook

Total Canadian Oil Sands Production

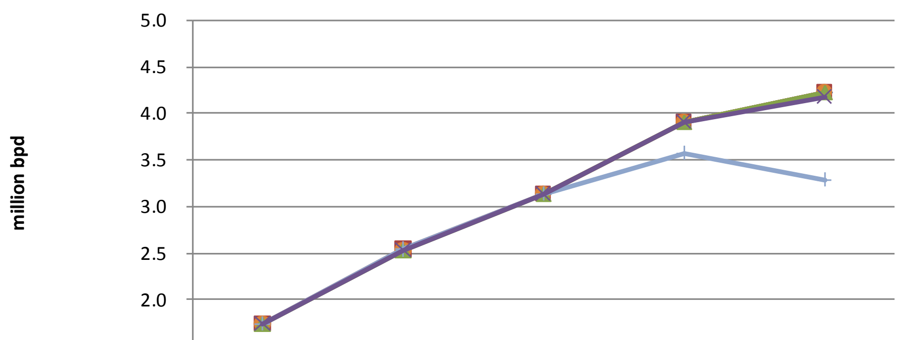


	2010	2015	2020	2025	2030
KXL	1.7	2.6	3.2	4.0	4.4
KXL+Gway	1.7	2.6	3.2	4.0	4.4
KXL No TMX	1.7	2.6	3.2	4.0	4.4
No KXL	1.7	2.6	3.2	4.0	4.4
No KXL Hi Asia	1.7	2.6	3.2	4.0	4.4
No Exp	1.7	2.6	3.2	3.7	3.7
NoExp+P2P3	1.7	2.6	3.2	4.0	4.2

Figure 5-52

Low Demand Outlook

Total Canadian Oil Sands Production



	2010	2015	2020	2025	2030
KXL	1.7	2.5	3.1	3.9	4.2
KXL+Gway	1.7	2.5	3.1	3.9	4.2
KXL No TMX	1.7	2.5	3.1	3.9	4.2
No KXL	1.7	2.5	3.1	3.9	4.2
No KXL Hi Asia	1.7	2.5	3.1	3.9	4.2
No Exp	1.7	2.5	3.1	3.6	3.3
NoExp+P2P3	1.7	2.5	3.1	3.9	4.2

Figure 5-53

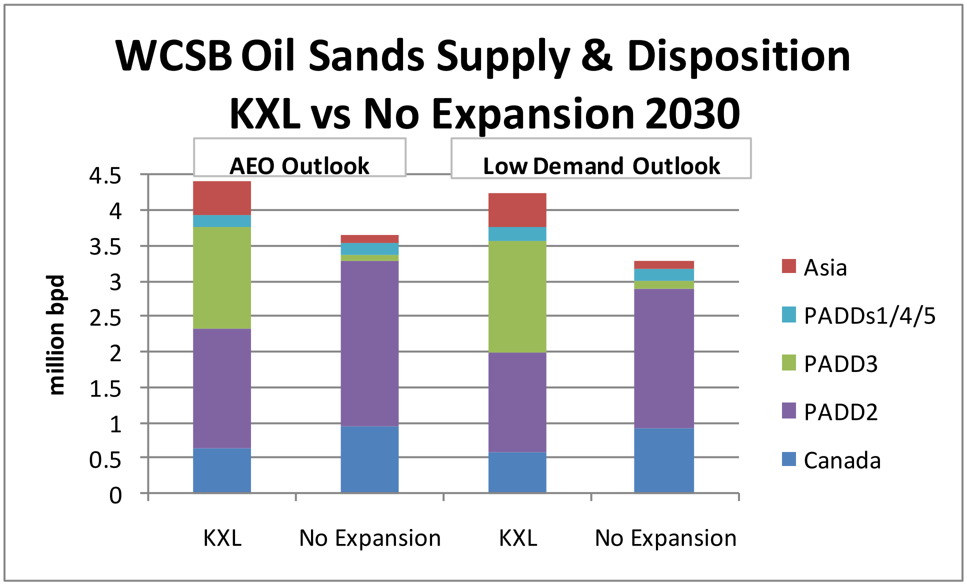


Figure 5-54

All scenarios in this study implicitly assume no expansion of WCSB crude oil movements by non-pipeline transport modes within Canada and the USA. Although not evaluated within this study, rail could offer producers a competitive alternative if pipeline capacity were to be so constrained that the discounted price for WCSB in PADD2 would accommodate the more expensive rail tariffs[80].

As discussed in Section 4.4.3, the No Expansion scenario explores extreme market conditions based on input assumptions that would have a relatively low probability of occurring. The potential for producers to avoid curtailment by using other proven transport modes, that would become more cost-effective for delivery of WCSB crude under a scenario where there was no pipeline expansion, renders the No Expansion scenario still less probable.

5.2.3.4 Effect of No KXL on U.S. Imports of WCSB Crude

The volume of WCSB crude imported by the U.S. would be unaffected by the availability of the KXL pipeline. In Figures 5-49 and 5-50, the line plots of Canadian imports of crude oil to the U.S. are almost identical for the KXL and No KXL cases. The results illustrated in Figure 5-45 and Figure 5-47 (as well as

[80] Rail movements of crude oils (and also products and streams such as ethanol) are commonplace where there is no available pipeline route. As outlined in Section 3.2.3, CN Rail / Altex is promoting its PipelineOnRail system for moving WCSB crudes and is already transporting diluent from Kitimat to Edmonton. In addition, rail linked in to barge (or tanker) could also play a role in the transport market. Small volumes of WCSB crudes are currently arriving in the Gulf Coast in part via barge.

Figure 5-46 and Figure 5-48) also show the similar 2030 results for these scenarios[81]. A key underlying reason is the premise that – if KXL were not built – other pipeline projects would likely go ahead. As discussed in Section 3.2.3, several potential projects are already visible for WCSB to PADD2 cross-border and PADD2 to PADD3 capacity.

5.2.3.5 Effect of British Columbia Expansion Projects on U.S. Imports of WCSB Crude

WCSB volumes into the USA could be materially impacted depending on the extent to which pipeline capacity is added to move WCSB crudes to ports in British Columbia, with resulting access via tanker to Asia and beyond.

Given the finding that building versus not building KXL would not of itself have significant impact on WCSB imports to the U.S., it is possible to use a combination of four scenarios to examine the effect of progressively greater levels of capacity for WCSB crudes to be taken west. Three KXL variants present BC capacity expansions ranging from none (KXL+No TMX 2,3 or other projects) to TMX 2,3 (KXL case includes TMX 2,3) to TMX 2,3 plus Northern Gateway (KXL+Gateway). The No KXL High Asia scenario, adds a fourth, and highest, level of capacity examined. In No KXL High Asia, TMX 2,3 (400,000 bpd total) is assumed on stream by 2020, Northern Gateway (525,000 bpd) by 2025 and Transmountain Northern Leg (400,000 bpd) by 2030, an incremental total capacity of 1.325 mbd.

Results from these four scenarios for 2030 are summarized in Figure 5-55. These are for the AEO outlook. Results under the Low Demand outlook are similar. WORLD results indicate that, if and as pipeline projects to the BC coast were to be implemented, they would likely to be filled, with major implications for WCSB volumes flowing into the USA.

[81] This finding is also consistent with the comparison of the KXL+Gateway scenario with the No KXL High Asia scenario. Although KXL would be available in one scenario and not in the other, the small differences in the crude oil flows observed could be better explained by the addition of the Northern Leg to the No KXL High Asia case, which would not available in KXL+Gateway.

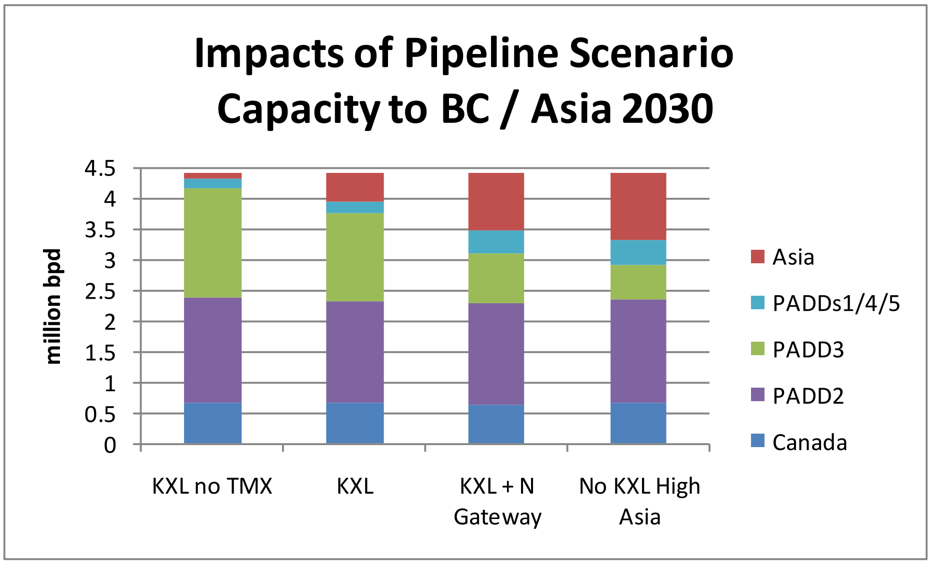


Figure 5-55

The KXL No TMX (2,3) scenario assumes no further expansion west is developed during the period to 2030. In the short term, this scenario represents what is closest to the current situation. Plans for TMX 2 and 3, Northern Leg and Northern Gateway have all been put forward but, as discussed in Section 3.2.3.1, none has reached a definitive stage yet, or is as advanced as KXL.

As capacity west is progressively raised, model results indicate that capacity would be fully utilized. Moderate increases occur to PADD5 Washington state refineries[82]. Beyond these, all volumes pipelined west go to Asia. Thus, under the No KXL High Asia scenario, the 1.325 mbd of available 2030 pipeline capacity is used to ship approximately 0.2 mbd to Washington refineries and 1.1 mbd to Asia. Again, as discussed in Section 3.2.3.1, a recent study has estimated that refineries in four north Asian countries, (China, Japan, South Korea, Taiwan), could today process up to 1.75 mbd of Western Canadian (mainly heavy) crudes[83]. An implication is that an earlier development of pipelines west than was considered here could lead to higher volumes moving to Asia, and sooner, than projected under the scenarios examined.

A lack of expansion west leads to maximum volumes of WCSB crudes coming into the U.S. over time and particularly into PADD3 – and *vice versa*. In other words, WORLD results and third party work illustrate both the potential interplay, or competition, between the USA and Asia for WCSB crudes and indicate this interplay would occur primarily between refineries in (north) Asia and PADD3.

[82] In this study, it was assumed that California Law AB32 would make it unattractive to run WCSB oil sands crudes in that state. If AB32 were not in place, refineries in California would represent a logical market for WCSB crudes, replacing declining volumes of Alaskan ANS and displacing what have been growing volumes of Middle Eastern crude oil imports.

[83] Market Prospects and Benefits Analysis for the Northern Gateway Project, Muse Stancil, January 2010.

5.2.3.6 *Effect of Pipeline Availability on U.S. Non-Canadian Crude Oil Imports*

Strongly evident from WORLD results is the interplay and inverse relationship between WCSB and non-Canadian foreign crude imports into the USA independent of KXL availability. As illustrated in Figures 5-56 and 5-57, WCSB oil sands imports into the USA are projected to be significantly affected by pipeline scenario, varying by up to 0.6 mbd by 2020 and over 1 mbd by 2030. Within this, the variability is projected to be primarily in the DilBit blends, more so than fully upgraded synthetic crude oil. Again, these volumes and variability are little impacted by U.S. product demand level.

Conversely, imports from non-Canadian sources into the USA, depend on both the pipeline scenario and the U.S. demand level - with two specific exceptions. Since Western Canada, Mexico and Venezuela are all major producers of heavy crudes and are all three major exporters of same into the USA, one could, *a priori*, expect that lower WCSB imports into the U.S. would lead to higher imports from Mexico and/or Venezuela and *vice versa*. This is not, however, projected to be the case. Crude oil imports into the USA from Mexico and Venezuela have been the subject of a steady decline in recent years. According to EIA statistics[84], crude oil imports from Venezuela have dropped from 1.3 mbd in 2004 to 0.95 mbd in 2009 and those from Mexico from 1.6 mbd in 2004 to 1.09 mbd in 2009, in total a decline from 2.9 mbd in 2004 to 2.14 mbd in 2009.

Mexico is suffering from rapid production declines, especially of its key heavy Mayan crude, much of which is purchased by refineries on the Gulf Coast. A continuing decline in Mexican production, led by Mayan, is widely expected by industry analysts[85]. Further, PEMEX has a project under way to upgrade one of its refineries (Minatitlan) so that it can process Mayan crude, thereby taking yet more Mayan volumes off export markets. The net effect is that imports to the USA of Mayan crude are projected in the WORLD cases to drop sharply by 2020.

In Venezuela, production of conventional crudes has been flat to declining. Production and upgrading of the massive extra heavy Orinoco oil reserves has been relatively static. Although volumes of Venezuelan production and exports are expected to gradually increase over time, EnSys took the view that inter-company deals and geopolitical interests would lead to a continuation of the trend of moving

[84] http://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_epc0_im0_mbblpd_a.htm.

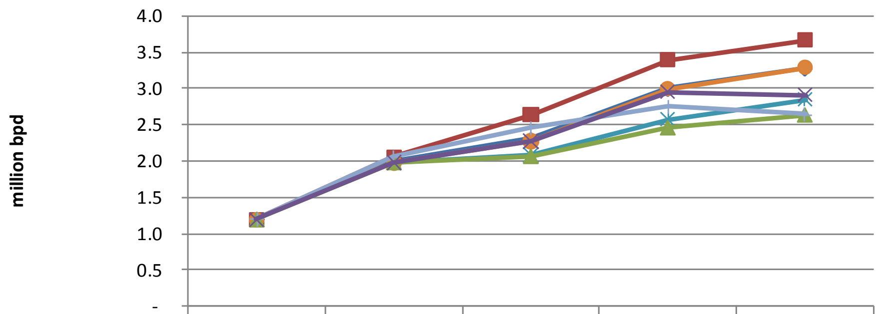
[85] A law was signed by President Calderon in Mexico that would allow foreign companies to participate in Mexican crude oil production. PEMEX' June 2010 business plan, http://www.pemex.com/files/content/business_plan_100712.pdf, page 39, projects crude oil production recovering from under 2.6 mbd in 2010 to 3.3 mbd by 2024. However, this projection is considered optimistic. For this study, EnSys used the projection for Mexican crude oil production in the EIA 2010 *International Energy Outlook*. The IEO projection, which we believe is broadly in line with other current projections, has the decline rate for total Mexican crude production slowing from over 7% p.a. 2007 through 2009 to under 4% p.a. average for 2010 through 2030. The decline rate for heavy Mexican crude is projected at over 6% p.a. average, (versus 12.2% p.a. average 2007 – 2009), thus both the volume and the proportion of heavy (Mayan type) crude decline progressively over time. The slowing of the projected decline rates versus recent history arguably is a reflection of assumed benefits arising from increased foreign participation in Mexico's production.

crudes to markets outside the USA, notably Asia, thereby removing potential for any significant upward reversal in exports to the U.S.

Consequently, combined U.S. import volumes of Mexican plus Venezuelan crudes are projected in all scenarios to drop from around 2 mbd today to around 0.9 mbd in 2020 and slightly less beyond 2020, as illustrated in Figure 5-58 and Figure 5-59. This development is only minimally affected by availability of pipelines delivering imported WCSB crude oil.

Reference Outlook

Canadian Oil Sands - Total - Refined in USA

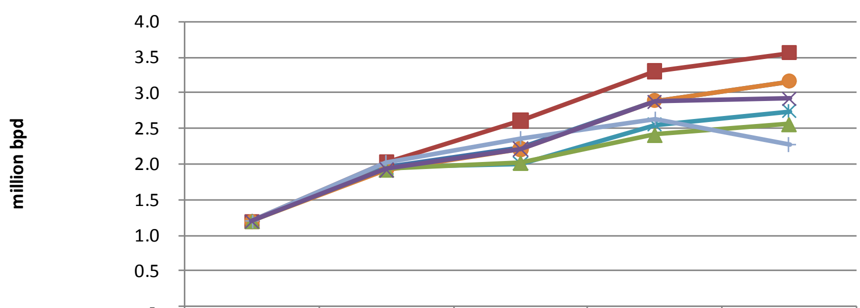


	2010	2015	2020	2025	2030
KXL	1.18	1.98	2.29	2.99	3.27
KXL+Gway	1.18	1.98	2.08	2.57	2.84
KXL No TMX	1.18	2.04	2.63	3.39	3.66
No KXL	1.18	1.97	2.26	2.99	3.28
No KXL Hi Asia	1.18	1.97	2.05	2.45	2.62
No Exp	1.18	2.06	2.46	2.74	2.64
NoExp+P2P3	1.18	1.97	2.26	2.94	2.89

Figure 5-57

Low Demand Outlook

Canadian Oil Sands - Total - Refined in USA

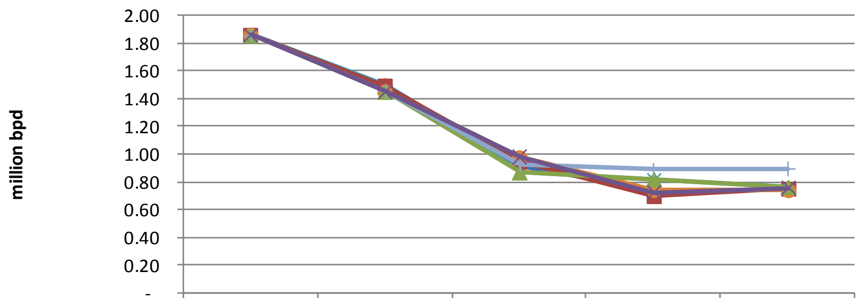


	2010	2015	2020	2025	2030
KXL	1.18	1.95	2.23	2.89	3.16
KXL+Gway	1.18	1.95	2.00	2.55	2.73
KXL No TMX	1.18	2.02	2.60	3.29	3.55
No KXL	1.18	1.91	2.20	2.89	3.16
No KXL Hi Asia	1.18	1.91	2.01	2.40	2.55
No Exp	1.18	2.01	2.35	2.62	2.26
NoExp+P2P3	1.18	1.91	2.20	2.87	2.91

Figure 5-56

Reference Outlook

US Crude Imports from Mexico & Venezuela

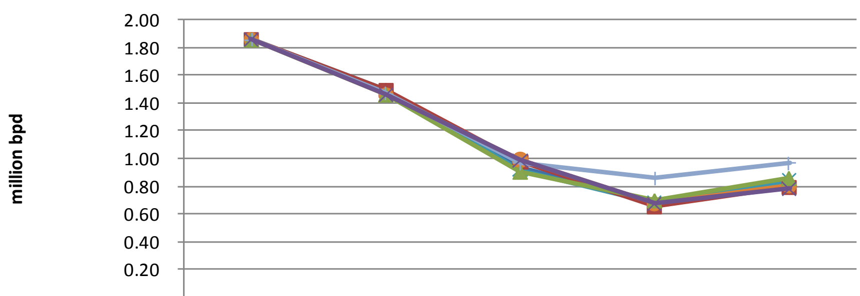


	2010	2015	2020	2025	2030
KXL	1.86	1.50	0.91	0.74	0.74
KXL+Gway	1.86	1.50	0.87	0.81	0.76
KXL No TMX	1.86	1.49	0.94	0.70	0.75
No KXL	1.86	1.45	0.98	0.74	0.74
No KXL Hi Asia	1.86	1.45	0.87	0.82	0.76
No Exp	1.86	1.45	0.93	0.89	0.89
NoExp+P2P3	1.86	1.45	0.98	0.72	0.76

Figure 5-58

Low Demand Outlook

US Crude Imports from Mexico & Venezuela

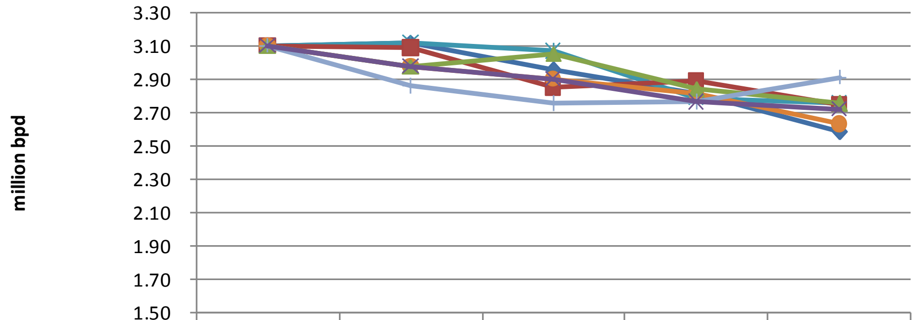


	2010	2015	2020	2025	2030
KXL	1.86	1.49	0.93	0.67	0.80
KXL+Gway	1.86	1.49	0.92	0.68	0.84
KXL No TMX	1.86	1.49	0.97	0.66	0.80
No KXL	1.86	1.46	0.99	0.67	0.80
No KXL Hi Asia	1.86	1.46	0.91	0.70	0.86
No Exp	1.86	1.47	0.97	0.86	0.96
NoExp+P2P3	1.86	1.46	0.99	0.68	0.78

Figure 5-59

Reference Outlook

US Crude Imports from Europe/FSU/Africa/Asia

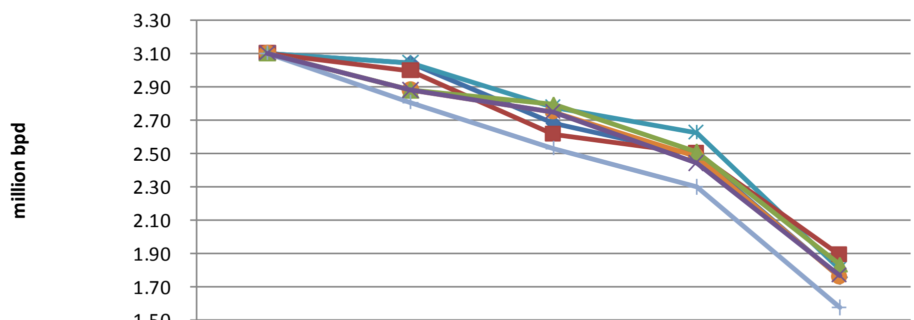


	2010	2015	2020	2025	2030
KXL	3.10	3.12	2.95	2.82	2.58
KXL+Gway	3.10	3.12	3.07	2.79	2.76
KXL No TMX	3.10	3.09	2.85	2.89	2.75
No KXL	3.10	2.98	2.90	2.82	2.63
No KXL Hi Asia	3.10	2.98	3.06	2.84	2.75
No Exp	3.10	2.86	2.76	2.76	2.91
NoExp+P2P3	3.10	2.98	2.90	2.76	2.72

Figure 5-60

Low Demand Outlook

US Crude Imports from Europe/FSU/Africa/Asia



	2010	2015	2020	2025	2030
KXL	3.10	3.05	2.68	2.49	1.75
KXL+Gway	3.10	3.05	2.77	2.63	1.80
KXL No TMX	3.10	3.00	2.62	2.50	1.89
No KXL	3.10	2.88	2.75	2.48	1.75
No KXL Hi Asia	3.10	2.88	2.80	2.51	1.83
No Exp	3.10	2.81	2.53	2.30	1.57
NoExp+P2P3	3.10	2.88	2.75	2.44	1.77

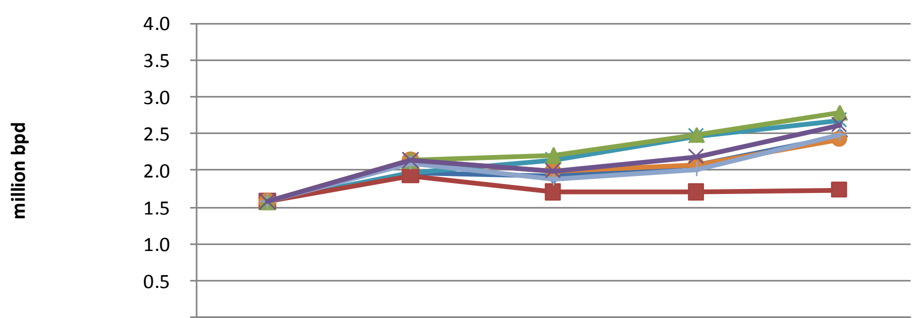
Figure 5-61

The main balancing sources for crude supplies into the U.S. are projected as Africa and especially the Middle East. Figure 5-60 and Figure 5-61 illustrate that crude imports from Europe/FSU/Africa/Asia are projected to vary moderately depending on pipeline scenario. The main variability within this group relates to crudes from Africa. The figures also show that imports from these regions are sensitive to and drop with lower U.S. product demand. Versus very slowly declining under the AEO outlook, from around 3 mbd in the 2010-2015 timeframe to around 2.7 mbd by 2030, import levels drop significantly under Low Demand, to 1.9 mbd by 2030.

Middle East crude oil imports are also projected as being impacted by both pipeline scenario and U.S. demand level (Figure 5-62 and Figure 5-63). Pipeline scenario is projected as affecting Middle East imports to the U.S. by as much as 0.5 mbd by 2020 and 1 mbd by 2030. Essentially, the more WCSB crude moves to Asia, the more Middle East crude (displaced from Asia) moves into the USA. Shifting from the AEO to the Low Demand outlook for U.S. consumption turns a projected slow growth in Middle East crude imports (around +1 mbd by 2030) into a significant decline post 2015. By 2030, the Low Demand outlook is projected as lowering Middle East imports by around 1.5 mbd versus the AEO outlook.

Reference Outlook

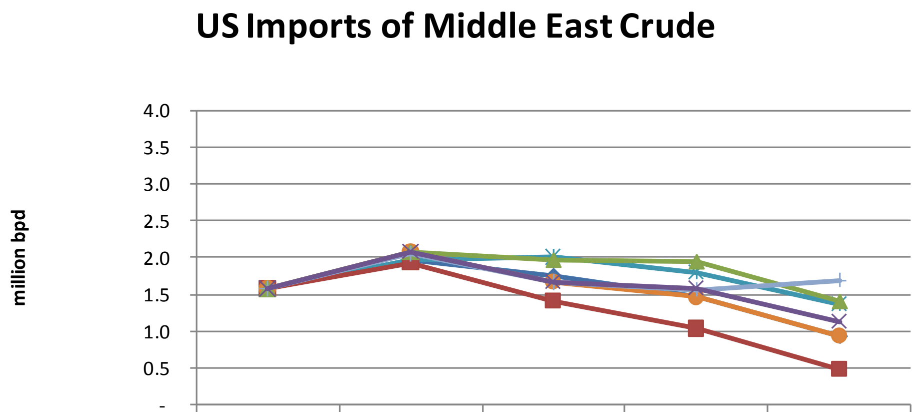
US Imports of Middle East Crude



	2010	2015	2020	2025	2030
KXL	1.57	1.96	1.93	2.08	2.46
KXL+Gway	1.57	1.96	2.13	2.46	2.68
KXL No TMX	1.57	1.92	1.70	1.70	1.73
No KXL	1.57	2.13	1.99	2.08	2.42
No KXL Hi Asia	1.57	2.13	2.20	2.49	2.79
No Exp	1.57	2.09	1.88	2.01	2.49
NoExp+P2P3	1.57	2.13	1.99	2.18	2.62

Figure 5-62

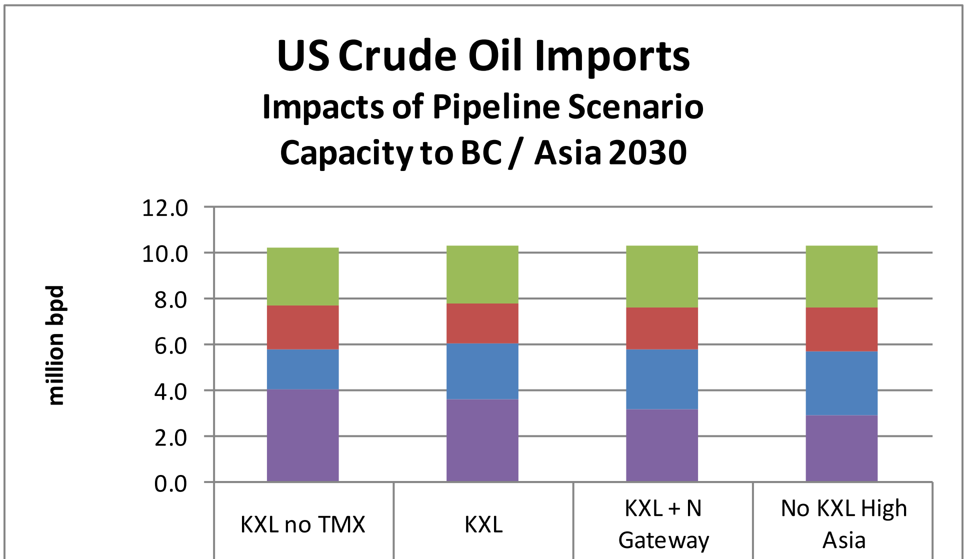
Low Demand Outlook



	2010	2015	2020	2025	2030
KXL	1.57	1.97	1.75	1.46	0.93
KXL+Gway	1.57	1.97	2.00	1.80	1.37
KXL No TMX	1.57	1.92	1.41	1.03	0.48
No KXL	1.57	2.08	1.67	1.46	0.93
No KXL Hi Asia	1.57	2.08	1.97	1.94	1.41
No Exp	1.57	2.04	1.65	1.56	1.68
NoExp+P2P3	1.57	2.08	1.67	1.59	1.12

Figure 5-63

Higher WCSB volumes moved to Asia, rather than the U.S., lead to higher U.S. imports of crude oils from non-Canadian sources, notably the Middle East. Figure 5-64 illustrates WORLD results for 2030, under the AEO outlook, for four scenarios spanning the range from low to high WCSB imports into the USA. The lowest import scenario (KXL No TMX) has KXL but no TMX expansion. The highest (No KXL High Asia) assumes pipeline capacity to the BC coast and hence onward by tanker to Asia that, by 2030, includes Transmountain TMX 2, 3 and Northern Leg and Enbridge Northern Gateway, projects that total 1.325 mbd. As Canadian crude imports to the U.S. drop between the KXL no TMX and the No KXL High Asia scenario by 1.1 mbd, those from the Middle East increase by essentially the same amount.



	KXL no TMX	KXL	KXL + N Gateway	No KXL High Asia
Other	2.5	2.6	2.7	2.7
Africa	1.9	1.7	1.8	1.9
Middle East	1.7	2.5	2.7	2.8
Canada	4.0	3.6	3.2	2.9

Figure 5-64

5.2.3.7 Effect of Pipeline Availability on Destinations for U.S. Crude Oil Import Revenues

Figures 5-65 and Figure 5-66 show U.S. total crude oil import costs for 2030 under both the AEO (Reference) and Low Demand outlooks as taken from WORLD model results. The imports costs in these figures are directly derived from WORLD results for crude oil import volumes, as described in the previous section, and are computed as volume of each crude grade imported multiplied by the delivered price for that grade as generated by the WORLD model, then summed by export region.

Total import costs vary little across all pipeline availability scenarios. However, the export regions to which the associated costs or “wealth transfers” would be made to pay for the crude oil imports vary substantially depending on the pipeline scenario. As discussed in Section 5.2.3.6, the main projected interplay is between crude oil imports from Canada and the Middle East. Under the pipeline scenarios that allow normal expansion, the highest WCSB and thus total Canadian oil imports are under the KXL No TMX scenario and the lowest are under the No KXL High Asia. Under the AEO outlook, the costs paid in 2030 for crude oils from Canada drop from $142 bn/year for oil sands plus $15 bn/year for conventional, total $157 bn/year, under KXL No TMX to a total of $101 + $12 = $113 bn/year under No KXL High Asia, (all in 2008 dollars). Thus the reduction in cost to the U.S. is $157 - $113 = $44 bn/year.

Against this, the costs of Middle East crude oil imports rise from $72 bn/year under KXL No TMX to $115 bn/year under No KXL High Asia, an increase of $43 bn/year. This shift relates to just over 10% of the total 2030 U.S. crude oil import cost of around $415 bn/year.

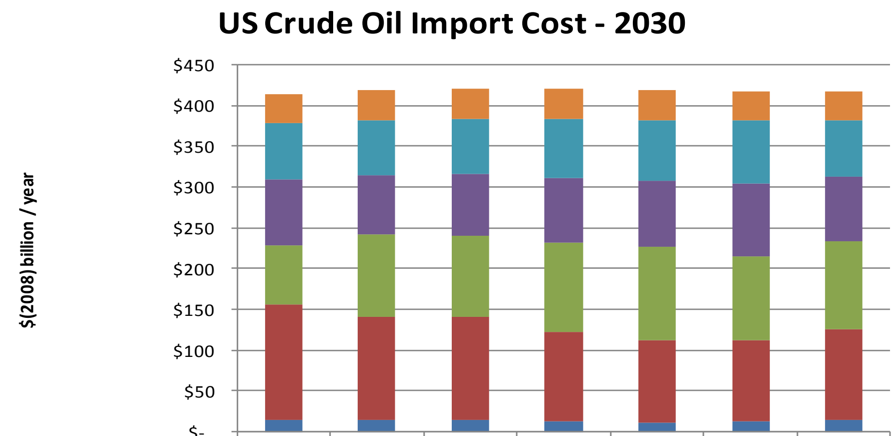
Under the Low Demand outlook, the corresponding projections are for the costs of Canadian crude oil imports to be $40 bn /year lower under No KXL High Asia and the costs of Middle East crude oil imports $37 bn/year higher. This shift in revenues is close in $bn / year to that under the AEO demand outlook. However, the percentage shift is larger, around 12%, since the total U.S. crude oil import bill is lower at $306 bn /year.

Under the AEO demand outlook, KXL No TMX pipeline scenario, Canadian crude oils comprise 38% of total U.S. crude oil import costs in 2030. Under the same pipeline scenario but Low Demand outlook, the proportion rises to 48%.

The data in Figures 5-65 and Figure 5-66 also reinforce how demand outlook has limited impact on the cost to the USA of crude oil imports from Canada but a substantial impact on costs of imports from (and thus potential “wealth transfer” to) regions other than Canada. As discussed in Section 5.2.3.5, EnSys’ projections were that crude oil imports from Mexico and Venezuela would change little across any scenario or demand outlook. The cost of imports from those two countries is consequently projected as changing little. Conversely, the cost of crude oil imports from Europe/FSU/Asia, Africa and especially the Middle East are projected to be substantially lower under Low Demand than under the AEO Reference outlook.

The charts reiterate the minimal differences anticipated between the KXL and No KXL scenarios by 2030. They also illustrate how oil sands would dominate US crude oil imports from Canada by 2030 and how the value of those imports would be cut under the No Expansion scenario.

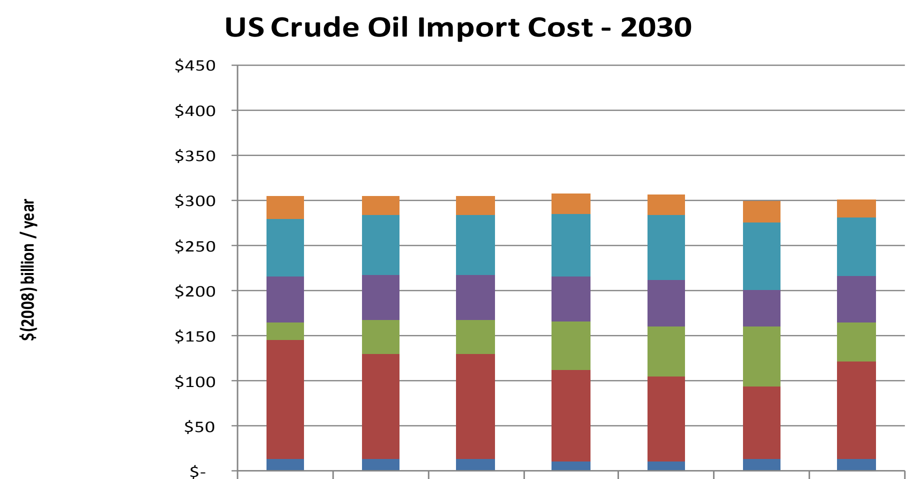
Reference Outlook



	KXL No TMX	KXL	No KXL	KXL+Gway	No KXL Hi Asia	No Exp	NoExp+P2P3
Europe/FSU/Asia	$36	$37	$36	$38	$36	$36	$36
South America	$69	$67	$68	$71	$74	$78	$69
Africa	$81	$72	$76	$79	$81	$89	$79
Middle East	$72	$102	$100	$110	$115	$103	$108
Canadian Oil Sands	$142	$127	$127	$110	$101	$99	$112
Canadian Conventional	$15	$15	$15	$13	$12	$14	$15

Figure 5-65

Low Demand Outlook



	KXL No TMX	KXL	No KXL	KXL+Gway	No KXL Hi Asia	No Exp	NoExp+P2P3
Europe/FSU/Asia	$25	$20	$20	$22	$22	$24	$19
South America	$65	$67	$67	$69	$72	$76	$64
Africa	$51	$50	$50	$50	$51	$40	$52
Middle East	$19	$36	$36	$54	$56	$67	$44
Canadian Oil Sands	$133	$118	$118	$101	$95	$81	$108
Canadian Conventional	$13	$13	$13	$11	$11	$13	$13

Figure 5-66

5.2.3.8 U.S. & Canada Regional Potential to Absorb WCSB Crude Oils

WORLD results show that, in considering potential destinations for WCSB crudes within the USA and Canada, it is necessary to consider the very different opportunities offered by different regions. Broadly, the results show limited potential for increased volumes to be refined in western and eastern Canada, PADDs 1, 4 and 5 and significant potential in PADD2 and especially PADD3.

Western Canadian refineries already rely totally on WCSB crude oils. Given projected flat Canadian oil demand growth, and recognizing this study did not include any "vision" scenario under which WCSB crude upgrading and refining would extend to developing significant product exports and petrochemicals, (see Section 4.2.3), western Canadian refineries are projected to have little additional ability to absorb WCSB crudes.

Eastern Canadian refineries today process a mix of WCSB and foreign crude oils. WORLD projections are for the mix to stay relatively stable over time. This avoids eastern Canadian refineries having to undertaken major investments to take in heavy WCSB streams.

Crude oils from WCSB are currently processed in only one small **PADD1** refinery in Warren, western Pennsylvania. Given that refinery's relatively isolated location, it was assumed that its ability to expand and to take in additional WCSB volumes would be minor.

PADD4 refineries take in WCSB crudes today but also represent one outlet for growing Bakken crude production. As discussed in Section 3.2.3.2, expansions of the Butte pipeline from the Bakken area to PADD4 are planned. Study results showed increases in Bakken crudes being run in PADD4 with resulting flat to reduced levels of WCSB crudes[86].

PADD5 refineries comprise two main groups, those in Washington state and those in California. **Washington** refineries were projected as able to take additional WCSB crudes under scenarios where pipeline capacity to BC is expanded. However, volumes are projected to be modest. The group's refinery capacity totals some 623,000 bpd but ANS crude comprises a primary intake. Even with continuing declines in ANS production, these refineries are projected to continue to take in appreciable proportions of ANS crude, thereby offering opportunities for WCSB crudes but limited in scale.

In contrast, **California** refineries include some 1.8 mbd of capacity comprising large, highly complex facilities that run a high proportion of heavy crudes. These refineries have been taking in growing volumes of Middle Eastern grades in recent years as production from California's own fields and from Alaska has declined[87]. In principle therefore, the California refineries represent a significant potential market for WCSB crude oils and a good fit with heavy grades, both to replace declining domestic production and to displace imports. This study, however, was undertaken on the basis that California

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[86] In 2009, PADD4 refineries processed 540,000 bpd of crude, of which 231,000 bpd was from Canada.

[87] PADD5 refineries in total processed around 50,000 bpd Middle East crudes in the mid 1990's. The level then rose progressively to 400,000 bpd by 2004. Since then, imports have remained in a 400,000 – 500,000 bpd range. Source: http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mcripp5pg2&f=a.

Law AB32 would be in place[88] and that this would effectively prevent the processing of any WCSB oil sands in the state (while still allowing conventional WCSB crudes). Consequently, the potential market for WCSB oil sands crudes in California was not examined.

As shown by the WORLD results across a range of scenarios, PADDs 2 and 3 represent the key areas with the potential to take in significant additional volumes of WCSB crudes.

WORLD results for **PADD2** are summarized in Figure 5-67 and Figure 5-68. Under the KXL scenario, PADD2 refinery processing of WCSB oil sands streams roughly doubles from today's levels to around 1.7 mbd post 2020. PADD2 oil sands volumes processed are sensitive to the assumed capacity of pipelines west to BC and thence by tanker to Asia. Introducing more such capacity reduces WCSB flows into PADD2 and *vice-versa*. WCSB volumes processed in PADD2 are projected to be highest under the No Expansion scenario. Constraining pipeline capacity to today's levels severely limits ability to move WCSB crudes to Asia or into PADD3 and creates economic incentives to maximize use of existing pipeline cross-border capacity into PADD2 (also onward to eastern Canada) so as to minimize production shut-in of WCSB crudes. AEO or Low Demand outlook makes little difference to WCSB volumes processed in PADD2 under any one pipeline scenario, except from 2025 to 2030 when volumes processed are lower under the Low Demand outlook.

A number of projects have been implemented or are under way in PADD2 to increase refinery intakes of heavy WCSB crudes, including oil sands. These projects have generally comprised high cost refinery upgrades entailing installation of cokers and other major processing units. They were included in the total capacity for PADD2 assumed to be on stream before 2015 and are a major factor in the increases projected for PADD2 processing of WCSB crudes[89]. PADD2 refining capacity totals 3.6 mbd. Other than in the No Expansion scenario, WORLD results indicate a potential for PADD2 to process up to 2 mbd of oil sands crudes[90]. Based purely on transport economics, the economic logic would be to process all available WCSB supply in PADD2 before sending any on to PADD3. This is because taking WCSB crudes into PADD2 backs out crude imports which are shipped in from the Gulf Coast up the Capline and other systems. Taking WCSB down to PADD3 while import crudes still flow up to PADD2 would mean incurring a double transportation cost as the two sets of crudes would pass each other. However, neither crude oils nor refinery configurations and processing capabilities are uniform. They vary widely and not all PADD2 refineries are amenable to being economically upgraded to process WCSB heavy streams while, at the same time, there is substantial existing capacity in the PADD3 Gulf Coast designed for heavy crudes. This reality leads to projections which combine a significant – but economically limited - degree of upgrading of PADD2 refineries with transporting WCSB streams down to the Gulf since refiners there have configurations able to take them.

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[88] California Proposition 23 to over-turn Law AB32, Global Warming Solutions Act of 2006, was defeated in the November 2nd, 2010 elections.
[89] Firm PADD2 projects included 250,000 bpd of crude distillation capacity and 170,000 bpd of coking.
[90] In the No Expansion scenario, the lack of alternative outlets leads to incentives to invest to further increase PADD2 WCSB processing, which consequently reaches a peak in the range of 2.3 – 2.4 mbd.

PADD3 Gulf Coast refining includes over 5 mbd of refineries capable of processing substantial volumes of heavy sour crudes (out of a total of 8.4 mbd of PADD3 capacity). In 2009, PADD3 as a whole imported 2.9 mbd of heavy crudes (defined by the authors as less than 29 degrees API). However, the prospects for continuing to maintain such import levels from sources other than Canada appear to be limited.

As discussed in Section 5.2.3.6, crude oil imports from Mexico and Venezuela, which flow predominantly into Gulf Coast refineries, have been in steady decline and are projected to continue to drop over the next several years, from 2.9 mbd total in 2004 to around 0.8 mbd by 2020. Several potential alternative sources exist outside of North America but none of these appears likely to fill the gap. Production from Ecuador is largely already committed. Heavy crude production from Colombia is increasing but volumes are limited, of the order of plus 100,000 bpd. Brazil has ambitious plans to increase its crude production but (a) not all of this is heavy crude and (b) Petrobras has announced plans to spend up to $60 billion in the coming years on four major refinery projects. Their strategy is to process the country's heavy crudes (e.g. around 16 API) in these refineries and to export the better quality crude grades. In short, this plan – if implemented – would keep at least part of Brazil's incremental heavy crude production "at home" and thus off international markets. The same strategy is also being employed in Middle Eastern countries where Saudi Arabia, Qatar and Kuwait are all either implementing or considering refining plans that would process heavy crude volumes domestically.

The recent very large Reliance refinery projects, which total some 1.2 mbd capacity in Jamnagar, India, comprise an ability to run predominantly heavy crudes. In addition, there is an on-going trend in selective refineries worldwide to install additional upgrading capacity, i.e. to process heavier crudes. The Japanese government has recently issued a new rule requiring refiners in the country to increase their ratios of upgrading per barrel of crude processed. This is likely to have one or both of two effects, either to reduce (close) active crude distillation capacity and/or to increase upgrading capacity through new projects. Either way, the country is likely to process a heavier crude slate in future. Finally, at least in the short term, analysts' projections are that the world's crude slate is likely to become somewhat lighter rather than heavier. This is, in part, because of short term increases in NGL's and condensates supply, driven by natural gas projects in the Middle East, also the U.S., and elsewhere.

Taken together, these developments create an outlook where PADD3 refiners could have difficulty in the future competing for and obtaining sufficient heavy crudes to fill available heavy crude processing and upgrading capacity, and therefore *a priori* could be expected to have an interest in acquiring heavy WCSB crudes. Based on WORLD model results, PADD3 refineries have the potential to process large and growing volumes of WCSB oil sands crudes, as summarized in Figure 5-69 and Figure 5-70. Comparing the KXL and No KXL scenarios, study results indicate that PADD3 refineries would process around 0.8 mbd of WCSB crudes by 2020 and 1.4 mbd by 2030 irrespective of whether KXL was or was not built[91]. (Stated Keystone XL capacity to the Gulf Coast is 700,000 bpd.) Results show these volumes would be higher if no capacity was built to the BC coast (KXL No TMX) and lower if capacity was built in addition to

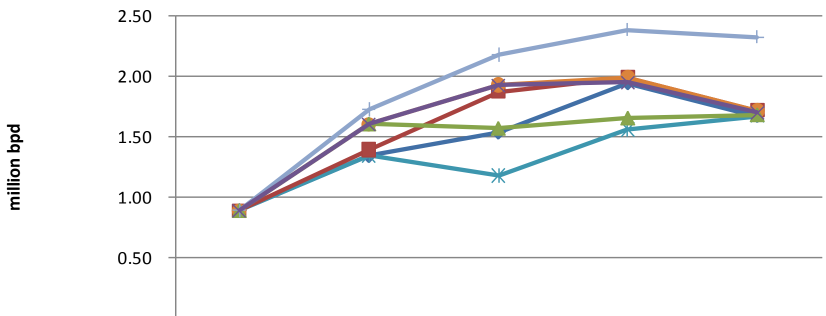
[91] TransCanada has stated that shippers have committed to move 380,000 bpd of WCSB crude oils to U.S. Gulf Coast refineries on Keystone XL if built. This commitment was built in to the KXL scenarios, setting a minimum level of WCSB crudes assumed to move to the Gulf Coast on the pipeline if built.

the TMX 2,3 projects included in the KXL and No KXL scenarios[92]. By 2030, WCSB volumes processed in PADD3 could range from 0.6 to 1.8 mbd under the AEO outlook depending on available pipeline capacity to the BC coast, (0.75 to 1.97 under the Low Demand outlook).

The scenario results indicate (a) that incentives exist to deliver significant and rising WCSB volumes to the Gulf Coast and (b) that PADD3 refineries would themselves competing with Asian refineries for WCSB crudes in scenarios where additional capacity to the BC coast and thence Asia was available. KXL would add to short term cross-border capacity but would also provide one means to deliver WCSB crudes to the Gulf Coast, (potentially from first quarter 2013, subject to permitting).

Reference Outlook

Canadian Oil Sands - Total - Refined in PADD-2



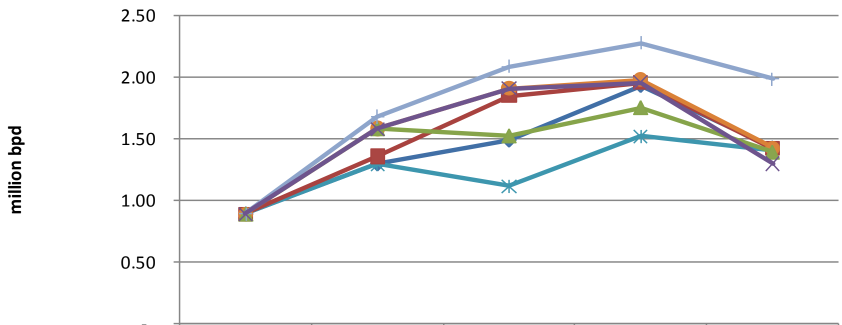
	2010	2015	2020	2025	2030
KXL	0.89	1.34	1.54	1.94	1.67
KXL+Gway	0.89	1.34	1.18	1.55	1.66
KXL No TMX	0.89	1.40	1.87	1.99	1.72
No KXL	0.89	1.60	1.92	1.99	1.71
No KXL Hi Asia	0.89	1.60	1.57	1.65	1.68
No Exp	0.89	1.72	2.18	2.38	2.32
NoExp+P2P3	0.89	1.60	1.92	1.95	1.70

Figure 5-67

[92] As discussed in Section 4.4, the options for Keystone XL to take in Bakken crudes at Baker Montana and West Texas/Mid-Continent crudes at Cushing were not included in the study scenarios. The notifications on related "open seasons" were too late to be considered and Transcanada has stated it will not make any decision on either option before early 2011.

Low Demand Outlook

Canadian Oil Sands - Total - Refined in PADD-2

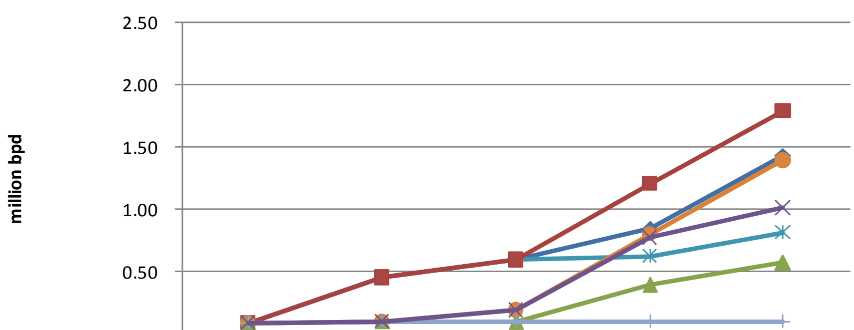


	2010	2015	2020	2025	2030
KXL	0.89	1.29	1.49	1.93	1.42
KXL+Gway	0.89	1.29	1.12	1.52	1.40
KXL No TMX	0.89	1.36	1.85	1.95	1.42
No KXL	0.89	1.58	1.91	1.97	1.42
No KXL Hi Asia	0.89	1.58	1.52	1.75	1.39
No Exp	0.89	1.68	2.08	2.27	1.98
NoExp+P2P3	0.89	1.58	1.91	1.95	1.30

Figure 5-68

Reference Outlook

Canadian Oil Sands - Total - Refined in PADD-3

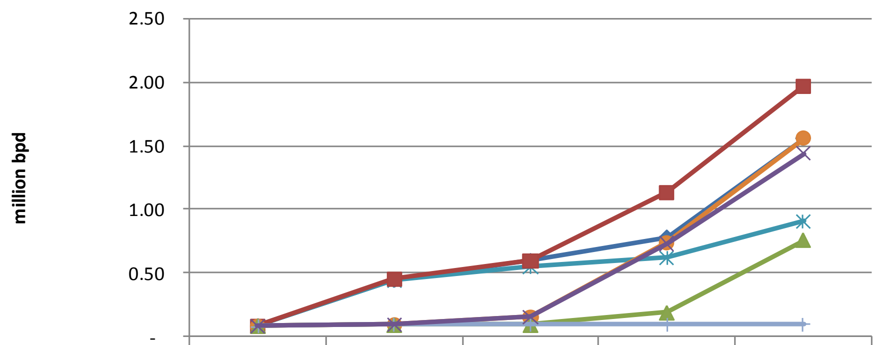


	2010	2015	2020	2025	2030
KXL	0.08	0.45	0.59	0.85	1.43
KXL+Gway	0.08	0.45	0.59	0.62	0.81
KXL No TMX	0.08	0.45	0.59	1.20	1.79
No KXL	0.08	0.10	0.19	0.80	1.39
No KXL Hi Asia	0.08	0.10	0.09	0.39	0.57
No Exp	0.08	0.10	0.10	0.10	0.10
NoExp+P2P3	0.08	0.10	0.19	0.77	1.01

Figure 5-69

Low Demand Outlook

Canadian Oil Sands - Total - Refined in PADD-3



	2010	2015	2020	2025	2030
KXL	0.08	0.44	0.59	0.78	1.56
KXL+Gway	0.08	0.44	0.55	0.62	0.91
KXL No TMX	0.08	0.45	0.59	1.13	1.97
No KXL	0.08	0.09	0.15	0.74	1.56
No KXL Hi Asia	0.08	0.09	0.09	0.19	0.75
No Exp	0.08	0.10	0.10	0.10	0.10
NoExp+P2P3	0.08	0.09	0.15	0.73	1.44

Figure 5-70

5.2.3.9 Effect on PADD3 Crude Oil Sources

Increases in crude imports from Western Canada to PADD3 predominantly offset imports from the Middle East. As shown in Figure 5-69 and Figure 5-70, the KXL No TMX and the No KXL High Asia scenarios represent the extremes of respectively high and low WCSB volumes into PADD3 (and the USA as a whole). If WCSB crudes move to Asia instead of the U.S., it is somewhat lighter crudes – notably Middle Eastern medium and heavy sour grades as the balancing crude supply – that fill their place[93]. Figure 5-71 and Figure 5-72 highlight the changes in PADD3 crude slate between KXL No TMX and No KXL High Asia scenarios under both AEO and Low Demand outlooks. By 2030, the difference between the KXL No TMX and the No KXL High Asia scenarios is an increase of 1.25 mbd Canadian crude imports and a reduction of 1 mbd in Middle Eastern crude imports. Comparing results for the same pipeline scenario and time frame (2020 or 2030) for AEO versus Low Demand outlook illustrates how U.S. demand reduction in turn reduces U.S. imports of Middle Eastern crude oils. Under the Low Demand

[93] Figures set out in Section 5.2.2.3 show some variation in PADD3 crude slate quality – by up to around 0.5 degrees API – depending on the scenario. Broadly, projected PADD3 crude slate is at its heaviest under scenarios which maximize WCSB crudes into the region and *vice versa*.

outlook, KXL No TMX scenario, Middle Eastern crude oil imports are projected as cut to a nominal level[94].

Reference Outlook

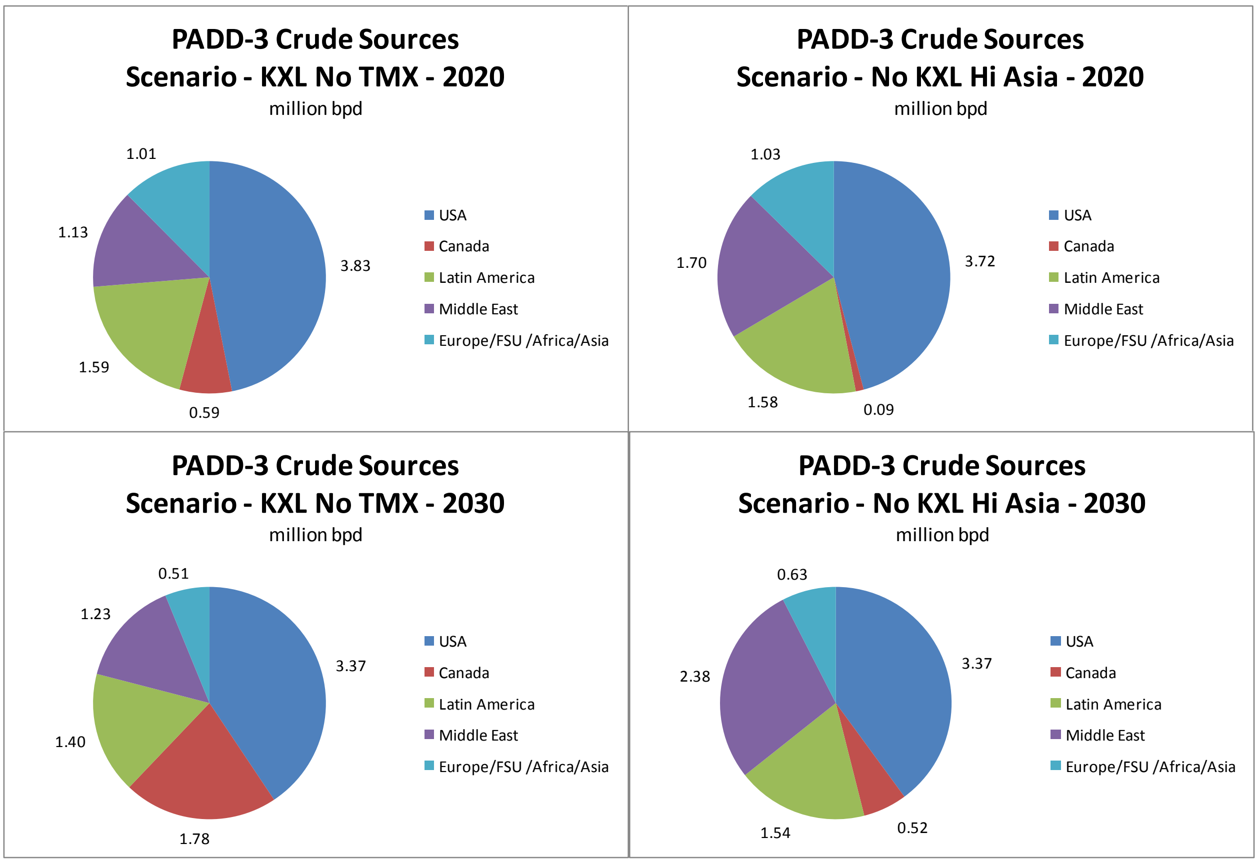


Figure 5-71

[94] This study did not assume or allow for Middle Eastern or other crude suppliers to deliberately subvent their crude prices in order to maintain flows into the USA or elsewhere. To the extent this were to happen, it would affect the results, e.g. to maintain higher Middle Eastern crude import volumes than are shown here.

Low Demand Outlook

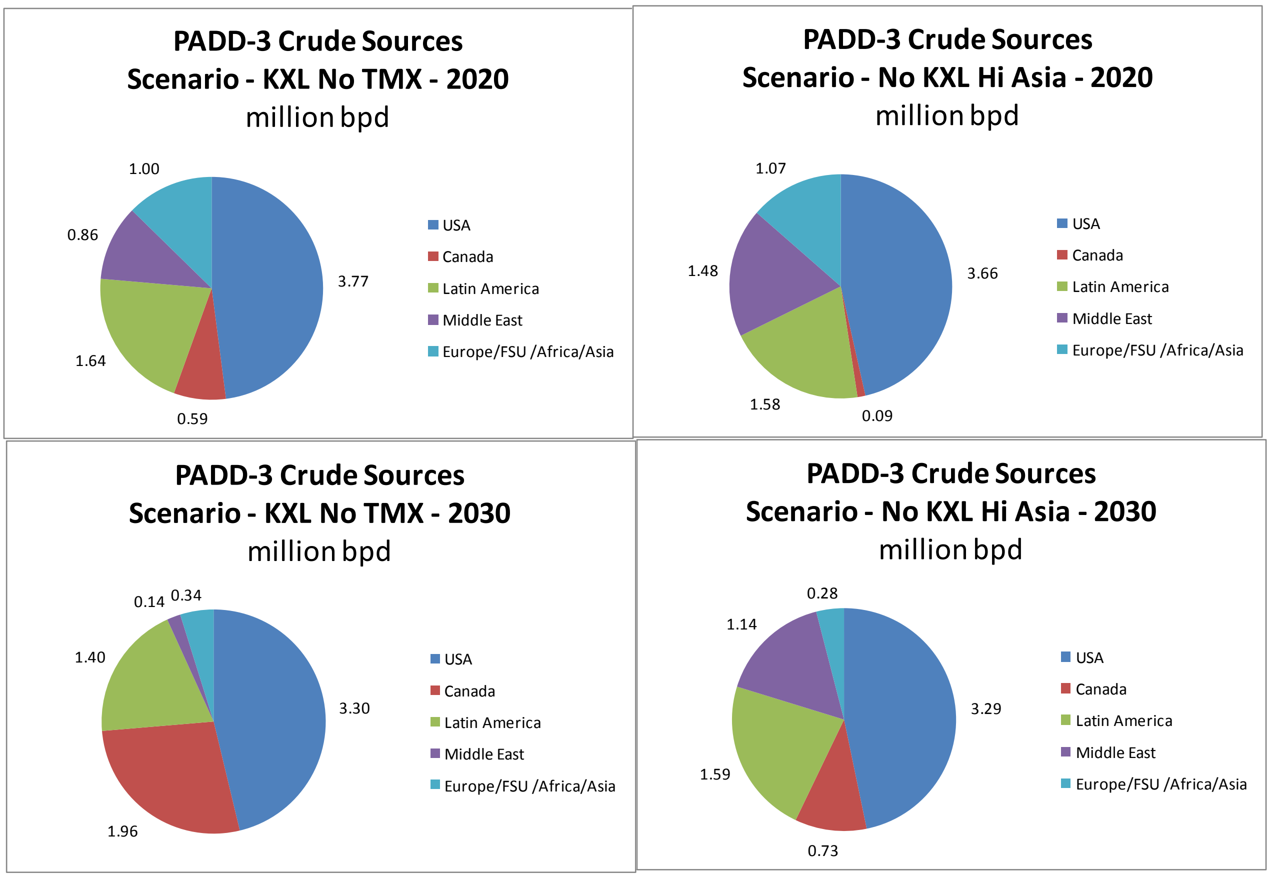


Figure 5-72

6 Conclusions

This study has considered and presented the projected impacts out to 2030 of Keystone XL, and of other potential WCSB export pipelines, on U.S. refining, oil markets and import dependency. The study has taken into consideration the effects of alternative U.S. product demand scenarios, as could be driven by legislative agendas focused on the environment and/or energy security, but has not considered either the potential consequences of any U.S. climate legislation, of life-cycle or other emissions aspects of Canadian oil sands or consequences for the U.S. or Canadian economy. Such considerations were not within EnSys' mandate from the Department of Energy.

The Keystone Mainline pipeline system now under start-up will have the capacity as of early 2011 to take 591,000 bpd of heavy WCSB crudes, including oil sands, from Hardisty Alberta to Steele City Nebraska and then onward to either Wood River/Patoka Illinois or to Cushing. Keystone XL would add a further 700,000 bpd of pipeline capacity to bring WCSB crudes to Cushing and thence south to Gulf Coast refineries. The project could also potentially (a) enable Bakken crudes in North Dakota and Montana to be linked in to KXL and taken to Cushing and the Gulf Coast and (b) enable U.S. crudes in the Cushing area to be taken into the line and transported to the Gulf Coast, subject in part to the volumes of WCSB crudes offloaded at Cushing.

WORLD and ETP studies indicate that building versus not building Keystone XL would not of itself have any significant impact on: U.S. total crude runs, total crude and product import levels or costs, global refinery CO_2 or life-cycle GHG emissions. This is because changing WCSB crude export routes would not alter either U.S., Canadian or total global crude supply, (other than a small impact under a No Expansion scenario), or U.S. and global product demand and quality. The same slate of crude oils would have to be refined even if reallocated geographically.

The combination of existing spare cross-border capacity with opportunities to provide alternative capacity over time, including several already-defined potential projects both cross-border and from PADDII to PADDIII, would enable industry to respond to KXL not being built, with the projected result that crude export dispositions from Western Canada and levels of WCSB imports to the USA would be similar to those which would obtain if KXL were built[95] Put differently, scenario results indicate that – if KXL were not built – there would be market demand to put in place broadly similar capacity, including to the U.S. Gulf Coast.

Production levels of oil sands crudes would not be affected by whether or not KXL was built. WCSB production would only be impacted (relative to the CAPP 2010 projection used in the study) if there were no further pipeline expansion out of WCSB and within the USA beyond projects currently under construction. Even then, because of existing available line capacity, oil sands production would not

[95] This unless KXL not being built led to expansions of pipelines to take WCSB crude to the British Columbia coast, thence Asia, instead of broadly similar capacity to bring WCSB crudes into the U.S.

begin to be curtailed until after 2020. Versus the base projections, WCSB production would be curtailed by approximately 0.8 mbd by 2030. Since, to occur, such a scenario would have to entail no expansion of (a) pipelines entirely within Canada that could take WCSB crudes from Alberta to the British Columbia coast, (b) existing cross-border lines from WCSB to the U.S., (c) existing internal domestic U.S. pipelines that could take WCSB crudes to market within the U.S. - and to eastern Canada and (d) alternative proven transport modes, namely rail possibly supported by barge, the scenario is considered unlikely.

Keystone XL would increase the cross-border capacity surplus such that it would then persist until 2020 or later. However, the 2005 through 2008 shortages in WCSB export pipeline capacity, and the Summer 2010 forced shutdown of over 650,000 bpd of capacity on the Enbridge Mainline/Lakehead system due to a spill, each led to adverse consequences including, production shut-ins, high price discounts on WCSB heavy grades and resulting loss of revenues to Canadian producers, shippers and government agencies; also difficulties for U.S. refiners. KXL would provide increased redundancy that would reduce the likelihood of such occurrences. KXL could also provide an additional means to bring Bakken crudes to market and/or to help relieve congestion at Cushing by allowing flexibility to ship locally available barrels to the Gulf Coast[96].

Study results indicate that the ability of KXL – or otherwise alternative projects - to transport heavy WCSB crudes to the Gulf Coast would satisfy incentives for Gulf Coast refiners to maintain supplies of heavy crudes at a time when volumes from traditional suppliers, notably Mexico and Venezuela, are continuing to decline. Volume commitments claimed by TransCanada for KXL indicate that firm interest from U.S. refiners does exist to bring at least 380,000 bpd of WCSB crudes to the Gulf Coast.

A central finding from this study is that the U.S. has the potential to take in substantially increasing volumes of crude oil from Canada over time, albeit with a steadily rising proportion of oil sands streams which would reach close to 90% by 2030. Study results indicate U.S. refining of Canadian crudes could rise from 1.9 mbd in 2009 to 4 mbd by 2030. Associated oil sands streams imports would rise from under 1 mbd in 2009 to over 3.6 mbd by 2030. This projected increase would curb dependency on crude oils from other sources notably the Middle East and Africa.

U.S. imports of WCSB crudes rise under all scenarios considered. However, the study shows that WCSB crude volumes into the U.S. are sensitive to the development of pipelines within Canada to the British Columbia coast and thence to markets in Asia, the region which will constitute 75% of the world's refining capacity growth between now and 2030. The Kinder Morgan TMX 2 and 3 projects would entail expansion along the existing Transmountain pipeline right of way. The Kinder Morgan Northern Leg would use partly existing, partly new facilities and rights of way and the Enbridge Northern Gateway entirely new facilities and right of way. The Northern Leg and Northern Gateway projects in particular face significant hurdles. However, construction of TMX 2 and 3 would add 0.4 mbd of capacity west to the BC coast and construction of all three projects would result in a total capacity of over 1.3 mbd.

[96] Congestion and high inventories at Cushing over the last two years, caused in part by the recession, have led *inter alia* to discontinuities in prices for West Texas Intermediate benchmark crude and a consequent diminution in WTI's role. Several major producers have replaced WTI with the new Argus Sour Crude Index (ASCI).

Implementing one or more of these projects would increase WCSB export capacity, move the system away from being almost entirely land-locked and diversify markets for WCSB crudes.

The evidence from the WORLD model cases is that, if pipeline projects to the BC coast are built, they are likely to be utilized. This is because of the relatively short marine distances to major northeast Asia markets, future expected growth there in refining capacity and increasing ownership interests by Chinese companies especially in oil sands production. Such increased capacity would alter global crude trade patterns. WCSB crudes would be "lost" from the USA, going instead to Asia. There they would displace the world's balancing crude oils, Middle Eastern and African predominantly OPEC grades, which would in turn move to the USA. The net effect would be substantially higher U.S. dependency on crude oils from those sources versus scenarios where capacity to move WCSB crudes to Asia was limited. Instead of reaching 3.6 mbd by 2030, WCSB oil sands volumes into the U.S. could be 2.6 mbd, possibly lower still and Middle East/African crude imports correspondingly higher.

The study has shown that reduction in U.S. petroleum product demand would not appreciably cut WCSB crude flows into the U.S. Rather, a low U.S. demand outlook would substantially reduce U.S. dependency on foreign (non-Canadian) crudes and products. A combination of increased Canadian crude imports and reduced U.S. product demand could essentially eliminate Middle East crude imports longer term. Low U.S. demand is also projected to reduce U.S. net product imports and potentially turn the USA into a net product exporter after 2020.

Keystone XL Assessment

Prepared for
Department of Energy Office of Policy

Final Report - Appendix

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Abbreviations & Acronyms Used in this Report

bbl	barrel
bpd	barrels per day
mbd	million barrels per day
tpa	tonnes per annum
mtpa	million tonnes per annum
DOE	Department of Energy
DOS	Department of State
EPA	Environmental Protection Agency
PADD	Petroleum Administration for Defense Districts
BC	British Columbia
CAPP	Canadian Association of Petroleum Producers
NEB	Canadian National Energy Board
WC	Western Canada
WCSB	Western Canadian Sedimentary Basin
ETP	Department of Energy's Energy Technology Perspectives Model
WORLD	EnSys' World Oil Refining Logistics & Demand Model

1 Overview of EnSys & WORLD Model

1.1 EnSys' Experience

EnSys is an independent consultancy led by senior experts with substantial oil industry and refining backgrounds and which specializes in providing analyses and projections to support strategic industry-related decisions most frequently at national, international and global levels. Our focus is on regulatory, climate, investment, economic, trade, supply, demand and technology developments and how these impact refining and oil markets.

EnSys brings to bear an essentially unique track record of refining sector analyses including global studies using EnSys' WORLD model that stretch back to 1987. These include a long history of analyses for US government agencies:

- DOE Offices of Strategic Petroleum Reserve and Energy Emergencies – several analyses of real and hypothetical emergencies from 1987 through 2005
- DOE, Oak Ridge Laboratory and U.S. Navy – a series of analyses and support to ORNL studies of regulations for reformulated and military fuels spanning the mid 1980's through early 2000's
- Argonne National Laboratory – assessment of potential carbon regime impacts on the global petroleum industry as part of the lead up to Kyoto
- EIA - supply of EnSys' WORLD model in 1992, support on NEMS and WORLD including re-supply of updated WORLD model in 2006
- EPA - several analyses of US fuels regulations including most recently on marine fuels and to support the US 2009 ECA submission to the International Maritime Organisation

as well as a wide span of public and private sector clients including:

- US DOE, EIA, EPA etc. as above
- World Bank, Inter American Development Bank, International Maritime Organisation
- Private sector oil and specialty companies: ExxonMobil, ConocoPhillips, Marathon, Koch, Amerada Hess, Shell, BP, Total, Afton Chemical, ARCO Chemical
- American Petroleum Institute – fuel and climate regulation studies
- National oil companies and energy ministries: Abu Dhabi, Qatar, Tunisia, Ecuador, Trinidad
- OPEC Secretariat (annual World Oil Outlooks)
- Bloomberg (daily refining netbacks)

- State of New York, City of New York, Suffolk County, State of New Hampshire.

Our stress is on impartial analysis in all our assignments and our goal in this study was to apply our best judgment to assess how the drivers of industry economics would lead to changes in the US, Canadian and global oil sector under different scenarios.

1.2 EnSys *WORLD* Model

WORLD is an advanced modeling system which captures and simulates the global and interlinked nature of today's and tomorrow's downstream oil industry. The model provides projections of global refining developments, crude and product flows, pricing and refining margins as shown in Figure 1-1. It is a highly flexible system, with the ability to model short, medium, and long-term forecasts. The model works by combining top down scenarios for projected oil price/supply and demand over the next twenty years with bottom up detail on crude oils, non-crudes, (NGL's, biofuels, etc.), refining, transportation, product demand and quality.

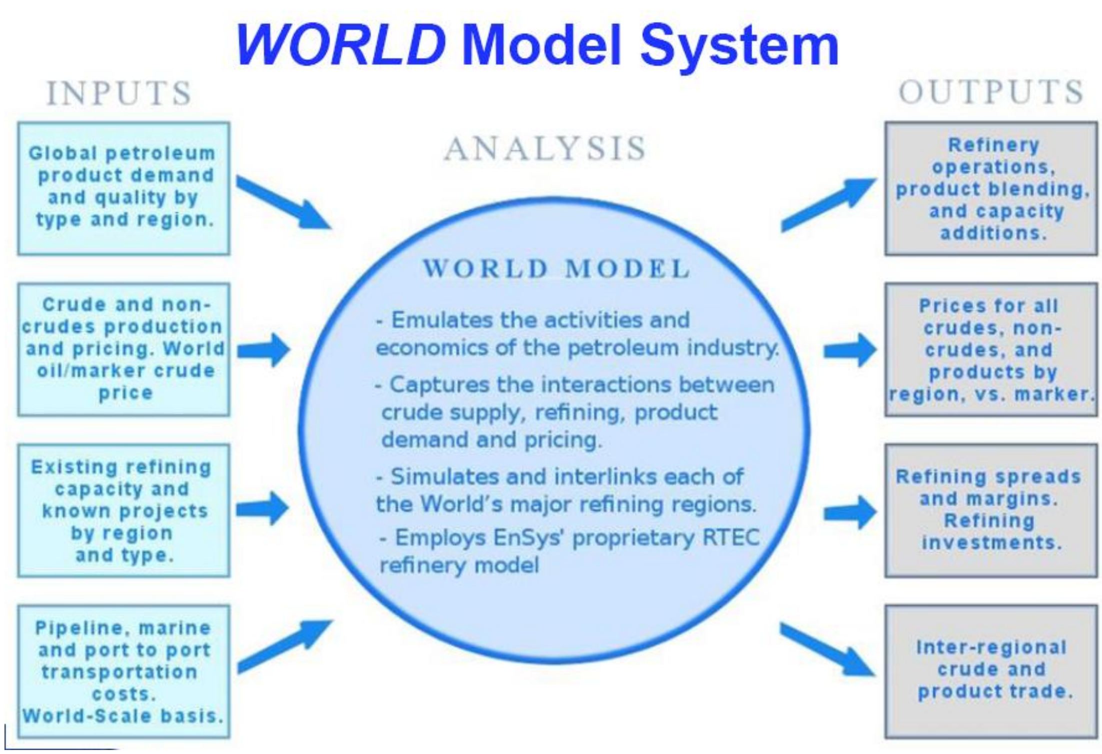


Figure 1-1

The version of WORLD used for this study for the Department of Energy comprised 22 regions with detail oriented to the US and Canada, including discrete representation of each PADD, Canada East and Canada West, (Figure 1-2), plus sub-PADD groupings for US refineries.

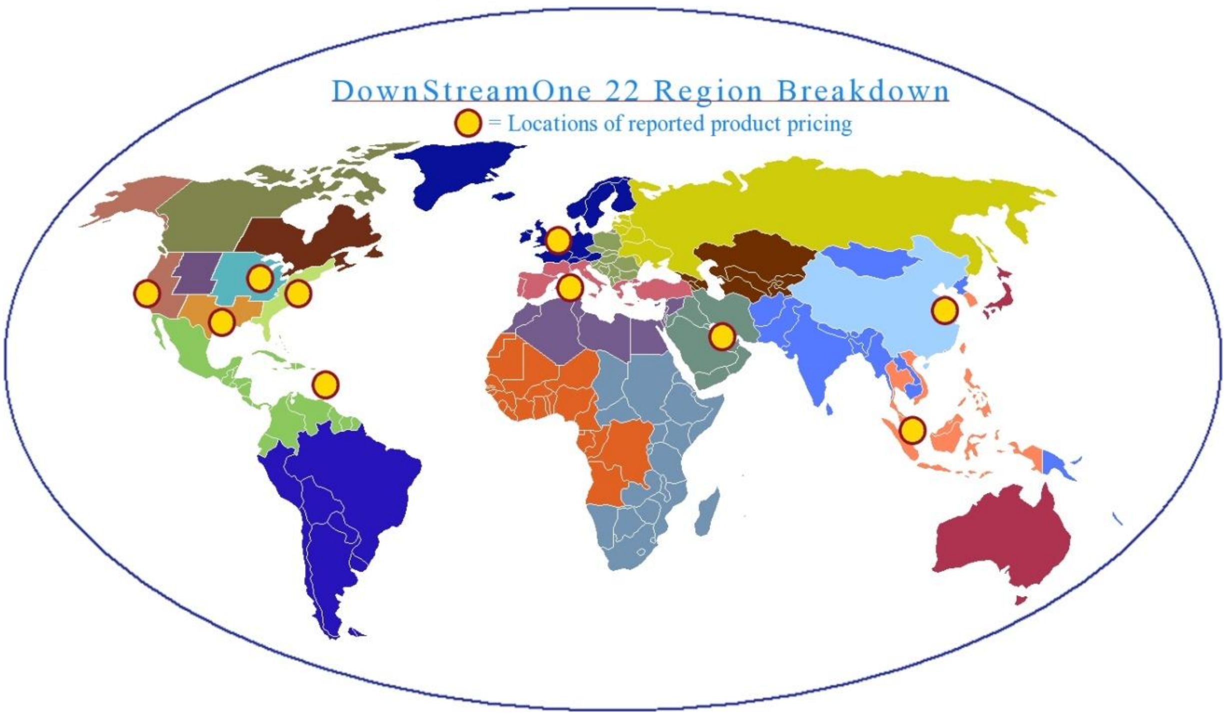


Figure 1-2

2 Study Starting Point, Set Up and Specific Premises

2.1 Reference Basis & Premises

This study used the following for its starting point:

- Employed the latest US-oriented version of WORLD:
  - 5 US PADD's, Canada East & Canada West plus 15 other world regions for a total of 22
  - Sub-PADD detailed breakdown / grouping of US refineries, total of 18 US refining groups
  - One refining aggregate group for each region outside US including Canada East & West
- Top level world regional supply/demand/world oil price outlook based on EIA Annual Energy Outlook 2010 Reference Case
- Alternative US low demand outlook taken from a March 2010 EPA report[1] examining more aggressive measures to cut transport fuel demand in the US supplemented by global demand and world oil price adjustments generated using the DOE ETP model (See Section 2.3.5)
- Detail of crude supply, non-crudes supply, product demand mix and quality, refining capacity and projects, crude and product transportation (mainly marine and inter-regional pipelines) basis and outlook built up from multiple sources as extensively applied in recent EnSys studies
- WORLD cases for 2010, 2015, 2020, 2025 and 2030 from recent EnSys studies

To best fit the model to the DOE study, several checks and adjustments were made, including:

- **AEO 2010 and the more recent IEO 2010 projections were compared and selected adjustments made**
  - The starting basis in WORLD at the beginning of the assignment was the AEO 2010 Reference Case (produced December 2009). Versus this, there are a range of specific differences in supply and demand projections by region in the 2010 EIA International Energy Outlook (IEO); for instance slightly lower total global demand by 2030. Because of the relatively limited differences between the two outlooks, and because of the limited time available and the focus on the USA and Canada, EnSys took the decision to move to the IEO 2010 basis only on a few parameters which potentially would materially impact the study, specifically:

[1] EPA Analysis of the Transportation Sector, Greenhouse Gas and Oil Reduction Scenarios, February 10, 2010, last updated March 18, 2010, in response to September 2009 request from Senator Kerry.

  - The AEO global demand was retained, leading to a projected 90.9 million bpd by 2015 (versus 88.7 in the IEO) and 105.9 million bpd in 2030 (versus 103.9 in the IEO). The AEO medium term outlook was also compared with and found to be closely in line with the then latest EIA Short Term Energy Outlook (June 2010) and the IEA's June 2010 Medium Term outlook.
  - USA demand outlook was not altered as it is the same in both AEO and IEO
  - Canadian product demand outlook was retained at the AEO levels. (The IEO has lower growth rates, 2020 demand 2.2 million bpd versus 2.37 in the AEI, 2030 demand 2.3 million bpd versus 2.55 in the AEO.)
    - Global, South American and US biofuels/ethanol production were tuned to IEO as were coal-to-liquids (CTL), gas-to-liquids (GTL) and shale oil. This was because the AEO does not contain specific regional projections for these fuels. AEO and IEO have the same projections for US biofuels.

  - USA liquids production:
    - AEO and IEO have the same projections for US conventional liquids supply – so AEO retained
    - AEO projections were used as the basis for projecting US production by region/state
      - However, AEO 2010 Table 113 shows near term declining crude production for the Rocky Mountain region despite the fact that ND (Bakken) production is rising rapidly. The table then has the region's production rising steadily long term. An adjustment was made wherein the short term dip in production projected in the AEO was replaced by an increase. Longer term AEO values were left unchanged[2].

- **Canada total liquids and oil sands production**. Since Canada's oil sands production is at the center of this study, projections from the IEO and Canadian sources, notably CAPP and the Alberta Energy Resources Conservation Board (ERCB), were compared. The AEO does not contain explicit projections for Canadian oil sands, only "North American non-conventional"
  - The IEO projections for Canadian oil sands production have lower growth than those from CAPP on which many export pipeline projects are being based. Since the CAPP projection reflects the Canadian industry's latest "best estimate" forecast, and includes a series of projects reactivated or initiated since the beginning of 2010, the CAPP projections were used. Table 2-1 below summarizes the CAPP projections and provides comparison with the IEO

[2] Given Bakken crude projections made available since these premises were set, it appears that the projections used in the model cases were likely to have understated future Bakken production. This is further discussed in the main Report, Section 3.2.3.2.

- Versus their 2009 outlook, the 2010 CAPP projection contains a lower proportion of fully upgraded light synthetic crude (SCO) and higher proportions of bitumen blends. This shift reflects delays and cancellations to a number of upgrading projects and the anticipation of growing available supplies of diluent.
- Details from 2010 and 2009 CAPP and related projections were used to arrive at a breakdown of bitumen blends between DilBit and SynBit. (DilBit is a blend of naphtha/condensate and bitumen, SynBit of SCO with bitumen.) Expected growing availability of condensates/diluents, from the Enbridge Southern Lights project and from CN Rail imports via Kitimat British Columbia as well as from western Canadian condensate itself has led to a shift to higher proportions of DilBit, less SynBit
- The CAPP projections used were very close to those already in WORLD
- Specific Western Canadian crude grades used were:
  - Conventional:
    - mixed (light) sweet
    - mixed (medium) sour
    - heavy
  - Oil sands:
    - synthetic fully upgraded
    - bitumen blends:
      - Western Canadian Select (WCS does include some conventional streams but is listed by CAPP under oil sands grades and volumes)
      - SynBit blend
      - DilBit blend (includes Cold Lake and Athabasca)

Table 2-1 summarizes the projection used for WCSB crude supply. Note, this relates to what CAPP terms as supply of streams to market downstream of upgraders and blending, not to raw production. Also, the CAPP projections went through 2025 and were extrapolated to 2030.

CAPP Crude Oil Forecast, Markets & Pipelines, June 2010							
CAPP Western Canadian Crude Oil Supply Forecast 2010 – 2025							
Blended Supply to Trunk Pipelines and Markets							
thousand barrels per day Actuals Forecast							
	2008	2009	2010	2015	2020	2025	2030
CONVENTIONAL							
Total Light and Medium	589	559	546	489	423	371	*325*
Net Conventional Heavy to Market	350	311	288	221	172	133	*103*
TOTAL CONVENTIONAL	939	870	834	710	595	505	*428*
Year on year Lt/Med	3.2%	-5.1%	-2.3%	-2.8%	-2.8%	-2.6%	-2.6%
Year on year Conv Hvy	-8.4%	-11.1%	-7.4%	-4.7%	-5.5%	-5.0%	-5.1%
OIL SANDS							
Percent SCO	37.2%	40.3%	43.0%	34.9%	31.5%	30.0%	*28.5%*
Upgraded Light Synthetic (SCO)	556	653	745	896	1,014	1,206	*1,260*
Bitumen Blends	937	970	986	1,669	2,202	2,818	*3,160*
TOTAL OIL SANDS AND UPGRADERS	**1,493**	**1,622**	**1,731**	**2,565**	**3,216**	**4,024**	***4,420***
c.f. IEO Canada Oil Sands/Bitumen	*1,510*			*2,360*	*2,870*	*3,490*	*4,240*
WESTERN CANADA OIL SUPPLY	2,432	2,493	2,565	3,275	3,811	4,528	*4,848*
ATLANTIC CANADA OIL PRODUCTION	342	268	250	190	190	145	*106*
Year on year Atlantic Canada	-7.3%	-21.6%	-6.7%	-2.6%	-15.6%	-6.5%	*-6.0%*
TOTAL CANADA OIL SUPPLY	**2,774**	**2,761**	**2,815**	**3,465**	**4,001**	**4,673**	***4,954***
Notes:							
CAPP separately projects Western Canada crude production and supply to market.							
EnSys used the supply to market figures, i.e. the net output from blending and upgrading.							
Projections for 2030 are EnSys extrapoloations based on DOE guidance.							
Bitumen blends include both DilBit and SynBit types - further split out in WORLD.							

Table 2-1

- **Canadian crude flows into US refineries, grouping of US refineries**
  - Detailed EIA crude oil imports data for 2009 were analyzed and compared with Canadian Association of Petroleum Producers (CAPP) data for Canadian oil production and flows into US regions
    - Reconciliation was essentially exact

    - These enabled EnSys to identify US refineries receiving Canadian crude by type and volume
- Taking into account
    - current routings and intake of Canadian crudes, (especially identified heavy and synthetic grades)
    - known US refinery projects for conversion to take Canadian heavy/oil sands and
    - projected pipeline developments, especially potential Keystone XL to US Gulf Coast Houston, Port Arthur area
- US sub-PADD refinery groupings in WORLD were adjusted to best fit the needs of the study. Table 2-2 summarizes the sub-PADD refinery groupings used

WORLD US Refinery Groupings for DOE Analysis

Groups	Operating Refineries in Group	Total Capacity bpcd	Average W Can Crude as % of Capacity
P1-Coastal/Lo Can	12	1,542,300	n.a.
P1-HiCan	2	76,700	93%
P2-East-LoCan	6	862,000	3%
P2-East-HiCan	7	1,501,650	55%
P2-North	4	484,250	53%
P2-South	8	778,700	6%
P3-GC Mid Med/Swt	10	1,564,112	4%
P3-GC East Med/Swt	4	278,100	4%
P3-GC Mid Sour/Coking	12	3,815,690	3%
P3-GC East Sour/Coking	6	1,456,500	5%
P3-GC West	4	737,050	1%
P3-Small/Inland	14	542,000	n.a.
P4	15	603,000	47%
P5-AK	6	382,175	n.a.
P5-WA	5	623,200	19%
P5-CA/HI Small/Inland/Swt	9	274,500	2%
P5-CA Hvy Sour	11	1,802,525	5%
Total	135	17,324,452	

Note: capacities and active refineries reflect recent definite closures

Note: all WORLD results reporting is by PADD

Table 2-2

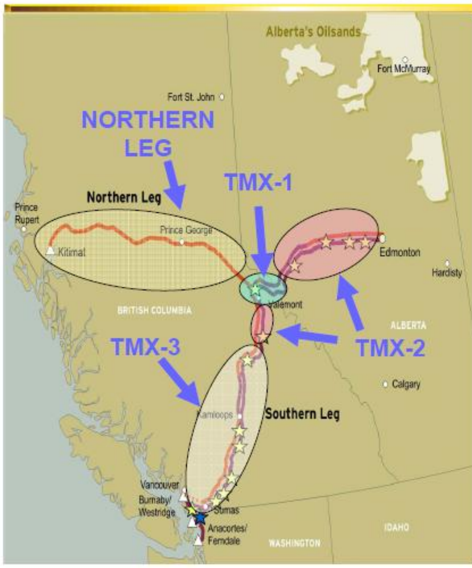
- **Canadian crude export routes, projects, capacities and tariffs**
  - 2009 Canadian crude flows were used as guidelines / basis for forward reference and scenario cases
  - Current and projected Canadian pipeline export routes were reviewed and best estimate start up dates and capacities developed for projects under each Scenario
  - Several sources were reviewed including: CAPP, Enbridge and TransCanada applications to the Canadian NEB, industry, consultant and press reports
  - Factual information on Keystone and KXL was reviewed directly with TransCanada in November. The information confirmed differed slightly from that assumed in WORLD model cases but did not materially alter results
  - Tariff information for the various export routes was taken from CAPP 2010 forecast and from published tariffs.

2.2 Pipeline Projects

The pipeline projects identified and considered in this study were discussed extensively in the main report. Additional diagrams are provided below for several of the projects.

KINDER MORGAN ENERGY PARTNERS, L.P.

Trans Mountain Expansion



Phased Expansion

	Planned Completion	Total Capacity	Estimated Cost
TMX-1 (+75,000)	Nov. 2008	300,000 BPD	$720MM
TMX-2 (+80,000)*	2013/14	380,000 BPD	$1.4B
TMX-3 (+320,000)*	2015/16	700,000 BPD	$2.1B
Northern Leg (+400,000)*	Post TMX-3	1,100,000 BPD	$3.5B

*Pending Shipper support and obtaining necessary permits

8

Figure 2-1

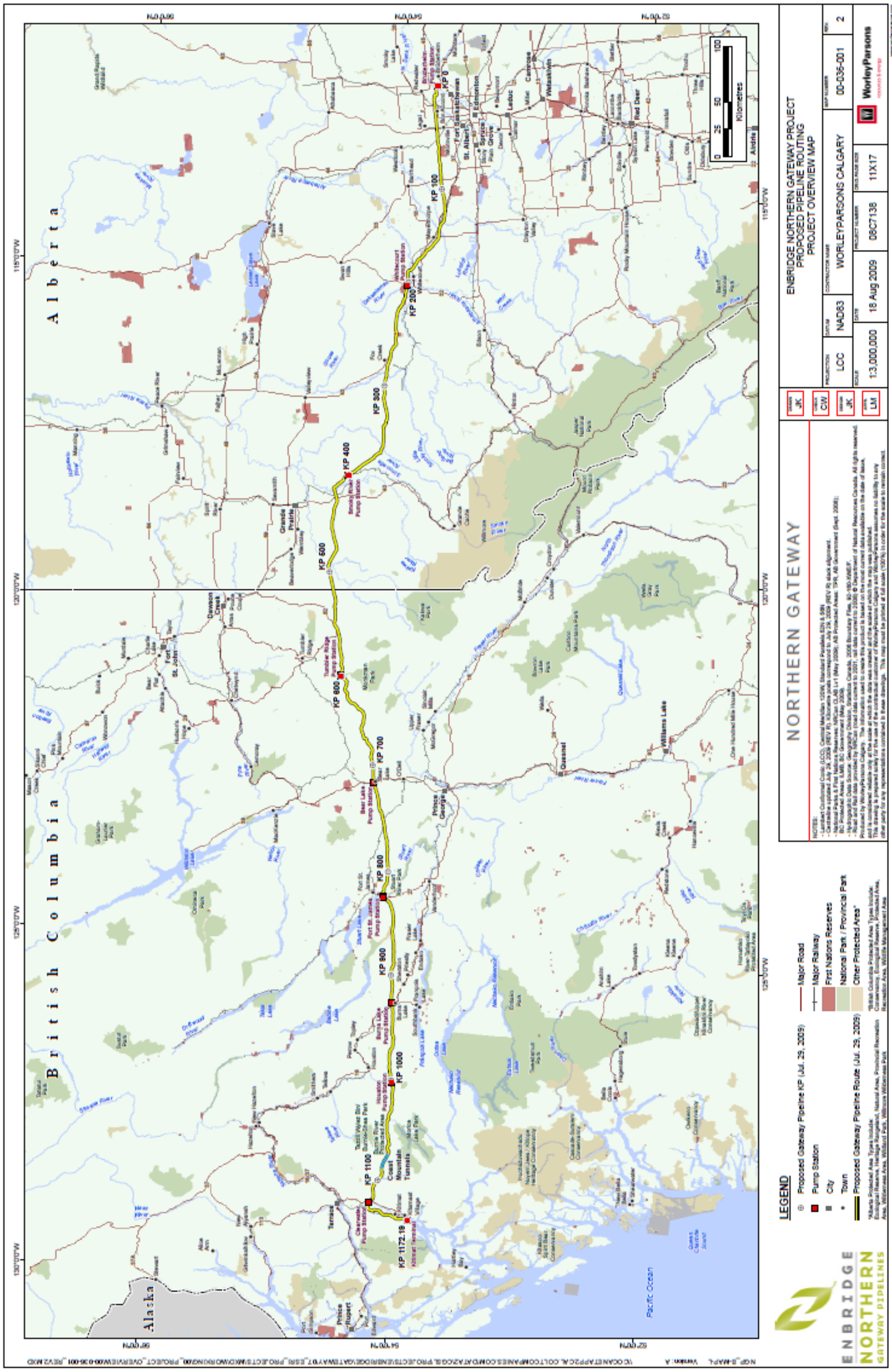

Alberta
British Columbia
Alaska
Pacific Ocean
NORTHERN GATEWAY

Figure 2-2

PAA Bakken North Project & Existing Bakken Area Assets

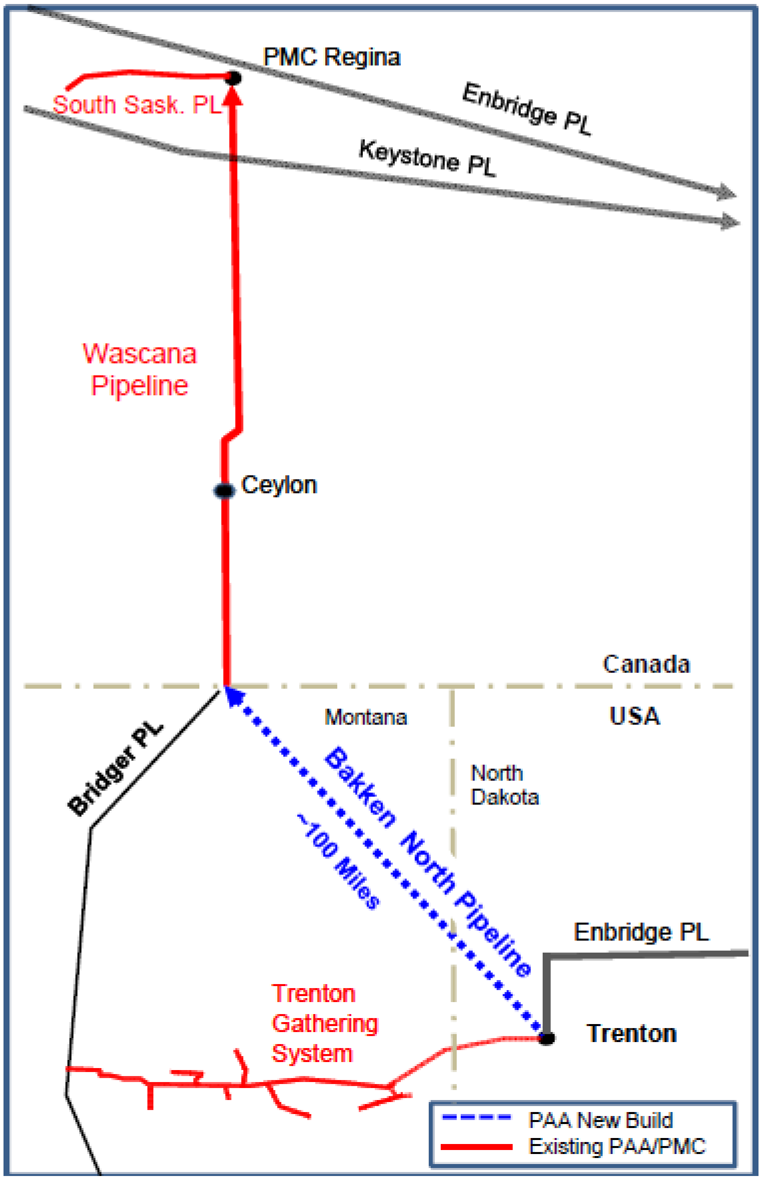


Figure 2-3


TransCanada
In business to deliver
Oil Pipelines
North Dakota
South Dakota
Montana
Minot
Garrison
Washburn
Mandan
Bismarck
Mobridge
Kenmare
Hazen
Beulah
Stanley
Tioga
Crosby
Williston
Watford City
Quintana Proposal
Dickinson
Mott
Lemmon
Hettinger
Bowman
Beach
Little Missouri
Sidney
Belle Fourche
Plains
Baker
Baker Tank Farm
Plentywood
Glendive
Poplar
Butte
Keystone XL
Wolf Point
Miles City
Proposed Marketlink Facilities
Legend
KeystoneXL
True Companies
Quintana Proposal
0
25
50
Miles

Figure 2-4

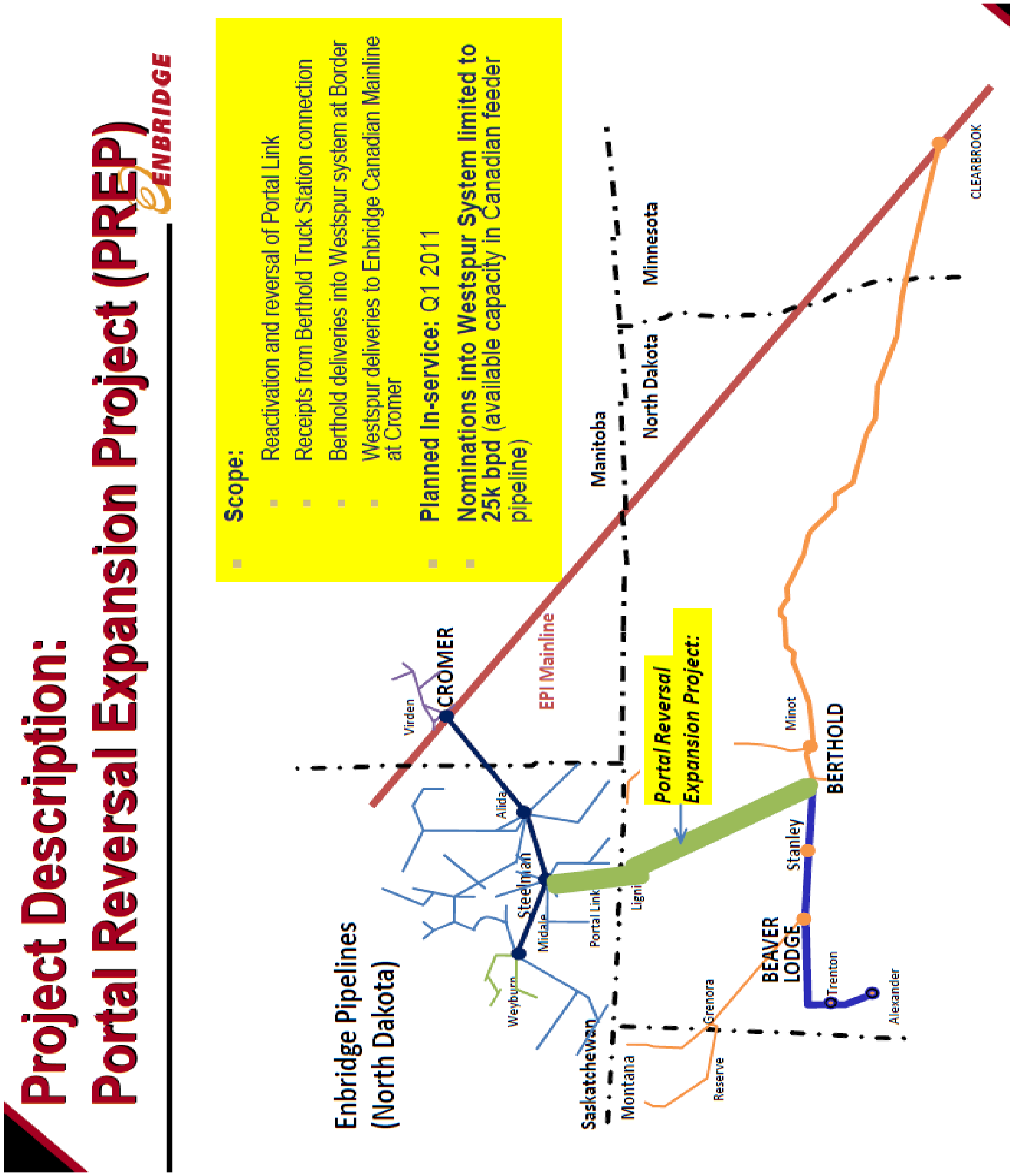

Project Description:
Portal Reversal Expansion Project (PREP)
ENBRIDGE
Scope:
Reactivation and reversal of Portal Link
Receipts from Berthold Truck Station connection
Berthold deliveries into Westspur system at Border
Westspur deliveries to Enbridge Canadian Mainline at Cromer
Planned In-service: Q1 2011
Nominations into Westspur System limited to 25k bpd (available capacity in Canadian feeder pipeline)
Enbridge Pipelines (North Dakota)
CROMER
Virden
EPI Mainline
Manitoba
North Dakota
Minnesota
CLEARBROOK
Portal Reversal Expansion Project:
Minot
BERTHOLD
Stanley
BEAVER LODGE
Trenton
Alexander
Alida
Steelman
Midale
Weyburn
Portal Link
Saskatchewan
Montana
Grenora
Reserve

Figure 2-5

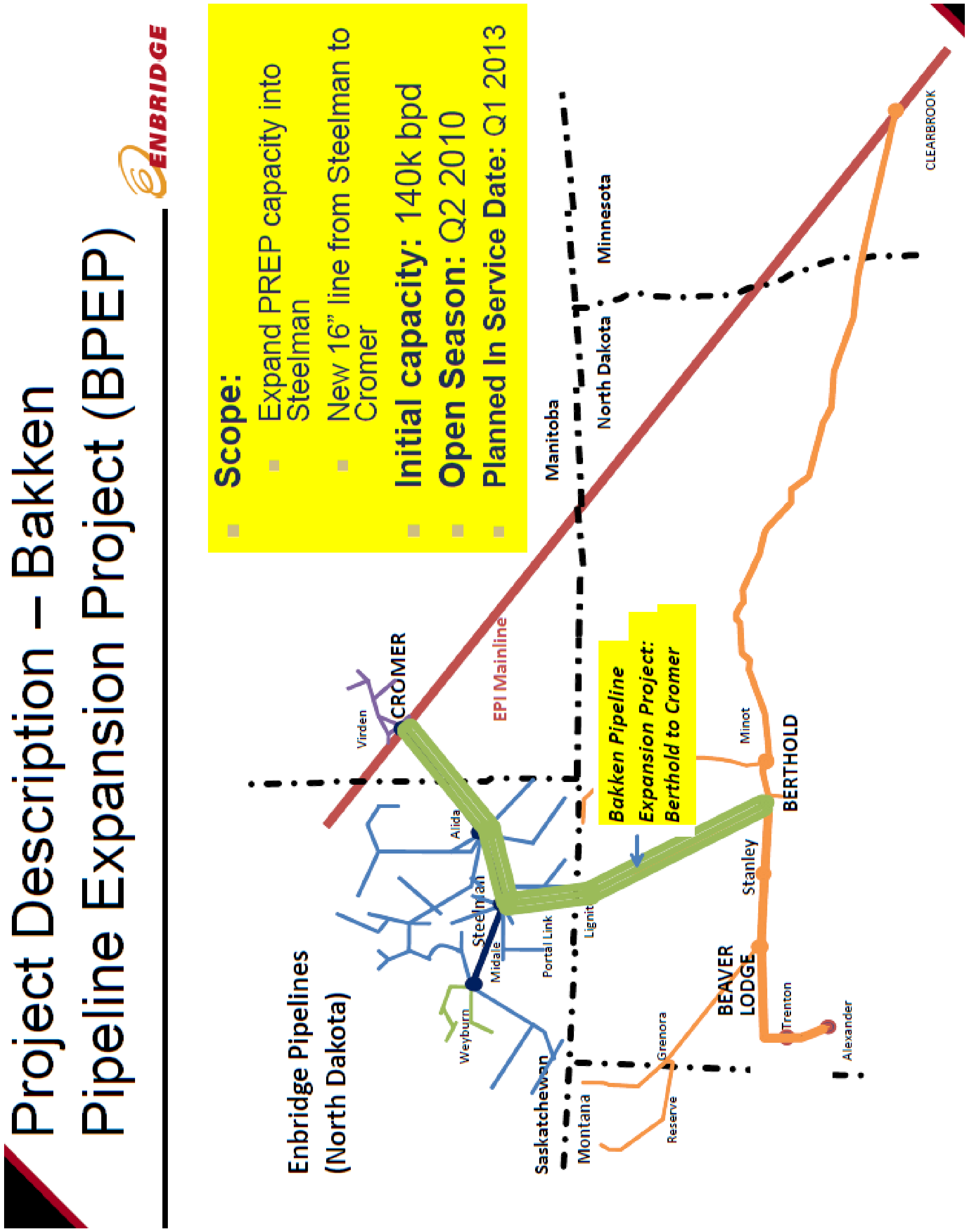


Figure 2-6

Source: Enbridge Pipelines (North Dakota), Ashok Anand, Senior Manager, Petroleum Quality & Service Metrics, COQA Presentation, June 10th2010

2.3 WORLD Model Modifications

A series of specific adjustments was made to the EnSys WORLD model for this study. These included adapting to and setting up the EIA, EPA and CAPP bases described in the previous section but also a series of further detailed adjustments. These were made both at the start of and during the course of the study, based in part on initial case results.

2.3.1 Pipeline Capacities & Routings

Section 3.2 of the main Report provides extensive coverage of the pipeline projects considered in this study. The following notes provide additional selected commentary.

- **Enbridge** plans for line expansions ex ND **Bakken** region were reviewed and updated. The Initial cases already embodied the planned capacity expansions. The expanding crude volumes out of ND via Enbridge Bakken expansions (Figures 2-5 and 2-6) will take up capacity on the EPL Mainline system. Part of the expanded volumes will in fact flow directly east through the line that joins the EPL at Clearbrook, Minnesota, south of the US/Canada border, part will flow north from ND joining EPL in Canada before flowing back into the US, thereby making a double border crossing. This detail was ignored in the EnSys WORLD simulation which had all the expansion effectively staying in the US and joining the EPL in the US.
- **Transmountain** (TM) base line capacity for crude was cut by 30,000 bpd[3] to reflect capacity used for moving products (which are considered to be delivered "locally" in WORLD within the WCan region)
    - The amount of TM capacity used for product was assumed to remain constant i.e. TMX expansions were assumed dedicated to expanding only crude volumes. This is line with Kinder Morgan Canada statements that they would expect expansions to be dedicated to crude not product

2.3.2 Condensate/Diluent Balance

WORLD model set up was adjusted to fully account for the condensate needed for DilBit production.

There is a span of uncertainty between future supply mix of DilBit versus SynBit. Earlier CAPP projections were showing higher proportions of future SynBit production and less DilBit compared to

[3] Product movements on the Transmountain line have been dropping steadily in recent years, dipping below 50,000 bpd in 2010. A flat figure of 30,000 bpd was used across the future modeling horizons.

current projections. Earlier projections also included an expectation that several new upgraders would be built in Western Canada. Further, several years ago, the Enbridge Southern Lights diluent line project did not exist nor did the Enbridge Northern Gateway proposal with its line that would bring diluent in from Asia to WCSB. Thus earlier projections were built on the basis that there would be limited condensate available beyond WCSB production and that there would be significant SCO present for use as diluent (for SynBit).

The EnSys projections for WCSB production were based on 2010 and 2009 CAPP data and related studies. The underlying premise is that significant condensate/diluent volumes will be available (including streams that are recycled) and that, consequently, SynBit will comprise a small proportion of bitumen blends and DilBit a high proportion. DilBit contains typically 25% condensate/naphtha diluent (and SynBit around 50% SCO). CAPP have WCSB condensate production slowly declining from around 157,000 bpd in 2010 to 129,000 bpd in 2030. At 25%, this is sufficient to support an average of around 520,000 bpd of DilBit. The Enbridge Southern Lights pipeline is currently in start-up. This will bring a mix of condensate and refinery naphtha diluents back up from the Chicago area to Hardisty/Edmonton. Initial capacity is 180,000 bpd of which around 80,000 bpd is reported to be committed. The system has been designed to be expandable to 330,000 bpd. Today around 27,000 bpd of condensate is reported as moving into WCSB via rail. This is understood to be coming at least in part from Kitimat via CN Rail. This may continue to move into WCSB. Growing US and shale gas production may also provide additional condensate volumes over time.

Thus, looking ahead to 2030, potential available condensate from within the US and Canada (which may well include recycled volumes via the Southern Lights line) totals around 460,000 bpd, possibly higher allowing for supplies from say Bakken shale and other developing areas. At 25% diluent concentration, this is sufficient to support at least 1.8 million bpd of DilBit and possibly 2 million bpd without resorting to additional condensate supplies. Potential additional sources could include condensates shipped up from the US Gulf Coast and potentially condensates from Asia. The Enbridge Northern Gateway project currently includes a 195,000 bpd diluent line that would run parallel to the WCSB crude line running west to Kitimat and would bring Asian condensate in to WCSB on the tanker “back haul” leg. EnSys’ projection, derived from CAPP data, is for 2.13 million bpd DilBit by 2030. This is therefore not inconsistent with potentially available diluent supplies and transportation systems. Our projection of a relatively small proportion of SynBit (7-10% of total bitumen blends) plus WCS, (which is a SynDilBit blend with some conventional), at 21-33%, thus appears a plausible outlook and one which is consistent with latest WCSB plans for less upgrading and for growth in WCS volumes.

The “condensate balance” was captured in WORLD by subtracting out of supply not only essentially all Western Canadian condensate but also volumes from PADDs 2, 3 and 4 plus supplemental volumes from outside the US, notably Asia. Again, the extent to which raw condensate production is needed versus diluent recycled as refinery naphtha (yielded from the diluent in the DilBit) is uncertain. Some degree of recycling is anticipated and, the higher the degree of recycling, the less the impacts are on “new” condensate diluents that need to be supplied. The assumption that was built in to EnSys' diluent balance was that the proportion of recycling would gradually increase over time.

2.3.3 (Relative) Freight versus Pipeline Costs

In part spurred by the Barr Report for the NPRA[4], the parameters used to escalate real (constant dollar) tanker and pipeline costs over time were reviewed. Two escalation factors were used. A factor based on growth in natural gas prices was used to escalate real (constant dollar) pipeline tariffs, this since pipeline operations use predominantly natural gas and electricity for fuel. A second factor was developed for tanker costs using change in crude oil price, this since marine bunker fuels are derived from crude oil. In both cases the variations in cost of natural gas or crude oil were applied as a power factor well below one to reflect that both transport modes embody other significant cost components. The resulting average annual (real) escalation rate was 0.8% p.a. for pipeline tariffs versus current (2010) levels. For tanker rates, the resulting escalation factors versus 2010 were in the range of 2-3% p.a. for shorter term horizons, leveling out to around 1.3% p.a. 2010 to 2030, driven by EIA's growth profile for crude oil prices (i.e. higher increases in the earlier years). The higher tanker escalation rates, relative to those for pipelines, reflect the higher rate of increase in crude costs relative to natural gas in the EIA AEO 2010. In addition, the escalation in tanker rates reflects anticipated increases over time in marine fuel supply costs resulting from MARPOL AnnexVI with its regulations for progressively tightening sulfur standards[5].

2.3.4 Marine Bunkers Outlook

One outcome of EnSys' work since 2006 with the EPA, API and IMO on marine fuels was the development by team members of rigorous present day consumptions and projections for marine fuels consumption worldwide. These analyses, which have been extensively supported by other experts, show that early 2000's global marine fuels consumption was at a level essentially twice that reported by the IEA (i.e. around 370 mmtpa versus the 140 mmtpa level per the IEA). The data indicate that this is a matter of misreporting of barrels rather than missing barrels, i.e. fuels actually consumed for marine bunkers are reported under other categories. Today, the misreporting has little consequence. However, when projected, the impact on future global oil demand total and mix is important because of the

[4] Low Carbon Fuel Standard "Crude Shuffle" Greenhouse Gas Impacts Analysis, Barr Engineering Company, June 2010

[5] The extent to which future ECA and global emissions standards are met by fuels modification versus via exhaust gas treatment (on-board scrubbing) is still an unknown. EnSys assumed a partial move toward use of lower sulfur fuels.

differences in growth rates between inland and marine heavy (residual/IFO) fuels. The IEA have acknowledged that there is a problem with their statistics. The projections developed by the RTI/Navigistics/EnSys team for the EPA have now been effectively endorsed by the IMO whose own projections are very similar.

Several recent EnSys WORLD studies have been run by first tuning to the "IEA basis" forecast for each future horizon (thus if the EIA's projection for 2015 is say 95 million bpd tuning to match that) and then switching to the "IMO basis" for marine fuels. The further out into the future, the more switching to the IMO basis raises projected global oil demand and the proportion within that of residual / IFO fuels on the basis of no change in marine fuels quality. So the basis to be used must be selected, either IEA or IMO.

In addition, while the MARPOL AnnexVI rules are clear, they leave open major uncertainty on (a) the timing of required conversion of the global standard to 0.5% sulfur and (b) the extent to which compliance may be achieved by either modifying fuels – to 0.1% for ECA fuel and 0.5% for non-ECA areas, in both cases meaning conversion to marine distillates – and/or by employing on-board scrubbing. The latter would allow certainly non-ECA fuels to stay at their current standards.

For the purposes of this study for the DOE, EnSys used the following assumptions regarding marine fuels:

- Marine fuels demand outlook is on the "IEA" basis. Although the "IMO" basis is arguably the more correct, EnSys wished to steer clear of entering into a potential debate around marine fuels and total global demand targets that would be inconsistent with EIA's projections
- Regarding quality / fuel mix:
    - All ECA fuels standards met by fuel use at the 0.1% sulfur standard
    - By 2015, USA/Canada ECA's in operation, in addition to the 2 northern European ECA's
    - By 2020, other additional ECA's in operation but global 0.5% sulfur standard deferred until after 2020
    - By 2025 through 2030, there is progressive increase in the proportion of IFO shifted to marine distillate but this is not total, reflecting that compliance is partly through fuel conversion, partly through scrubbing.

This quality outlook contains significant uncertainty but, EnSys believes, represents a "middle of the road" projection that avoids either of the potential extremes of total scrubbing or total IFO conversion to marine distillate.

2.3.5 EPA Low Demand Outlook

A second "**Low Demand**" outlook was also applied to assess the impacts of a US petroleum outlook entailing much reduced consumption of transport fuels. This was based on a February/March 2010 study by the EPA[6] which involved the examination of "more aggressive fuel economy standards and policies to address vehicle miles traveled". Projections were used from the EPA's Scenario A, leading to reductions in US consumption versus the AEO 2010 outlook starting post 2015 and reaching 1.2 mbd by 2020 and 4.0 mbd by 2030. The US demand reductions are detailed in Table 2-3 while Table 2-4 summarizes key details of both the AEO and Low Demand outlooks.

The AEO and Low Demand outlooks for US demand are compared in Figures 2-7 and 2-8. As can be seen, the impact is predominantly on transport fuels led by a 2.8 mbd reduction in gasoline consumption. Under the AEO outlook, US petroleum demand continues to slowly increase, although associated growth in supply of biofuels under the RFS-2 mandate means projected ex-refinery demand for products is essentially flat. Under the Low Demand outlook, a marked reduction in US demand begins to take hold after 2015 and continues through 2030.

Since WORLD comprises an integrated global approach, the impacts of the projected reduction in US demand on the global supply system were estimated using the Department of Energy's ETP model as applied by Brookhaven National Laboratory. US demand reduction was taken to cut world oil price which in turn led to small increases in oil demand in non-US regions. The effects are summarized in Table 2-4. The net global oil demand reduction in 2030 was 3.7 mbd. On the supply side, ETP projections were for the reduction to be met primarily by cuts in OPEC crude production, notably from the Middle East; further that there would be small reductions in US, Canadian and other non-OPEC supplies, including those for biofuels. As indicated in Table 2-4, total Canadian oil production was projected to be cut by 0.2 mbd by 2030, principally oil sands streams.

Total Liquids Demand Reductions

million bbl/d oil equivalent

	2010	2015	2020	2025	2030
Gasoline	0.000	0.176	0.831	1.810	2.765
Distillate	0.000	0.001	0.120	0.223	0.460
Jet Fuel	0.000	0.095	0.190	0.380	0.760
Fuel oil	0.000	0.000	0.006	0.011	0.023
Other	0.000	0.000	0.005	0.009	0.018
Total	**0.000**	**0.272**	**1.152**	**2.433**	**4.027**

Table 2-3

[6] EPA Analysis of the Transportation Sector, Greenhouse Gas and Oil Reduction Scenarios, February 10, 2010, last updated March 18, 2010, in response to September 2009 request from Senator Kerry.

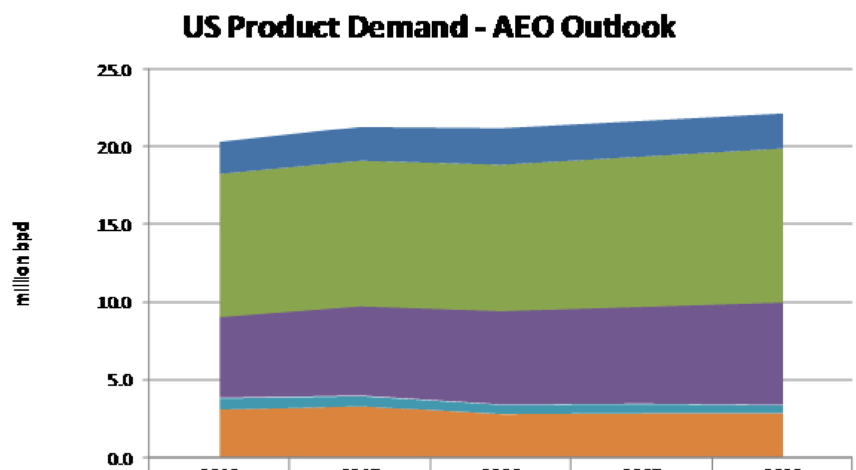
Summary of AEO and Low Demand Projections

	AEO Outlook (6)			**Low Demand Outlook** (7)		
	2010	2020	2030	2010	2020	2030
World oil price $/bbl (1)	$ 67.40	$ 98.14	$ 111.49	$ 67.40	$ 96.80	$ 107.00
Liquids demand						
million bpd						
USA (50 states)	19.2	20.6	21.5	19.2	19.4	17.5
Canada	2.3	2.4	2.5	2.3	2.4	2.6
other OECD (2)	24.8	25.7	25.8	24.8	25.7	25.9
China	8.5	12.4	15.8	8.5	12.4	15.8
other non-OECD	31.0	34.6	40.3	31.0	34.7	40.4
Global	85.9	95.6	105.9	85.9	94.5	102.2
Canada crude oil supply (3)						
Conventional (4)	1.10	0.82	0.54	1.10	0.80	0.51
Oil Sands (5)	1.73	3.22	4.42	1.73	3.15	4.25
Total	2.83	4.04	4.96	2.83	3.95	4.76

Notes:

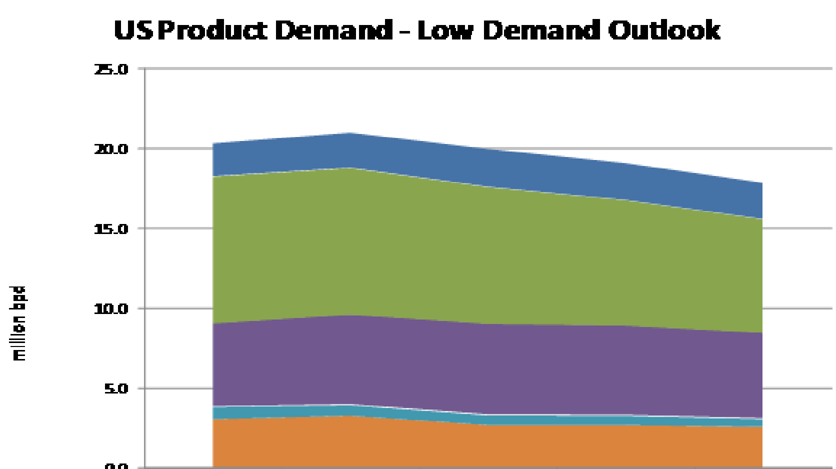
1. World oil price taken as price of US imported crude oil. Values are constant dollars $ 2008
2. Comprises: Mexico, Europe, Japan, South Korea, Australia, New Zealand
3. Projections to 2025 taken from CAPP 2010 Report Growth projection, 2030 estimates via extrapolation
4. Include both Western and Eastern Canada
5. Comprises blended / upgraded supply streams to market not raw production
6. Basis EIA Annual Energy Outlook 2010 Reference Case
7. Basis EPA Analysis of the Transportation Sector, Greenhouse Gas and Oil Reduction Scenarios, February 10, 2010, last updated March 18, 2010

Table 2-4



	2010	2015	2020	2025	2030
LPG	2.0	2.2	2.4	2.3	2.3
Gasoline/E85	9.2	9.3	9.4	9.6	9.9
Jet/ Distillate	5.2	5.8	6.0	6.2	6.6
Residual Fuel	0.8	0.7	0.6	0.6	0.6
Other	3.1	3.3	2.8	2.8	2.8

Figure 2-8



	2010	2015	2020	2025	2030
LPG	2.0	2.2	2.3	2.3	2.3
Gasoline/E85	9.2	9.2	8.6	7.8	7.1
Jet/ Distillate	5.2	5.7	5.7	5.7	5.4
Residual Fuel	0.8	0.7	0.6	0.6	0.5
Other	3.1	3.3	2.7	2.7	2.6

Figure 2-7

3 WORLD Model Results

Set out below is the full suite of results from WORLD 2030 cases showing the impacts of different pipeline scenarios on WCSB crude oil routings into Canadian refineries, US refineries by PADD and Asia; also total non-Canadian crude and product imports and total Middle Eastern crude imports.

Figure 3-1 shows flows for 2009 as a point of reference. Charts are then presented in pairs putting together results from corresponding scenarios under respectively AEO (reference) and Low Demand (EPA) outlooks. Figures 3-2 and 3-3 show the AEO and Low Demand 2030 results for the KXL scenario which was used as a central or reference scenario. Circles and arrows on the charts, plus associated comments, highlight significant changes versus the KXL AEO outlook case.

Western Canadian Crude Oil

Supply and Consumption 2009

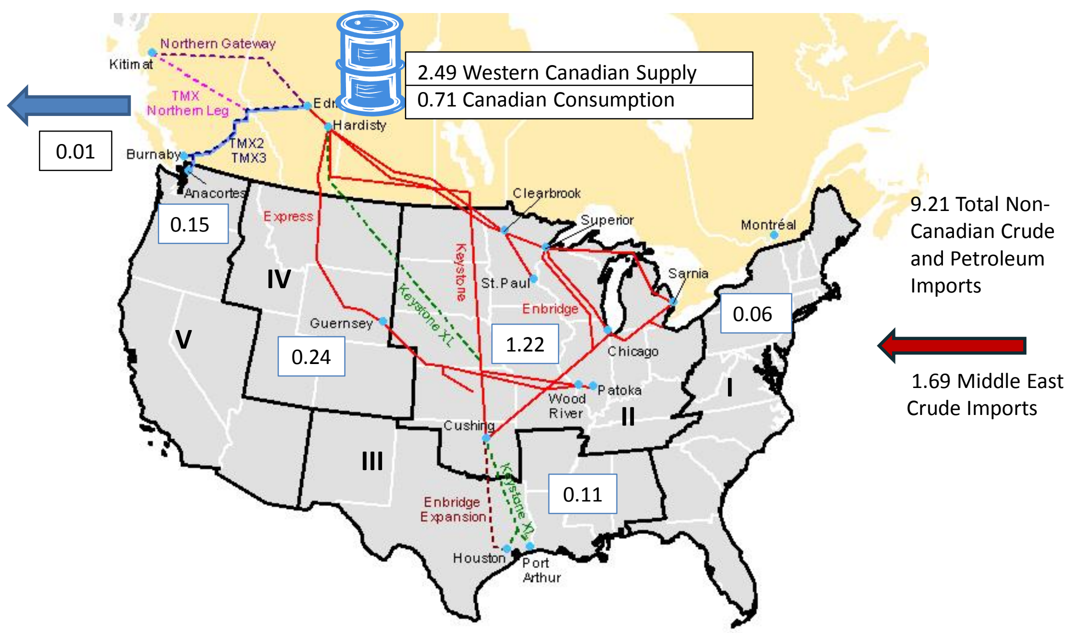


Figure 3-1

Reference Outlook

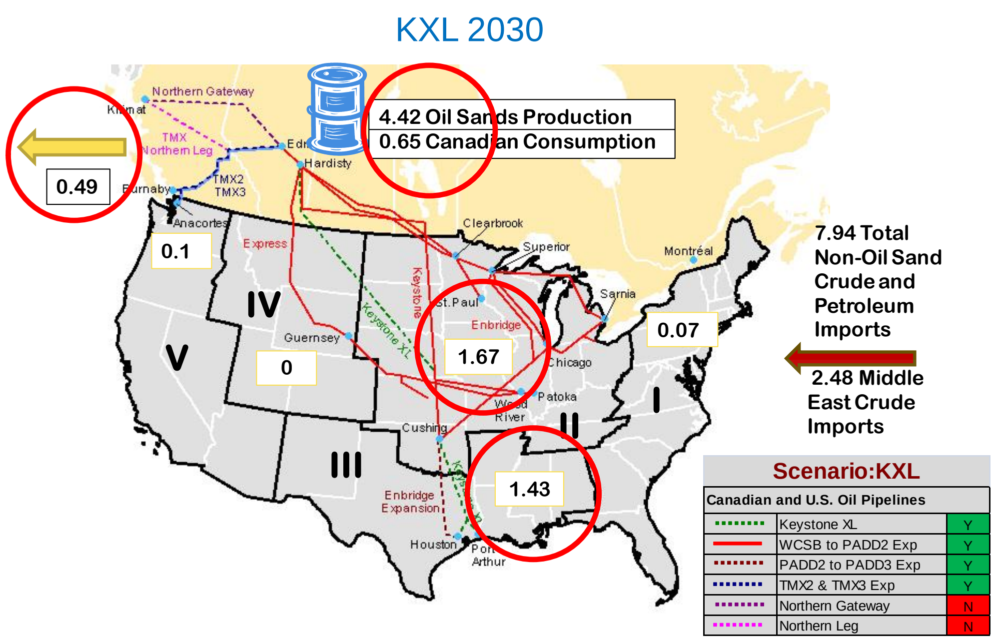


Figure 3-2

Low Demand Outlook

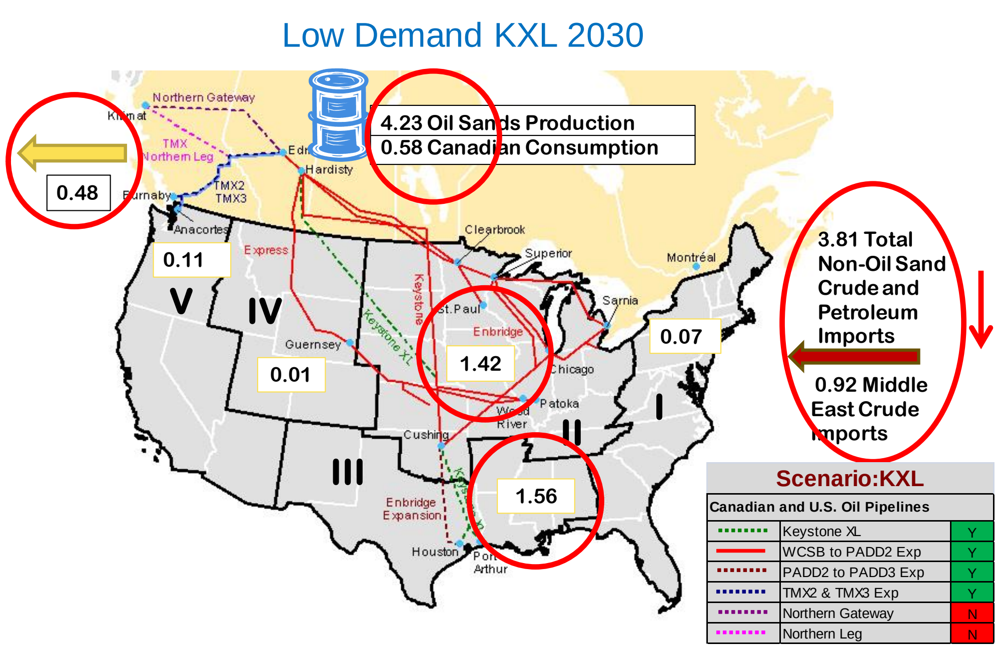


Figure 3-3

The AEO versus Low Demand KXL results highlight that there is some redistribution of WCSB oil sands streams between PADD2 and PADD3 between the two demand outlooks but that total WCSB oil sands imports into the USA remain almost unchanged. Under Low Demand, WCSB oil sands intake into PADD2 is lower, because of the reduced demand in the region. PADD3 refineries process more WCSB oil sands under Low Demand. Product demand in PADD3 is also reduced, as it is across the whole of the USA, but – with no change in line capacity to take WCSB crudes to Asia – essentially the volumes PADD2 can no longer economically handle are processed in PADD3, backing out crudes from the Middle East and other non-Canadian sources.

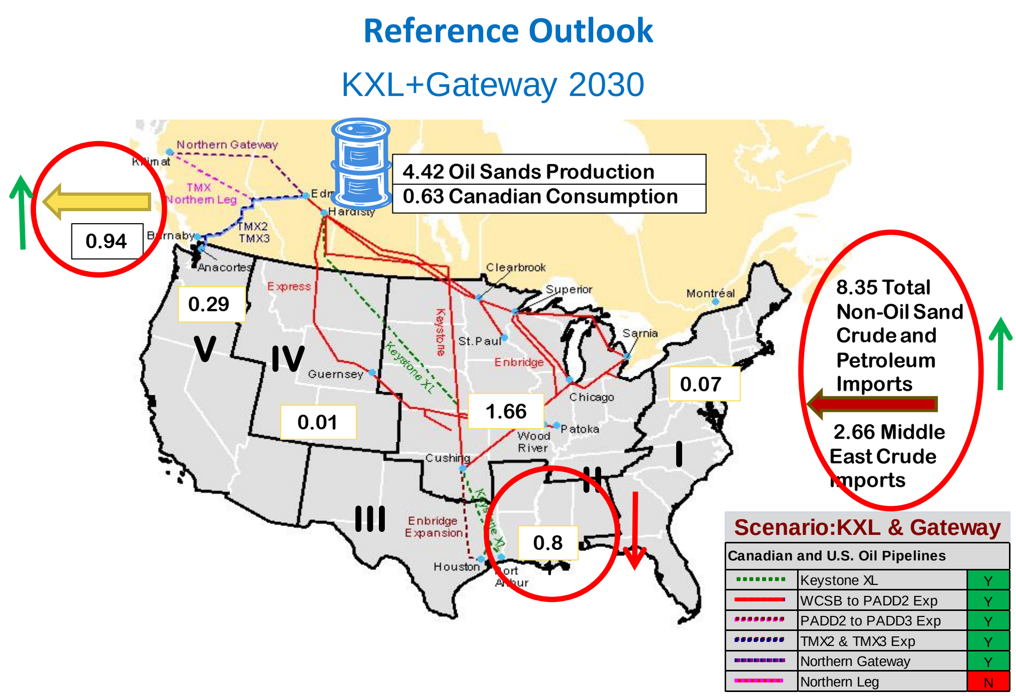


Figure 3-4

Scenario: Keystone XL + Gateway; Adding the Northern Gateway expansion increases exports to Asia by about 0.5 mbd at the expense of exports to U.S. PADD 3. Total US non oil sand crudes and product imports increase by close to 0.4 mbd.

Low Demand Outlook

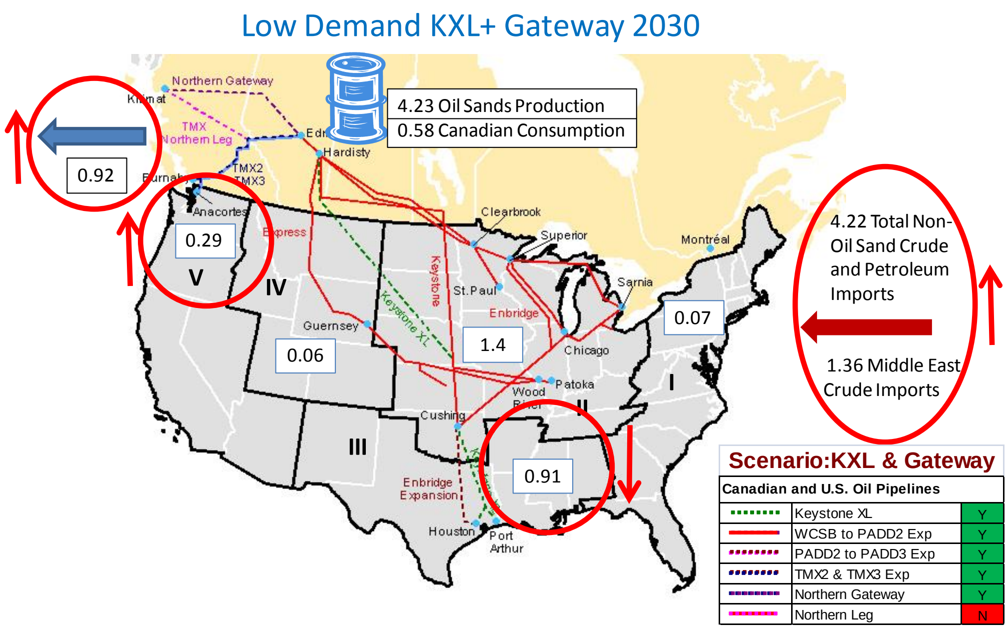


Figure 3-5

Scenario: Low Demand Keystone XL + Gateway; Adding the Northern Gateway expansion increases exports to Asia by about 0.5 mbd at the expense of exports to U.S. PADD 3 relative to the Low Demand KXL scenario. Total US non oil sand crudes and product imports increase by 0.4 mbd. The impacts in terms of import/export changes are the same as in the AEO demand scenarios.

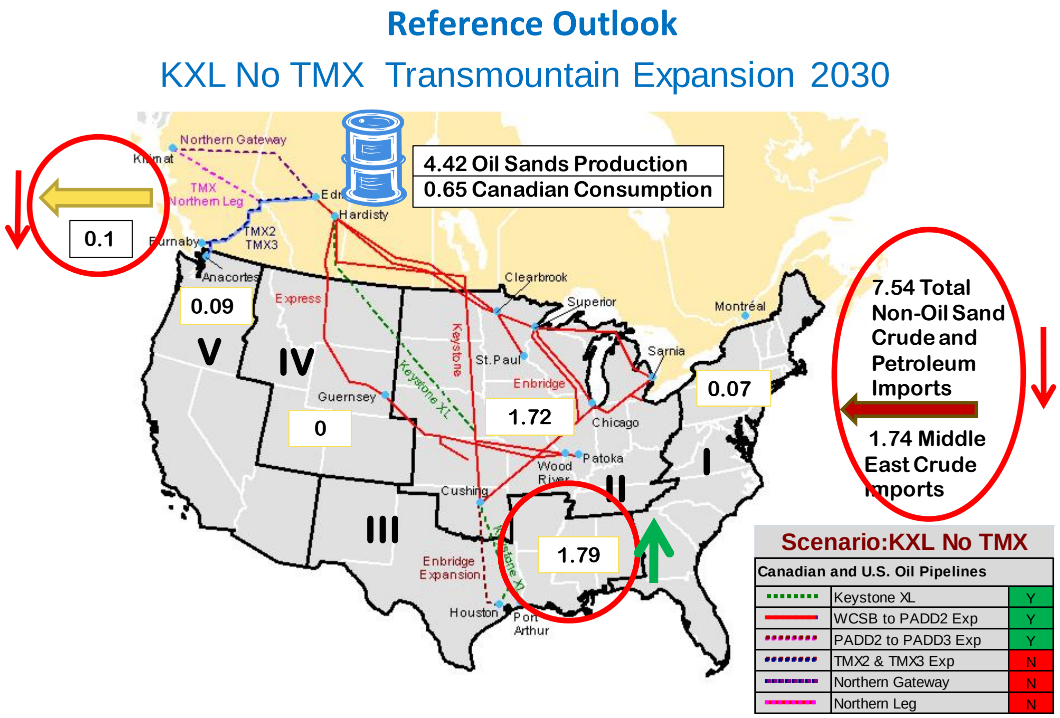


Figure 3-6

Scenario: Keystone XL + No TMX Exp; Asian exports do not increase above today’s limited levels. Versus the KXL scenario, they are diverted primarily to U.S. PADD 3 by about 0.4 mbd. Middle East crude imports to U.S. decline.

Low Demand Outlook

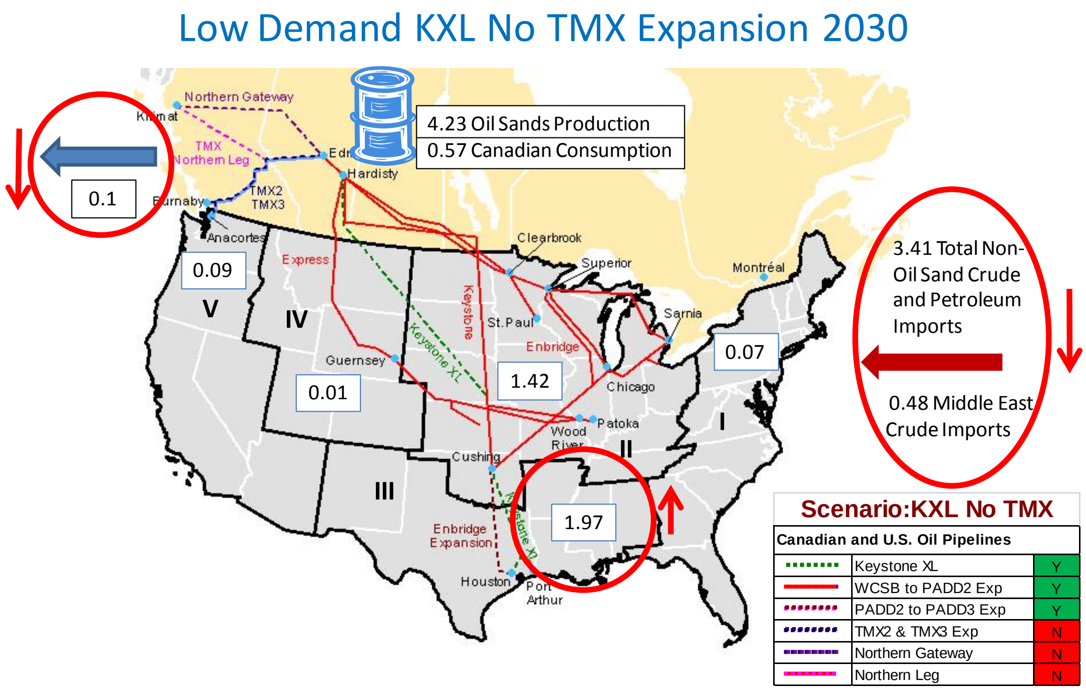


Figure 3-7

Scenario: Low Demand Keystone XL No TMX Exp; Asian exports are diverted primarily to U.S. PADD 3 by about 0.4 mbd. Middle East crude imports to U.S. decline. Results are the same as for the AEO demand scenario above.

Reference Outlook

No KXL 2030

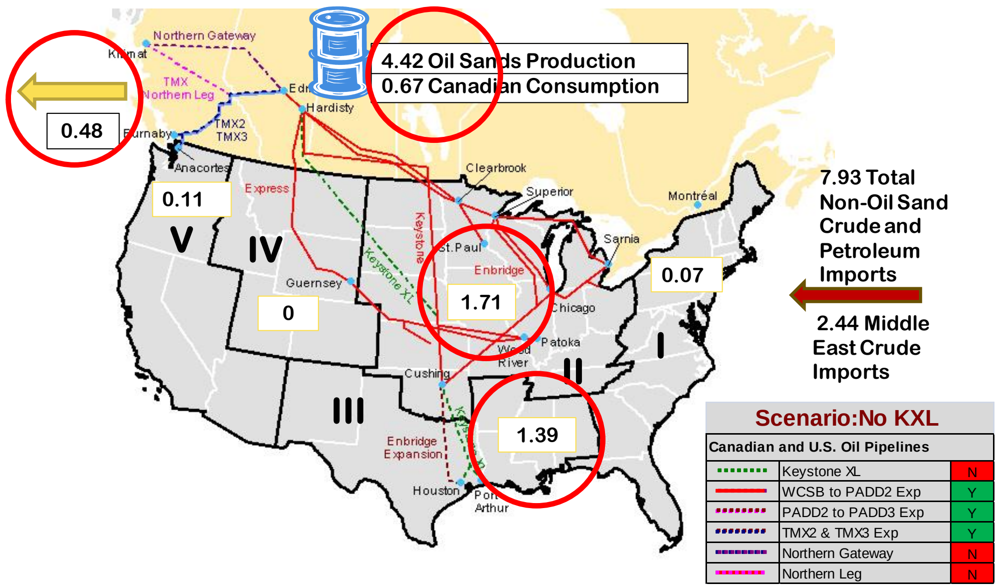


Figure 3-8

Scenario: No Keystone XL; Minimal impact relative to the KXL scenario, existing pipeline capacity expands to accommodate exports of oil sands to U.S. resulting in crude oil flows very similar to those under KXL.

Low Demand Outlook

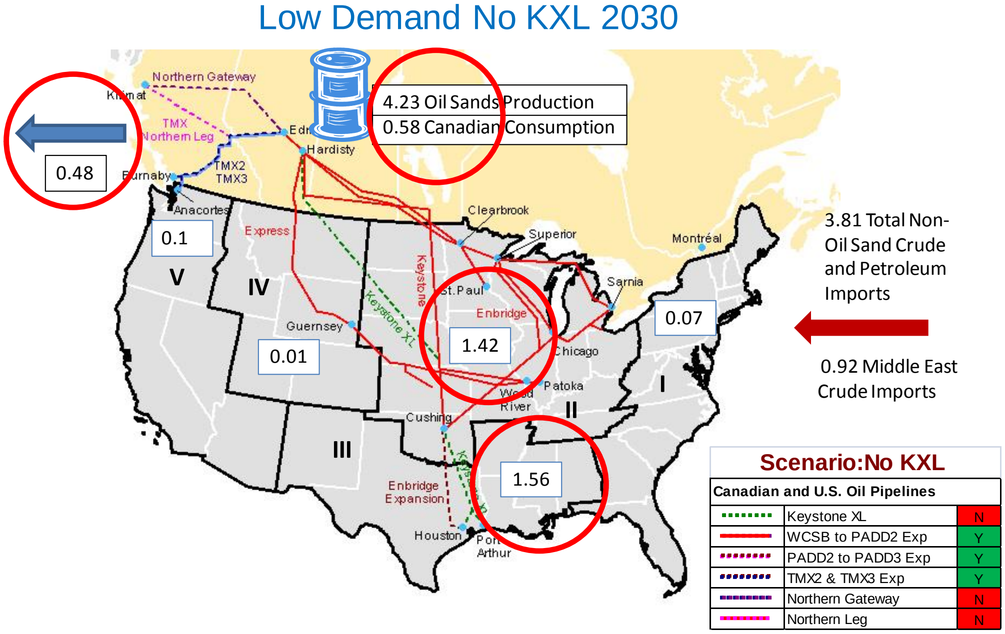


Figure 3-9

Scenario: Low Demand No Keystone XL; Minimal impact relative to the Low Demand KXL scenario, existing pipeline capacity expands to accommodate exports of oil sands to U.S.

Reference Outlook

No KXL Hi Asia 2030

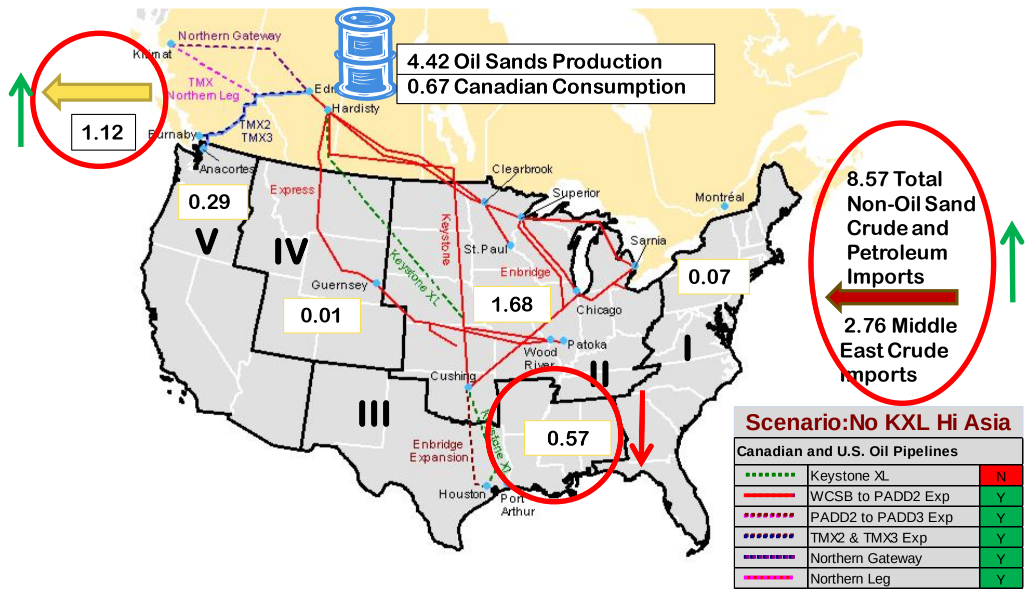


Figure 3-10

Scenario: No Keystone Hi Asia; Exports of oil sands crudes to Asia reach levels over 1 mbd at the expense of exports to U.S. PADD 3. Total petroleum and Middle Eastern crude imports to the U.S. increase. Preliminary WORLD cases showed that WCSB exports to Asia could go higher if pipeline capacity to the BC coast were available.

Low Demand Outlook

Low Demand No KXL Hi Asia 2030

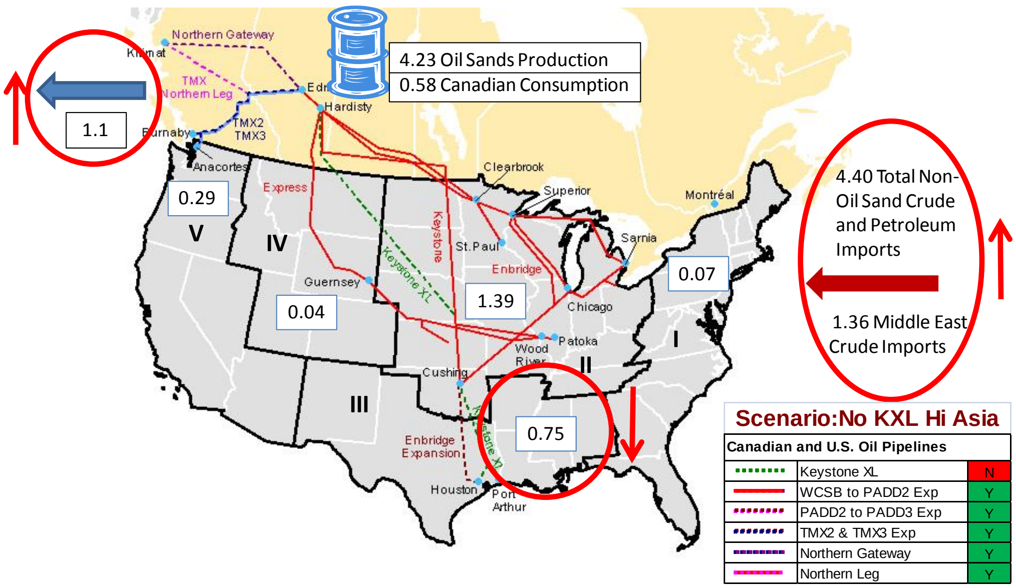


Figure 3-11

Scenario: Low Demand No Keystone Hi Asia; Additional exports of oil sands crudes to Asia at the expense of exports to U.S. PADD 3. Total petroleum and Middle Eastern crude imports to the U.S. increase.

Reference Outlook

No Expansion 2030

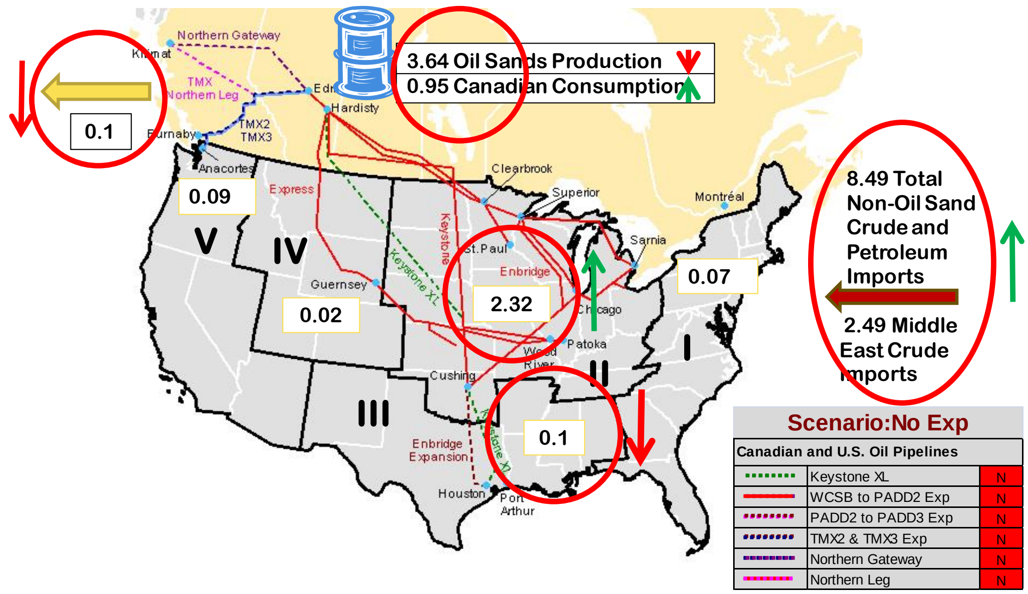


Figure 3-12

Scenario: No Expansion; Oil sands production declines by 0.75 mbd, Canadian consumption and exports to PADD 2 increase to make maximum use of existing available pipeline capacities. Canadian exports of oils sands to Asia and U.S. PADD 3 decline significantly. Total petroleum and Middle Eastern Crude imports to the U.S. increase. This is the only scenario where oil sands production declines significantly.

Low Demand Outlook

Low Demand No Expansion 2030

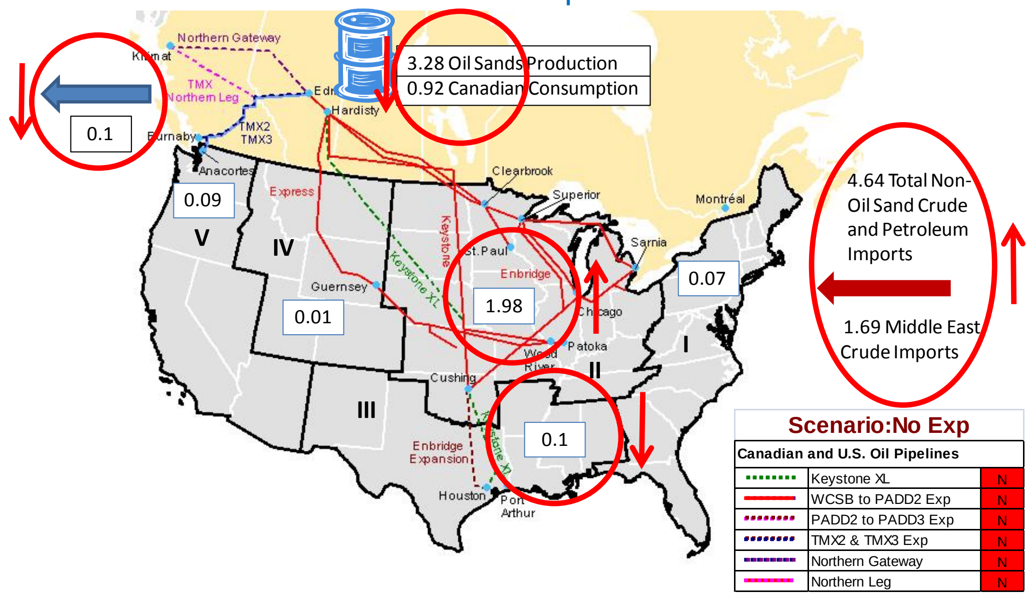


Figure 3-13

Scenario: Low Demand No Expansion; Oil sands production declines by 0.95 mbd, Canadian consumption and exports to PADD 2 increase. Canadian exports of oils sands to Asia and U.S. PADD 3 decline significantly. Total petroleum and Middle Eastern Crude imports to the U.S. increase. This is the only low demand scenario where oil sands production declines significantly.

Reference Outlook

No Expansion, Except PADD II to PADDIII and TMX 2030

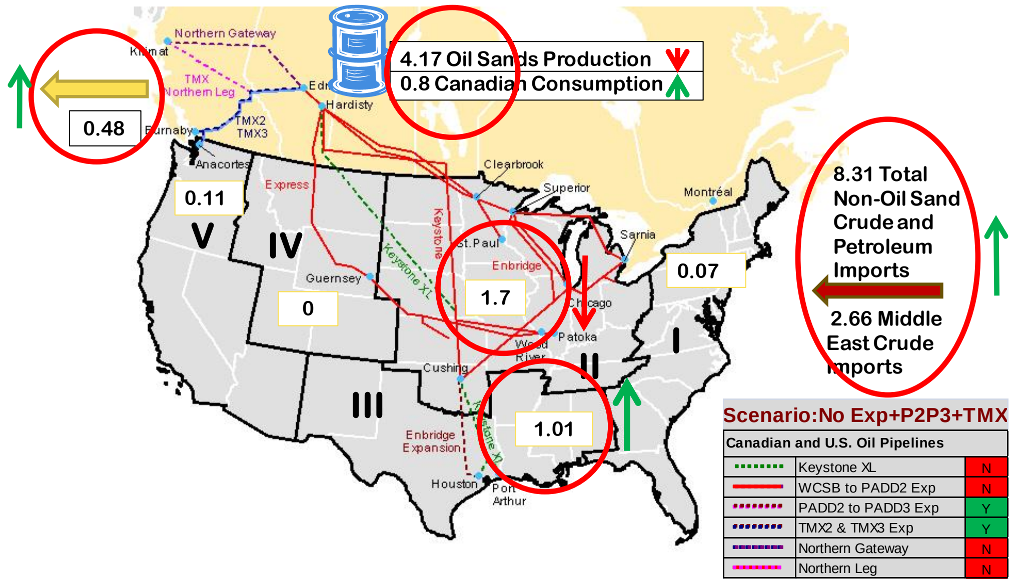


Figure 3-14

Scenario: No Expansion +P2P3 + TMX; Relative to the full No Expansion scenario oil sands production increases 0.6 mbd. As a result oil sands output is only cut slightly (by 0.17 mbd) versus the assumed full production level of 4.42 mbd. Versus No Expansion, exports of oil sands are shifted from U.S. PADD 2 and Canadian consumption to Asia and U.S. PADD 3, i.e. dispositions are closer to those obtaining under the KXL scenario. Total non oil sand crudes imports drop slightly versus No Expansion and increase slightly versus KXL scenario.

Low Demand Outlook

Low Demand
No Exp Except PADD II/PADDIII and TMX Expansion 2030

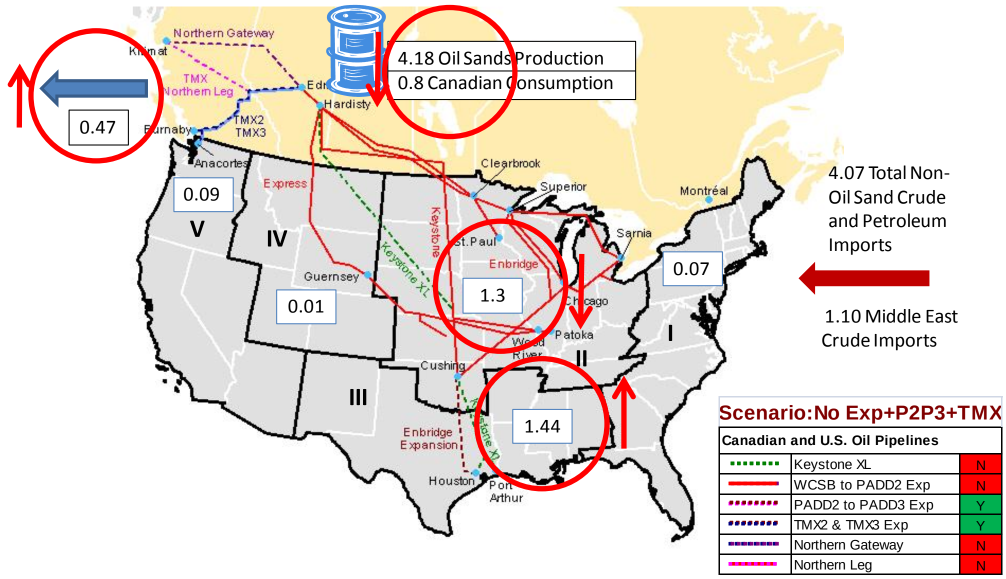


Figure 3-15

Scenario: No Expansion +P2P3 + TMX; Relative to the low demand No Expansion scenario oil sands production increases 0.9 mbd such that reduction versus projected full production is minor. Versus No Expansion, exports of oil sands are shifted from U.S. PADD 2 to Asia and U.S. PADD 3. Total non oil sand crudes imports decline appreciably versus No Expansion and increase slightly versus KXL.

4 Estimated Life-Cycle Carbon Emissions

The WORLD model does not contain endogenous lifecycle analysis (LCA) of GHG emissions. Brookhaven National Laboratory (BNL) used the DOE version of the Energy Technology Perspective (ETP) model to evaluate the global changes in LCA GHG emissions for the Keystone XL analysis scenarios, following the methodology and lifecycle GHG assumptions used to evaluate the indirect impacts of GHG emission from changes in petroleum product consumption in the RFS2.[7] The ETP was calibrated to replicate the WORLD model petroleum market results and then calculated the LCA GHG emissions for each scenario. The ETP model is a MARKAL-based model that was developed by the International Energy Agency and was modified and updated for DOE[8],[9]. It is a partial equilibrium model that incorporates a representation of the physical energy system and represents the flow of energy carriers through the energy infrastructure from the resource base through the various energy conversion technologies to the end-user.

The DOE ETP model consists of fifteen world regions. These are broken out as: United States; Canada, Mexico; IEA Europe; Japan; South Korea; Australia/New Zealand; Central and South America; Eastern Europe; Former Soviet Union; Middle East; China; India; Other Developing Asia; and Africa. The model runs through 2050 in five year increments, though only results through 2030 were displayed to remain consistent with the EnSys modeling. While all major energy sources are covered, including coal, oil, natural gas, nuclear power, and renewable energy, the purpose of this study was to isolate the impact of various petroleum market perturbations resulting from the analyzed scenarios on total worldwide transportation sector greenhouse gas emissions.

THE DOE ETP model GHG emissions changes were determined using the LCA values consistent with EPA's Renewable Fuel Standard Program (RFS2) Final Rule. Lifecycle GHG emissions for transportation fuels may be grouped into five general areas: material acquisition, raw material transport, liquid fuel production, product transport and vehicle operation.[10] Changes in upstream emissions (comprising the first two categories listed above) were calculated across scenarios using the modeled feedstock production changes from ETP and emissions factors for various crude oils as established by EPA.

Because ETP aggregates countries into regions for modeling simplicity, emissions accounting for regions was estimated by taking the average LCA GHG emissions for crude oils produced in the countries in each region. For example, upstream values for crudes produced from Africa were estimated by taking the

[7] Petroleum Indirect Impacts Analysis (February 1, 2010), EPA-HQ-OAR-2005-0161-3156
[8] IEA, 2006. Energy Technology Perspectives 2006. Organisation for Economic Cooperation and Development (OECD)/IEA, Paris, France.
[9] IEA, 2008. Energy Technology Perspectives 2008. OECD/IEA, Paris, France.
[10] DOE/NETL, An Evaluation of the Extraction, Transport and Refining of Imported Crude Oils and the Impact on Life Cycle Greenhouse Gas Emissions, March 27, 2009, DOE/NETL-2009/1362

average of the values for Nigeria, Angola, and Algeria. Table 4-1 shows the upstream GHG emission factors by region. Given the focus of this study, Canadian oil sands were treated separately from the rest of their geographic region. Downstream GHG emissions, including refining and combustion, were calculated endogenously.

Upstream Oil Production Lifecycle GHG Emissions (kg CO2e / mmBtu LHV)

	Crude oil	Bitumen
Africa	16.5	
Australia	6.0	
Canada	5.7	20.8
China	9.9	
Central and South America	7.0	18.3
Non-OECD Europe	6.2	
Former Soviet Union	8.0	
India	10.0	
Japan	6.0	
Middle East	6.5	
Mexico	8.4	
Other Developing Asia	10.0	
South Korea	-	
United States	5.7	
OECD-Europe	6.2	

Note: While not technically upstream, the values above include 0.8 kg CO2e/million Btu for all feedstocks to reflect transportation of products not otherwise accounted for in the ETP model.

Source: Personal Communication from EPA "Crude Oil LCAs for ETP" dated 2 October 2009.

Table 4-1

Results may be seen in Figures 4-1 through 4-12. Overall transportation sector emissions in 2030 were projected to be 10,400 mtpa in the Low Demand scenario and 11,100 mtpa CO2e in the AEO Base Case. Only in the No Expansion scenarios were changes in the world GHG emissions greater than 20 mtpa (0.2%). In the other scenarios, reductions in domestic GHG emissions were balanced by GHG increases in the rest of the world. In particular, the No KXL vs KXL scenario shows changes at the limits of modeling precision.

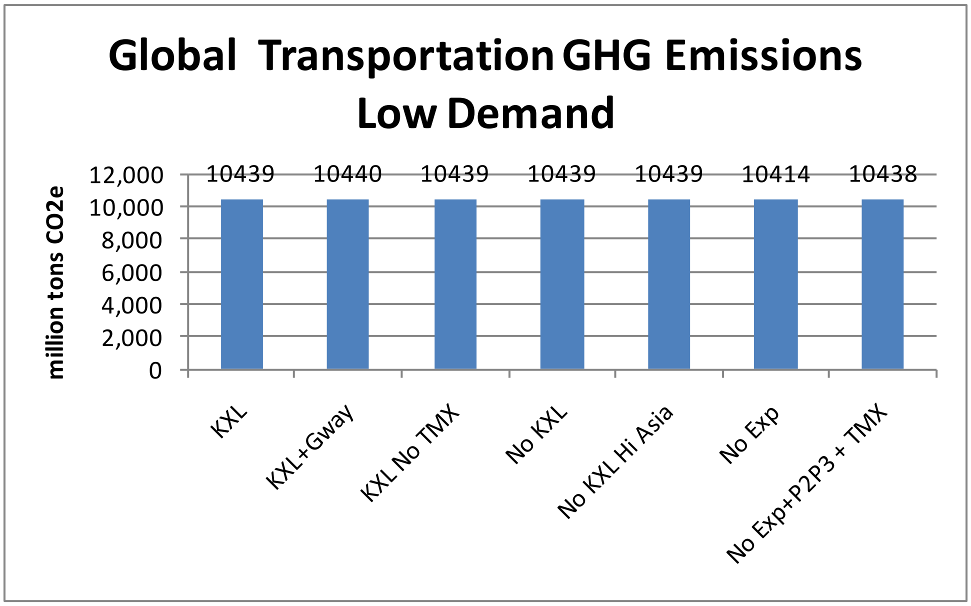


Figure 4-1

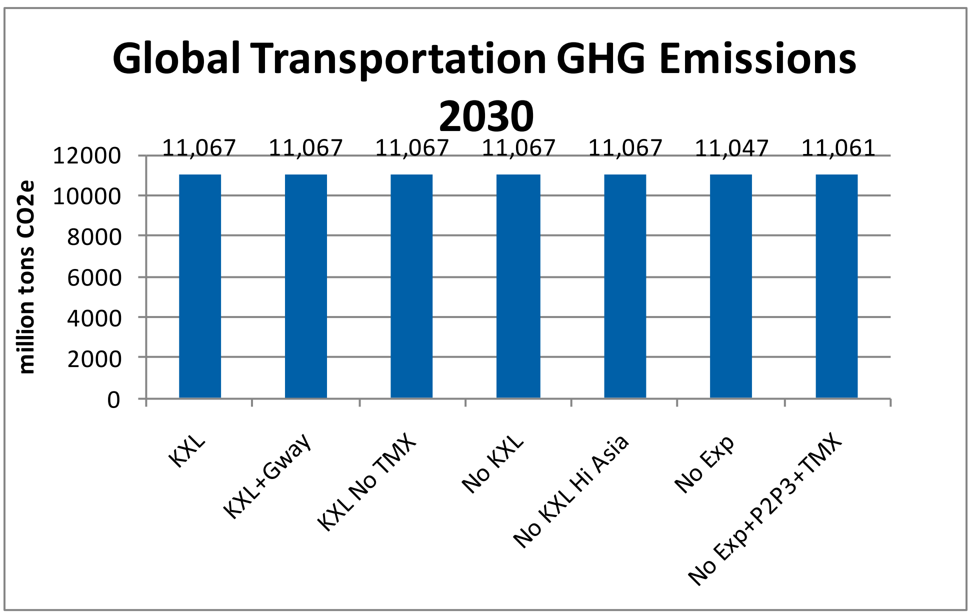
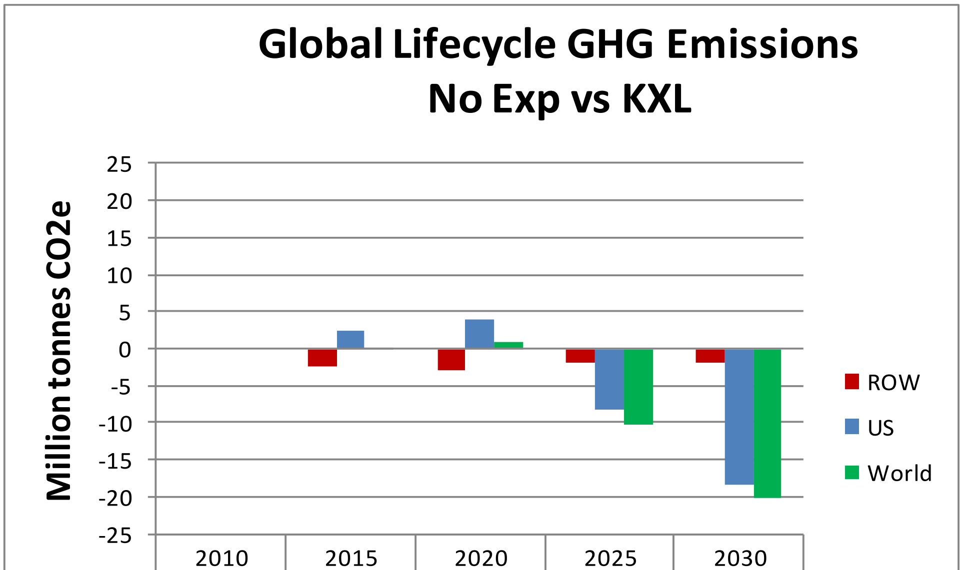
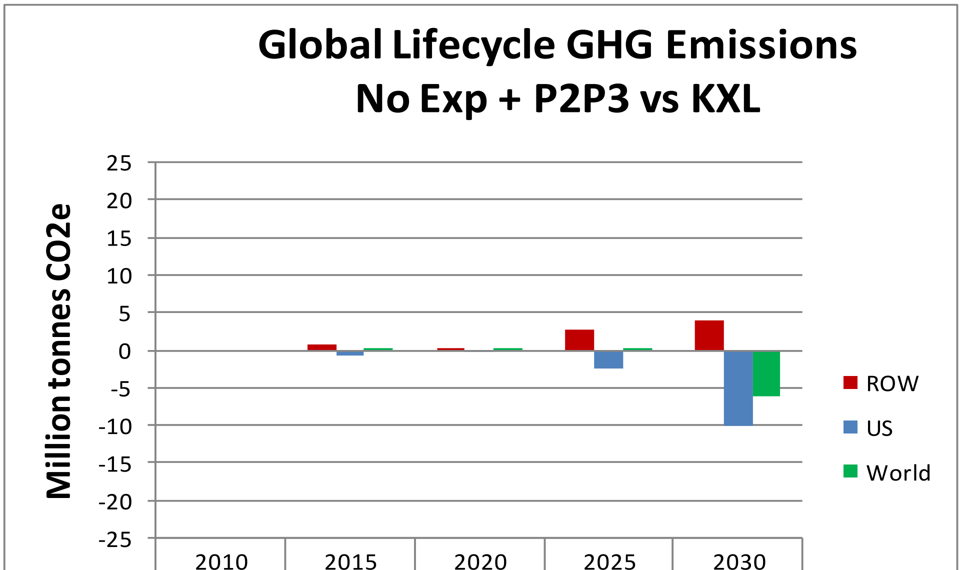


Figure 4-2



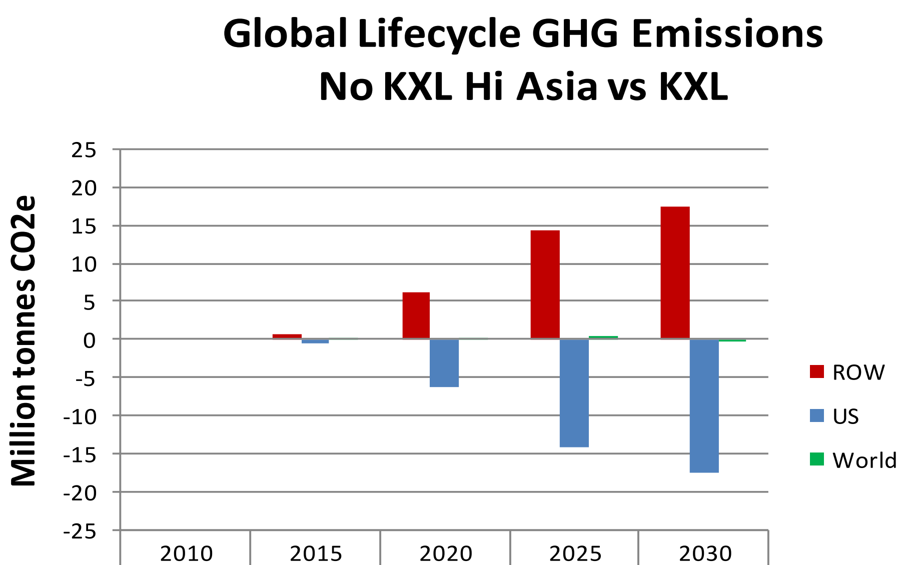
	2010	2015	2020	2025	2030
ROW	0.0	(2.5)	(2.9)	(1.9)	(1.8)
US	0.0	2.5	3.8	(8.3)	(18.4)
World	0.0	0.0	0.9	(10.2)	(20.2)

Figure 4-3



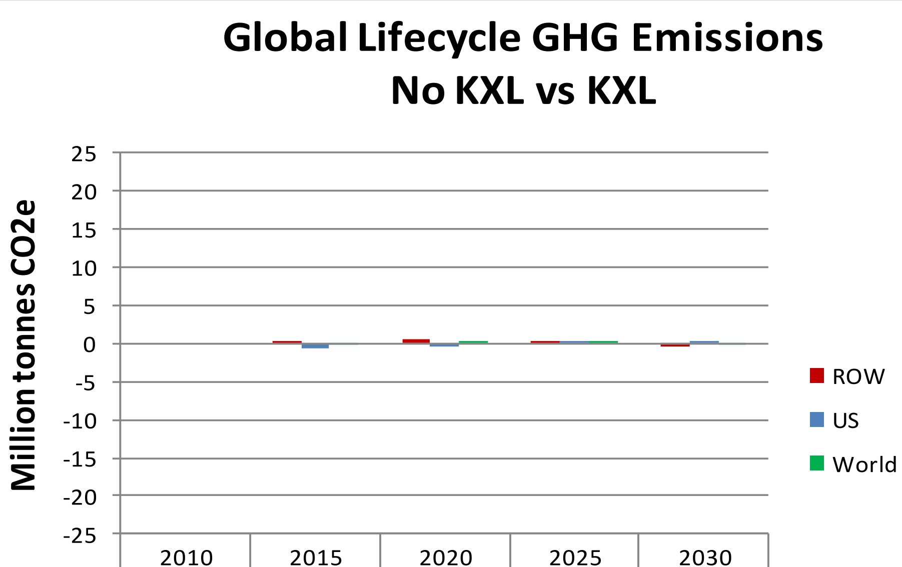
	2010	2015	2020	2025	2030
ROW	0.0	0.7	0.3	2.6	4.1
US	0.0	(0.6)	(0.2)	(2.5)	(10.2)
World	0.0	0.1	0.2	0.1	(6.1)

Figure 4-4



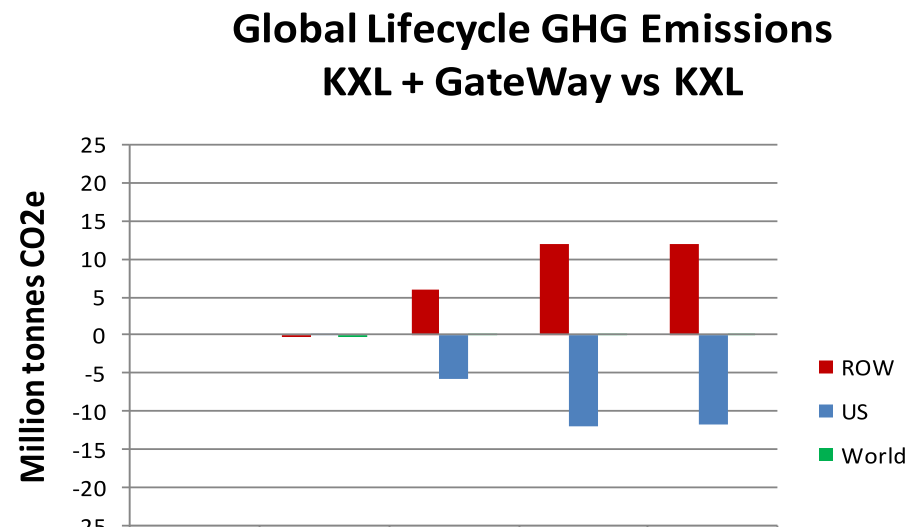
	2010	2015	2020	2025	2030
ROW	0.0	0.6	6.3	14.4	17.4
US	0.0	(0.5)	(6.3)	(14.1)	(17.6)
World	0.0	0.1	0.0	0.3	(0.2)

Figure 4-5



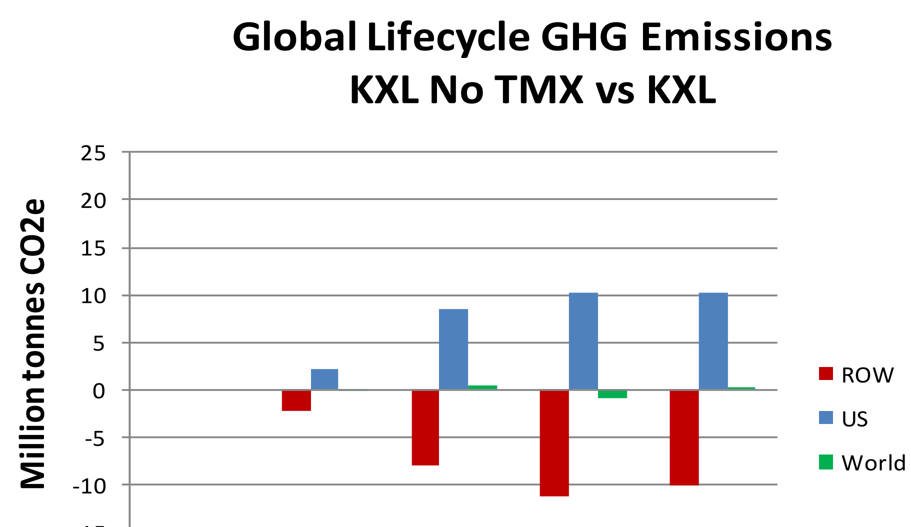
	2010	2015	2020	2025	2030
ROW	0.0	0.5	0.5	0.2	(0.4)
US	0.0	(0.6)	(0.5)	0.1	0.2
World	0.0	(0.1)	0.0	0.3	(0.2)

Figure 4-6



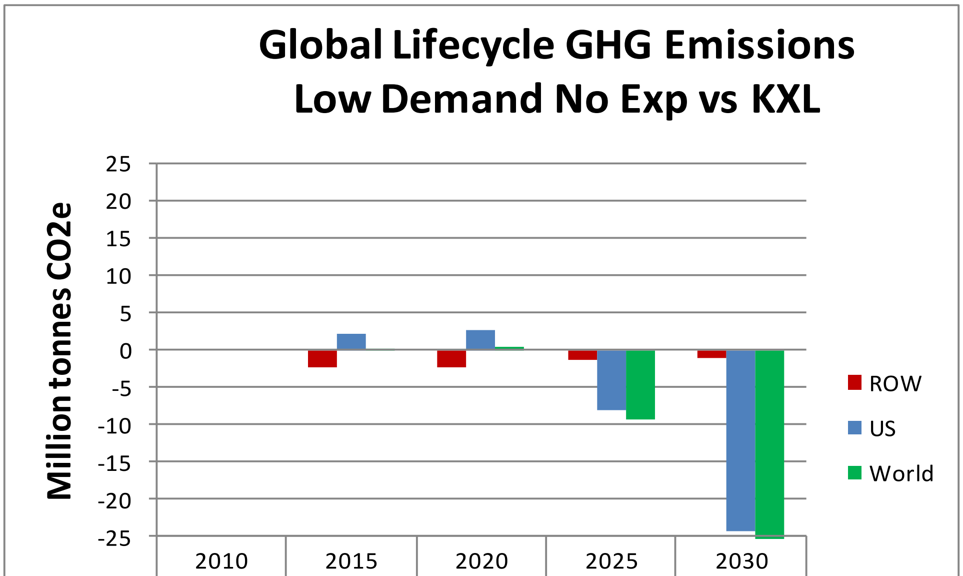
	2010	2015	2020	2025	2030
ROW	0.0	(0.1)	5.9	12.0	12.0
US	0.0	0.1	(5.7)	(11.9)	(11.8)
World	0.0	(0.0)	0.2	0.2	0.1

Figure 4-7



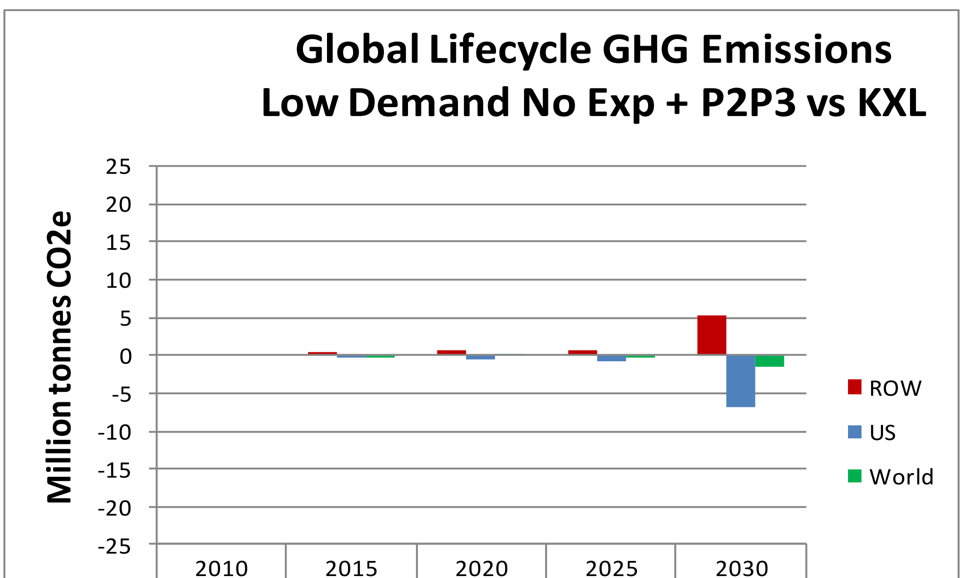
	2010	2015	2020	2025	2030
ROW	0.0	(2.2)	(8.0)	(11.2)	(10.0)
US	0.0	2.2	8.6	10.3	10.3
World	0.0	(0.1)	0.5	(1.0)	0.3

Figure 4-8



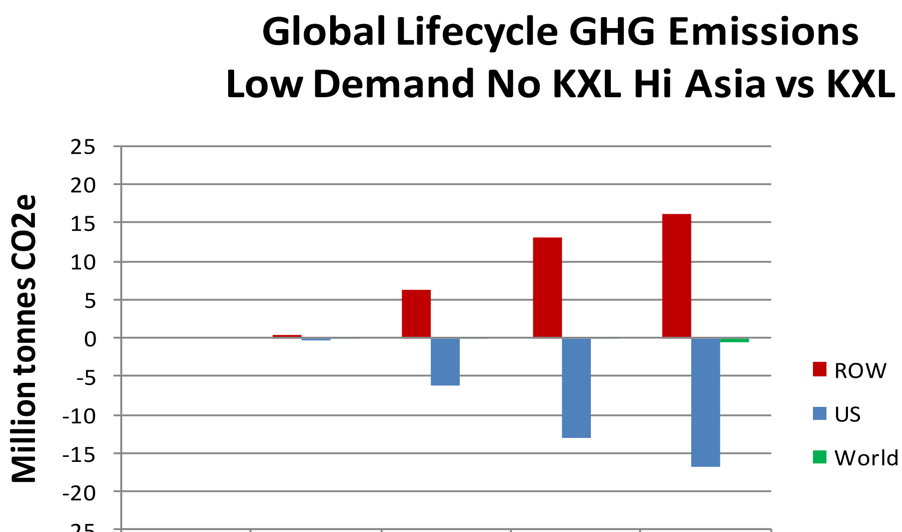
	2010	2015	2020	2025	2030
ROW	0.0	(2.2)	(2.3)	(1.4)	(1.1)
US	0.0	2.2	2.8	(7.9)	(24.3)
World	0.0	0.0	0.5	(9.3)	(25.4)

Figure 4-9



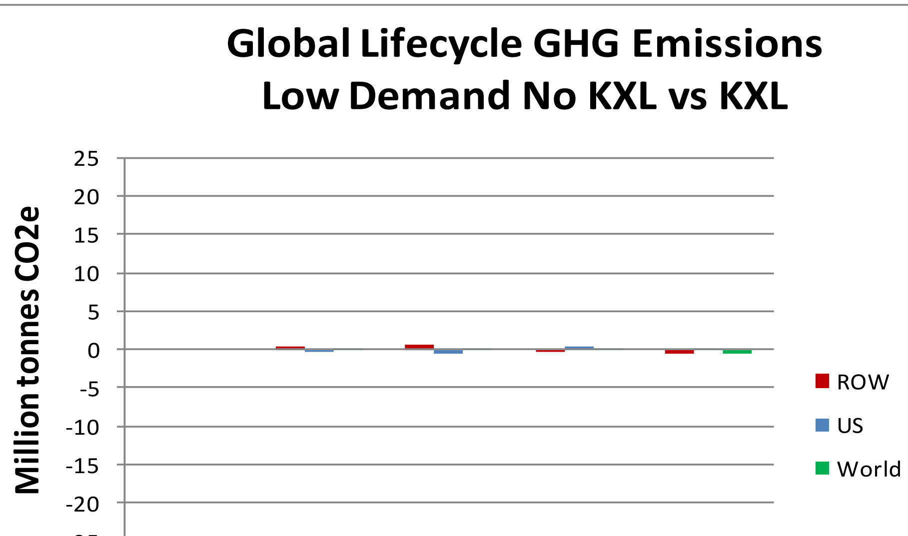
	2010	2015	2020	2025	2030
ROW	0.0	0.4	0.6	0.7	5.3
US	0.0	(0.4)	(0.5)	(0.7)	(6.8)
World	0.0	(0.0)	0.1	(0.0)	(1.5)

Figure 4-10



	2010	2015	2020	2025	2030
ROW	0.0	0.4	6.4	13.2	16.3
US	0.0	(0.4)	(6.2)	(13.0)	(16.7)
World	0.0	0.0	0.2	0.1	(0.5)

Figure 4-11



	2010	2015	2020	2025	2030
ROW	0.0	0.4	0.6	(0.3)	(0.6)
US	0.0	(0.4)	(0.5)	0.4	0.1
World	0.0	0.0	0.1	0.1	(0.5)

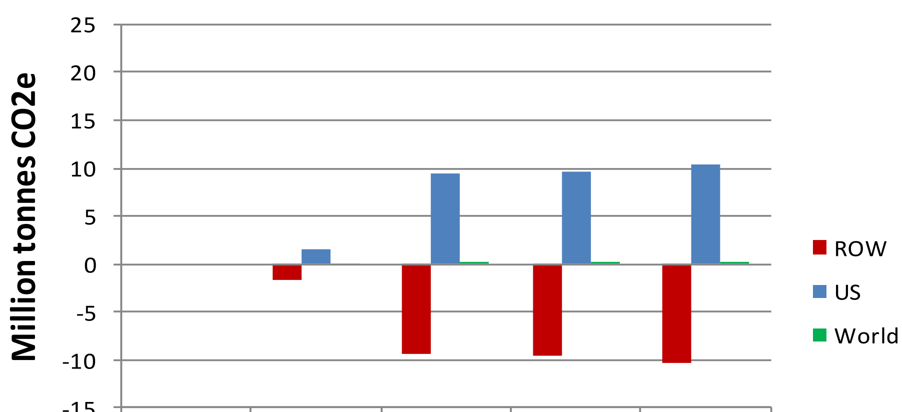
Figure 4-12

Global Lifecycle GHG Emissions
Low Demand KXL + GateWay vs KXL

	2010	2015	2020	2025	2030
ROW	0.0	(0.1)	5.9	12.0	12.0
US	0.0	0.1	(5.7)	(11.9)	(11.8)
World	0.0	(0.0)	0.2	0.2	0.1

Figure 4-13

Global Lifecycle GHG Emissions
Low Demand KXL No TMX vs KXL



	2010	2015	2020	2025	2030
ROW	0.0	(1.6)	(9.3)	(9.5)	(10.3)
US	0.0	1.6	9.5	9.7	10.4
World	0.0	(0.0)	0.2	0.2	0.0

Figure 4-14