Executive Summary

- The US Department of State (USDOS) Final Supplemental Environmental Impact Statement (FSEIS) on the proposed Keystone XL (KXL) pipeline found that construction of the pipeline is "unlikely to significantly impact the rate of extraction in the oil sands." This finding rests on the conclusion that (1) relative to other transport options such as crude-by-rail, the project-level economic impact of KXL amounts to only $8/bbl; and (2) if jettisoned, KXL will be replaced by a combination of new or expanded cross-border pipelines, new or expanded east-west pipelines within Canada, and expanded crude-by-rail shipments.

- Focusing just on the possibility of export from western Canada to refiners on the US Gulf Coast, we find differences in transport costs will potentially affect as much as 510,000-525,000 barrels per day (510-525 kbpd) of bitumen production.[1] We derive these estimates by (1) recreating the FSEIS Table 1.4-27, which calculates break-even Maya-equivalent prices for oil sands projects with plant gate supply costs of $45/bbl (assuming different transport options); (2) extending this analysis to consider plant-gate supply costs of $50/bbl, $55/bbl, and $60/bbl; and (3) comparing these estimated Maya-equivalent breakeven prices with one widely cited projection of Maya prices for 2015-2017. We note that this analysis was not performed in the FEIS and is an important test in our view.

- Assuming use of "committed" tariffs, our simple analysis suggests that export to the US Gulf Coast can be profitable via pipeline at plant-gate supply costs up to $58-62/bbl (depending on the tariff cost assumed). Conversely, profits for rail-based transport become uncertain after plant-gate supply costs of $48/bbl and disappear at plant-gate supply costs of $53/bbl. Hence, we define KXL-affected projects within a "narrow" range of $53-$60/bbl and an "expansive" range of $48-$60/bbl.

- In both our "narrow" and "expansive" ranges, there is at least 510 kbpd of bitumen production that may be affected by KXL.

[1] This corresponds to ~730 kbpd of *diluted* bitumen (i.e. dilbit), which is a blend of 25-30% bitumen and 70-75% (diluent). Following USDOS, we assume that 100 kbpd of KXL's capacity will be devoted to tight oil from the Bakken Shale formation, leaving 730 kbpd for bitumen production. We assume that 100% of this amount will travel as dilbit.

The Keystone XL Pipeline:
The "Significance" Trap

Building on November 2013 Carbon Tracker Initiative report on Canadian oil sands this paper specifically responds to the USDOS FSEIS findings that development of the Keystone XL (KXL) pipeline is "unlikely to significantly impact the rate of extraction in the oil sands."

We find that FSEIS modeling does not fully explore how the lower transportation costs (relative to rail) enabled by KXL improve producer economics and hence affect future oil sands production.

On a stand-alone basis, we find all the available capacity of KXL is economic over rail costs, and this is equivalent to incremental bitumen production in 2018 of 500-525 kbpd (i.e. 25% of Canada's total 2013 bitumen production) and more over time.

Through 2050, cumulative lifecycle greenhouse gas (GHG) emissions attributable to "KXL-enabled production" are equivalent to the annual GHG emissions from one billion passenger vehicles or the annual carbon-dioxide (CO_2) emissions from 1400 coal-fired power plants. Put differently, they are nearly equal to total US CO_2 emissions in 2013.

The FSEIS modeling scenarios also decline to examine the prospects for higher oil sands production in an IEA 450ppm 2°C world scenario that challenges marginally priced production from Canadian oil sands. For example, future US CO_2 emissions under all of the FSEIS scenarios fail to meet the official US target of reducing 2020 CO_2 emissions 17% below 2005 levels (much less the more ambitious 2°C-relevant goal of reducing 2050 emissions 50% below 2005 levels).

Analysts CTI:
James Leaton
Reid Capalino
Luke Sussams

External Research Advisors:
Mark Fulton
Mark Andrich

This equates to ~730 kbpd of diluted bitumen and ~100% of the KXL's available capacity for heavy oil from western Canada. Any impact on production from a KXL-driven change in transport costs is likely to be strongest in the short term and to affect new projects more substantially than projects that are already producing (though both will be affected).

- Through 2050, cumulative lifecycle GHG emissions attributable to "KXL-enabled production" range from 4943 - 5316 million metric tons of carbon dioxide-equivalent (MMTCO_2e). This level of emissions is equivalent to the annual GHG emissions from one billion passenger vehicles or the annual carbon-dioxide (CO_2) emissions from 1400 coal-fired power plants. These figures are not adjusted on a global net basis (i.e. to take into account increased US imports of bitumen displacing heavy crude imports from Latin America). Cumulative "KXL-enabled" incremental emissions through 2050 are equal to (1) 14-15% of total projected lifecycle GHG emissions from Canadian oil sands through 2050 (assuming all currently planned production actually comes online); or (2) nearly equal to *total* US CO_2 emissions in 2013.

- One key takeaway of this analysis is that the scenarios modeled in the FSEIS appear incompatible with a 2°C carbon-constrained world. In particular, projected 2035 US oil demand is 68-86% above what is projected in the International Energy Agency's 450 ppm scenario.

- The FSEIS modeling scenarios link economic viability of oil sands to a scenario of rising oil prices that is highly unlikely to prevail should the world begin to reduce GHG emissions robustly. The FSEIS modeling confirms the conclusion of our earlier work that long-term economic viability of oil sands production is strongly tied to rising oil prices.

- Finally, the question of whether increased production and GHG emissions enabled by KXL are "significant" is highly subjective. From a perspective that rates climate change as urgent and severe a threat as "terrorism, epidemics, poverty", however, even fractions of a percent of the remaining 2°C carbon budget may be too high a cost to bear.

Acknowledgements

The analysts would like to acknowledge the contributions of Oil Change International, who gave their local insights on the project economics analyzed herein, along with the contributions of the commodity analysts who shared their opinions.

1. Background

“*Our national interest will be served only if this project doesn’t significantly exacerbate the problem of carbon pollution. The net effects of the pipeline’s impact on our climate will be absolutely critical to determining whether this project can go forward.*”

- **President Barack Obama, June 2013**

“*Terrorism, epidemics, poverty, the proliferation of weapons of mass destruction: all challenges that know no borders. The reality is that climate change ranks right up there with every single one of them. It is time for the world to approach this problem with the cooperation, the urgency, and the commitment that a challenge of this scale warrants.*”

- **Secretary Of State John Kerry, February 2014**

In a June 2013 speech at Georgetown University, President Obama declared that his administration would approve the proposed Keystone XL oil pipeline “only if this project doesn’t significantly exacerbate the problem of carbon pollution.”[2] The recent USDOS FSEIS states that KXL is highly likely to pass this test, concluding the proposed Keystone XL (KXL) pipeline is “unlikely to significantly impact the rate of extraction in the oil sands.”[3] Having previously emphasized the risks of oil sands investment and the potential role of KXL in improving producer economics (particularly in the short term), this note critiques the FSEIS analysis on several points. Specifically, we note that:

1. Drawing on portions of the FSEIS modeling, our analysis suggests that at least 500,000-525,000 barrels of bitumen per day (kbpd) may be made economic by the KXL pipeline. Our focused analysis here looks at this in more detail.
2. Assumptions of FSEIS modeling scenarios (in terms of future oil prices, production growth, and midstream infrastructure investment) are inconsistent with a scenario in which the US, Canada, and other countries are reducing carbon emissions in line with constraining future climate change to 2°C.

In our November 2013 note *KXL: Mirage in the Oil Sands* we looked primarily at the long-term outlook for Canadian oil sands asking if the risk would prove too high for investors at what we perceived as high commercial break evens. We concluded at the margin, they were a bet on rising oil prices.

At the same time we tackled the question of “additionality” from constructing KXL, but in a very focused way – would it simply cause any more production to flow short term and would it prove something of a catalyst to the whole push to lift Canadian Oil Sand production. In both cases we argued ‘yes’.

In discussing the “Implications for Production” of its modeling, footnote 154 of the FSEIS states:

> The methodology used to draw conclusions about production implications is similar to the one employed in a recent report published by Carbon Tracker Initiative (2013). However, that report’s conclusions were different due to various analytical issues.

This leads us to look closely at those conclusions, but this time within the framework of this EIS report itself.

---

[2] The White House – Office of the Press Secretary, “Remarks by the President on Climate Change,” June 25 2013, Georgetown University, Washington D.C., http://www.whitehouse.gov/the-press-office/2013/06/25/remarks-president-climate-change.

[3] US Department of State (USDOS), *Final Supplemental Environmental Impact Statement (FSEIS) - Keystone XL Project*, “1.4 Market Analysis – 1.4.5.4 Implications for Production,” 1.4-131, January 2014, http://keystonepipelinexl.state.gov/documents/organization/221147.pdf

2. How will Keystone XL affect oil sands production?

The FSEIS concludes that approval/denial of this project will not significantly change demand for, or production from, oil sands. By implication, this means that it will not significantly impact carbon emissions. The FSEIS conclusions emerge from its modeling of oil sands production across four different scenarios through 2030 using the Ensys Inc. WORLD model, a software model.[4] The complexity and lack of transparency as to the inner workings of such models make them difficult for outside analysts to examine.

As a complement to its main analysis, Section 1.4.5.3 of the FSEIS "briefly examines the transportation costs and breakeven impacts of different options for connecting oil sands producers in western Canada with refiners on the Gulf Coast". Another short-term sensitivity analysis the FSEIS used focused on different options to export oil sands from Canada, particularly rail and pipelines.[5] In a very narrow sense, if rail can get the oil out economically then adding a pipeline is unlikely to result in "additional" production.[6] Indeed, this was the approach we took back in our November paper. Ignoring for a moment the possibility of other cross-border pipelines or east-west pipelines within Canada and focusing on export from western Canada to the US Gulf Coast, the transport costs of crude-by-rail versus pipelines become central to the question of whether the KXL pipeline will increase production from oil sands.

Focusing on export of bitumen blends from western Canada to refiners on the US Gulf Coast, Table 1.4-27 of the FSEIS (Supply Costs, Transport Costs, Modeled Quality Discounts, and Implied Breakevens) calculates Maya-equivalent breakeven prices across five different export options (assuming a range of transport costs for each option). The conclusions that the FSEIS draws from this analysis are that "the most cost-effective way to move dilbit from western Canada to the Gulf Coast is by pipeline through a committed tariff," with use of rail (or "uncommitted" pipeline tariffs) adding anywhere from $7-$11.4/bbl to the upper bound of required break-even prices.

---

[4] USDOS, *FSEIS - Keystone XL Project*, 1.4-9 notes that "EnSys's WORLD model provides an integrated analysis and projection of the global petroleum industry that encompasses total liquids, captures the effects of developments, changes, and interactions between regions, and projects the economics and activities of refining crude oils and products. WORLD has been used for DOE's Office of Strategic Petroleum Reserve since 1987, and has been applied in analyses for many organizations, including the EIA, U.S. Environmental Protection Agency, the American Petroleum Institute (API), the World Bank, the Organization of the Petroleum Exporting Countries (OPEC) Secretariat, the International Maritime Organization, Bloomberg, and major and specialty oil and chemical companies."

[5] In introducing this analysis USDOS notes that "The EnSys WORLD model described in Section 1.4.4, Updated Modeling, does not separately model diluent flows or include an option to economically transport marginal barrels of bitumen as railbit or rawbit. Therefore, conclusions drawn from its results may not reflect rail's full economic possibilities as described in Section 1.4.3, Crude Oil Transportation." *FSEIS - Keystone XL Project*, "1.4.5.3 Transportation Cost Sensitivities," 1.4-28.

[6] For example, USDOS concludes that "The absence of the proposed Project and all other new and expanded cross-border pipelines, east-west pipelines, and rail shipments to the Canadian West Coast for export is still unlikely to have a significant effect on the level of oil sands production due to the economic feasibility of crude-by-rail shipments." *FSEIS - Keystone XL Project*, 1.4-133.

Table 1 Supply Costs, Transport Costs, Modeled Quality Discounts, and Implied Breakevens

Blend	Dilbit	Dilbit	Dilbit	Railbit	Rawbit	Dilbit is 70% bitumen/30% diluent. Railbit is 85% bitumen. Rawbit is 100% bitumen
Transport Mode	Pipeline (Committed)	Pipeline (Uncommitted)	Rail	Rail	Rail	Dilbit can travel by pipeline or rail. Railbit and rawbit can only be transported by rail
Plant Gate Supply Cost ($/bbl)	$45.00	$45.00	$45.00	$45.00	$45.00	Hypothetical supply cost of a barrel of bitumen at the producing facility. Value is close to average lifetime in situ supply cost
Diluent Price ($/bbl)	$100.00	$100.00	$100.00	$100.00	$100.00	Assumed price for diluent (such as condensate) in western Canada. Trades near the price of light sweet crude.
Diluent Acquisition Cost ($/bbl)	$43.00	$43.00	$43.00	$43.00	$43.00	Assume all producers must dilute bitumen to use pipelines from producing facility to trading hub. Acquisition cost reflects the price of diluent times the amount (0.43 barrel) added to a barrel of bitumen to make a dilbit blend.
Blend Supply Cost at Plant Gate (£/1.43bbl)	$88.00	$88.00	$88.00	$88.00	$88.00	Supply cost plus diluent acquisition cost. Reflects total supply cost at the plant gate for 1.43 barrels of bitumen and diluent.
Transportation to Hardisty ($/1.43bbl)	$1.43	$1.43	$1.43	$1.43	$1.43	Assumption for cost of transportation of 1.43 barrels of dilbit from producing facility to trading hub (e.g. Hardisty, Edmonton, Lloydminster).
DRU Processing Cost ($/bbl)[a]	$0.00	$0.00	$0.00	$2.37	$2.87	Assessed cost to use a DRU to separate diluent from dilbit blend. Cost is higher for conversion to rawbit because more diluent in recovered.
Diluent Revenue ($/bbl)	$0.00	$0.00	$0.00	$24.85	$42.14	Revenue from reselling diluent recovered from DRU. Assume some conversion loss and that the resale price of diluent equals purchase price.
Blend Supply Cost in Western Canada ($/bbl)	$62.54	$62.54	$62.54	$56.89	$50.16	Supply cost for one barrel of blend at trading hub.
Transport Cost to Gulf Coast ($/bbl)	$8.10-$10.51	$15.52-$16.93	$15.00-$21.00	$17.00-$24.00	$17.50-$24.50	The range in estimated costs to transport one barrel of blend from western Canada to the Gulf Coast. The upper end of the pipeline cost range reflects the uncommitted and committed tariffs estimated in Figure 1.4.3-17, while the lower end of the range reflects lower potential tariffs on certain routes. The rail cost ranges reflect the rates for transporting a given barrel on unit trains (low end) as opposed to manifest trains (high end), as well as the difference in freight rates across blends. These rail cost ranges include the rail cost estimates presented in Figure 1.4.3-19.
Landed Supply Cost in Gulf Coast ($/bbl)	$70.64-$73.05	$77.06-$79.47	$77.54-$83.54	$73.89-$80.89	$67.66-$74.66	Blended supply cost plus transport cost to Gulf Coast
Average Price Discount to Maya Crude (%)	92%	92%	92%	89%	87%	Modeled average quality discount for each blend relative to Maya, an imported Mexican heavy crude, at the Gulf Coast. Railbit and rawbit have larger discounts because they are heavier blends. In reality, some refiners could prefer barrels with more bitumen feedstock.
Required Maya CIF Price[b] ($/bbl)	$76.78-$79.40	$83.76-$86.38	$84.28-$90.80	$83.03-$90.89	$77.77-$85.82	Notional heavy crude breakeven prices at the Gulf Coast, taking into account landed supply costs (including transportation) and quality discounts.

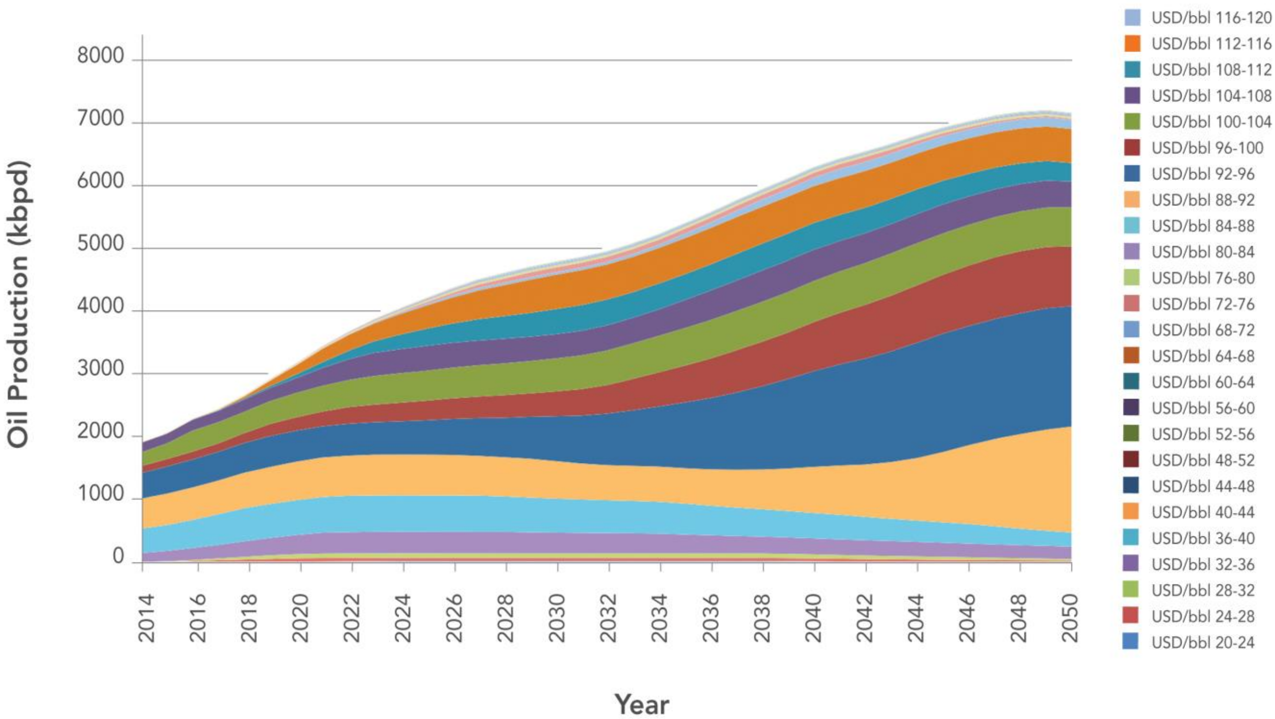
Source: USDOS FSEIS

(a) This estimate was based on the assumption that bitumen is diluted to dilbit and transported to hubs in Edmonton/Hardisty/Lloydminster areas, and is then processed through a DRU to produce either railbit or rawbit. This is consistent with recently announced projects. Some producers may be able to save on these costs by accessing rail facilities much closer to their production area. (b) CIF = cost, insurance, and freight

The FSEIS declines, however, to explore the implications of its analysis in Table 1.4-27 for future production from Canadian oil sands. Doing so requires (1) extending this analysis to include "plant gate supply costs" above $45/bbl; (2) comparing the calculated Maya-equivalent implied breakeven prices with other projections of future Maya prices; and (3) surveying the supply stack of projected oil sands production to determine the amount of production potentially affected by the availability of different transport options.

In Table 1.4-27, the FSEIS explains its choice of a plant gate supply cost (i.e. hypothetical supply cost of a barrel of bitumen at the producing facility) of $45/bbl as a value "close to average lifetime in-situ supply cost." The figure below, however, illustrates most oil sands supply coming online beginning in 2014 to have a plant gate supply cost above $45/bbl. Given that production from both mining and in-situ projects will be seeking new routes to market, the figure below shows oil production from both of these sources. The cost profile for future production from just in-situ sources, however, is very similar, as can be seen in Appendix B.

Figure 1 Total oil sands production growth (kbpd) broken down by plant gate supply cost ($/bbl), 2014-2050



Source: Rystad Energy UCube, Carbon Tracker analysis 2014
Includes production from both new and existing mining and in-situ projects. Assumes no transportation constraints.

Having previously examined the impact of KXL on highly marginal projects with plant gate supply costs of $65/bbl, for the purposes of this analysis we shift our focus to the projects with plant gate supply costs of $45-60/bbl.[7]

Economic Benefits of KXL at Plant Gate Supply Costs Above $45/bbl

Keeping all other assumptions intact (i.e. on the blends being transported, transport costs, diluent costs, and price discounts owing to quality differentials), the table overleaf extends the analysis of Table 1.4-27 to calculated Maya-equivalent breakeven prices given plant gate supply costs of $50/bbl, $55/bbl, and $60/bbl; it then compares each calculated price to the Goldman Sachs projected 2015-2017 Maya price of $89/bbl.[8]

[7] Following the USDOS FSEIS Market Analysis methodology, we use the terms "breakeven price" and "plant gate supply cost" interchangeably. Specifically, we use at-the-gate breakeven prices calculated from Rystad Energy UCube data that incorporate a 10% discount rate into their breakeven price calculation.

[8] Goldman Sachs, *Getting oil out of Canada: Heavy oil diffs expected to stay wide and volatile*, Exhibit 3, June 2013. We use the Goldman Sachs estimate because (1) it is a widely cited market estimate; (2) the FSEIS favorably cites Goldman Sachs research on oil sands; and (3) it is roughly in line with current forward prices. Over the last few years Maya has

Table 2 Implied Maya-Equivalent Breakeven Prices versus 2015E-2017E Projected Maya Prices

	Minimum Dilbit Pipeline	Maximum Dilbit Pipeline	Minimum Dilbit Rail	Maximum Dilbit Rail	Minimum Raibit Rail	Maximum Raibit Rail	Minimum Rawbit Rail	Maximum Rawbit Rail
Plant Gate Supply Cost ($/bbl)	45	45	45	45	45	45	45	45
Required Maya CIF Price ($/bbl)	76.74	79.36	84.24	90.76	82.89	90.75	77.61	85.65
Below 2015E-2017E Maya Price? (Y/N)	Y	Y	Y	N	Y	N	Y	Y
Plant Gate Supply Cost ($/bbl)	50	50	50	50	50	50	50	50
Required Maya CIF Price ($/bbl)	80.54	83.16	88.04	94.57	87.66	95.53	83.35	91.40
Below 2015E-2017E Maya Price? (Y/N)	Y	Y	Y	N	Y	N	Y	N
Plant Gate Supply Cost ($/bbl)	55	55	55	55	55	55	55	55
Required Maya CIF Price ($/bbl)	84.35	86.97	91.85	98.37	92.44	100.30	89.10	97.15
Below 2015E-2017E Maya Price? (Y/N)	Y	Y	N	N	N	N	N	N
Plant Gate Supply Cost ($/bbl)	60	60	60	60	60	60	60	60
Required Maya CIF Price ($/bbl)	88.15	90.77	95.65	102.18	97.21	105.08	94.85	102.89
Below 2015E-2017E Maya Price? (Y/N)	Y	N	N	N	N	N	N	N
2015E-2017E Maya Price ($/bbl)	89	89	89	89	89	89	89	89

Source: USDOS FSEIS, Goldman Sachs, Carbon Tracker Analysis 2014

Note: "Maximum" and "Minimum" refer to whether assumed transport costs or at the low or high-end of the ranges assumed in the EIS Table 1.4-27. For clarity and relevance to KXL, "pipeline" shows only committed pipeline, not uncommitted pipeline.

The results of this simple analysis underscore the potential benefits of KXL for oil sands producers looking to export to the US Gulf Coast. As plant gate supply costs rise above $45/bbl, opportunities for profitable export to the Gulf Coast via rail begin to disappear. By the time plant gate supply costs reach $48/bbl, profitable export opportunities for all three rail transport options depend on assuming low-end rather than high-end transport costs; by the time plant gate supply costs reach $53/bbl, these opportunities disappear for all three rail-based transport options (irrespective of whether one assumes low or high-end transport costs for each option).

Conversely, on a pipeline that has committed tariffs, export to the Gulf Coast continues to look profitable all the way up to supply costs of $58-$62/bbl (depending on where in the $8.10-$10.51/bbl range one specifies applicable pipeline tariffs). For example, the above table suggests that a $56/bbl oil sands producer has only option for profitable export to the Gulf Coast - a pipeline (with committed tariffs). A narrow interpretation of these results would emphasize oil sands production in the supply cost range of $53-$60/bbl as being "unlocked" for export to the Gulf due to the KXL pipeline; a more expansive interpretation would include all projects within the supply cost range of from $48-$60/bbl in the category of oil sands production potentially affected by KXL.[9]

To summarize, in moving up the supply stack toward plant gate supply costs higher than $45/bbl, the projected economic advantages of pipeline relative to rail change from being beneficial (in the sense of enabling higher $/bbl profits) to being decisive (in the sense of affecting whether or not profitable export is worthwhile).

traded within a range of a few dollars of WTI, and at the moment 2015-2017 forward prices for WTI are trading within a range of $80-94/bbl (relative to an April 2014 WTI price of $102/bbl).

[9] To be conservative, our "expansive" range ignores potential pipeline-enabled production above $60/bbl (i.e. from $60-$62/bbl).

Why our "expansive" range exceeds $0-$8/bbl

Two reasons explain why our "expansive" range exceeds the previously mentioned FSEIS estimate of a $0-$8/bbl "transport penalty" for use of rail as opposed to pipeline.[10]

1. **Quality-related price discounts**: First, following the lead of Table 1.4-27, we incorporate information on price discounts at the Gulf Coast for bitumen blends of different quality (e.g. dilbit versus railbit versus rawbit). Including Table 1.4-27 figures for "Average Price Discount to Maya Crude" - which range from 92% for dilbit to 87% for rawbit - increases the maximum "transport penalty" up to $9.5/bbl (assuming that one is using midpoint transport costs for all options).

2. **Willingness to compare high-cost rail against low-cost pipeline**: Second, each pipeline or rail option has a range of relevant transport costs (e.g. $8.10-$10.51/bbl for dilbit by committed pipeline and $17.50-$24.50/bbl for rawbit by rail), and we calculate and compare breakeven prices for each option assuming both low-end and high-end transport costs. Our $48-$60/bbl "expansive" range therefore assumes high-end transport costs for rail option and low-end transport costs for pipeline with committed tariff (and, as a result, yields a range of potentially affected production that is wider than $9.5/bbl). This approach is justified owing to (1) the wider range of transport costs for rail as opposed to pipeline (i.e. $6-7/bbl versus $2.40/bbl); and (2) the possibility that costs for each option will evolve differently over time.

Quantity of Future Oil Sands Production with $48-$60/bbl Plant Gate Supply Costs

Recognizing the economic advantages afforded by pipelines as opposed to rail leads to the question of how much incremental oil sands production the 830,000 barrel per day (830 kbpd) KXL pipeline might ultimately enable. The upper limit on "KXL-enabled" incremental production is set by the carrying capacity of the pipeline itself. Roughly 100 kbpd of KXL's capacity will be reserved for oil from the Bakken Shale formation in Montana and North Dakota, leaving 730 kbpd to accommodate diluted bitumen from western Canada.[11] To flow in a pipeline, however, bitumen must be diluted with natural gas liquids or some other diluent, usually in a ratio of ~30% diluent to 70% bitumen. As a result, 730 kbpd of diluted bitumen (i.e. dilbit) equates to 500-525 kbpd of bitumen. 500-525 kbpd is therefore the maximum amount of incremental bitumen production that KXL could enable (we focus on a central value of 510 kbpd). As a point of reference, 510 kbpd equates to 25% of western Canada's total estimated bitumen production for 2013.

The next step is to determine whether there is 500-525 kbpd of incremental production in the plant gate supply cost ranges at which the "KXL premium" might decisively affect production economics. The figure below depicts future production from new and existing projects (both mining and in-situ) with plant gate supply costs in the range of $48-$60/bbl.[12] Note that by 2018 combined production from such projects equals 675 kbpd, or 20% more than KXL's total bitumen capacity. Within the "expansive" cost range of $48-$60/bbl there is by 2018 675 kbpd of bitumen production for which export to the Gulf Coast looks economic via pipeline (with committed tariffs) but uneconomic via rail (i.e. more than adequate to fill KXL's entire bitumen-

---

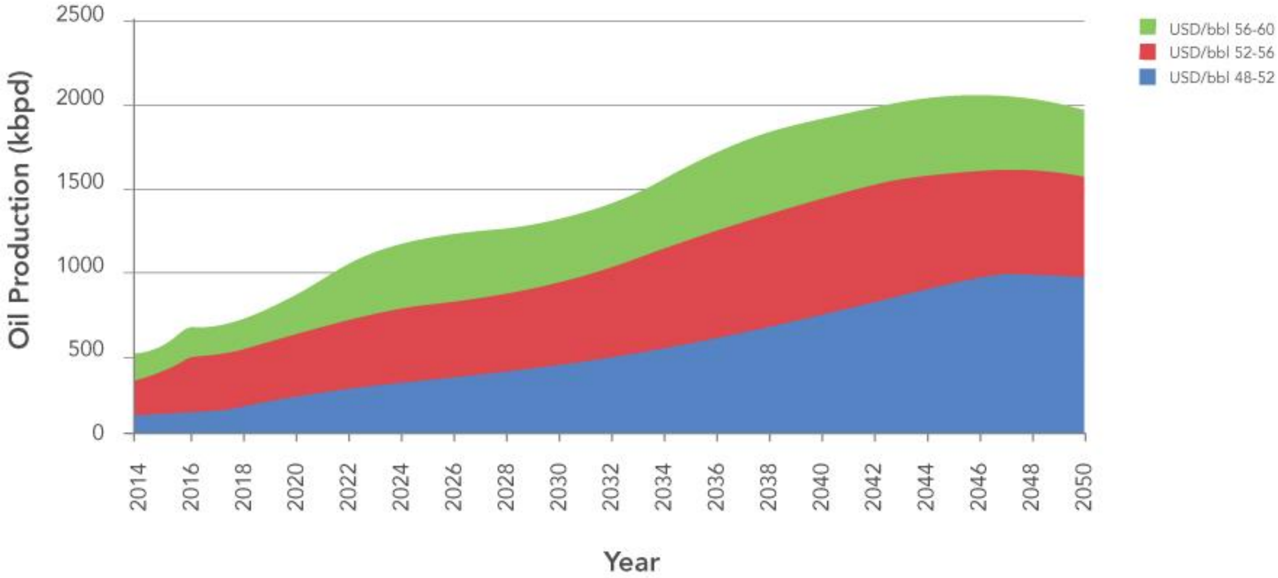
[10] USDOS notes that "constraints on the proposed Project and other infrastructure would only impact the margin between prices and supply costs by $0 to $8 per barrel depending on the assumptions made about the development of other cross-border and/or east-west capacity." *FSEIS - Keystone XL Project*, 1.4-34.

[11] We assume that 100% of the available ~730 kbpd capacity for Canadian oil will flow as dilbit.

[12] To be conservative, our "expansive" definition omits the potential impact on oil sands projects with plant gate supply costs above $60/bbl. For a breakdown of how much production is expected to come from currently producing assets vs. new assets please see Appendix C.

carrying capacity); within the "narrow" cost range of $53-$60, the 2018 production volume is 517 kbpd (again, adequate to fill all of KXL's bitumen capacity).

Figure 2 Total oil sands production growth at $48-60/bbl plant gate supply cost, 2014-2050



Source: Rystad Energy UCube, Carbon Tracker analysis 2014
In-situ and mining, existing and new fields. Assumes no transportation constraints.

Table 3 overleaf shows projected 2018 production within various cost ranges, broken down by just in-situ production versus mining and in-situ, and compared with KXL's actual bitumen-carrying capacity. The economic advantages of pipeline (with committed tariffs) over rail could potentially affect up to 675 kbpd of bitumen production right at the assumed start of 2018 (again, were such pipeline capacity to become available). **In effect we think that the rational economic approach is to produce up to the highest marginal cost. Moreover, it seems reasonable to surmise that construction of KXL may make development of such additional pipeline capacity more likely with up to 2000kbd at the peak.**

Table 3 Oil sands production in the plant-gate cost range of $48/bbl and above that is available to meet KXL's bitumen-carrying capacity of 525 kbpd (oil sands production for the cost range of $48-$60 is also shown)

Oil Sands Production (kbpd)			
Available at Plant-gate cost range	2023 In-situ only	2018 Mining and in-situ	2018 Mining and in-situ % of KXL bitumen capacity
$48 - $58	366	510	100
$53 - $60	202	517	101
$48 - $60	500	675	132

Source: Rystad Energy UCube, Carbon Tracker analysis 2014

Values in "% of KXL bitumen capacity" column refer to values in the "Mining and in-situ column" divided by an assumed KXL bitumen capacity of 510 kbpd.

New Projects Drive Production

Note that inasmuch as the shift from pipeline to crude-by-rail may increase the required breakeven price for oil sands producers above projected future prices, this is most likely to affect production from *new* projects (rather than projects that are already producing).[13] Once online, a site will continue to produce so long as the market price exceeds its variable cost of production (i.e. operating costs). The FSEIS asserts that the variable costs of in-situ projects can be as low as $20-$40/bbl[14], meaning that a Maya-equivalent bitumen price would have to decline to $58-$75/bbl before production would become uneconomic.

That said, the plant gate supply costs for all existing production included our analysis (i.e. in Figures 1 and 2 above) do indeed reflect a *variable* cost of production (i.e. exclude sunk capital expenses).[15] Indeed the build up of new production over coming years in the $48-60 plant gate cost range is the driver of increased production.

Oil Sands Production With Plant Gate Supply Costs Above $60/bbl

The analysis above indicates that, as plant gate supply costs in western Canada move from $45/bbl to $60/bbl, the economics of export to Gulf Coast refiners via crude-by-rail begin to deteriorate - making export via pipeline (using committed tariffs) the only viable alternative. At plant gate supply costs above $60/bbl, even the near-term economics of export to Gulf Coast refiners via committed tariff pipelines begin to look questionable (assuming a 2015-2017 Maya price of $89/bbl). Figure 1 above, however, projects that by 2030 more than one million barrels per day of new capacity may come online with plant gate supply costs above $60/bbl. Recognizing this underscores how, at least from the perspective of export to Gulf Coast refiners, the long-term economics of oil sands production depend on rising oil prices for Maya and other crude blends.

[13] As production from "new" projects takes time to ramp up, however, in the short term production from existing projects may comprise the majority of "KXL-enabled" production.

[14] USDOS, *FSEIS - Keystone XL Project*, 1.4-137.

[15] For a break-out of new versus already producing projects, see Appendix C.

Even with other planned pipeline and rail projects, replacements for KXL not a certainty

The major caveat to the analysis above is that it ignores the potential for additional cross-border pipelines or new east-west pipelines within Canada.[16] Inasmuch as development of such infrastructure provides new routes to access the Gulf Coast (or other markets), then eventually some (or, possibly, all) of what we term "KXL-enabled production" may find alternative paths to market even without the pipeline being built.

That said, we also note that prospects for development of such infrastructure (particularly over this decade) look decidedly mixed. Alternative transport oil sands transport projects (whether cross-border or within Canada) may be rejected due to the same climate-based political pressure that has caused additional State Department scrutiny of the KXL project. For example, several other large-scale pipeline projects – including Enbridge's Northern Gateway and Alberta Clipper pipelines and Kinder Morgan's Transmountain pipeline – are all encountering robust opposition centered on climate and other environmental concerns.[17] Rail terminals intended to ship bitumen are also encountering significant opposition as well as calls for stricter oversight.[18] Though rail operators are taking steps to increase safety – BNSF Railway recently announced plans to buy as many as 5,000 new tank cars specifically designed to transport crude oil – the cost implications of these increases to safety measures are not yet clear.[19]

Whatever the outcome of any individual project, the (quite proper) heightened scrutiny for infrastructure projects connected to oil sands suggests that the lengthy and contentious vetting process over KXL may become the rule, rather than the exception. In the case of rail, heightened safety concerns have caused public officials on both sides of the border to call for tighter safety standards that may add cost, delay construction of new rail terminals, or both.[20]

Moreover, as we noted in our December 2013 piece, *industry growth projects already assume other major proposed pipelines as complements to, rather than substitutes for, KXL.*[21] Analysts estimate the current takeaway capacity for Western Canadian oil to be roughly 3mbd – with roughly 1.5mbd of this amount allocated to bitumen from oil sands producers. In other words, in 2012 production from oil sands in Western Canada already exceeded available takeaway capacity by at least 0.3mbd. Owing to rising production from

---

[16] Other caveats are that our analysis is focused on a near-term snapshot using a single (though widely cited) oil price scenario. The magnitude of the impact varies depending on whether one assumes low or high-end transport costs for each export option (and, in particular, what one assumes for the transport costs of rail); moreover, addition of new infrastructure to handle "rawbit" (i.e. rail-based transport of raw bitumen) may expand the opportunities for profitable rail transport to the Gulf Coast.

[17] CBC News, "Northern Gateway pipeline opposition groups threaten 'direct action'", December 20 2013, http://www.cbc.ca/news/canada/british-columbia/northern-gateway-pipeline-opposition-groups-threaten-direct-action-1.2472410.

[18] Global Research, "Shipping Crude Oil by Rail: New Front in the Tar Sands Wars," December 8 2013, http://www.globalresearch.ca/shipping-crude-oil-by-rail-new-front-in-tar-sands-wars/5360776. Reuters, "Analysis – As Keystone looms larger, Canada oil-rail builders face delays," February 3, 2014, http://uk.reuters.com/article/2014/02/03/uk-keystone-canada-rail-analysis-idUKBREA1218S20140203.

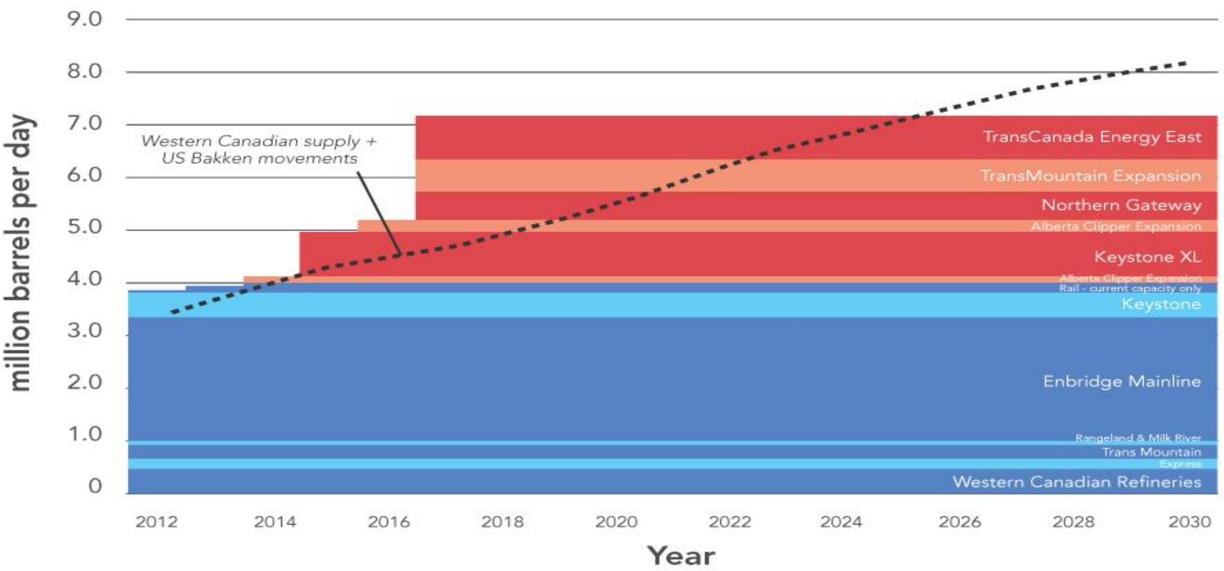
[19] Laura Stevens, "BNSF Railway Boosts Safety Efforts," *The Wall Street Journal*, February 20 2014, http://online.wsj.com/news/articles/SB10001424052702304275304579394983087734524?mg=reno64wsj&url=http%3A%2F%2Fonline.wsj.com%2Farticle%2FSB10001424052702304275304579394983087734524.html. This article surmises that the new BNSF cars may cost anywhere from 14-67% more than conventional rail tank cars.

[20] NYS Governor's Press Office, "Governor Cuomo Orders Review of Crude Oil Rail Safety in New York State," January 29 2014, https://www.governor.ny.gov/press/01292014-crude-oil-rail-safety.

[21] Carbon Tracker Initiative, Keystone XL Pipeline: A Potential Mirage for Oil Sands Investors, December 13 2013, http://www.carbontracker.org/wp-content/uploads/2013/12/KXL-FINAL-13-DEC-CLEAN+DATED-FINAL.pdf

Western Canada and the US Bakken formation, CAPP projects a need for Canada's total export capacity to double by 2030 (i.e. to 8mbd); *even if all proposed pipelines (including KXL) are built, from 2025 Canada will still need to add an additional 1mbd of export capacity*. Therefore, particularly in the short term, KXL is likely to enable higher production than will otherwise occur.

Figure 3 Western Canadian Sedimentary Basin (WCSB) Takeaway Capacity vs. Supply Forecast



Source: Canadian Association of Petroleum Producers (CAPP), “Crude Oil: Forecast, Markets, & Transportation,” 2013.

3. How the FSEIS modeling scenarios contradict the imperatives of a 2°C world

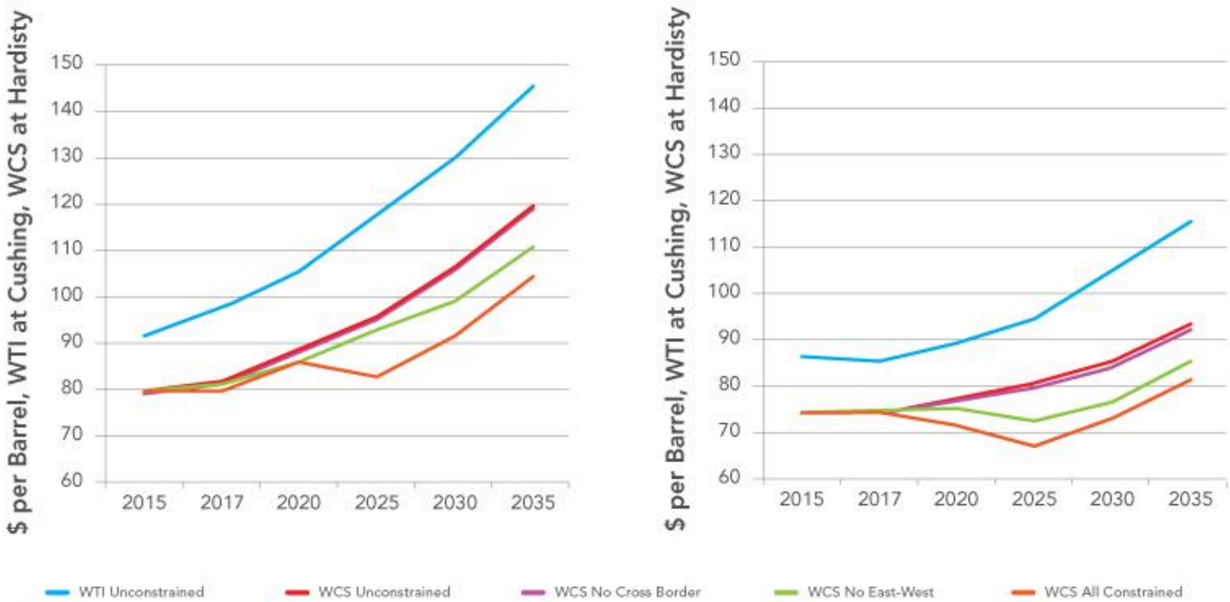
That the addition/absence of KXL will affect the level of production from oil sands is a proposition that can be argued most strongly in the short-term (i.e. over the next 5-10 years). Indeed, the FSEIS observes that “assertions that transportation constraints could affect producers in the next couple of years unless the proposed Project [i.e. Keystone XL] is approved do not necessarily conflict with this document’s long-run production conclusions or the forecasts upon which they rely.”[22]

Over the long term, however, the FSEIS affirms the conclusion of a prior Draft Supplemental EIS that “approval or denial of any one crude oil transport project, including the proposed Project [i.e. Keystone XL], remains unlikely to significantly impact the rate of extraction in the oil sands.”[23] This conclusion reflects the FSEIS finding across that prices received by bitumen producers remain above supply costs across scenarios that assume a range of different supply/demand projections as well as transportation constraints. Simply put, the FSEIS argues that over the long term, absence of KXL can be compensated for by other cross-border pipelines (or expansion of existing pipelines), additional east-west pipelines within Canada (which then allow export to Asia and other markets), or expanded crude-by-rail shipments either to US Gulf Coast or on east-west routes within Canada – or some combination thereof. Projected rising oil prices (underpinned by a continued growth in global oil demand) is assumed to make these alternatives to KXL economically viable.[24]

[22] USDOS, *FSEIS - Keystone XL Project*, 1.4-134.
[23] USDOS, *FSEIS - Keystone XL Project*, 1.4-131.
[24] Indeed, along with constraints on all new and expanded Canadian and cross-border pipeline capacity, USDOS cites a requirement "that prices persist below current or most projected levels in the long run" as one of "the primary

Rather than scrutinizing each of these assumptions and conclusions (that the reader can scrutinize), it is worth noting that none of the FSEIS scenarios include a supply/demand outlook or other elements that would be consistent with a global energy sector that is evolving to contain the risks of climate change (for example, by reducing carbon emissions from fossil fuel consumption). In particular, the FSEIS scenarios assume growing global oil demand and a trajectory for future oil prices strongly at odds with the trends likely to persist in a world that is aggressively reducing carbon emissions. *For example, in the International Energy Agency's 450 PPM scenario[25] US 2035 oil demand declines from 17.3 mb/d in 2011 to 10.2 mb/d in 2035; by contrast, in the FSEIS modeling 2035 oil demand ranges from 18.9 mb/d in the Reference Case to 17.1 mb/d in the Low/No Net Imports case (i.e.68-86% above the IEA's 450 ppm case).[26]* Moreover, the FSEIS scenarios project a trend of rising oil prices that is unlikely to prevail in a world where demand for oil – globally and specifically in the Americas – is declining.[27]

Figure 4 USDOS FSEIS WCS Prices by Pipeline Scenario in Reference Case (top) and Low/No Imports Case (bottom)



Source**: USDOS FSEIS**

assumptions required to create conditions under which production growth would slow due to transportation constraints." *FSEIS - Keystone XL Project*, 1.4-136.

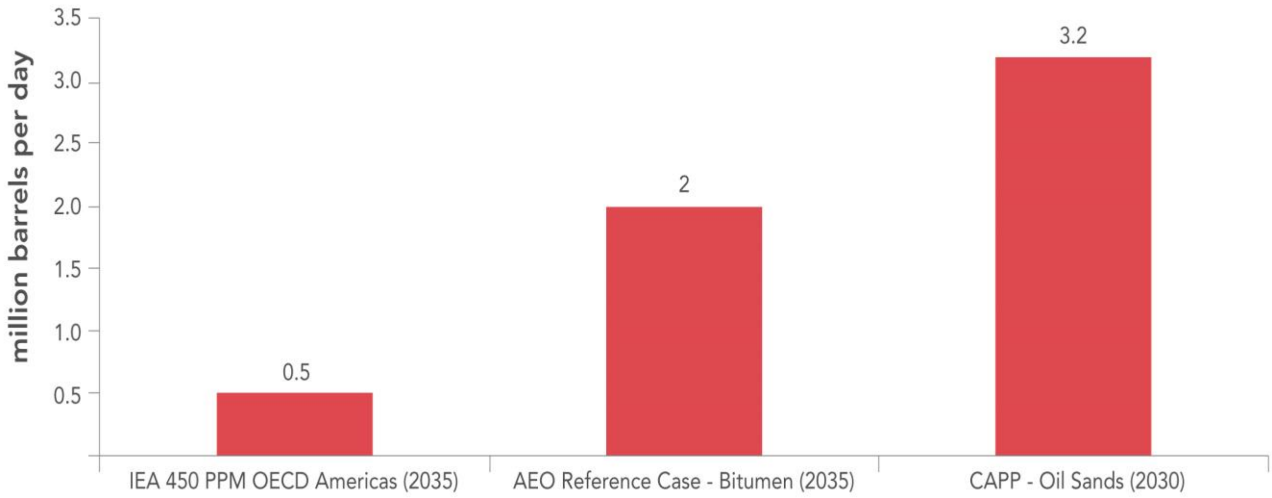
[25] IEA, *World Energy Outlook 2013*, “Annex A Tables for Scenario Projections,” United States: 450 Scenarios. The IEA 450 Scenario “sets out an energy pathway that is consistent with a 50% chance of meeting the goal of limiting the increase in average global temperature to 2°C compared with pre-industrial levels.”

[26] USDOS, *FSEIS - Keystone XL Project*, “1.4.2.4 US Oil Consumption,” 1.4-16. International Energy Agency (IEA), *World Energy Outlook 2013*, “Annex A Tables for Scenario Projections,” United States: 450 Scenarios, November 12 2013, http://www.worldenergyoutlook.org/publications/weo-2013/.

[27] USDOS specifically notes that “oil sands production is expected to be most sensitive to increased transport costs in a range of prices around $65 to 75 per barrel.” *FSEIS - Keystone XL Project*, “1.4-137.

As the figure below illustrates, the FSEIS scenario is geared toward a projected increase in bitumen production that is inconsistent (or incompatible) with a 2°C world and is closer to the growth path projected by industry. *Note that our estimated range of "KXL-enabled" production (500-525 kbpd) equals net oil production growth throughout the entire OECD Americas region under the IEA's 450 Scenario.* Recognizing a 2°C world requires oil production to flatten (or decline) rather than increase provides the proper context for evaluating whether any production attributable to KXL is "significant".

Figure 5 Projected oil sands production growth from 2013 onwards under AEO reference scenario cited by FSEIS and CAPP Projection versus IEA 450 PPM oil production growth for entire OECD Americas region



Source: USDOS FSEIS, IEA, Carbon Tracker Analysis 2014

The upshot of this is that the conclusions of the FSEIS – that a tide of rising oil demand and rising oil prices will ensure profitable oil sands production and export even with higher-cost transport options – must be interpreted as analysis centered on a world where curbing climate change is not a priority.[28] *Should the FSEIS have included a scenario that considered a pathway of decarbonisation akin to the IEA's 450 PPM scenario – in which declining oil demand and stable oil prices make higher-cost transport alternatives to KXL less likely to be developed – than the potential impact of KXL on enabling more oil sands production would likely be harder to dismiss as a short-term phenomenon.*

What are the climate implications of KXL-enabled additional production?

Recognizing that dismissing the impact of KXL on oil sands production as merely "short-term" is far easier to do under scenarios that do not incorporate serious climate constraints, there remains the question of the quantity of greenhouse gas (GHG) emissions that any additional production related to KXL will produce. Following the FSEIS, in answering this question we focus on emissions over the full lifecycle (i.e. extraction, processing, refinement, and combustion) and assume GHG conversion factors of 0.53-0.57 tCO_2e/bbl.[29]

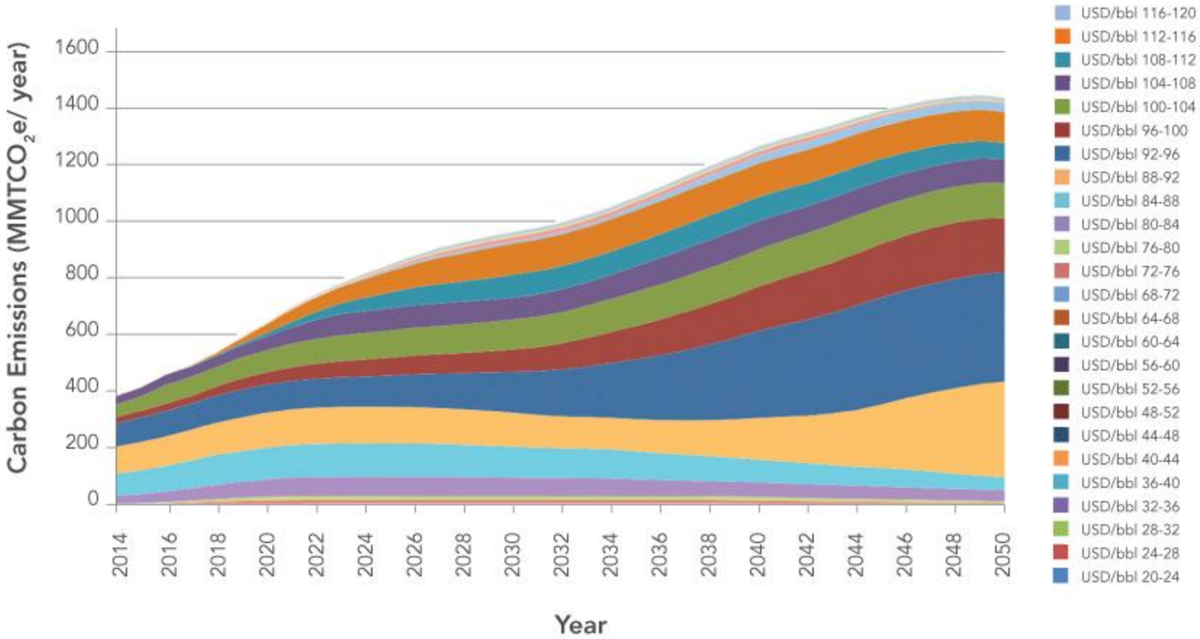
[28] USDOS observes that "Oil prices would have to be substantially lower than current oil prices or those projected for WTI in the Reference, High Resource, and Low/No Net Imports Cases, which average between $100 to $113 per barrel in real terms through 2035… To achieve a low-price world, one would have to make other assumptions about demand and/or assume that supply from other high cost resources, such as from shale or deepwater, is not affected by lower prices." *FSEIS - Keystone XL Project*, "1.4-136 – 1.4-137 (note 168).

[29] GHG conversion factors taken from USDOS, *FSEIS - Keystone XL Project*, "Appendix U (Lifecycle Greenhouse Gas Emissions of Petroleum Products from WCSB Oil Sands Crudes Compared with Reference Crudes)," Table 6-3, 77. Figures converted from $kgCO_2e$ to tCO_2e at a rate of 1000 kg to 1 metric ton.

Moreover, for simplicity, we calculate the level of emissions attributable to "KXL-enabled" incremental production and ignore any "market analysis" adjustments to account for increased US bitumen imports displacing imports of heavy crude from Mexico and Latin America. To the extent such displacement occurs, it may reduce the emissions impact below what we have calculated here.

For new and existing oil sands projects, the figure below illustrates annual CO_2e emissions broken down by plant-gate supply cost category. Total annual emissions are projected to increase from 450 $MMTCO_2e$/year in 2018 to 1000 $MMTCO_2e$/year in 2035 and 1400 $MMTCO_2e$/year by 2050. For reference, projected 2050 emissions from oil sands production are equal to 4.5% of total global emissions in 2011.[30]

Figure 6 GHG emissions for Total oil sands (in-situ and mining) for new and existing projects

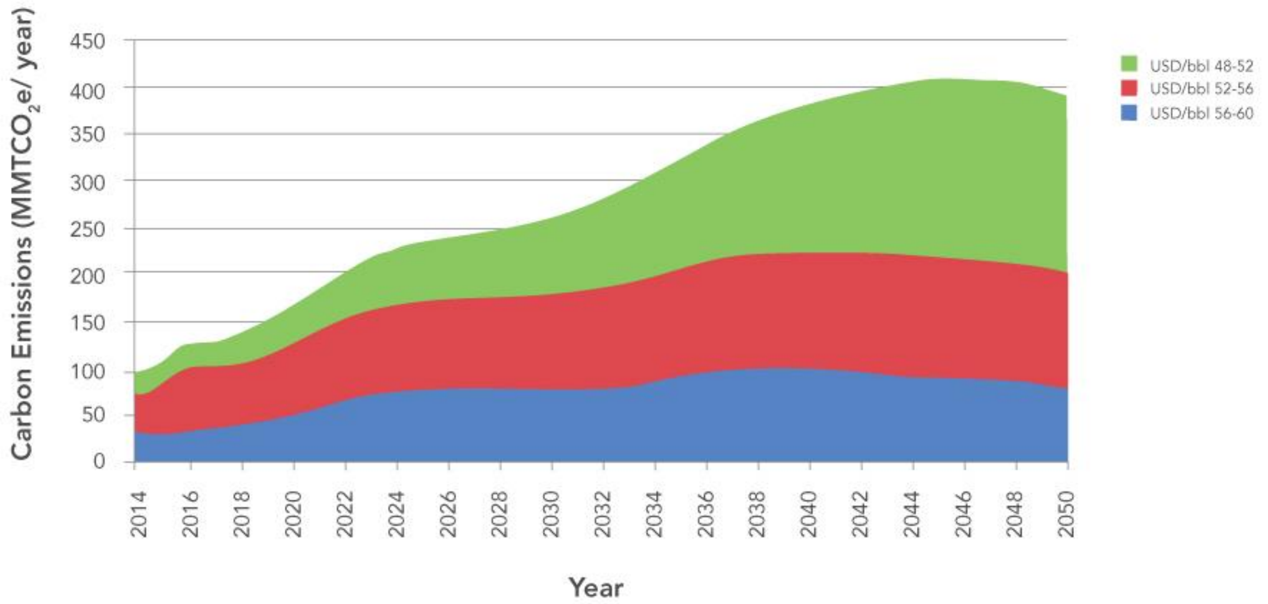


Source: Rystad Energy UCube, Carbon Tracker analysis 2014.
GHG Emissions conversion factor of 0.55 tCO_2e/bbl. Assumes no transportation constraints.

Focusing just on projects in the range of \$48-\$60/bbl, as shown below, annual CO_2e emissions are projected to rise from 135 $MMTCO_2e$/year in 2018 to 320 $MMTCO_2e$/year in 2035 and 390 $MMTCO_2e$/year in 2050.

[30] IEA, *World Energy Outlook 2013*, “Annex A Tables for Scenario Projections,” World Balance: New Policies Scenario. Note that the 4.5% figure cited above is a rough approximation, as IEA figures are in CO_2 and our oil sands figures are in CO_2e. That said, the relatively low (~1%) share of methane emissions in overall lifecycle GHG emissions from Canadian oil sands suggests that the difference between CO_2 and CO_2e will be relatively small. For example, USDOS observes that “Compared to other fuel sources, such as shale gas, and certain oil producing regions, such as Nigeria, methane emissions from WCSB oil sands crudes are a small portion of lifecycle GHG emissions. According to NETL (2009), methane emissions represent only 4% of WTT GHG emissions and 1%of WTW GHG emissions, using 100-year global warming potential values. *FSEIS - Keystone XL Project*, 4.1.6.

Figure 7 GHG emissions for Total oil sands (in-situ and mining) for new and existing projects with plant-gate supply cost of $48-$60/bbl



Source: Rystad Energy UCube, Carbon Tracker analysis 2014.
GHG Emissions conversion factor of 0.55 tCO_2e/bbl. Assumes no transportation constraints.

Finally, the figure overleaf projects cumulative CO_2e emissions through 2050 by level of plant gate supply cost. Cumulative CO_2e emissions through 2050 across the entire cost range equal 35000 $MMTCO_2e$. Comparing this with the remaining global carbon budget through 2050 for an 80% probability to stay below 2°C - calculated by Carbon Tracker and the Grantham Research Institute as 900,000 $MMTCO_2$[31] - shows it to be 3.9% of the remaining total global carbon budget.

To estimate cumulative GHG emissions from KXL-enabled "incremental production", we note that for KXL's entire capacity of 830 kbpd the FSEIS calculated cumulative lifecycle GHG emissions through 2050 to be 5145-5880 $MMTCO_2e$.[32] Of this 830,000 kbpd, there is capacity to carry 730 kbpd of diluted bitumen (i.e. 500-525 kbpd of bitumen), which our analysis suggests could come entirely from KXL-enabled production.

Using GHG emission factors for western Canada oil sands crude of 0.53-0.57 tCO2e/bbl, we estimate *cumulative emissions from KXL-enabled production to be 4943 - 5316* $MMTCO_2e$.[33] Cumulative KXL-enabled

---

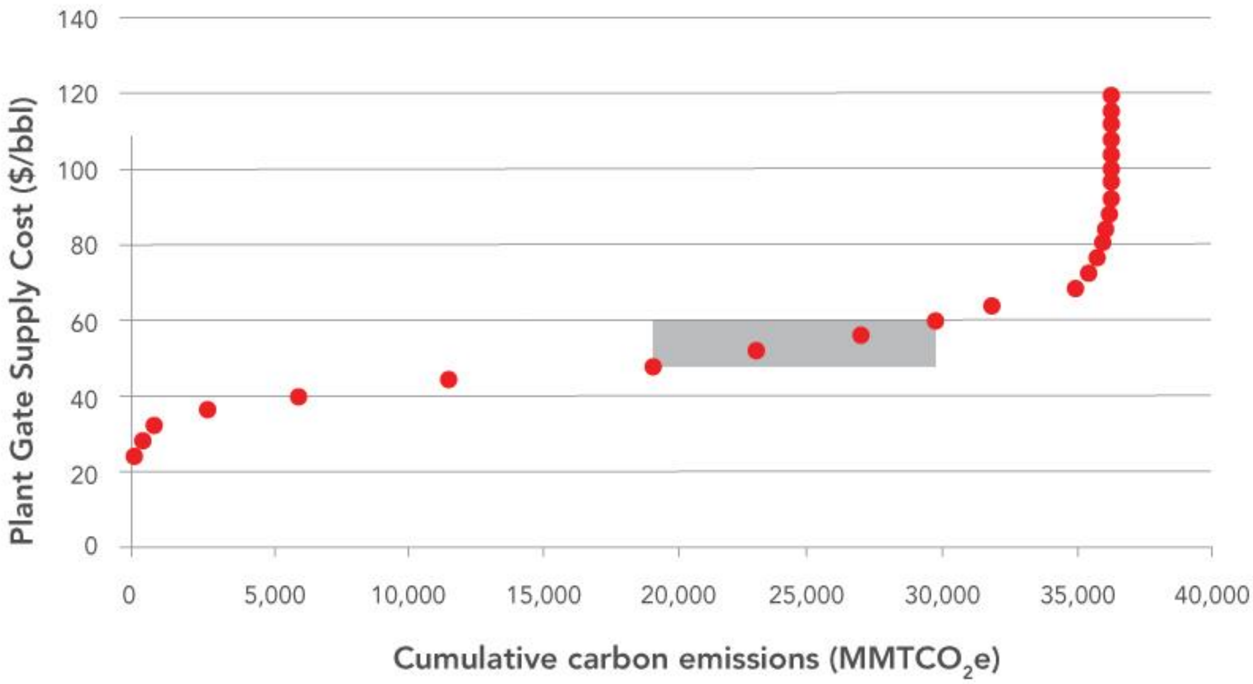
[31] Carbon Tracker Initiative and the Grantham Research Institute for Climate Change and the Environment, *Unburnable Carbon 2013: Wasted capital and stranded assets*, June 2013. Note that, as with the IEA numbers above, the 2°C carbon budget is in terms of CO_2 rather than CO_2e. Again, the very low (~1%) share of methane emissions in overall lifecycle GHG emissions from Canadian oil sands makes the difference between CO_2 and CO_2e figures *de minimis*.

[32] USDOS, *FSEIS - Keystone XL Project*, 4.14-4 observes that "The total annual lifecycle emissions associated with production, refining, and combustion of 830,000 barrels per day (bpd) of oil sands crude oil transported through the proposed Project, as determined through this assessment, are approximately 147 to 168 $MMTCO_2e$." We multiply this range by 35 to get cumulative figures through 2050 of 5145-5880 $MMTCO_2e$.

[33] We calculate a similar range by simply taking 88% (i.e. 730/830 = 0.88) of the original FSEIS range, which yields an estimate of cumulative emissions from KXL-enabled production of 4525 - 5172 $MMTCO_2e$. The slight difference between this estimate and the one above may involve differences in (1) the assumed production mix of Canadian oil sands crude flowing through KXL (i.e. our assumption of 100% diluted bitumen versus the FSEIS baseline assumption of

emissions (through 2050) are equivalent to the annual GHG emissions from one billion passenger vehicles or the annual CO_2 emissions from 1400 coal-fired power plants.[34] Moreover, they are nearly equal to total US CO_2 emissions in 2013.[35] Increasing emissions in this way contradicts the official US target of reducing 2020 CO_2 emissions 17% below 2005 levels (much less the more ambitious 2°C-relevant goal of reducing 2050 emissions 50% below 2005 levels).

Figure 8 Canadian Oil Sands Cumulative GHG emissions from 2014 to 2050 vs. Plant Gate Supply Cost



Source: Rystad Energy UCube, Carbon Tracker analysis 2014.
GHG Emissions conversion factor of 0.55 tCO_2e/bbl. Assumes no transportation constraints.
The chart shows the amount of carbon produced as oil price increases by $5 increments and break-even price meets the plant-gate supply costs.

4. Is the climate impact of KXL-enabled incremental production "significant"?

The calculations above show the challenge of determining whether the KXL pipeline will "significantly exacerbate the problem of carbon pollution". Significance, as many have said, is in the eye of the beholder. Carbon emissions associated with extraction of Canada's oil sands - one of the largest sources of unconventional oil in the world - amounts to 3.9% of the remaining 2°C global carbon budget. Potential

80% diluted bitumen and 20% upgraded synthetic crude oil); and/or (2) different assumptions about the refinery yields of gasoline and other distillates per barrel of oil sands crude. That said, as the vast majority of GHG emissions for oil sands crude occur during extraction and combustion (and GHG emissions during these stages are nearly identical for diluent and synthetic crude oil), the differences are very minor.

[34] US Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator," http://www.epa.gov/cleanenergy/energy-resources/calculator.html, accessed February 24, 2013

[35] US Energy Information Administration, "US energy-related CO_2 emissions in 2013 expected to be 2% higher than in 2012," January 13 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=14571.

incremental bitumen production enabled by KXL, however, amounts to only ~0.5%. **The US President has to decide if just one single pipeline that could use up 0.5% of the total remaining 2°C global carbon budget is indeed significant.**

As noted above, the FSEIS scenario is geared toward a projected increase in bitumen production that is inconsistent (or incompatible) with a 2°C world. For example, the projected increase in US oil demand under the FSEIS modeling scenarios is inconsistent with the goals of President Obama's recent Climate Action Plan, including its pledge to limit 2020 GHG emissions 17% below 2005 levels.[36] **With respect to KXL in particular, *our estimated range of "KXL-enabled" production (500-525 kbpd) matches net oil production growth throughout the entire OECD Americas region under the IEA's 450 ppm scenario.* Recognizing a 2°C world requires oil production to flatten (or decline) rather than increase provides the proper context for evaluating whether any production attributable to KXL is "significant".**

Rather than setting a standard of "significance", however, a different decision framework might instead emphasize climate change to be a threat as urgent and severe as "terrorism, epidemics, poverty" and "the proliferation of weapons of mass destruction".[37] From this perspective, decisions that aggravate the threat by even fractions of a percent can be too costly to bear. Exercising leadership on climate change requires evaluating the KXL decision from exactly such a perspective.

The imbalance between the remaining 2050 carbon budget for a 2°C world (900 $GtCO_2$) and the carbon embedded in existing fossil fuel reserves 2,860$GtCO_2$[38] means that through 2050 only 20% of existing fossil fuel reserves can be burned. Given that oil sands are among the more expensive sources of remaining oil reserves[39], they are an obvious candidate to see future production curtailed (relative to a business-as-usual projection) in a 2°C world.

Regardless of the final decision on KXL, the importance of the word significant cannot be overemphasized. It is clear that the Obama administration needs to provide a significance test that is measurable – and therefore meaningful – either for each project or for a series of potential projects over a period of time. Otherwise any and all projects can pass the significance test regardless of carbon emissions and climate forcing impact.

[36] Executive Office of the President, "The President's Climate Action Plan," June 2013, http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf
[37] Michael R. Gordon and Coral Davenport, "Kerry Implores Indonesia on Climate Change Peril," *The New York Times*, February 16 2014, http://www.nytimes.com/2014/02/17/world/asia/kerry-urges-indonesia-to-help-stem-climate-change.html?_r=0
[38] Carbon Tracker Initiative and the Grantham Research Institute for Climate Change and the Environment, *Unburnable Carbon 2013: Wasted capital and stranded assets*, June 2013.
[39] IEA, *World Energy Outlook 2013*, "Figure 13.17 – Supply Cost of Liquid Fuels," 454.

Appendix A – FSEIS Modeling Scenarios

Table A1 FSEIS Table 1.4-19 Supply-Demand and Pipeline Cases, and the Resulting Scenarios

	EIA AEO Reference Case: U.S. crude oil production peaks at 7.5 million bpd in 2019 and then declines	**EIA AEO High Resource Case:** Larger recoverable oil and gas resource assumptions result in U.S. crude oil output reaching 10 million bpd by 2020 and then remaining flat	**EIA Low/No Imports Case:** Assumes High Resource supply plus greater demand-side efficiency, leaving United States a net oil exporter by 2035	**High Latin American Supply Case:** Assumes higher Latin American production with Reference Case
Unconstrained: Allow all cross-border and Canadian east/west pipelines	*Reference Unconstrained Scenario*	*High Resource Unconstrained Scenario*	*Low/No Imports Case Unconstrained Scenario*	*Higher Latin American Unconstrained Scenario*
No East-West Pipelines: Allow cross-border pipelines but no new Canadian east/west pipelines or rail to Canadian West Coast	*Reference No East-West Scenario*	*High Resource No East-West Scenario*	*Low/No Imports No East-West Scenario*	*Higher Latin American No East-West Scenario*
No Cross-Border Pipelines: No cross-border pipelines but allow Canadian east/west pipelines[a]	*Reference No Cross-Border Scenario*	*High Resource No Cross-Border Scenario*	*Low/No Imports No Cross-Border Scenario*	*High Latin American No Cross-Border Scenario*
All Constrained: No new cross-border, east-west Canadian pipelines, or rail to Canadian West Coast	*Reference Constrained Scenario*	*High Resource Constrained Scenario*	*Low/No Imports Constrained Scenario*	*High Latin American Constrained Scenario*

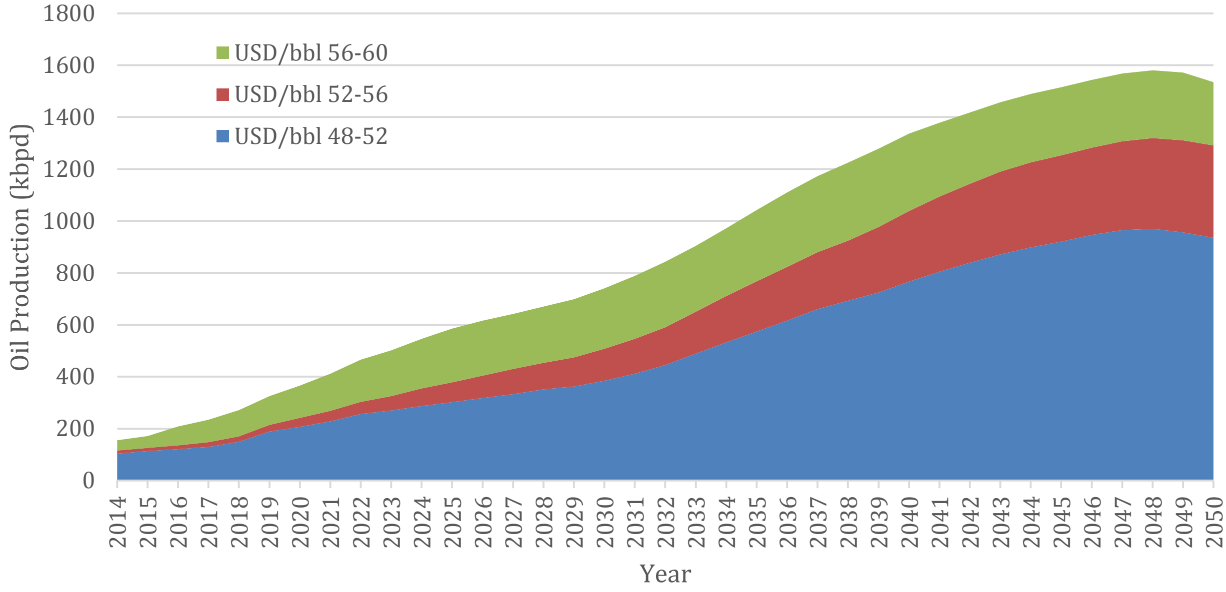
Source: USDOS FSEIS

(a) Where permitted, planned pipelines begin after several years, including the northern leg of TransCanada Keystone XL (2017), TransCanada Energy East (2018), expansion of Kinder Morgan Trans Mountain (2020), and Enbridge Northern Gateway (2025).

APPENDIX B – In-situ analysis

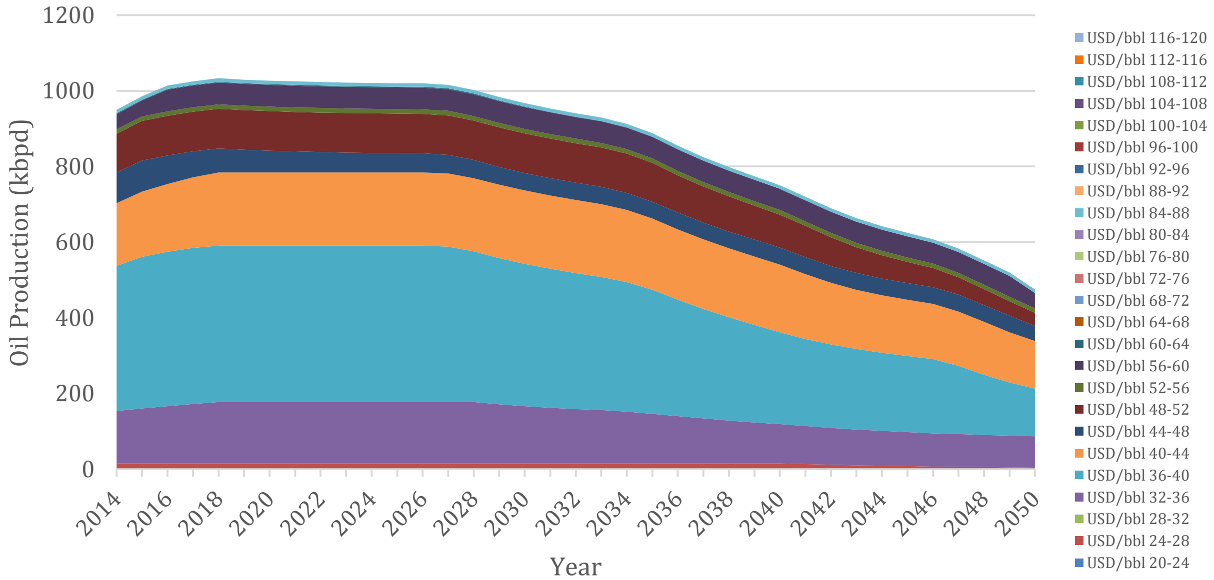
For completeness we also include all key charts on an in-situ basis only. This does not significantly alter our conclusions. Breaking down the production profile of each by plant-gate supply costs, we also compare existing production ("in production") assets and "new" production assets. New production is defined using the Rystad Energy UCube database life cycle terminology as assets that are either under development, being discovered or undiscovered (e.g. no awarded licenses).

Figure A1 – All in-situ assets ($48-$60 / bbl only)



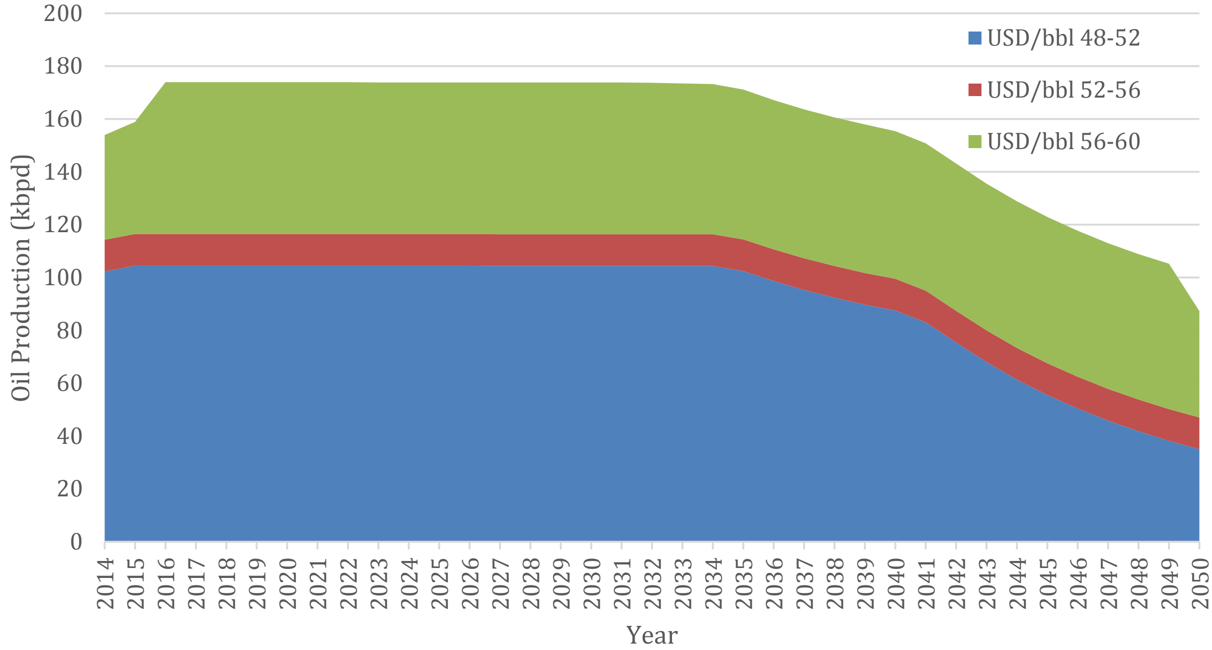
Source: Rystad Energy UCube, Carbon Tracker analysis 2014.

Figure A2 – In-situ assets that are in production



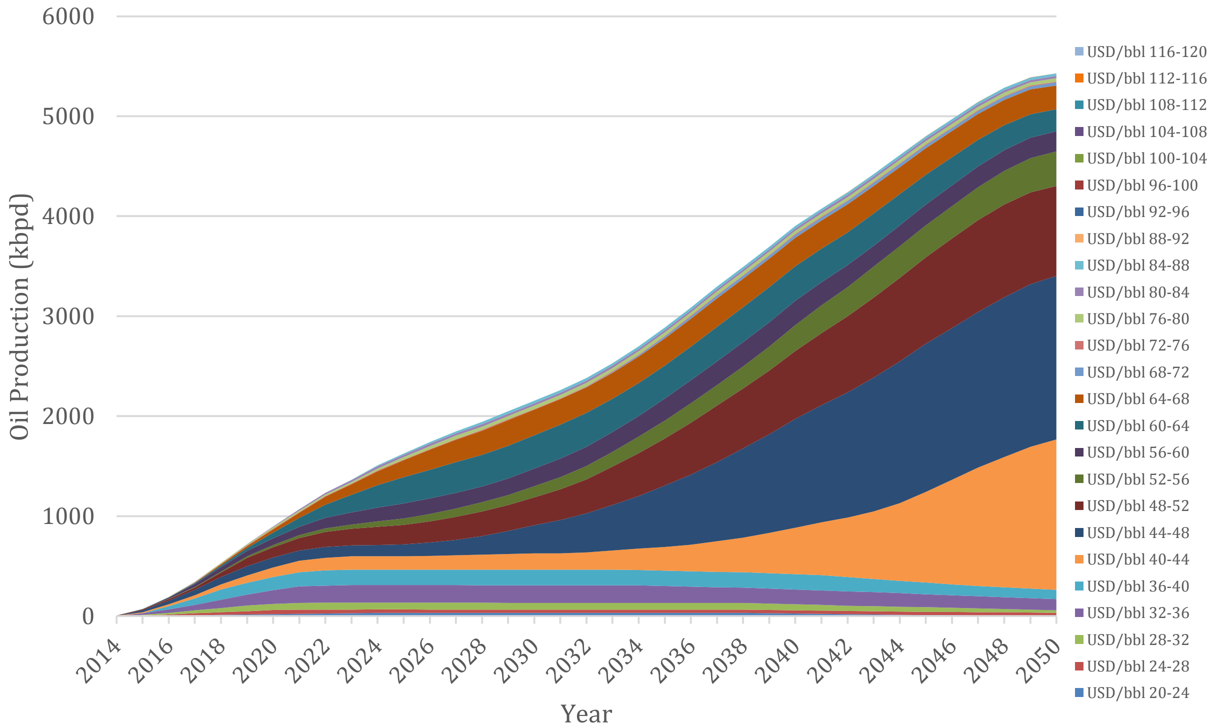
Source: Rystad Energy UCube, Carbon Tracker analysis 2014.

Figure A3 – In-situ assets that are in production ($48-$60 / bbl only)



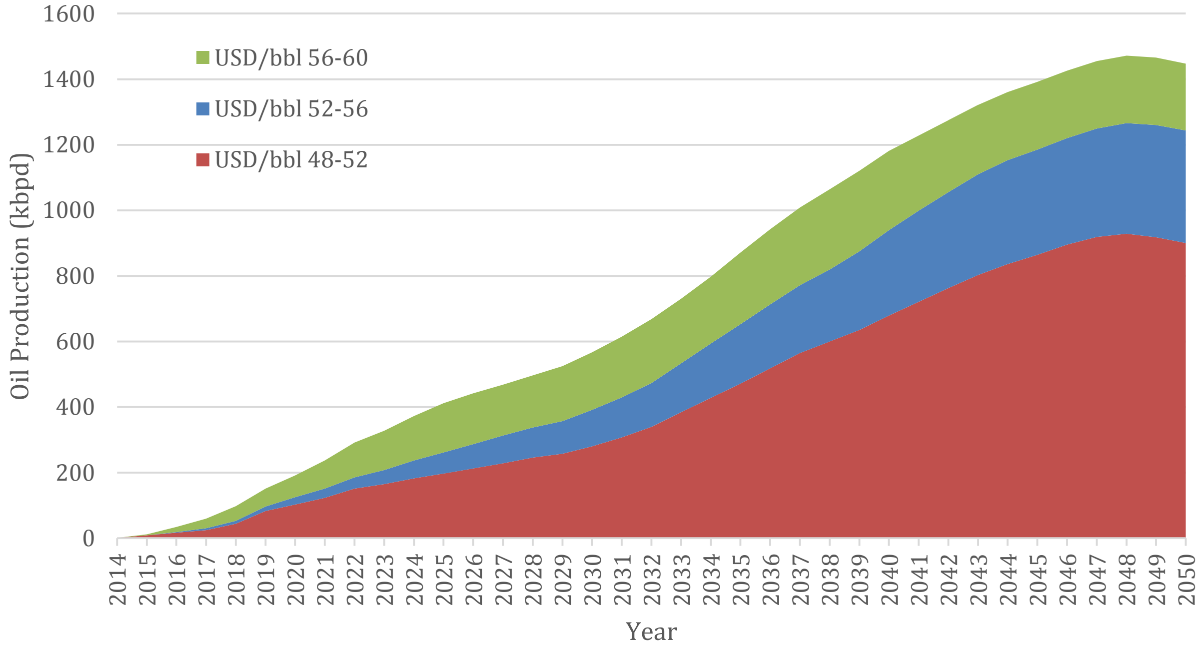
Source: Rystad Energy UCube, Carbon Tracker analysis 2014.

Figure A4 – Production from new, in-situ assets



Source: Rystad Energy UCube, Carbon Tracker analysis 2014.

Figure A5 – In-situ production from new assets only ($48-$60 / bbl only)

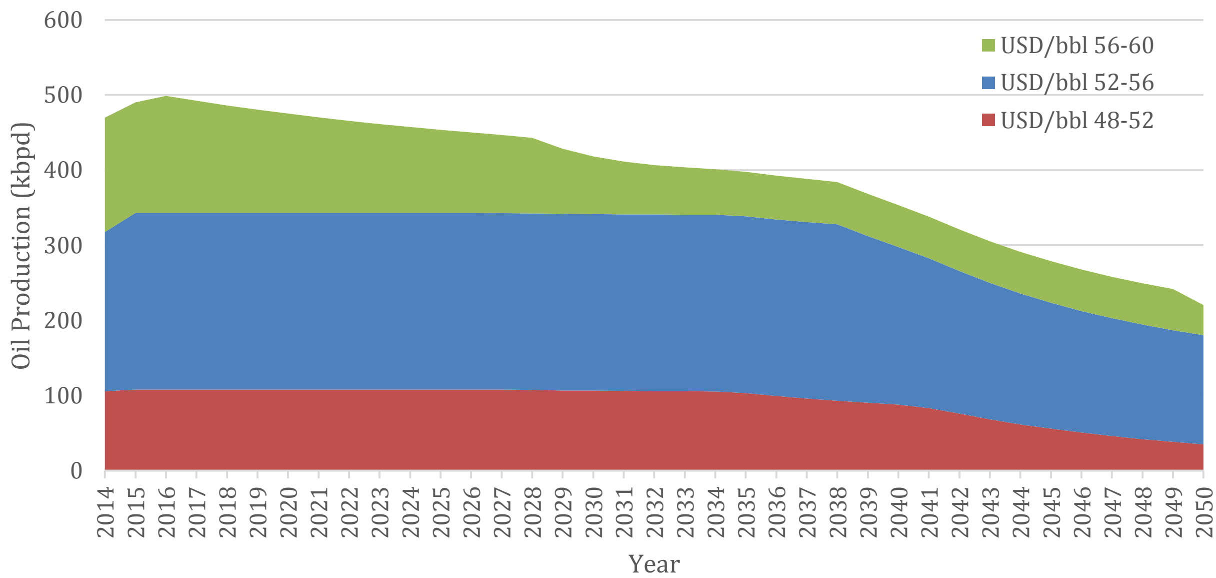


Source: Rystad Energy UCube, Carbon Tracker analysis 2014.

Appendix C – Total production from all in-situ and mining oil sands assets by existing and new production

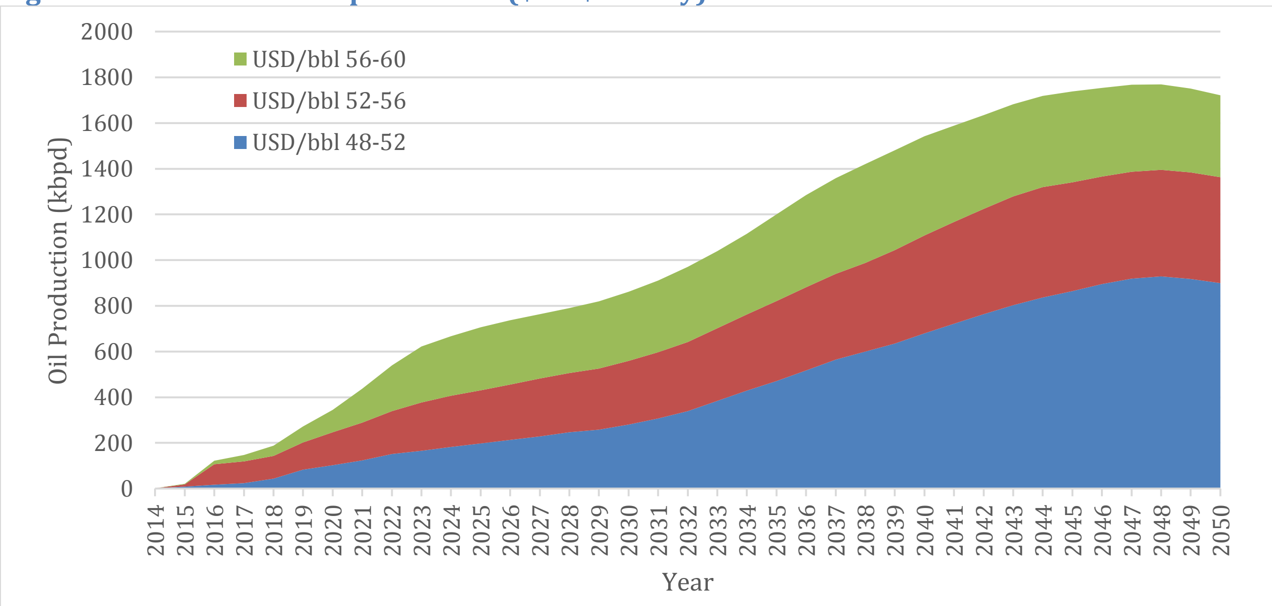
Breaking down the production profile of each by plant-gate supply costs. In the following charts we compare existing production ("in production") assets and "new" production assets. New production is defined using the Rystad Energy UCube database life cycle terminology as assets that are either under development, being discovered or undiscovered (e.g. no awarded licenses).

Figure A6 –Existing assets oil sands production ($48-$60 only)



Source: Rystad Energy UCube, Carbon Tracker analysis 2014.

Figure A7 – New oil sands production ($48-$60 only)



Source: Rystad Energy UCube, Carbon Tracker analysis 2014.

www.carbontracker.org

@carbonbubble

Disclaimer