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Greenhouse Gas Emissions Implications of the Keystone XL Pipeline

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Cover photo: Hundreds of metres of pipe are stacked in a field outside Morden, Manitoba, as part of the construction of the existing part of the Keystone XL pipeline, in Canada. © Loozrboy / Flickr

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WORKING PAPER NO. 2013-11

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ABSTRACT

Climate policy and analysis often focus on energy production and consumption, but seldom consider the role of energy transportation infrastructure in shaping energy systems, energy use and related greenhouse gas emissions. The proposal to extend the Keystone XL pipeline, to connect Canadian oil sands production with refineries and ports in the Gulf of Mexico, has brought these issues to the fore. This paper looks how the pipeline might affect global GHG emissions, with particular focus on its potential to affect global oil consumption by increasing supply and thus decreasing prices – an aspect that has received remarkably little attention among existing Keystone assessments. We consider a range of possible outcomes, if the Keystone XL pipeline were not completed: 1) that the same amount of oil (100% of Keystone capacity) would reach the market anyway by other means; 2) that half of it would; or 3) that none would. For the latter case, we find that the pipeline's impact on global oil prices, though modest (less than 1%), could be enough to increase global oil demand by 510,000 barrels per day, or 62% of Keystone XL capacity. Such an increase could boost global GHG emissions by as much as 93 million tCO_2e per year in 2020. If only half of the oil were to otherwise reach the market, the impact would be roughly half that size. These findings suggest that the U.S. government should more closely examine the pipeline's potential effect on oil markets before making a final decision. An advantage of a simple model such as the one we constructed – using publicly available supply curves and peer-reviewed demand elasticities – is that it is highly transparent, and allows one to gauge the magnitude of possible effects. Similar approaches could also be used to analyze other proposed fossil-fuel infrastructure projects.

Risks of and Responses to the New Fossil Fuel Economy

This paper is part of a two-year SEI project that aims to deepen understanding of the risks posed by new investments in fossil fuel infrastructure, and of the possible responses by policy-makers and civil society to mitigate or avoid these risks. In particular, this initiative examines major decisions regarding new investments in fossil fuel extraction and trade infrastructure, especially in venues where green growth or low-emission development strategies (LEDS) are under development or consideration. Our aim is to provide resources and tools to help planners and policy-makers assess the risks of, and responses to, fossil development, as part of low-carbon and green growth planning.

For a full list of our publications, see http://www.sei-international.org/projects?prid=2055.

Acknowledgments

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EXECUTIVE SUMMARY

Climate policy and analysis often focus on energy production and consumption, but seldom consider the role of energy transportation infrastructure. How might the choices we make about coal export terminals, or oil and gas pipelines, shape the future development of our energy systems? How might they affect energy use, and the resulting greenhouse gas emissions?

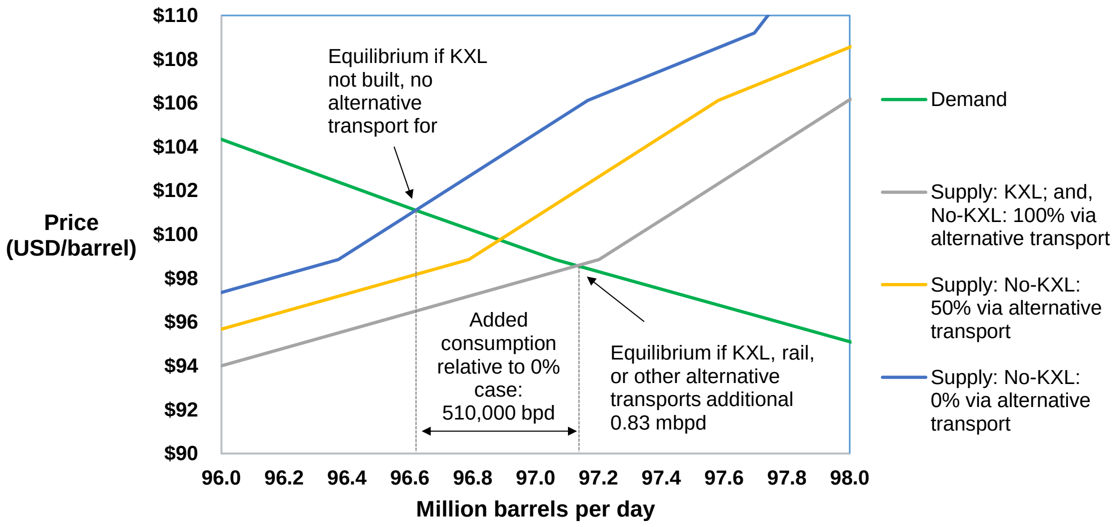
The proposal to extend the Keystone XL pipeline, to connect Canadian oil sands production with refineries and ports in the Gulf of Mexico, has brought these questions to the fore. Environmental activists have argued that Keystone XL would strike a serious blow to the climate, and President Barack Obama has said he will only approve Keystone XL if it "does not significantly exacerbate the problem of carbon pollution". Similar issues have been raised with regard to proposed coal export terminals in the U.S. Pacific Northwest.

Several analyses of Keystone XL's emissions impact have been published with very different conclusions. Draft analysis commissioned by the U.S. Department of State found that the pipeline would lead to little change in global GHG emissions. Other studies refer to the emissions associated with oil transported by the Keystone XL pipeline – 830,000 barrels per day, and 181 million tons of carbon dioxide equivalent (CO_2e) per year. Many have emphasized the emissions associated with the high resource intensity of oil sands production, on the assumption that Canadian oil sands would substitute for less resource-intensive sources of oil – without changing global oil consumption – the difference amounting to roughly 19 to 25 million tons CO_2e per year.

To a great extent, the different estimates reflect divergent, even opposing perspectives on how Keystone XL would affect the amount of Canadian oil sands production that reaches the market, and whether that added production would either displace other supplies or add to them. This paper does not assess whether Keystone XL would in fact lead to more Canadian oil sands production, a highly speculative question given the politicized nature of various pipeline and rail expansion proposals. Rather, it focuses on a key issue that has received much less attention: how Keystone XL might affect the global oil market by increasing supply, decreasing prices, and thus increasing global oil consumption. Even if those effects are small in global terms, they could be significant in relationship to Keystone XL and U.S. climate policy.

To capture a range of possibilities, we examined three possible implications for Canadian oil sands production if the Keystone permit were rejected: 1) that the same amount of oil (100% of Keystone capacity) would reach the market anyway through other transport options; 2) that half of it would; or 3) that none would. For the latter two cases, our analysis finds that the pipeline's impact on global oil prices, though modest (less than 1%), would be enough to increase global oil demand by hundreds of thousands of barrels per day. Figure ES-1 summarizes the model and its results. Based on our assumptions regarding demand and supply responsiveness, and consistent with other, peer-reviewed literature, global oil use would increase by as much as 510,000 barrels per day, or 62% of Keystone XL capacity, in the case that none of the oil would otherwise reach the market.

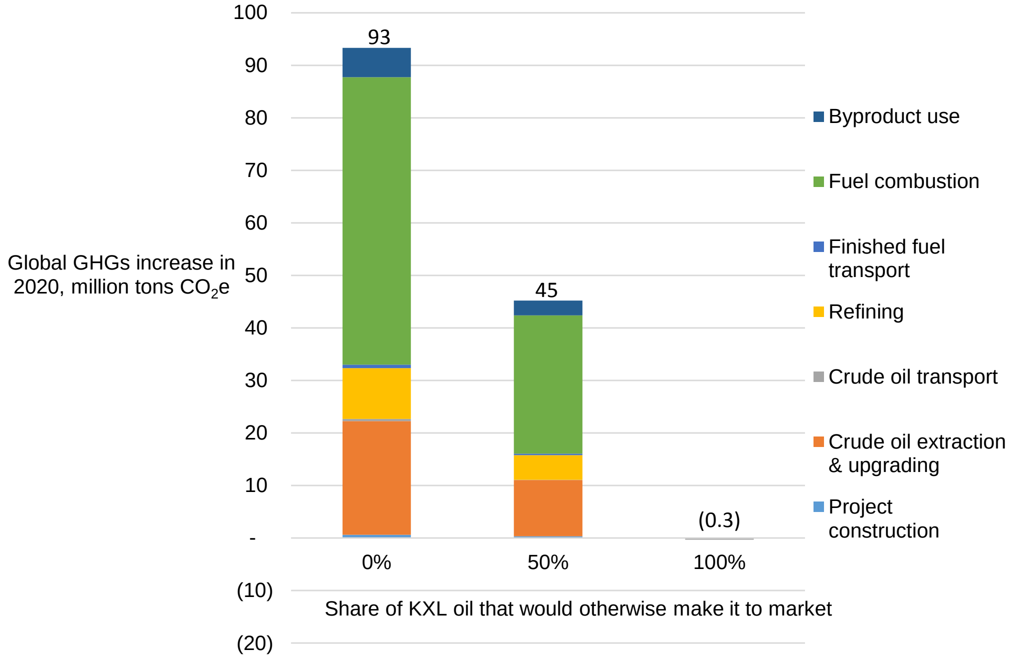
Figure ES-1: Simple model of global supply and demand for oil



Note: Analysis assumes elasticity of demand to be –0.2.

As shown in Figure ES-2, such an increase would boost global GHG emissions by as much as **93 million tCO_2e per year,** potentially for most of Keystone XL's 50-year lifespan. If only half of the oil would otherwise reach the market, the impact would be roughly half that size.

Figure ES-2: Total annual GHG emissions impact of Keystone XL, by life-cycle phase, 2020, considering price effects



These potential impacts are about **four to five times greater than** the GHG implications of simply *displacing* average crude imported into the U.S. with oil-sands crude. A 93 million tCO_2e increase in annual emissions would be roughly equivalent to 1–2% of current U.S. emissions and 10% of the emission reductions that the U.S. government has pledged to achieve by 2020 (to 17% below 2005 levels). It would also be greater than the emission reductions that several proposed federal climate mitigation policies could achieve in 2020, such as U.S. Environmental Protection Agency performance standards on industrial boilers, cement kilns, and petroleum refineries.

Policy implications

Our analysis points to a gap in existing assessments of the Keystone XL project. If a simple supply-and-demand model such as ours shows that the pipeline's effect on oil prices could quadruple its total GHG impact, it is crucial that such effects be more clearly addressed in analyses that could inform President Obama's decision. An advantage of a simple model such as the one we constructed – using publicly available supply curves and peer-reviewed demand elasticities (the extent to which changes in oil consumption have responded to changes in oil prices) – is that it is highly transparent, and allows one to gauge the magnitude of possible effects. By contrast, proprietary models like the one used for the prior State Department market analysis lack transparency in key assumptions, such as how the global oil market may respond to changes in supply.

The answer to the question of whether Keystone XL will "significantly exacerbate the problem of carbon pollution" is likely to hinge upon how much the pipeline increases the global oil supply – and through its price effects, global oil consumption. At full capacity, Keystone XL is expected to be able to carry 830,000 barrels per day. Some have argued that if the pipeline is not built, then other modes, particularly rail, will be used to transport an equivalent amount of oil. However, there is far more prospective added Canadian oil sands production (4.5 million barrels per day) than Keystone XL itself can carry. Rail routes may be needed and used whether or not Keystone XL is completed. If Keystone XL ultimately enables significantly greater development of Alberta's oil industry, and thus increases the global oil supply and, in turn, consumption, then indeed, the "problem of carbon pollution" could be "significantly exacerbated".

1. INTRODUCTION

Climate policy and analysis have historically focused on how we produce and consume energy, but far less on how we transport it. Yet choices regarding energy transportation infrastructure – from fossil fuel export terminals to pipeline networks – can influence the direction of future energy transitions and have major social, environmental, and political consequences. Often overlooked, these considerations have been brought to the fore by the proposal to extend the Keystone XL pipeline to connect crude oil production from Canadian oil sands with ports and refineries in the Gulf of Mexico (Jones 2013).

Proposed coal export terminals in the U.S. Pacific Northwest, designed to bring coal from the Powder River Basin, in Wyoming and Montana, to Asian markets, have generated similar debates. In both cases, a key point of discussion is the role that new transport infrastructure will play in shaping future energy use and greenhouse gas emission paths. Indeed, on June 25, 2013, President Barack Obama stated that he would only approve the extension of Keystone XL across the United States if it "does not significantly exacerbate the problem of carbon pollution" (The White House 2013). That raises the question: How exactly should one measure the emissions impact of new energy transportation infrastructure?

With upstream oil and gas sector investment projected at nearly $700 billion per year for the next two decades (IEA 2013b; Barclays 2013), along with considerable investment in new coal mines, ports and shipping, it is crucial to understand the implications of this infrastructure for future greenhouse gas emissions. This paper proposes a systematic analytical framework to examine those implications, and applies it to Keystone XL.

We build on prior assessments, applying some elements of the draft *GHG Protocol Policy and Action Accounting and Reporting Standard*,[1] identifying the key uncertainties, and including a supply-demand perspective that, until now, has been largely absent from the Keystone XL debate. The goals of the paper are to a) provide a rubric that can be used to better understand the key assumptions and uncertainties that underlie divergent views; b) test the draft GHG Accounting and Reporting Standard's applicability to infrastructure investments; and c) offer new insights on the potential impact of Keystone XL on global oil consumption and emissions, using simple approaches that can be extended to similar projects.

Existing Keystone XL assessments

We are, of course, far from the first to examine the question of Keystone XL's impact on global GHG emissions. Over the last four years, the U.S. Department of State has undertaken an extensive Environment Impact Statement (EIS) process, which is scheduled to be completed in early 2014. The Draft EIS found that the Keystone XL pipeline would lead to virtually no change in global GHG emissions relative to a no-pipeline case (EnSys 2010, p.41

[1] Coordinated by the World Resources Institute, with input from numerous analysts and stakeholders, the *GHG Protocol Policy and Action Accounting and Reporting Standard* will provide guidance on quantifying the greenhouse gas effects of policies and actions, aiming to "increase the consistency and transparency in the way government agencies, international financial/aid institutions, businesses, and civil society organizations account for GHG reductions" (http://www.ghgprotocol.org/mitigation-accounting). We use the Second Draft for Pilot Testing; the Standard is subject to revision, and a draft is scheduled for release in 2014. The authors of this paper have been involved in the development of the Standard as members of the Advisory Committee and Technical Committee, and this analysis is, in part, a pilot test of the draft Standard.

in the appendix).[2] It found that "production volumes [of Western Canada oil sands crude oil] were not affected by changes in assumptions about pipelines…" (EnSys 2010, p.80).[3] Similarly, industry consultant IHS CERA concluded that the Keystone XL pipeline would have "no material impact on US GHG emissions", arguing that absent the pipeline, Venezuelan heavy crude would likely substitute for Alberta oil sand crude at Gulf Coast refineries (with a similar profile of life-cycle emissions in extraction and processing), and that that similar volumes of Canadian oil sands crude would reach the market via rail or other pipelines (Forrest and Brady 2013).

Others have questioned these findings. The U.S. Environmental Protection Agency criticized the State Department conclusion that "oil sands crude will find a way to market with or without [Keystone XL]", asserting that it was "not based on an updated energy-economic modeling effort" (Giles 2013, p.3). The International Energy Agency's *World Energy Outlook 2013* notes that approval of Keystone XL and other pipelines would be needed to increase Canadian oil sands production, implying that not all of the oil would otherwise make it to market (IEA 2013b, p.491). And several critics of the Keystone XL proposal have suggested that other transportation options face serious obstacles or would not be able to carry heavy crude. They argue that alternative pipeline routes to western Canada are limited by insufficient investor interest and broad public opposition, that alternative pipelines in the U.S. to the Gulf Coast are limited by technical capacity and economic constraints, and that large-scale transportation of oil by rail is less likely due to lower efficiencies and safety concerns (NRDC 2013; Sierra Club et al. 2013; Kretzmann et al. 2013; Droitsch 2011). Given these obstacles, one might argue that all of the GHG emissions associated with production and consumption of the Canadian oil could be attributed to Keystone XL – 181 million tCO_2e per year, according to Kretzman et al. (2013).

2. METHODOLOGICAL APPROACH

We analyze two scenarios: the U.S. government approves or rejects Transcanada's application to build and operate the Keystone XL pipeline to the Gulf Coast.

Under the permit approval scenario, which we refer to as the "KXL case", we assume that the import of crude oil from Western Canada, pipeline transport and delivery to Gulf Coast ports will begin in 2016. Under this case, we assume, for simplicity and transparency, that the KXL pipeline would ramp up to transport 830,000 barrels per day of Canadian oil sands crude by 2020 and then for the remainder of its entire 50-year lifetime (U.S. Department of State 2013, pp.4.15–2).

Under the permit rejection scenario, we consider three cases, defined by how much of the oil that would have been transported by Keystone XL still makes it to market – or put another way, the extent to which the rejection of the pipeline might affect the amount of Canadian oil that is produced and reaches the market over the next 50 years:

- Full KXL oil transport capacity (830,000 barrels per day) provided by other means (100% by alternative transport);

[2] The study did also include a "No Expansion" case, which assumed not only that Keystone XL would not be built, but that no other line that was not operational as of 2010 would be built. In that scenario, global GHG emissions would be virtually unchanged in 2020 and reduced by 20 million tons CO_2e in 2030, relative to if Keystone were built (EnSys 2010, p.84) – roughly 10% of the total emissions associated with the crude the pipeline would carry.

[3] The U.S. Department of State used this finding to support its conclusion that "approval or denial of any one crude oil transport project, including the proposed [Keystone] Project, remains unlikely to significantly impact the rate of extraction in the oil sands" (U.S. Department of State 2013, pp.1.4–1) and, by extension, GHG emissions.

- Half of KXL oil transport capacity (415,000 barrels per day) provided by other means (50% by alternative transport);
- No oil transport capacity provided by other means (0% via alternative transport).

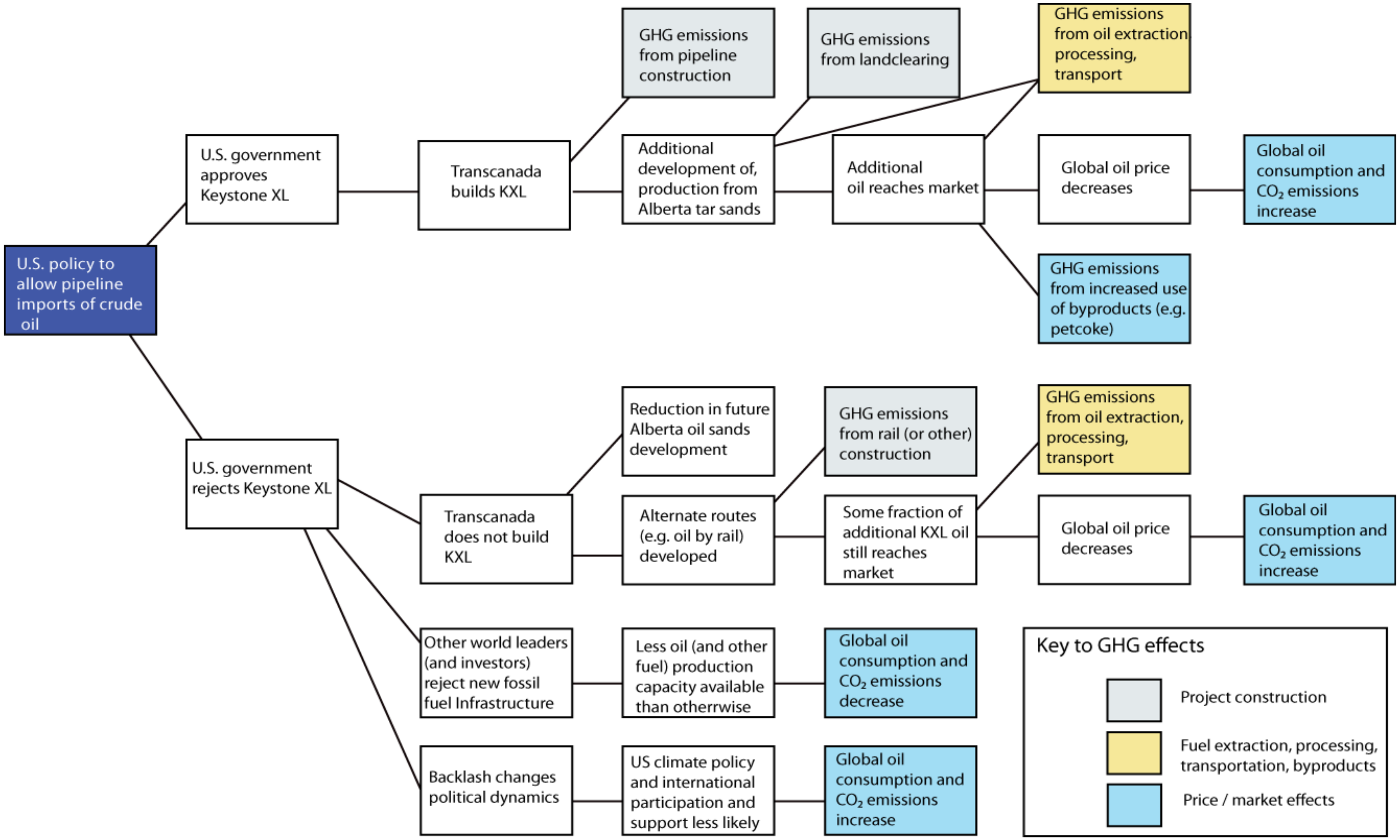
It is important to note that although we focus here on whether other transportation options (rail or other pipelines) might substitute for Keystone XL, as the question is usually framed, industry forecasts suggest all options are likely to be pursued regardless of Keystone XL's fate. The proposed pipeline would only be able to transport about 20% of the 4.5 million barrels per day by which the Canadian Association of Petroleum Producers (2013) expects Canadian oil sands production to grow by 2030. Numerous transportation infrastructure projects would be needed to support that level of production, including expanded rail capacity and proposed pipelines to Western or Eastern Canada. Thus, ultimately, the question is not so much whether the oil that would flow through Keystone might otherwise flow through rail cars, but rather whether the total amount of oil exported from Canadian oil sands would increase as the result of Keystone XL. Rail capacity, for example, will likely be used to some extent regardless of whether Keystone XL is built – so what matters is how much more, over a 50-year time horizon, it would be used absent Keystone XL.

In the first no-pipeline case we consider, the rejection of Keystone XL would not affect the total amount of Canadian oil sands production over the next 50 years: the oil would all still reach the market by other means. In the second case, we assume Canadian oil sands production would drop by 415,000 barrels per day – half of Keystone XL's capacity. In the third case, production would be 830,000 million barrels per day lower than it would have been if Keystone XL were built. Thus, both the approval and rejection scenarios could lead to a series of consequences for GHG emissions.

We describe the major cause-and-effect relationships in a causal chain diagram, an element of the draft GHG Protocol Standard, as shown in Figure 1. We identify three types of GHG effects, as indicated by separate colors in Figure 1: (1) emissions impacts resulting from construction of the oil transport infrastructure (pipeline or otherwise, such as rail) and any incremental expansion of oil sands production; (2) emissions resulting from oil extraction, transport, and refining; and (3) emissions that result from increases or decreases in global oil consumption (or, in some cases, substitute fuels) that result from price effects.[4]

[4] Consistent with the example causal chain depicted in the *Standard*, "intermediate effects" are depicted as boxes with no color.

Figure 1: Causal chain for analysis of U.S. policy regarding pipeline imports of crude oil



Overview of GHG effects considered

Emissions associated with oil extraction, transport, and refining – the gold boxes in Figure 1 – have received most attention in the literature to date. As U.S. EPA stated in a comment letter to the State Department, "it is this difference in GHG intensity – between oil sands and other crudes – that is a major focus of the public debate about the climate impacts of the oil sands crude."[5] The State Department conducted extensive research on these "life-cycle", "well to wheel (WTW)" emissions of Canadian oil sands relative to alternate crude oils, and we use those estimates here.

Emissions associated with possible effects on global oil price and consumption have received less attention. As noted above, those emissions depend on the extent to which the availability of Keystone XL would affect the level of development of, and production from, Canadian oil sands. As shown in Figure 1, under the approval scenario, the Keystone XL pipeline is built, enabling oil sands production to increase, adding to global oil supplies. By increasing global supply, global oil prices decrease, which in turn increases global oil consumption. Under the rejection, no-KXL scenario, to the extent that other routes (e.g. rail) are used instead of Keystone XL to enable increased oil sands production, global oil supplies also increase, leading, similarly, to added oil consumption. The *net* impact on global oil consumption, i.e. the difference between the KXL and no-KXL cases, is thus a direct function of the fraction of Keystone XL capacity that other transportation modes can meet if Keystone XL is not built.

Standard microeconomic theory provides the tools to examine the effect of adding new production capacity to an existing market (Perloff 2013). Remarkably, however, few analyses have directly applied these tools – supply and demand curves and elasticities (the extent to which changes in one economic variable lead to changes in others) – to analyze the impact of specific fossil fuel infrastructure investments on global oil consumption, as we do here. Such supply-demand dynamics are, in principle, embedded within proprietary models such as EnSys' World Oil Refining Logistics & Demand (WORLD) model, which was used to assess the oil market impact of Keystone XL for the U.S. State Department's EIS (2013). However, because such models are typically complex and opaque, with little information about built-in assumptions, it can be difficult to both capture and perceive incremental supply-demand effects at the scale of an investment such as Keystone, which would transport only about 1% of the global oil supply.

Other causal relationships could also lead to changes in global GHG emissions, such as whether the U.S. decision on Keystone XL leads to other policies (or prevents policies) at the domestic or international levels. For example, given the large amount of attention that Keystone XL has drawn around the world, might rejecting the Keystone XL permit on account of its climate impact enable other government decision-makers to make similarly hard choices to restrict fossil-fuel infrastructure development elsewhere – or dissuade prospective investors from supporting it? Or might such a decision lead to political backlash within the U.S., hindering the Obama administration's ability to advance climate policies or participate effectively in future international climate negotiations? President Obama is no doubt considering these and other possibilities. However, as we are aware of no established method for quantifying these effects (and because such effects would be highly speculative), we do not attempt to quantify them here.

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[5] Letter from Cynthia Giles, Assistant Administrator for Enforcement and Compliance Assurance, U.S. Environmental Protection Agency, to Jose W. Fernandez, Assistant Secretary, Economic, Energy, and Business Affairs, and Kerri-Ann Jones, Assistant Secretary, Oceans and International and Environment and Scientific Affairs, U.S. Department of State, April 22, 2013 (p.2).

GHG emission impacts are assessed primarily for the year 2020. We also estimate the cumulative GHG emissions over the 50-year lifespan of the pipeline and estimate what fraction of the emissions would occur in the U.S., where this policy would be implemented, compared with the rest of the world, though in the context of global climate change, that distinction is irrelevant. The analysis includes emissions of CO_2, CH_4, and N_2O that occur along the life cycle of the crude oil handled by Keystone.

A simple model of global oil supply and demand

To quantify the potential effect of Keystone XL's impact on global oil markets, we built a relatively simple model of global oil supply and demand curves based on the approach outlined by Perloff (2013). The benefit of a simple model is that it can capture first-order price-response effects, while providing transparency of input assumptions and methodology. Models such as this have been used to analyze the oil market impact of major U.S. policies in the past – for example, to gauge the potential impact on global oil prices of the proposed expansion of oil extraction from the Arctic National Wildlife Refuge (Perloff 2013) Similar modeling approaches have also been used to examine the oil market impacts of introducing biofuels (Rajagopal and Plevin 2013), and the global coal market impacts of new coal export terminals (Power and Power 2013).

A simple model may miss more complicated effects, such as cartel behavior, in which a small number of producers may manipulate the oil supply and prices, or depletion effects, in which supplies dwindle (and become more expensive) over time. However, our literature review and analysis of global oil price behavior found little compelling evidence of effective cartel influence; in the case of recent price increases, we found that low demand price elasticity, low supply elasticity (or the "failure of global production to increase"), and growing demand from emerging economies are the main determinants of price (Hamilton 2008). In general, just as underinvestment has tended to lead to price increases (Barclays 2013), investment in supply infrastructure will tend to lead to price decreases.

To model the economics of global oil supply, we draw our global oil supply curve for 2020 from the work of oil industry consultant Rystad Energy (Nysveen 2013). Similar to other oil supply curves (IEA 2013a; Citi Research 2013), Rystad's supply curve starts with a significant segment of conventional oil production in lower-cost regions (such as the Middle East), followed by a more steeply rising segment of higher-cost, less conventional resources (such as deepwater, enhanced recovery, oil sands) that represent the marginal resource. For example, Rystad's cost curve shows the cost of oil supply in 2020 rising sharply after 90 million barrels per day. (Supply and demand curves are included in Appendix 1.)[6]

To model a demand response, we use the results of a literature review by the National Bureau of Economic Research (Hamilton 2008) that indicate a long-run elasticity of demand for crude oil of –0.2 to –0.3. We use these elasticities to approximate demand curves near the assumed equilibrium consumption level of 96.6 million barrels per day in 2020 (U.S. EIA 2013). This level of consumption implies (based on the Rystad supply curve) a real oil price of $101 USD/barrel in 2020 in the case where no Keystone XL makes it to market.

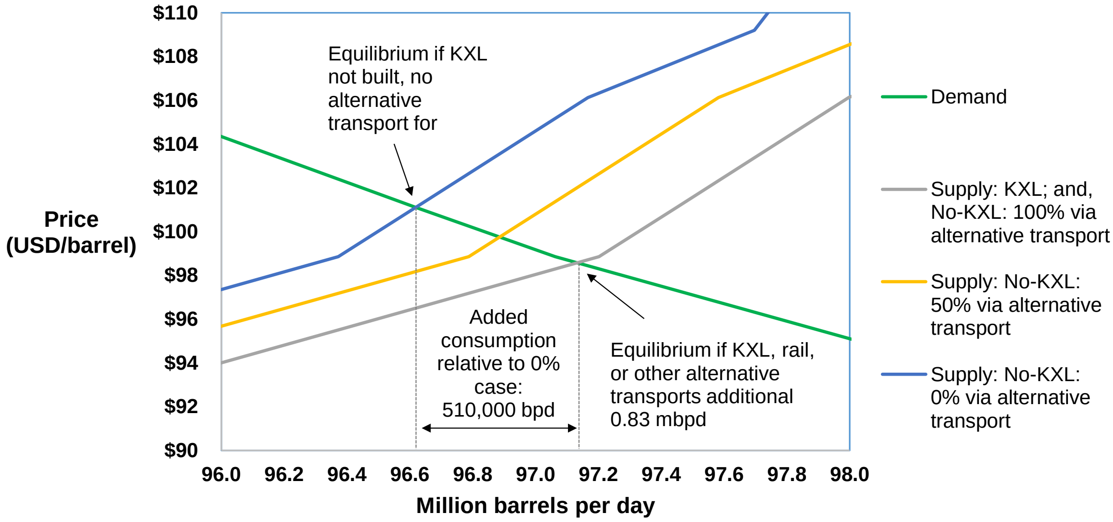
We assess the oil market impacts of alternative scenarios of oil supply by shifting the supply curve (to the right) by the quantity of oil expected to be added to the global markets from the Canadian oil sands. This process is depicted in Figure 2, which shows how the equilibrium consumption level increases (while price decreases) with increasing supply, from 96.62 million barrels per day in the no-pipeline scenario case where no Keystone XL oil makes it to

[6] For simplicity, we assume that Rystad's cost curve does not already include the oil to be carried by Keystone XL.

market, to 97.13 million barrels per day if all the Keystone XL oil makes it to market (via the pipeline or otherwise), an increase of 510,000 barrels per day.[7]

We assume that oil products refined from the Canadian crude transported by Keystone would be delivered to the market at a cost of about $70 per barrel (Nysveen 2013), and that alternative routes (if Keystone XL is rejected) would add about $6 per barrel due to more expensive transportation, such as by rail (Fielden 2013). We should note that there is substantial uncertainty around these costs.[8]

Figure 2: Simple model of global supply and demand for oil



Note: Analysis assumes elasticity of demand to be –0.2.

3. RESULTS

GHG impacts without considering price effects

To provide continuity with other analyses (NRDC 2013; U.S. Department of State 2013), we first report impacts of Keystone XL on oil production and GHG emissions, absent any price effects. Under the existing U.S. State Department analysis, oil transported by Keystone XL displaces an equivalent amount of crude oil, with characteristics equivalent to the average crude consumed in the U.S. (net of Canadian crude). As a result, the total amount of oil products consumed globally is largely unchanged, and the only emissions impact is that associated with differences in extraction, upgrading, refining and transport of the Canadian oil. Because of the energy and emissions intensity of producing refined products from Canadian oil sands crude (80% higher than average crude consumed in the U.S.), the net emissions associated with oil transported by Keystone XL are 19 to 25 million tons CO_2e per year,[9] relative to a no-KXL scenario where none of this oil would otherwise make it to the

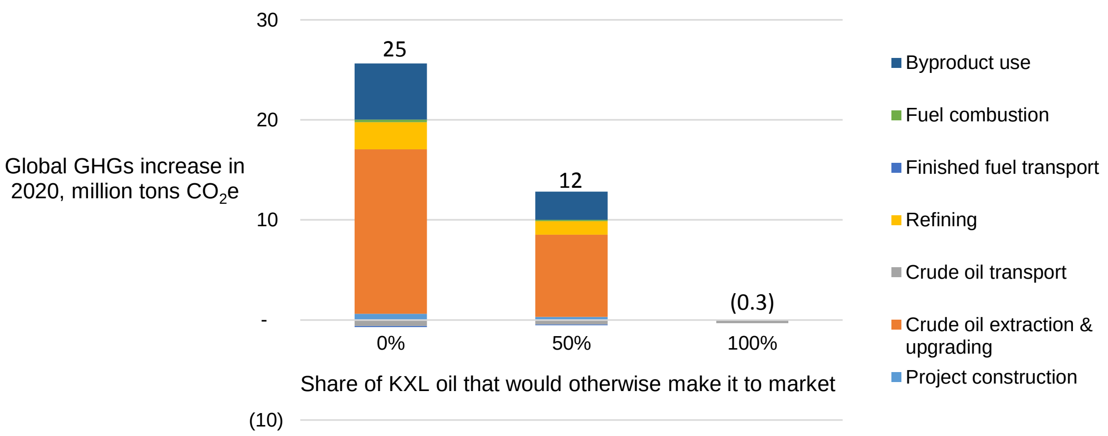
[7] In the case where elasticity of demand is greater, –0.3, the demand curve would be flatter and the impact on global oil consumption would be higher.

[8] At the same time, as long as the total cost of producing the oil is less than the world oil price, the cost of production has no material impact on global consumption levels, as indicated by our supply and demand model described in the next section.

[9] For the purposes of this simplified analysis, we assume that the full capacity of 830,000 barrels per day is reached by 2020, and that all of oil is Alberta crude. It is conceivable that it would take until beyond 2020 for additional Alberta crude production to ramp up to this level, and that a fraction of capacity would be used to transport shale oil from the Bakken deposits in the U.S.

market. As shown in Figure 3, if all of that oil would otherwise make it to market by another route, then the net emissions would fall close to zero, reflecting only the relatively small difference in emissions associated with operation of Keystone XL vs. other transportation modes. (Detailed results are shown in Appendix 2.)

Figure 3: Annual GHG emissions impact of Keystone XL, by life-cycle phase, without considering price effects and assuming all Keystone XL oil displaces other oil, 2020



Looking more closely at the results for the case where none of the oil would otherwise make it to market (0% on the X axis), our results for the difference in life-cycle GHG emissions are drawn from those reported in the State Department assessment, 18.7 million tons CO_2e – for crude extraction, upgrading, and refining (orange and yellow bars). In addition, we include the impact of land clearing in Alberta to support expanded production by the volume carried by Keystone XL (light blue, less than 1 million tCO_2e when annualized over 50 years) and increased use of byproducts (dark blue, 6 million tCO_2e). In total in this case, without considering price effects, the impact of Keystone XL is about 25 million tCO_2e in 2020, similar to that estimated by some critics of the State Department's assessment (NRDC 2013).

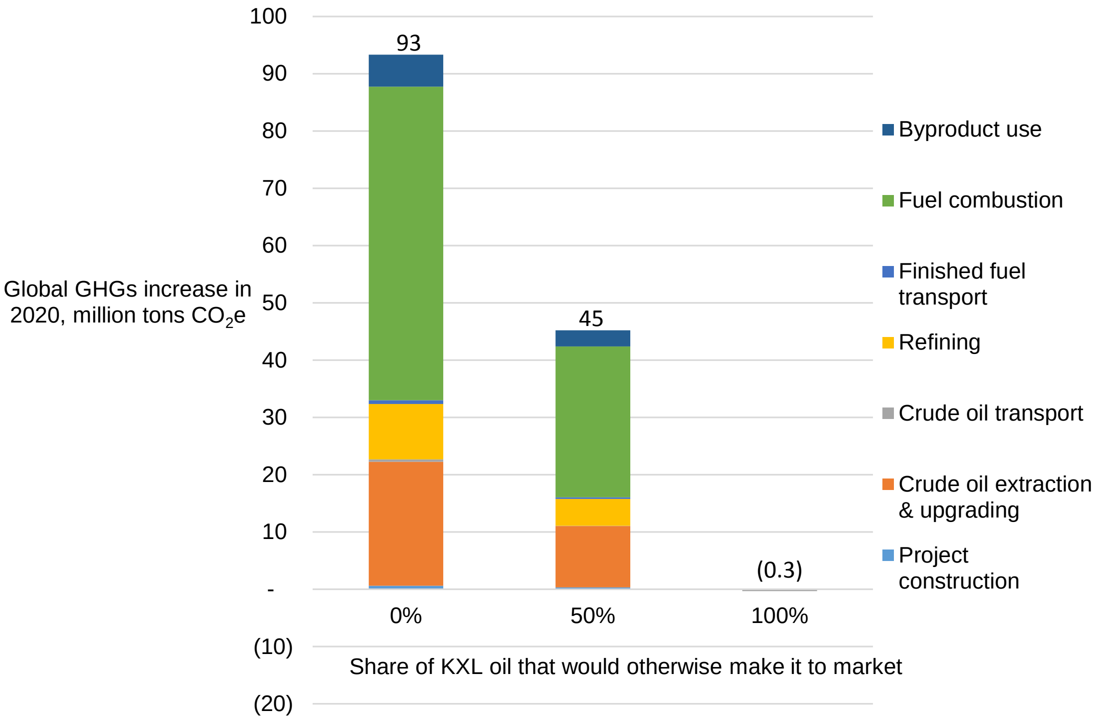
GHG impacts considering price effects

We now consider the potential impact of added oil supply on global oil markets, by taking into account price effects using our simple supply-demand model. As indicated in Figure 2, adding 830,000 bpd to global oil markets would have the effect of shifting the supply curve to the right, decreasing global oil prices and increasing global oil consumption by 510,000 bpd.[10] In other words, given demand and supply responses, slightly over 60% of the additional oil brought to the market leads to increased consumption. Although the impact on global oil demand would be fairly small – less than 1% – the emissions associated with consumption of that oil far exceed any of the other GHG impacts.

Figure 4 shows the cumulative emissions impacts of all these factors combined. Note that consideration of price effects increases the emissions impact of Keystone XL by a factor of nearly 4, as compared with the no-price-effect results shown in Figure 3. Annual GHG emissions in 2020 increase by 93 million tCO_2e in the case where none of the oil transported by Keystone XL would otherwise make it to market, and by 45 million tCO_2e if half were to reach market. Well over half the emissions impact is due to increased global oil combustion.

[10] The remaining 320,000 bpd of Keystone XL production thus displaces production elsewhere.

Figure 4: Total annual GHG emissions impact of Keystone XL, by life-cycle phase, 2020, considering price effects



4. DISCUSSION

Our analysis suggests that many prior analyses of Keystone XL have overlooked or dismissed what could be the pipeline's most significant GHG impact: that of increasing oil consumption by increasing supplies and lowering prices. The fact that induced changes in price and demand may be small (less than 1%) relative to global levels may lead observers to dismiss these shifts as imperceptible or hard to trace. Indeed, *ex post* detection and attribution of these shifts to an individual infrastructure investment such as Keystone XL would be nearly impossible, given the small signal relative to the "noise" of other factors in global oil markets. However, *ex ante* analysis, such as the one conducted here, suggests that the use of supply and demand elasticities is in fact most applicable where deviations are small. And most importantly, this is an incremental analysis; marginal changes that may be small from a global context (Keystone XL capacity is about 1% of global oil supply) may be quite substantial in the context of the activities in question. Our analysis suggests, for example, that over half of the carbon in the oil transported by Keystone could represent a net addition to the atmosphere.

Furthermore, in the case of Keystone XL, GHG emissions impacts may also be quite significant in the context of efforts to reduce global GHG emissions. Table 1 compares the possible emission increases in 2020 due to Keystone XL to potential emissions decreases due to various climate policies being considered by the U.S. government. As shown, the potential emissions increases from Keystone XL in 2020 could be greater, for example, than the potential decreases due to U.S. EPA performance standards on industrial boilers and cement kilns and petroleum refineries, as estimated by Bianco et al. (2013).[11]

[11] Our Keystone XL estimate reflects global emissions impact. While the other estimates are only for emissions within the U.S., assuming limited leakage and other cross-boundary impacts, global emissions impact should be similar. Of the 93 million tCO_2e of potential increase in emissions, we estimate that 11 million tCO_2e would occur in

Table 1: Comparison of the potential global GHG emissions impacts of Keystone XL decision and other U.S. government policies, 2020

	Emissions increase or decrease, 2020
Keystone XL	0 to 93
New Source Performance Standards for New and Existing power plants	(160) to (575)
Performance standards to reduce emissions from industrial boilers and cement kilns	(16) to (30)
Performance standards on petroleum refineries	(3) to (31)

Sources: Authors' analysis, Bianco et al. (2013).

There are many uncertainties underlying our analysis. We address an important one – whether Keystone XL will affect the level global oil supply – by analyzing three cases across the spectrum of possible impacts. As noted, a wide range of viewpoints exist on this question, and they are unlikely to be easily resolved. Our findings are also particularly sensitive to the demand and supply relationships (in our model, the demand elasticity and the shape of the supply curve) around the market-clearing price. Future demand response (elasticity) to changing oil prices will depend the availability of substitutes, which tend to be more limited in the short term (e.g. labor to undertake conservation activities such as carpooling) but greater in the long term, where there is time to invest capital in alternatives such as biofuels or high-efficiency or electric vehicles. As a result, long-term demand elasticities tend to be greater than shorter-term elasticities.

Table 2 shows how results (inclusive of price effects) for annual GHG emissions vary with the demand elasticity assumption of –0.3 instead of –0.2 (used above), reflecting the range of long-term elasticities suggested by a review published by the U.S. National Bureau of Economic Research (Hamilton 2008).

Table 2: Increase in annual GHG emissions attributable to Keystone XL, 2020
(million tons CO_2e)

	Percent of KXL capacity that would otherwise reach the market in a no-pipeline scenario		
	0%	50%	100%
Higher demand elasticity (–0.3)	106	53	-0.3
Lower demand elasticity (–0.2)	93	45	-0.3

Uncertainties also exist on the supply side. The steepness, or elasticity of the supply curve, near the market-clearing price has a strong influence on the estimated reduction in global oil price associated with Keystone XL. In other words, the cost and feasibility of increasing production from marginal sources of oil are central to the determining impact of Keystone XL. The marginal sources are likely to be, as noted above, less conventional sources. To the extent that these sources have higher upstream emissions intensities than the average crude oil consumed in the U.S., the differential with Alberta oil sands would be lower, reducing the difference in emissions from extraction, upgrading and refining as shown above. Furthermore, technological progress in oil extraction and processing could flatten the supply curve, increasing the price elasticity of supply, and reducing the price – and emissions – impact of

the U.S. in 2020 (due to increased fuel consumption as a result of lower global oil prices) and 82 million tCO_2e would occur in other countries (due to both increased fuel consumption and extraction emissions in Alberta).

Keystone XL. Alternatively, the curve could steepen, and increase the emissions impact, for example, if depletion effects are stronger than assumed by industry analysts.

Over the 50-year lifespan of Keystone XL (and assuming a continuation of the supply and demand relationships that underlie the analysis shown in Figure 4), the cumulative impact of the pipeline on global GHG emissions would be 4.3 billion tons CO_2e, assuming that none of the oil would otherwise get to market.[12] Taking this long-term, cumulative perspective suggests comparisons to how much carbon can be released over the next several decades to maintain a chance of limiting global warming to less than particular temperature thresholds, such as 2°C or 1.5°C – the world's carbon "budget".

5. CONCLUSIONS

In this paper, we map and quantify the possible GHG effects of the U.S. government decision to approve or reject the Keystone XL pipeline. Broadly speaking, three types of effects are possible: (1) emissions associated with project construction; (2) those associated with fuel extraction, processing and transportation (e.g., the "life cycle", or "well to wheels" emissions associated with oil sands crude compared to alternative crudes; and (3) price or market effects that arise from how Keystone XL may change global oil supply, leading to changes in global oil consumption and therefore GHG emissions. We find that although the first two effects have been the focus of most of the public attention, the third effect could well have the greatest impact on global GHG emissions.

We find that approval of the Keystone XL pipeline could lead (depending on assumptions about how much of the oil would otherwise make it to market) to an increase in global GHG emissions four times as big as prior analyses have concluded and potentially counteract some of the flagship emission *reduction* policies of the U.S. government. This finding – developed here using a simple supply and demand model -- points to the need for greater availability and transparency of oil supply and demand analyses. Simple models such as the one we construct– using publicly available supply curves and demand elasticities – could provide some advantages over the opaque and proprietary models used by existing prominent analysts, such as EnSys' model used to support the findings of the U.S. Department of State. And, though we conduct this analysis for Keystone XL, the rubric and method employed could also be applied to other pending investments in infrastructure to extract and supply fossil fuels.

Our analysis points to a gap in existing assessments of the Keystone XL project. If a simple supply-and-demand model such as ours shows that the pipeline's effect on oil prices could quadruple its total GHG impact, it is crucial that such effects be more clearly addressed in analyses that could inform President Obama's decision. An advantage of a simple model such as the one we constructed – using publicly available supply curves and peer-reviewed demand elasticities (the extent to which changes in oil consumption have responded to changes in oil prices) – is that it is highly transparent, and allows one to gauge the magnitude of possible effects. By contrast, proprietary models like the one used for the prior State Department market analysis lack transparency in key assumptions, such as how the global oil market may respond to changes in supply.

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[12] This calculation assumes Keystone XL comes online in 2016 and ramps up to throughput of 830,000 bpd in 2020, holding constant thereafter to 2065. We assume an elasticity of supply (e_s) of 0.11 in 2020 (as implied by the Rystad cost curve), increasing to 0.3 in 2065 (Perloff 2013), and with elasticity of demand (e_d)of -0.1 in 2016, –0.2 in 2020, and –0.4 in 2065. The fraction of the added throughput of oil sands that ends up as added global oil consumption is calculated as e_d / (e_d - e_s) (Power and Power 2013).

The answer to the question of whether Keystone XL will "significantly exacerbate the problem of carbon pollution" is likely to hinge upon how much the pipeline increases the global oil supply – and through its price effects, global oil consumption. At full capacity, Keystone XL is expected to be able to carry 830,000 barrels per day. Some have argued that if the pipeline is not built, then other modes, particularly rail, will be used to transport an equivalent amount of oil. However, there is far more prospective added Canadian oil sands production (4.5 million barrels per day) than Keystone XL itself can carry. Rail routes may be needed and used whether or not Keystone XL is completed. If Keystone XL ultimately enables significantly greater development of Alberta's oil industry, and thus increases the global oil supply and, in turn, consumption, then indeed, the "problem of carbon pollution" could be "significantly exacerbated".

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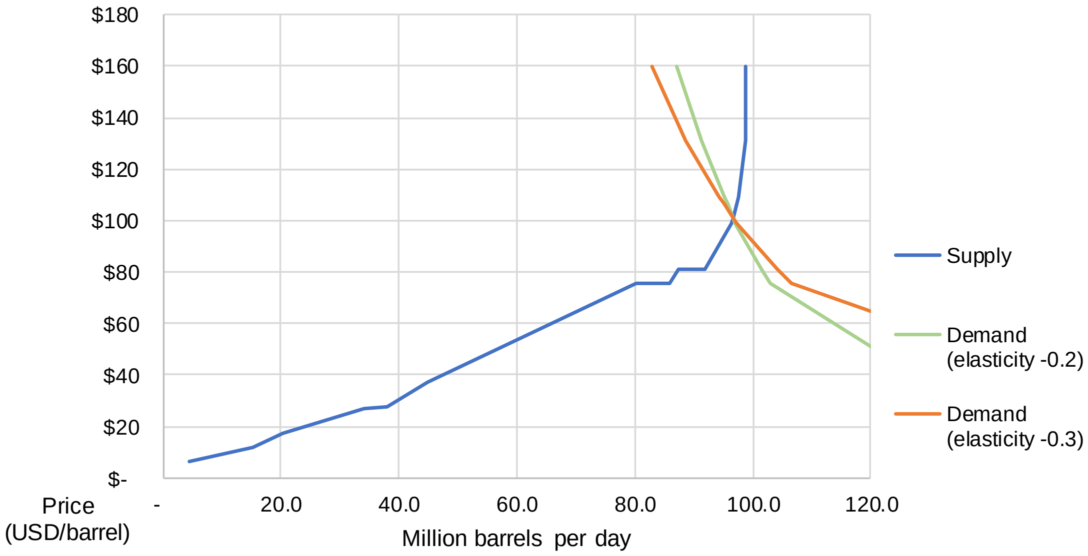
APPENDIX 1: GLOBAL OIL SUPPLY AND DEMAND CURVES FOR 2020

Figure A1: Global oil supply and demand curves for 2020



Sources: Nysveen (2013, for supply), and Hamilton (2008, for long-run demand elasticities).

APPENDIX 2: ADDITIONAL RESULTS

The following tables provide additional details for the cases described in the main body of this working paper. To calculate the net effect of KXL on global GHG emissions (the numbers presented in the main body), subtract the chosen KXL-not built (0%, 50%, or 100%) case from the KXL is built case.

Table A1: GHG emissions without considering price effects and assuming all Keystone XL oil displaces Other Oil (Analogous to U.S. State Department Analysis), 2020[13]

	Keystone XL built	Keystone XL is not built (by % of KXL oil that would still reach markets)		
		100%	50%	0%
Effects on oil production				
Added Canadian oil sands production (million bpd)	0.83	0.83	0.42	-
Global oil price	$101.1	$101.1	$101.1	$101.1
Displaced crude oil production (million bpd)	0.83	0.83	0.42	-
Added global oil consumption (million bpd)	-	-	-	-
Effects on global GHGs (million tons CO_2e)				
Added Canadian oil sands production				
WTW sources considered by State Department	129.2	129.5	64.7	-
Land clearing, byproduct use	6.2	6.2	3.1	-
Displaced crude oil production				
WTW sources considered by State Department	110.5	110.5	55.2	-
Net effect				
WTW sources considered by State Department	18.7	19.0	9.5	-
Land clearing, byproduct use	6.2	6.2	3.1	-
Total	**24.9**	**25.3**	**12.6**	-

[13] In the policy case, and considering the sources analyzed by the U.S. State Department, we report the same net impact as the State Department: 18.7 million tCO_2e.

Table A2: GHG emissions with and without Keystone XL, considering price effects, 2020

	Keystone XL built	Keystone XL is not built (by % of KXL oil that would still reach markets)		
		100%	50%	0%
Effects on oil production				
Added Canadian oil sands production (million bpd)	0.83	0.83	0.42	-
Global oil price	$98.6	$98.6	$99.8	$101.1
Displaced crude oil production (million bpd)	0.32	0.32	0.15	-
Added global oil consumption (million bpd)	0.51	0.51	0.27	0
Effects on global GHGs (million tons CO_2e)				
Added Canadian oil sands production				
WTW[14] sources considered by State Department	129.2	129.5	64.7	-
Land clearing, byproduct use	6.2	6.2	3.1	-
Displaced crude				
WTW sources considered by State Department	42.1	42.1	19.7	-
Net effect				
WTW sources considered by State Department	87.1	87.4	45.0	-
Land clearing, byproduct use	6.2	6.2	3.1	-
Total	**93.3**	**93.7**	**48.1**	-

Note: This analysis assumes elasticity of –0.2.

14 "Well-to-wheels".

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