Enough Already: Meeting 2°C PRB Coal Demand Without Lifting the Federal Moratorium

Executive Summary

Following the precedent from two previous programmatic reviews, in January 2016 the US Secretary of the Interior announced a moratorium on new coal leasing on public lands pending completion of a comprehensive review. Nearly 90% of coal produced from public lands is from leases in the Powder River Basin (PRB) of Wyoming and Montana.

In this paper, potential coal supply from the PRB (estimated using Wood Mackenzie data) is compared with a demand profile consistent with an International Energy Agency (IEA) scenario to restrict global warming to a two degrees Celsius (2°C) outcome, in line with the upper limit at the recent COP21 agreement in Paris. Demand for coal over the period is found to be far outweighed by supply from existing leases alone, meaning that no new federal acreage in the Powder River Basin is required to be leased by the Federal government through the end of our assessment period in 2040.

When potential supply is compared to the EIA's Annual Energy Outlook (AEO) 2016 Reference Case for PRB coal production, which does not constrain warming to 2°C, total business as usual (BAU) supply is provided by existing leases until 2031, with production from new leases only being required thereafter. Given the time period until new leases are required, and that new leases are only required in a scenario incompatible with the United States' commitment to taking actions consistent with limiting global warming to levels well below 2°C while pursuing efforts to keep warming to no more than 1.5°C, it makes sense to continue the moratorium for the foreseeable future.

Although demand and supply are not always matched on an annual basis, this can be covered by adjustments to production schedule, as shown by recent output swings within the PRB.

Key Findings

- Using Wood Mackenzie supply data, we find that reserves at existing mine leases are more than sufficient to meet 2°C demand through the IEA 450 timeframe of 2040.
- Accordingly, the Bureau of Land Management does not need to issue any new leases to meet demand in the review period.
- Further, some production from existing mines will be surplus to requirements. Closure and reclamation of existing operations will need to be fully funded by the operators.
- Comparison with the (non-2°C compliant) EIA AEO Reference case implies that new leases will enter meaningful production in 2031 under a BAU scenario.
- We therefore recommend that, to be consistent with the Administration's aspirations at COP 21, the current short-term moratorium on new leases within the PRB be extended indefinitely.
- A review of other studies shows that PRB specific policies will result in net savings to CO_2 emissions despite some substitution with fossil fuels from other sources.

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"New leases" includes both new mine operations and additions to existing mines

The dataset for this paper includes (a) marketable reserves for existing mines from leases that have already been awarded or are exempt from the moratorium; and (b) estimated potential production from new mines (meaning potential new discrete developments producing from new leases). Production from new leases can also come from a nearby lease being awarded to an existing operation and added to its reserves; such potential future production is not included. "Potential production" in this paper should therefore not be thought of as maximum possible production.

There is a very large amount of federal coal to the west of existing PRB operations, which could be leased and moved onto as current reserves are depleted. Indeed this is a more likely source of future supply due to the greater risks of commissioning a new mine.

Production from "existing mines" or "existing leases" therefore represents what would be produced from existing mines with no further additional leases awarded, which in aggregate is found to be in excess of that needed to satisfy 2°C demand. As such, the conclusion that no new leases are needed in the period 2016-2040 refers to both new mines and new leases that act as extensions to existing mines.

Extended or permanent moratorium will help avoid future value destruction

It is well established that globally, not all known fossil fuel reserves and resources can be burned while limiting global warming to 2°C. In this exercise we look more closely at Powder River Basin (PRB) coal, using IEA and EIA scenarios to demonstrate a possible 2°C demand scenario which assumes that PRB coal faces a similar trend to the US as a whole. This is arguably a conservative approach, given that the EIA's Reference Case envisions PRB coal production declining at a greater rate than the US average.

Any potential future investment in new coal mines therefore exposes companies to the risk of wasting capital on unneeded capacity in a decarbonizing world. The dangers of stranded assets have already been starkly illustrated in the US coal sector, where competition with natural gas and renewables (among other factors) has driven the major producers into bankruptcy protection. In this context, indefinitely extending the current short-term moratorium on new leases within the PRB, or making it permanent, is a straightforward strategy that will mitigate the risk of wasting capital and destroying investor value, as well as avoiding a major source of carbon emissions.

There is potential for material capital expenditure on new mines ($2.9bn in the period to 2040). That said, their development should be considered highly uncertain and no investment is expected to take place before 2029, meaning that there will be very limited impact on the finances of the companies concerned in preventing new mining operations being established.

Oversupply from existing leases means that potential changes to leasing terms alone are not sufficient

A variety of changes to federal leasing terms are under consideration (including higher rental fees and royalty payments, more stringent reclamation bonding, and social cost of carbon adders). As these would apply to new leases or lease renewals only, the conclusion that supply from existing leased acreage is greater than needed in a 2°C world is unaffected.

Indeed, it is estimated that 22% of potential production from existing leases will not be needed under the IEA's 450 Scenario. Ensuring that the closure and reclamation of the unneeded currently operating leases are approached responsibly and that obligations are fully financed by the mining companies is critical.

Moratorium results in net carbon savings, despite some expected substitution

Detailed modeling by other parties indicates that localized policy changes targeting only federal coal within the PRB will result in some of the affected coal being replaced by coal mined in other regions. This substitution is larger for PRB-specific policies than under national limits such as the Clean Power Plan that affect the entire US. Nevertheless, in all studies policy action results in net carbon savings.

Despite there being substantial non-federal coal reserves and resources within the PRB region, these are distributed in small blocks throughout federally-owned regions and are not economically mined independent of federal reserves. These ownership patterns make it difficult or impossible to bypass new federal limits and fees on PRB coal. While some shifts to other coal basins are expected in other studies, there remain net reductions in CO_2 emissions from the changes. Many of the scenarios also indicated that the incremental revenues from increased royalty rates equaled or exceeded the drop in demand for PRB coal, yielding stable or increased gross royalty collections for both federal and state governments.

Section One: Overview

On Earth Day 2016 the US Secretary of State joined representatives of 174 other nations at the United Nations to sign the Paris Climate Agreement, the main aim of which is to keep the global temperature rise this century to well below 2 degrees Celsius (2°C) above pre-industrial levels. Pursuit of such a target has broad implications for US energy policy, as the Obama administration has reflected in its Nationally Determined Contribution to the Paris Agreement and in the President's June 2013 Climate Action Plan.[1]

One area of significance relates to the leasing of federal lands for production of coal. The US Department of Interior's Bureau of Land Management (BLM) has responsibility for coal leasing on roughly 570 million acres where the Federal Government acts as trustee on behalf of the American people, who own the rights to the coal.[2] Mines operated under the BLM's more than 300 coal leases have over the past decade produced 3.9 billion metric tonnes of coal and account for nearly 41% of US coal production.[3] Nearly 90% of this production comes from mines in the Powder River Basin (PRB) of Montana and Wyoming, which in 2015 produced roughly 350 million metric tonnes (Mt) of thermal coal for the US domestic market.[4]

In January 2016, noting that the Federal Government had not conducted a programmatic review of its coal leasing program in more than 30 years, the US Secretary of the Interior announced a comprehensive federal coal program review. Among other topics, key areas for review included:

- The appropriate leasing mechanisms to determine how, when, and where to lease;
- How to account for the environmental and public health impacts of the coal program; and
- The role of federal coal in fulfilling the energy needs of the United States.[5]

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[1] Executive Office of the President, "The President's Climate Action Plan," June 2013, https://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf

[2] Authority for BLM leasing stems from the Mineral Leasing Act of 1920 and the Mineral Leasing Act for Acquired Lands of 1947 (including subsequent amendments to these laws). US Department of the Interior Bureau of Land Management (BLM), "Coal Operations," updated March 2016, http://www.blm.gov/wo/st/en/prog/energy/coal_and_non-energy.html

[3] BLM, "Coal Operations."

[4] With another 7.7 million metric tons being produced for export. US Energy Information Administration (EIA), *American Energy Outlook 2016 (AEO 2016)*, "Coal Production by Region and Type," https://www.eia.gov/forecasts/aeo/data/browser/#/?id=95-AEO2016&cases=ref2016~ref_no_cpp&sourcekey=0, and "World Steam Coal Flows By Importing Regions and Exporting Countries", https://www.eia.gov/forecasts/aeo/data/browser/#/?id=96-AEO2016&region=0-0&cases=ref2016~ref_no_cpp&start=2013&end=2040&f=A&linechart=ref2016-d032416a.4-96-AEO2016~~ref_no_cpp-d032316a.16-96-AEO2016&ctype=linechart&sourcekey=0.

[5] BLM, "Fact Sheet: Modernizing the Federal Coal Program," January 16 2016, http://www.blm.gov/style/medialib/blm/wo/Communications_Directorate/public_affairs/news_release_attachments.Par.47489.File.dat/Coal%20Reform%20Fact%20Sheet%20Final.pdf Other areas for review included whether current royalty rates provide a fair return to US taxpayers; whether US coal exports should factor into leasing decisions; and how the management, availability, and pricing of federal coal impacts domestic and foreign energy markets and portfolios.

Following the precedent from two previous programmatic reviews, the Secretary's January 2016 announcement also instituted a moratorium on new coal leasing on public lands pending completion of the comprehensive review. In explaining this moratorium the Interior Department noted "serious concerns raised about the federal coal program and the large reserves of undeveloped coal already under lease to coal companies", and stressed how "leasing decisions can benefit from recommendations that come out of the review."[6]

In the spirit of providing such recommendations, this study examines what level, if any, of new coal leasing is consistent with efforts to achieve a 2°C climate outcome. Previous Carbon Tracker analyses have examined the need for new thermal coal mines globally under a 2°C climate pathway, and noted that such a pathway "does not see demand for thermal coal through 2035 exceeding the amount that can be produced from mines that are already producing."[7] In this study we perform a similar exercise with a more granular focus on the role of PRB coal from federal lands in the US domestic market.

This study proceeds as follows. Section Two estimates demand for PRB coal through 2040 in a 2°C scenario. Section Three compares these demand estimates with the quantities that can be produced from existing PRB leases (in our database virtually all supply comes from Federal lands), and also surveys the capital expenditures (capex) associated with potential new PRB mines. Section Four considers the implications of this comparison for the federal coal leasing program. Section Five situates our analysis of federal coal leases in the context of previous studies that have addressed this topic, and considers whether and how their results affect our core conclusions.

[6] BLM, "Fact Sheet: Modernizing the Federal Coal Program."

[7] While our analysis indicated some slight domestic shortfalls in India and South Africa, the deficits could be met by further investment in existing mines after 2025, or via imports. Unneeded potential production from new thermal coal assets corresponded to 2,081 Mtpa, 70 $GtCO_2$, and $177 billion of capex 2015-2025. Carbon Tracker Initiative and Energy Transition Advisors, *The $2 trillion stranded assets danger zone: How fossil fuel firms risk destroying investor returns*, Nov 2015, http://www.carbontracker.org/report/stranded-assets-danger-zone/

Section Two: Projecting demand for PRB coal in a 2°C scenario

To estimate demand for PRB coal in a 2°C scenario, we draw on historic data for PRB coal production from the EIA as well as projections of long-term energy demand from the IEA 450 Scenario. Updated most recently in the IEA's 2015 *World Energy Outlook*, the IEA 450 Scenario represents an emissions pathway that is consistent with a 50% chance of limiting the increase in long-term average global temperature to 2°C compared with pre-industrial levels. We note that the use of IEA 450 Scenario to reflect US government aspirations related to climate change is a reasonably conservative choice given that (1) the 450 Scenario accords with only a 50/50 chance of achieving a 2°C outcome; and (2) the Paris Agreement expresses ambition to achieve a level of warming "well below two degrees C" above pre-industrial levels. Technical experts have cautioned that a 2°C target should be approached as an upper-limit "guardrail" instead of an adequate target to avoid dangerous climate change.[8]

For the US and all other major energy-consuming nations, the 450 Scenario projects energy demand by sector and fuel type through 2040.

Focusing on the US electric power sector

Nearly all US coal consumption occurs in the electric power generation sector; as of 2013, power generation accounted for 92% of total US coal demand.[9] Power generation is also the relevant sector with respect to estimating demand for PRB coal, as PRB mines produce exclusively *thermal* coal that is sold (almost entirely) to coal-fired power plants, as opposed to *metallurgical* coal which is sold to steel mills and other industrial facilities. Table 1 summarizes projected growth rates for coal demand in power generation and related CO_2 emissions under a 450 Scenario.

Using the IEA's most recent base year of 2013, under a 450 Scenario US coal demand for power generation declines by 3.4% per year through 2040. Note that CO_2 emissions from coal consumption decline nearly three times as much, which reflects assumed deployment of technology for carbon capture and sequestration (CCS) beginning in the 2020s; analysis below considers the impact of relaxing this assumption.[10]

Table 1 Compound annual growth rates (%) for US coal demand and coal CO_2 emissions related to power generation in 450 Scenario, 2013-2040

	CAGRs (%)			
	2013-20	**2020-30**	**2030-40**	**2013-40**
Coal Demand - Power Generation (Mtce)	-5.4	-6.6	1.4	-3.4
Coal CO_2 Emissions - Power Generation (Mt)	-5.5	-16.4	-6.6	-10.1

[8] Secretariat of the UNFCCC, "Report on the structured expert dialogue on the 2013–2015 review" (2015), available at: http://unfccc.int/resource/docs/2015/sb/eng/inf01.pdf

[9] IEA, *WEO 2015*, Annex A. Note that 92% share is calculated on an energy-equivalent basis, rather than a tonnage basis.

[10] The IEA's assumption of deployment for carbon capture and sequestration (CCS) technology causes US thermal coal consumption in the 450 Scenario to increase by 15 percent (i.e. 29 million tons of coal equivalent) from 2030 to 2040. Our analysis varies the timing of CCS deployment to assess its impact on our core conclusions. It may be considered prudent to err on the side of caution regarding the likelihood of CCS competitiveness and deployment, given the current trajectory of development.

Source: IEA, CTI analysis 2016

Making use of growth rates for US power-sector coal demand in the 450 Scenario

Table 1 shows 2°C-consistent growth (decline) rates for coal demand and coal CO_2 emissions related to the entire US power sector. These rates, however, can be used to approximate 2°C-consistent demand for PRB coal in particular. The usefulness of such a strategy depends on how closely the trajectory of PRB coal demand in a 2°C scenario resembles the trajectory of US power-sector coal demand overall. To assess this, we compare projections from the US Energy Information Administration (EIA) of US coal production by region from the Reference Case of its 2016 Annual Energy Outlook (AEO).[11] Note that the AEO 2016 Reference Case assumes implementation of the Clean Power Plan (CPP), which aims to reduce overall CO_2 emissions from the US power sector 32% below 2005 levels by 2030. Though CPP-targeted emissions-reductions are less than half of what occurs in the 450 Scenario, examining regional responses to CPP implementation provides a sound proxy to investigate how required reductions in coal consumption in a 2°C scenario will be allocated across different regions.

Table 2 presents projected cumulative average growth rates (CAGRs) for coal production from the major coal-producing regions, as well as for the US overall, over the 2015-40 period. Projections include both thermal and metallurgical coal, though relative volumes to the metallurgical sector are too small to materially affect the values. A key finding is that under the Clean Power Plan the long-term decline trajectory for PRB coal is comparable to the decline trajectory for US thermal coal overall. Indeed, because PRB coal production is expected to decline *more* than overall US thermal coal, applying aggregate US growth rates from the 450 Scenario to PRB coal production can be considered a conservative view.[12] This is the approach that we take below.

[11] EIA, *AEO 2016* "Coal Production by Region and Type." In energy-economic models such as the one used to produce AEO analysis, the level of consumption in a given year will determine the amount of required production. To focus on required production to meet domestic demand, we net out from PRB production projected thermal coal export flows to Asia and the Americas (which we assume to come from federal PRB mines). Through 2040 these exports average 14.3 Mt per year under both EIA scenarios, with over two-thirds of this amount going to Asia.

[12] Given the greater emissions-reduction required in a 450 Scenario, however, the excess decline in PRB coal over overall US thermal coal may diminish.

Table 2 Trajectories for US coal production by region under AEO 2016 Reference Case

	2015-40 CAGR (%)
Powder River Basin	-1.5
Northern Appalachia	-1.5
Central Appalachia	-1.8
Eastern Interior	0.3
US Total (excluding premium metallurgical coal)	-1.2
US Total	-1.2

Note: Regions other than the Powder River Basin include some metallurgical coal in addition to thermal coal.
Source: EIA, CTI analysis 2016

Generating the demand projections

Table 3 applies growth rates from the 450 Scenario to the EIA's figure for 2015 PRB coal production.[13]

Table 3 Annual demand (Mt) and CAGRs (%) for PRB coal under different scenarios, 2015-2040

	Annual Demand (Mt)				*CAGRs (%)*			
	2015	**2020**	**2030**	**2040**	**2015-20**	**2020-30**	**2030-40**	**2015-40**
450 Scenario	350	248	125	143	-6.6%	-6.6%	1.4%	-3.5%
450 (CCS starts 2030)	350	248	41	58	-6.6%	-16.4%	3.5%	-6.9%
450 (no CCS)	350	248	41	21	-6.6%	-16.4%	-6.6%	-10.6%
AEO 2016 Reference Supply	*350*	*339*	*285*	*227*	*-0.6%*	*-1.7%*	*-2.2%*	*-1.7%*

Source: IEA, EIA, CTI analysis 2016

The **"450 Scenario"** makes use of the EIA's figure for 2015 PRB coal production, and the 2013-2020, 2020-2030, and 2030-2040 growth rates for "Coal Demand - Power Generation (Mtce)" from the IEA's 450 Scenario (shown in table 1 above).[14] As discussed below, importantly the IEA assumes the deployment of CCS from 2020 in this scenario which obviously allows more coal to be used per unit of carbon emissions than would be the case otherwise.

The **"450 Scenario (CCS starts 2030)"** considers how a 2°C-consistent trajectory for PRB coal demand changes if widespread deployment of CCS technology is delayed from 2020 to 2030. Absent deployment of CCS, required reductions of CO_2 emissions from coal and coal consumption proceed in lock-step (as is the case in the 450 Scenario from 2013-2020). Beginning after 2020 in the 450 Scenario, coal CO_2

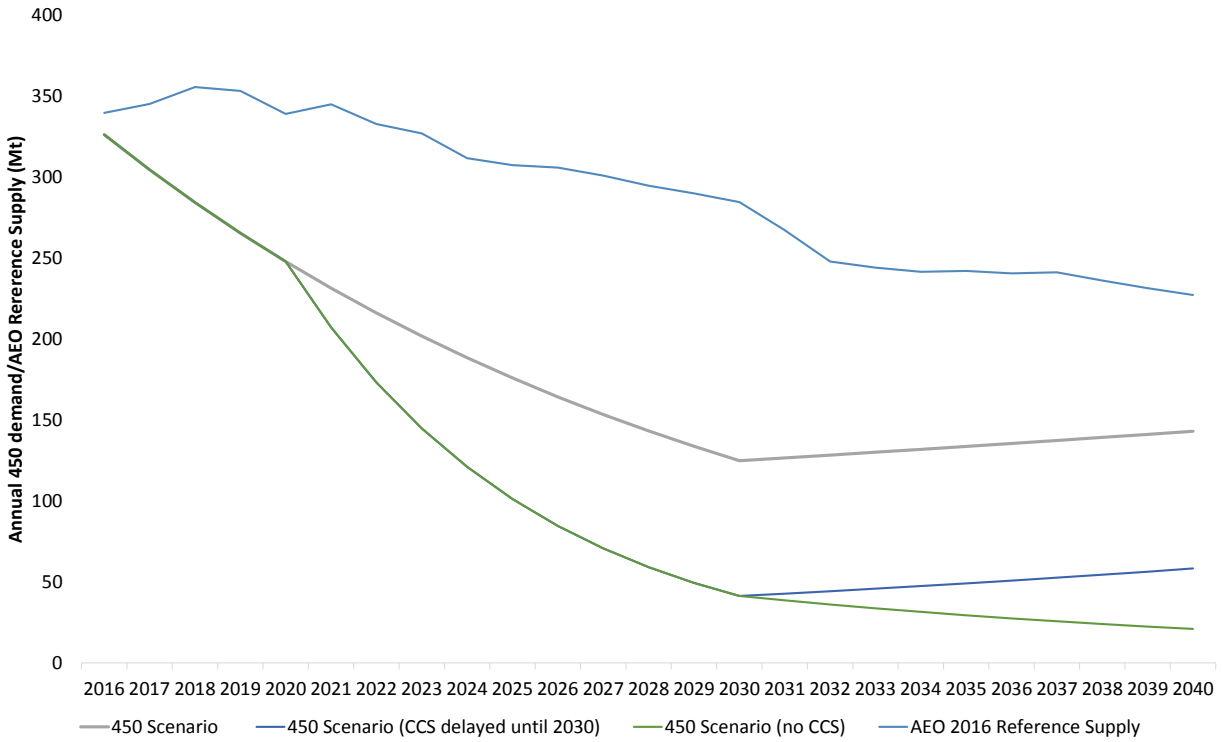
[13] EIA, *AEO 2016* "Coal Production by Region and Type." Note that EIA data is in short tons, which have been converted to metric tons at a rate of 1 short ton equals 0.907185 metric tons.
[14] The 2020 value in the 450 Scenario of 248 Mt is computed by applying the 2013-2020 growth rate of -5.4% to the EIA's figure for 2013 PRB coal production; since actual 2015 PRB coal production of 361 Mt is above the level that would occur in a 450 Scenario, to reach 2020 demand of 248 Mt demand from 2015-2020 has to decline at a rate of 6.6% (rather than 5.4%, as in the 450 Scenario).

emissions begin to decline more rapidly than coal consumption due to the impact of CCS. As discussed below, however, achieving the pace of CCS deployments assumed in the 450 Scenario will require surmounting many technical, financial, and regulatory challenges. To simulate a decade-long delay in widespread CCS deployment, annual PRB coal demand from 2020-2030 in the "450 Scenario (CCS starts 2030)" follows the CAGR of 450 Scenario power-sector CO_2 coal *emissions with no offset from CCS* (i.e. demand of -16.4% rather than -6.6%). From 2030-2040, as CCS is deployed however, this scenario sees the same level of absolute increase in annual PRB coal demand (17 Mt) as in the 450 Scenario.

The **"450 Scenario (no CCS)"** assumes no CCS deployment through 2040. As a result, from 2020-2040 annual PRB coal demand follows the CAGRs of 450 Scenario power-sector coal CO_2 *emissions* (i.e. -16.4% and -6.6% for the periods 2020-2030 and 2030-2040).

The final row depicts projections of PRB coal production (rather than demand) under the US Energy Information Administration's **Annual Energy Outlook (AEO) 2016 Reference Case**[15]; note that the AEO 2016 Reference Case assumes implementation of the Clean Power Plan.

Figure 1 PRB coal demand/supply under different scenarios, 2016-2040 (Mt)



Source: IEA, EIA, CTI analysis 2016

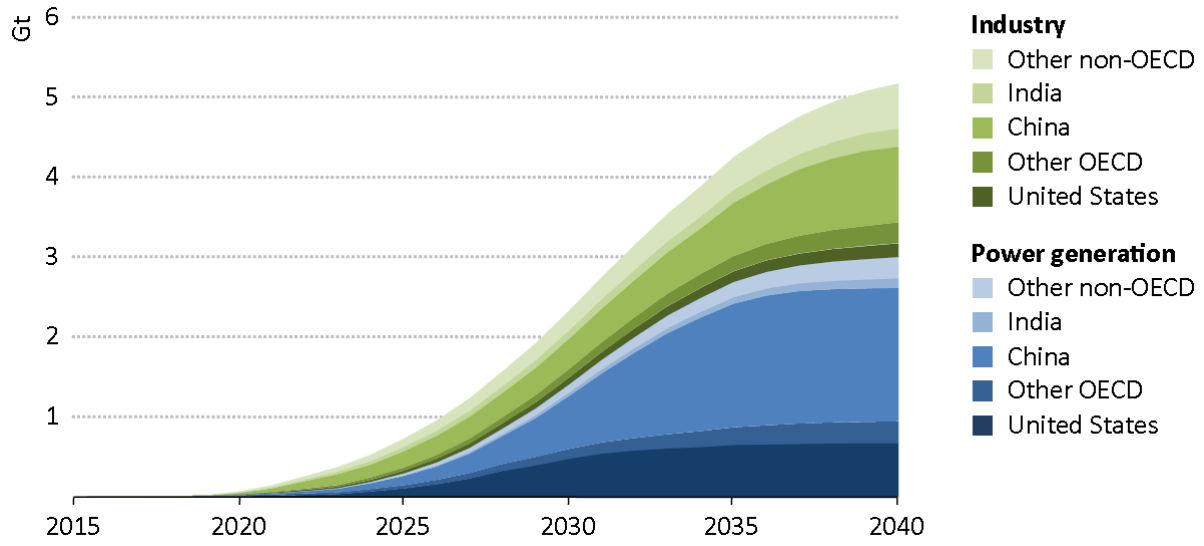
[15] EIA, *AEO 2016* "Coal Production by Region and Type."

Assumptions related to CCS deployment

As shown in the initial 450 Scenario table above (Table 3), power-sector CO_2 emissions related to coal decline nearly three times as fast as power-sector coal consumption through 2040. Furthermore, power-sector coal consumption reverses its decline and begins a slow increase during the 2030-40 period. This reflects the IEA's assumption of CCS deployment. By eliminating or significantly reducing the quantity of CO_2 emitted per unit of coal or natural gas combusted, CCS has the potential to increase the level of fossil fuel consumption while staying within a given CO_2 emissions budget. Conversely, an absence of viable CCS technology requires greater drops in fuel consumption to meet a given CO_2 emissions reduction target.

The 450 Scenario sees CCS installed at both power plants and industrial facilities (e.g., oil refineries and natural gas processing facilities); installations related to thermal coal come exclusively via coal-fired power plants. These installations are a combination of retrofits and new-builds. The figure below shows assumed CCS deployments for the US capturing over 500 million metric tons of CO_2 per year by 2040. As there are substantial obstacles to achieving this scale-up (discussed in greater detail in our November 2015 report) achieving rapid CCS deployment will be challenging.[16] Hence, there is a strong basis for examining how delays or removal of CCS affect required reductions in coal consumption.

Figure 2 CO_2 captured in the 450 Scenario by sector and region



Note: Includes capture of CO_2 emissions from metallurgical coal. Industry includes the following sectors: steel, cement (energy- and process-related), chemicals and paper production; oil refining; coal-to-liquids, gas-to-liquids and natural gas processing
Source: IEA, *World Energy Outlook Special Report: Energy and Climate Change*, Figure 4.4

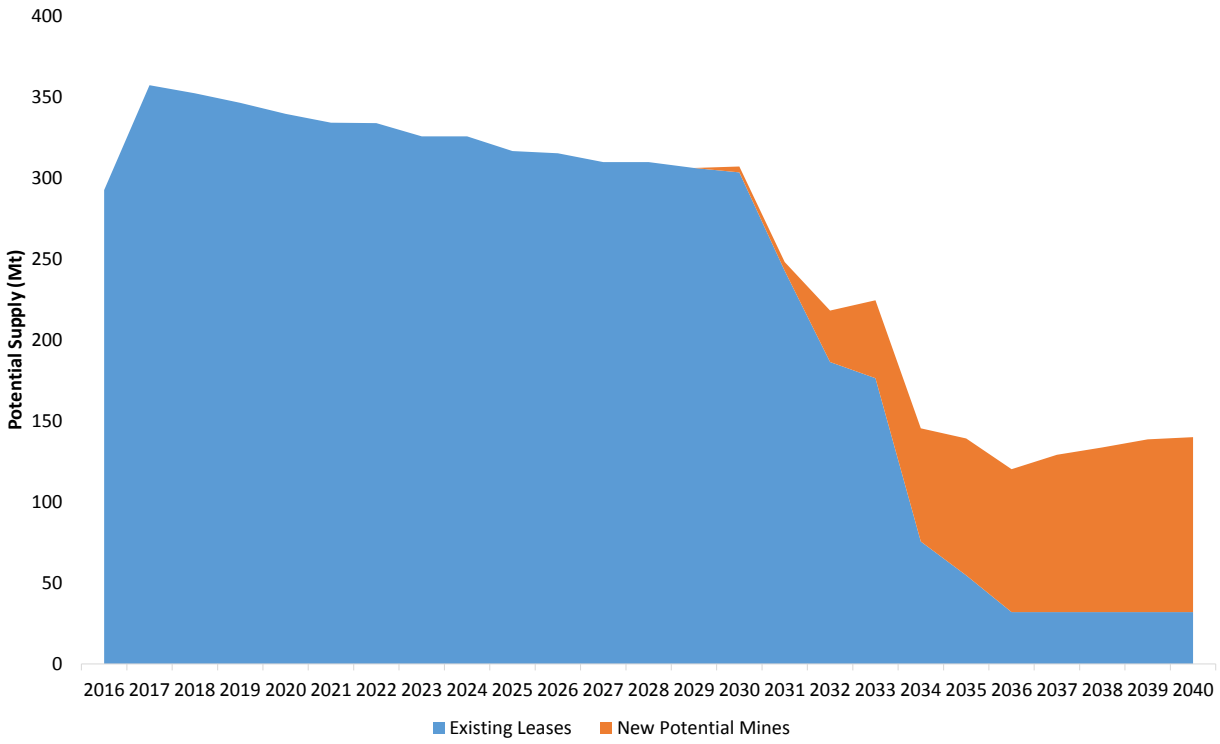
[16] Carbon Tracker Initiative and Energy Transition Advisors, "*The $2 trillion stranded assets danger zone*."

Section Three: Comparing projected 2°C demand with potential supply

Having estimated US domestic demand for PRB coal through 2040 in a 2°C scenario, we now examine whether this level of demand can be met via production from existing leases. To do this, we draw on asset-level data from Wood Mackenzie's Global Economic Model (GEM). Such analysis can inform discussion of what leasing schedule for new PRB leases, if any, is consistent with a 2°C scenario.

Figure 3 illustrates potential production of thermal coal for the US domestic market from existing PRB leases through 2040, and some of the incremental supply from potential new mines. From a 2017 level of 357 Mt, potential production from 17 existing leases declines to only 32 Mt by 2040. Minor production from new mines commences in 2030, growing to ten new mines with a potential production of 108 Mt (or 77% of total potential production) by 2040.

Figure 3 Potential production of thermal coal for US domestic market from existing and new PRB leases, 2016-2040 (Mt)



Source: CTI analysis of data from Wood Mackenzie Global Economic Model, 2016

The available dataset for this paper includes (a) marketable reserves for existing mines from leases that have already been awarded or are exempt from the moratorium; and (b) estimated potential production from new mines (discrete developments producing from new leases). New leases can also expand allowable production to parcels adjacent to existing operations, but within the same overall mine site. Because available data does not capture this subset of potential production from new leases by existing mine operations, the "potential production" in this paper should not be considered maximum possible production.

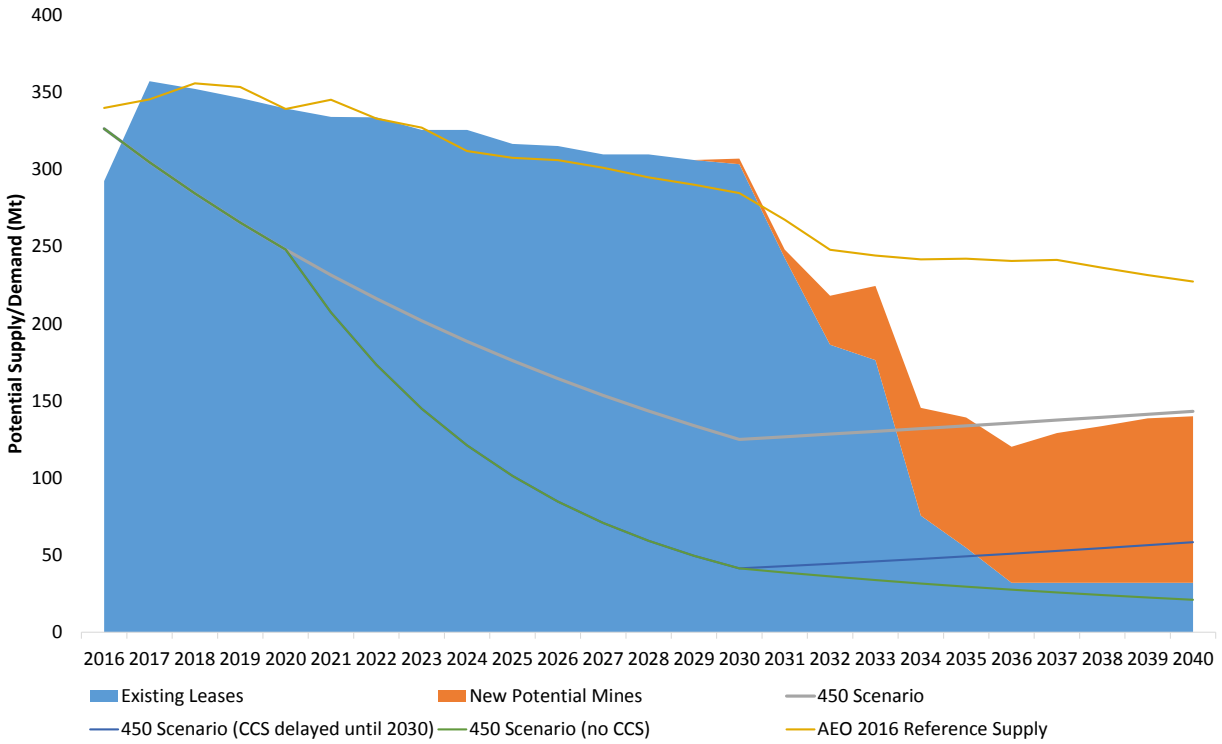
Figure 4 combines the production profile of existing PRB leases and potential new mines with the demand projections from above. Under the 450 Scenario with no CCS, potential production from existing leases is sufficient to meet projected demand in every year through 2040. Under the other two variants of the 450 Scenario, potential production from existing leases is sufficient to meet projected demand through 2040 *assuming some flexibility for miners to (1) modify production timing in the face of changing market demand; and/or (2) stockpile excess potential production during years in which potential production exceeds demand.* Required stockpiling would be equivalent to 2.0-11.7% of cumulative 2016-2040 potential production from existing leases, with drawdown beginning in 2034-2036. As noted in Section Five, modifying production schedules is a more likely strategy, though either approach would be sufficient to avoid the need for production from new leases through 2040.

When the potential production profile is compared with the AEO 2016 Reference Case for supply (which assumes implementation of the Clean Power Plan), the EIA's reference case production is approximately aligned with that from existing leases until the early 2030s. At this point, new leases/mines are assumed to enter production in order to complete the assumed supply.

In summary, ***even without additional efforts to pursue a 2°C scenario beyond those already announced, significant production from new leases is not expected to be needed until 2031.***[17] We note further that the recent "direction of travel" for US energy and environmental policy suggests that additional such efforts are likely to be forthcoming. Accordingly, given the time period until new leases are required and that new leases are only required in a scenario incompatible with the United States' climate commitments, we believe it makes sense for the Federal Government to extend the moratorium for the foreseeable future.

[17] As with any capital-intensive production process, substantial lead-time will be required between the award of the lease and commencement of production.

Figure 4 Potential production of PRB coal versus projected demand under different scenarios, 2016-2040 (Mt)

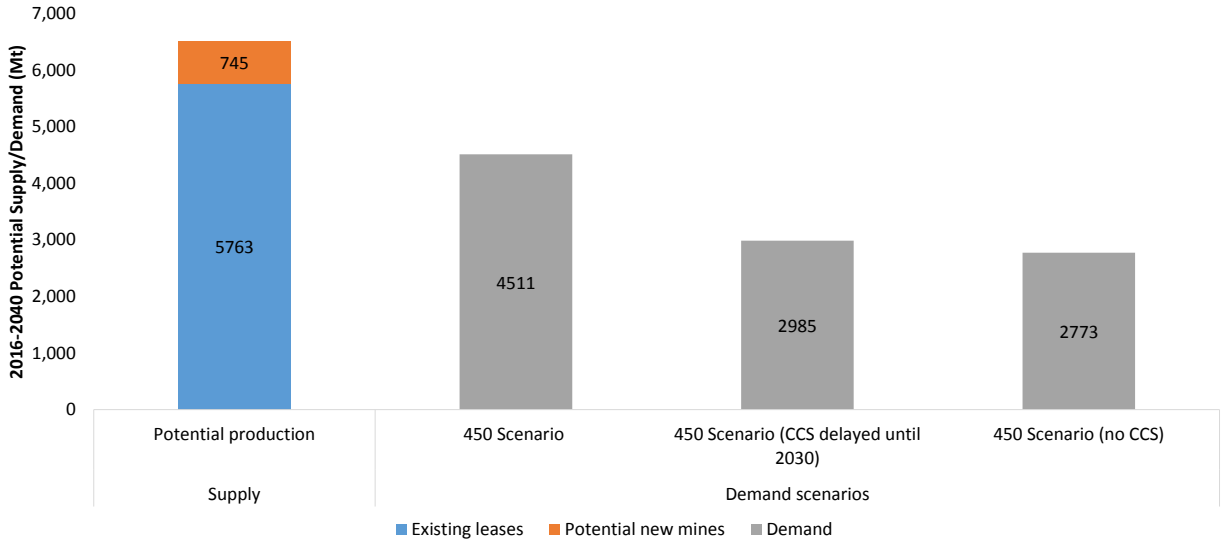


Source: CTI analysis of data from Wood Mackenzie Global Economic Model, IEA, EIA, 2016

It should be noted again that Wood Mackenzie's data does not include all potential new supply. There is a large amount of coal on federal lands within the PRB to the west of the existing operations that can be moved onto as reserves are depleted, which is not covered (hence the apparent shortfall towards the end of the period). This is actually considered to be a more likely source of supply than the new mines shown in the above chart, which will involve greater risk.

Figure 5 below shows supply-demand balances under different scenarios, under all of which aggregate production from existing leases alone exceeds 2°C demand. As a result, no new leases are needed in the period 2016-2040, whether via entirely new mines or new tracts adjacent to existing mining operations.

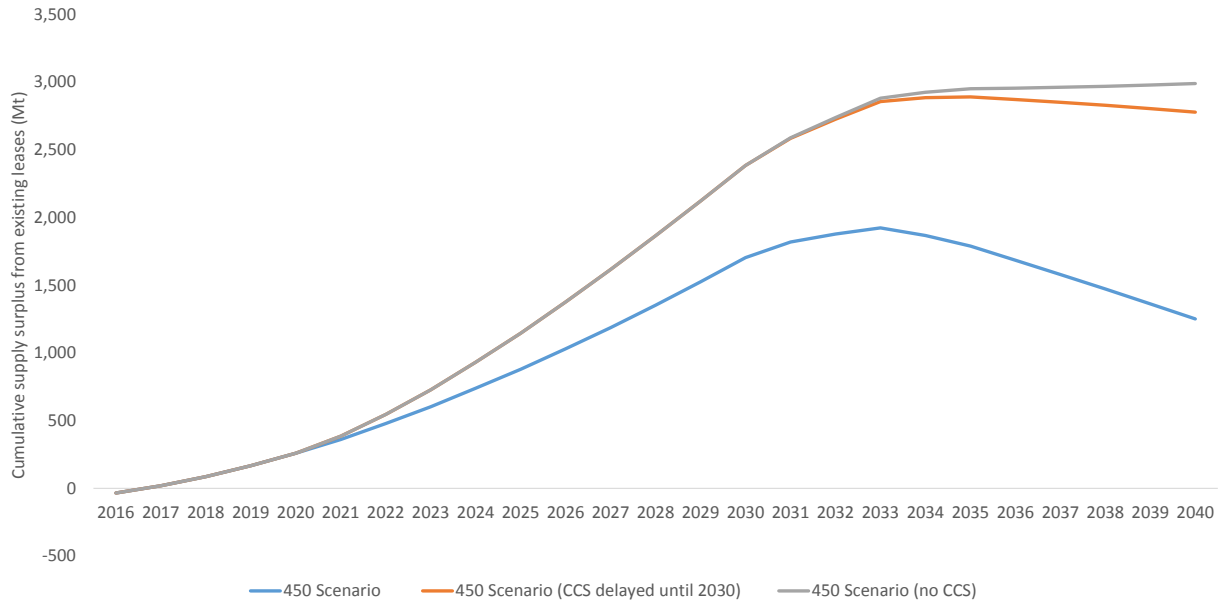
Figure 5 Cumulative potential production of PRB coal versus projected demand under different scenarios, 2016-2040 (Mt)



Source: CTI analysis of data from Wood Mackenzie Global Economic Model, IEA, EIA, 2016

The figure below shows the cumulative supply surplus from existing leases under different scenarios over time.

Figure 6 Cumulative supply surplus from existing leases under different demand scenarios, 2016-2040 (Mt)



Source: CTI analysis of data from Wood Mackenzie Global Economic Model, IEA, EIA, 2016

Table 4 below shows the year in which demand exceeds potential production from existing leases on an annual basis for each scenario (towards the end of the period), and provides estimates of the amount of production from the earlier period of excess supply that would need to be deferred/stockpiled to ensure that this is covered.

Table 4 Comparison of annual PRB supply-demand balances under different scenarios, 2016-2040

	Year in which projected annual demand exceeds annual potential production from existing leases	Sum of annual deficits of potential production from existing leases vs. demand (Mt)	Sum of annual deficits as % of cumulative 2016-2040 production from existing leases (Mt)	Year in which cumulative supply surplus from existing operations falls to zero
450 Scenario	2034	672	11.7%	Beyond 2040
450 Scenario (CCS delayed until 2030)	2036	113	2.0%	Beyond 2040
450 Scenario (no CCS)	Beyond 2040	0	0	N/A

Note: Calculations of annual deficits are illustrative, and do not take into account shifting of production timing.
Source: CTI analysis of data from Wood Mackenzie Global Economic Model, IEA, EIA, 2016

Stockpiling and delaying production as means to extend production from existing leases

The analysis above describes stockpiling of excess production as one means for existing PRB leases to meet required 2°C demand through 2040. Section Five notes a variety of constraints on the ability of miners to stockpile excess production, including the expense, market impact (i.e. via a supply overhang that depresses prices), and fire hazard. Such constraints will limit the ability of existing PRB leases to adapt to changing market demand under a 2°C scenario by stockpiling alone.

The other adaptation strategy available to existing leases, however – to modify production timing to align with long-term supply and demand – suffers from far fewer constraints. Section Five notes that existing companies regularly adjust production in the face of changing market demand, with the year-over-year change in shipments of PRB coal reaching nearly 10% in 2014-2015 (with much larger percentage changes at some individual mines). More recently, PRB coal production has fallen from 95.9 Mt in the first quarter of 2015 to 62.7 Mt in the first quarter of 2016, which the EIA notes is the lowest level since the second quarter of 1995.[18]

Section Five further finds that BLM lease terms – specifically the Interior Department's demonstrated willingness to extend lease lifetimes for as long as the leasing firm continues to produce – will accommodate production timing shifts as means to align production from existing PRB leases with a 2°C demand profile.

[18] EIA, "Quarterly coal production lowest since the early 1980s," June 10 2016, http://www.eia.gov/todayinenergy/detail.cfm?id=26612

Hence taking into account market realities leaves intact our basic conclusion that existing PRB leases can meet projected demand through 2040 in a 2°C scenario.

Section Four: Implications for the federal coal leasing program

Our analysis suggests that pursuit of a 2°C or less climate commitment obviates the need to award new leases for PRB coal mining through at least 2040. Under the power system that the US must transition to if it is to fulfill its Paris Agreement commitments, the 745 Mt of potential production from new PRB mines is unneeded to meet projected demand through 2040.

In contrast, awarding leases for such mines invites up to $2.9 billion of investment that is at odds with America's stated climate ambitions and should prove unnecessary as the world moves towards a 2°C outcome. As PRB mines account for the majority of coal produced on federal lands, this suggests that a continued moratorium on all new leases is warranted under a 2°C scenario. Indeed, taking steps to slow production from the PRB would send a strong signal to other parties to the Paris Agreement that the United States is beginning to put its own house in order.

Note that because the US's current energy trajectory (as exemplified by the AEO Reference Case) does not fully align with a 2°C trajectory, a federal coal moratorium has the potential to yield incremental climate benefits even if current federal policies such as the Clean Power Plan are fully implemented. Inasmuch as implementation of such demand-side policies is delayed or weakened due to political opposition, then the role for supply-side restrictions such as a federal coal moratorium become all the more salient as drivers of US alignment with a 2°C scenario.

Although the focus of this paper is on the adequacy of coal supply from existing leases to meet mid-term domestic demand, the moratorium extension is part of a broad array of policy changes relating to PRB that are under consideration. Discussed in Section Five, these include higher royalty rates, national constraints on carbon emissions from the power sector, and social cost of carbon surcharges. They are generally complementary to our finding that existing PRB leases are adequate to meet demand under the target scenarios agreed to in the Paris Agreement.

Section Five: Comparisons with other studies

Our review of reserves available on existing PRB federal leases indicates that they are adequate to meet projected demand levels consistent with the IEA's 2°C trajectory through 2040, both with and without CCS.[19] In other words, starting with a 2°C demand scenario, we determined what level of supply was necessary to meet projected demand.

In ordinary markets, private decisions commonly guide the pace and development of new supplies. However, slow-downs or restrictions on the exploitation of natural resources have sometimes been used to achieve a variety of public policy goals. With respect to federal coal in the PRB, rising CO_2 levels in the atmosphere mean that not all known reserves and resources of fossil fuels can be burned without risking grave damage to the climate system. Many known fossil fuel deposits will need to be left in the ground.[20] The heavily-concentrated government ownership of unleased PRB coal reserves, in combination with existing leases that can adequately supply the transitional period for existing coal plants, suggest that extending an existing moratorium on new PRB leases would be feasible and supportive of policies to curb US greenhouse gas emissions.

Although the physical reserves associated with existing leases support the idea of a moratorium on new leases under the scenarios we evaluated, it is important to test how robust this conclusion is in the face of alternative inputs or assumptions. Three recent modeling assessments of PRB leasing policy changes allow us to do so: Wood Mackenzie (2016), ICF International (2016) in cooperation with Vulcan Philanthropy, and Erickson and Lazarus (2016) for the Stockholm Environment Institute (using input from the ICF study as well as additional analysis). The U.S. Council of Economic Advisors released a related analysis (USCEA 2016) that is based primarily on data developed in the ICF (2016) analysis.

While the scenarios and assumptions in these assessments varied somewhat, all evaluated market impacts dynamically, assessing the impact of national and PRB-specific policy changes on key parameters such as demand, PRB coal production levels, fuel substitution, prices, and CO_2 emissions levels. Although the results of these assessments are instructive in assessing how robust our conclusions about the adequacy of existing leases are, it is also notable that many of them include a higher level of coal demand than is compatible with an end goal of limiting warming to 2°C.

The other factors that could adjust our figures and conclusions are presented below. Interestingly, ***none of the papers reviewed showed results that would alter our core conclusion that reserves on current federal PRB leases are adequate to meet domestic supply needs with minimal dislocations under most scenarios.*** *Indeed, many of the proposed policy changes examined would accelerate a drop in demand for PRB coal, further delaying the need for new production relative to that shown in Table 4. However,*

[19] Under the AEO 2016 scenario with the CPP (which would not limit warming to 2°C), carbon emissions are constrained starting in 2022 after which reliance on fossil fuels begins to drop. Although the decline is not as fast as under the IEA 450 scenarios, existing federal leases are projected to supply the domestic market through 2031 in this simulation (Table 4).

[20] SEI's Erickson and Lazarus (2016: 14) note that under the 2° scenarios they assessed, the reference case for US coal production is "on pace to substantially overproduce coal, such that both federal and non-federal coal supply would need to be reduced to attain a pathway consistent with 2 degrees C."

the overall carbon impacts of these different policy paths are more complex due to the potential for coal substitution.

- **Policy scenarios for coal demand**. If there were mainstream demand scenarios that projected much higher coal consumption than the ones we used, shortfalls from existing leases could be higher than we predict. Drivers could be higher domestic demand or a rapid increase in coal exports from the PRB region.

- **Matching coal production with anticipated demand.** Our assessment (Figure 4) indicates that production from existing leases will operate at a surplus in the near-term for most scenarios, followed in some cases by deficits (on an annual basis). To minimize shortfalls in later years, mines need to balance near-term supply surpluses with longer-term demands. If they are unable to do this, such as by stockpiling or slowing near-term extraction rates, market dislocations may be larger than what a review of physical stocks alone would indicate.

- **Interactions between federal coal and private coal.** Federal mines in the PRB region often have related or adjacent parcels owned by native tribes, states, municipal governments or private landholders. The large scale surface mining approach used in most of the PRB results in extraction occurring concurrently from seams on land owned by different types of entities, referred to as "logical mining units." Policies that affect the economics of the federal leases can have spillover effects on adjacent non-federal reserves due to the mining technologies used. To the extent that changes in federal policy make these non-federal parcels uneconomic to mine as well, the reduction in supply may be larger than we project. Conversely, non-federal holdings are also quite large in some areas, and if firms are able to shift to non-federal land for coal extraction to bypass the federal requirements, the remaining coal on existing federal leases will last longer.

- **Interactions between multiple changes in federal leasing policy**. In addition to the current lease moratorium on federal PRB lands, other policy shifts are being seriously considered at the federal level. These include per-ton surcharges on federal coal to ensure a minimum federal price (the "royalty adder"); separate increases in the percentage royalty rate on federal coal from 12.5% to 18.75%; a "social cost of carbon (SCC) adder to address greenhouse gas emissions concerns with the coal; more stringent financial assurance requirements for mine closure and reclamation; and making some form of lease moratorium permanent. These changes would reduce the demand profile for PRB coal.

I. Policy scenarios for coal demand

Our review of demand scenarios used in other studies indicate that they would not change our core conclusions on the adequacy of PRB coal reserves to supply projected domestic demand.

A. Domestic demand

Although the demand scenarios used in the other modeling sometimes differed from the IEA 450 scenarios used, there was a large amount of overlap. Those incorporating the CPP introduce pressure to reduce fossil fuel consumption across the country (Wood Mackenzie, ICF/Vulcan, and Erickson and Lazarus), and with it demand for PRB coal falls relative to the no policy baseline. Scenarios focused on a maximum specific warming target introduce more pressure to reduce greenhouse gases (with larger concomitant reductions in PRB demand) than do scenarios put forth by the US EIA Annual Energy Outlook. In addition to the IEA 450 scenarios adopted in our work, Erickson and Lazarus used a 2 degree scenario developed by McGlade and Ekins (2015) that also aims to limit warming to 2°C, though with a higher probability of success (66%, versus only 50% in the IEA 450 scenario). The greater assumed probability of restricting warming means more binding constraints on coal, and indirectly the ability for coal reserves on existing leases to last longer.

Lease modifications, in terms of higher minimum fees, royalty rates, or leasing restrictions all drive up the cost of PRB federal coal specifically. Because leases are contracts, changes to terms normally affect only new leases or lease renewals (every ten years after the initial 20 year lease period), muting the influence of the policy changes on extraction from existing leases. CEA concludes the changes will have "a very minor impact on existing operations" (CEA 2016: 26). The modeling results indicate that while the brunt of these policy changes hit federal leases inside the PRB, there are also more widespread effects such as shifts to other fuels (mostly natural gas) and other coal basins. Although substitution with other coal sources reduces the carbon benefits of a PRB lease moratorium compared with a simple reduction in coal demand of the same amount, it does increase the ability to serve residual demand using existing PRB lease reserves.[21]

B. PRB exports

Were coal exports from the PRB to rise sharply, reserves for existing leases (evaluated against domestic demand) might run out sooner. Although there have been a number of serious efforts in recent years to greatly expand the export capacity, they have not been successful thus far. Of the six proposals for new coal terminals in the Pacific Northwest that were under discussion back in 2010, only one remains active.[22] With a combined processing capacity of about 90.7 Mtpa/year (more than 25% of current PRB production), the terminals would have been material. However, while public opposition to the terminals has been strong, their lack of success is also due in large part to economics. Wood Mackenzie international coal analyst Andy Roberts noted how much the market for coal has declined in recent years, pointing out that PRB coal sold in Asian markets a few years ago would have fetched prices 20 times its cost, while at current prices exporters would be earning revenues 12 times below cost (Storrow 2016).

[21] While not the focus of this paper, the modeling exercises also project revenue gains by both the federal and state government under nearly all of the policy reform scenarios. That is, the increased payments to governments from the higher fees more than offset reductions in demand for PRB coal from the higher prices. CEA notes of the current situation that "there are large economic rents being earned on federal coal, and only a small fraction of these rents are currently going to the States and the U.S. Treasury" (CEA 2016: 26).

[22] Natasha Geiling, "The Plan To Revive Big Coal's Fortunes Isn't Panning Out," *Climate Progress*, May 11, 2016.

None of the papers reviewed indicated that coal exports will be a material factor in the demand for PRB coal over the period of analysis. Global coal prices are weak, under continued pressure from low natural gas prices in the power sector, and Asian demand is way down from levels a few years back. Moreover, previous CTI analysis has indicated that a 2°C scenario obviates the need for production from new thermal coal export mines globally through at least 2035.[23]

The ICF/Vulcan analysis expects exports of PRB coal to remain stable, but at their current low level; and for most of this tonnage to flow out of Canadian export terminals. Erickson and Lazarus (2016: 21, 39) use EIA estimates for PRB steam coal exports. These do rise, albeit at a very slow rate over the next two decades. They nonetheless expect that in the face of less favorable lease arrangements for PRB federal coal, domestic exports will be easily replaced by non-federal coal and by coal mined in other countries.

II. Matching coal production with anticipated demand

Supplier flexibility would allow existing lease holders to more effectively alter production schedules to supply long-term needs. We looked at three aspects of this issue: the feasibility of stockpiling coal to maximize near-term capital utilization while storing surplus production for later years; matching supply with current demand by modifying the extraction schedule; and potential rigidities in lease terms that would restrict the ability to shift production out into the future.

A. Coal stockpiling does not seem a feasible strategy to balance supplies over the modeling period

Although some coal stockpiling is routine in the marketplace, the levels needed to balance short-term surpluses with longer-term deficits under a stockpiling strategy to address long-term demand for PRB coal run into the hundreds of millions of metric tons – exceeding 670 Mt in 2034 under the 450 scenario (Table 4). As a point of comparison, coal stockpiles for the entire United States were 176 million tons as of March 2016 – and this figure is close to its highest level since 2009 (EIA 2016a).

Stockpiling PRB coal to balance surplus years with deficits towards the end of the modeling period does not seem feasible for a number of reasons:

- **Stockpiling is expensive.** Funds to mine the coal have already been expended, and the firm must then pay to store the coal and attempt to keep it from degrading. The inventory being produced and held long term is fairly low value, further worsening the economics.

- **Stockpiles create a supply overhang that depresses prices**. With last winter a warm one, in combination with declining demand for coal, stockpiles in the PRB have been building to historically high levels. As of March 2016, stockpiles of Powder River Basin coal were at 102 days of burn in January, roughly 50% above the five-year average. (Platts, 8 March 2016). Even if the stated intention is to hold supply for many years, its mere existence affects market prices.

[23] Carbon Tracker Initiative and Energy Transition Advisors, *The $2 trillion stranded assets danger zone: How fossil fuel firms risk destroying investor returns*, Nov 2015, http://www.carbontracker.org/report/stranded-assets-danger-zone/

Indeed, Platts estimated that supply would need to be cut by about 32 million metric tons per year (Mtpa) to bring prices back up.[24] Holding stockpiles for even longer periods of time also exposes already weak (or bankrupt) mining companies to a great deal of market risk that coal demand will never materialize, or that the actual sale prices for the inventory end up being much lower than had been assumed.

- **Fire hazards.** PRB coal piles have a tendency to spontaneously combust, including both in transit and in stockpiles. *Power Magazine* noted that "Operators familiar with the unique requirements of burning PRB coal will tell you that it's not a case of 'if' you will have a PRB coal fire, it's 'when.'" (Douberley, 2013). This fact clearly complicates long-term storage of large quantities.

B. Modifying production timing does seem feasible to match long-term supply and demand

Despite large economies of scale in PRB surface mining, the existing companies regularly adjust production in the face of changing market demand. *Coal Age* notes declines of PRB shipments of coal between 2014 and 2015 of nearly 10%, with even larger reductions in some mines. Industry representatives quoted in the article blamed much of the decline on rail problems linked to heavy rains, though also acknowledge shutting one large mine due to higher costs, and that the size of the future PRB coal industry is likely to be smaller than in the past (Christian and Fawad, 2015). Layoffs at PRB mines in March 2016 are another indication that production shifts to address changes in demand for coal (Morton, 2016).

C. Lease duration will not limit the ability of existing leases to supply to 2040

BLM coal leases normally have an initial term of 20 years.[25] However, "for all fuels, onshore or offshore, the DOI will extend lease terms as long as the leasing firm continues to produce" (Erickson and Lazarus 2016: 4). Modifying output levels would not affect the mine's production status. Even bankruptcy of the leaseholder does not affect the mining rights; indeed, the lease is considered an important asset during the reorganization under a Chapter 11 bankruptcy filing and the firm is under pressure to keep the coal flowing (Cohan 2016).

III. Interactions between federal and non-federal coal under proposed policy changes

Modifications to PRB leasing rules would affect only coal mined on federal lands, and generally only in relation to leases signed after the new rules go into effect.[26] If *existing* leases, for which terms are

[24] "PRB coal producers must cut production to boost prices: analyst," Platts S&P Global, 2 November 2015.
[25] If a reserve isn't being diligently developed, BLM has the option to terminate a lease in as little a ten years (BLM 2016).
[26] Our data, taken from Wood Mackenzie's Coal GEM service, predominantly captures federal reserves contained in already-granted leases for existing mines and Wood Mackenzie's estimates for future lease acreage. As such it is not reflective of the full resource potential of the Powder River Basin, and does not include as much of the coal on non-federal lands which may be featured in other studies. However, the extremely limited ability to mine non-

largely fixed, are adequate to supply producers for decades to come, the impact of the new terms on our conclusions about a lease moratorium is greatly lessened. Available data suggest that royalty adders can be included in new leases and lease renewals (at year 20, and every 10 years thereafter), which results in a phase-in on existing leases over a period of decades. Modifications to bonding rules can be phased in a bit more quickly (at the renewal of SMCRA operating permits, which run five years) (Gerarden, Reeder and Stock 2016; Stock 2016; Cantwell 2016).

Higher costs for federal coal could affect non-federal coal in one of two ways. If these parcels are intertwined with the federal leases, it may not be economic to separate them out, and some non-federal reserves could cease production along with declines in PRB output. In fact, the ICF/Vulcan analysis estimated that the associated reduction in non-federal coal from changes in federal rules would be as much as half that from federal coal (Erickson and Lazarus, 21). Conversely, if non-federal coal deposits are also large, mining could shift to these from federal lands, reducing the drop in PRB coal production overall.

These factors will affect the impacts of a federal lease moratorium on regional economics and national GHG reductions, so they are worth discussing even if they don't affect the physical ability to meet long-term demand with existing leases.

A. Could non-federal reserves replace federal reserves within the PRB?

Based on aggregate geological data, the potential for intra-PRB substitution seems large. ICF notes that

> *At existing mines in the four states of interest [WY, MT, UT, CO], there are non-federal reserves of close to 1,000 million tons, and federal coal reserves of about 8,300 million tons. Additional non-federal coal reserves in Wyoming are approximately 30,000 million tons, while reserves on federal lands are about 360,000 million tons. Not all of these reserves are likely to be economic at current coal prices; however, it provides an indication of the vast quantities of coal available. (ICF 2016, 16).*

In contrast, total production of coal from the PRB in 2014 was less than 365 Mt – so these non-federal reserves represent decades of potential production.[27] The resource base is not the only factor; many domestic customers for PRB coal-run power plants specifically configured to handle it.[28] While shifting

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federal deposits independent of federal tracts (see Figure 7 for an illustration of why), and the general alignment of Wood Mackenzie findings with the other papers reviewed, both suggest this limitation does not materially affect our conclusions.

[27] The estimated resource base in a detailed survey done for Xcel Energy in 2011 was 20.6 billion short tons (Lee and Bate 2011: 2-2). This is lower than the ICF study, but still equivalent to about fifty years of current demand.

[28] A 2015 review of coal basins by Goldman Sachs found conflicting opinions on the ease and extent of coal switching from PRB to Illinois Basin coal within the current PRB customer base. There was general agreement that PRB plants with existing dry scrubbers would not switch; those with existing wet scrubbers could switch; and those with no scrubbers might consider switching if located closer to Illinois Basin sources (Hoskote and Guthana 2015: 3). The ICF model includes power plant-specific data, so also incorporates the ability to switch coal sources on a granular basis.

to other types of coal is possible with capital investment, shifting to other coal acreage within the PRB could well be both less disruptive and less expensive.

Despite this potential, the ICF model precludes the ability to substitute non-federal PRB coal for PRB coal:

> *Under the modeling assumptions regarding the comingling of federal and non-federal coal in logical mining units, coal cannot be preferentially mined on non-federal lands to substitute for declines in federal coal production. Therefore, when the SCC adders cause decreases in federal coal production, comingled non-federal coal witnesses a reduction as well. (ICF 2016, 30).*

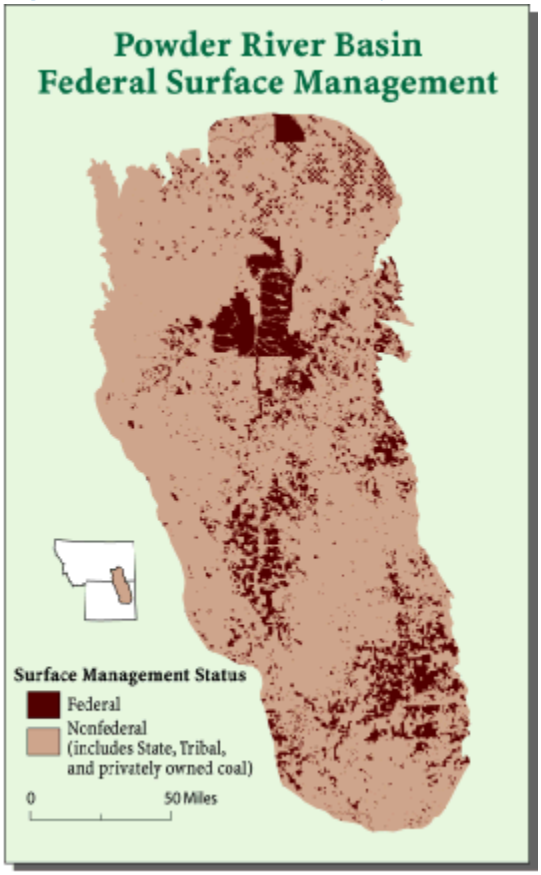
ICF's simplifying assumption seems plausible relative to moderate modifications in lease terms (such as minimum fees per ton or increased royalty rates). However, with spot prices for PRB coal in June 2016 of less than $10 per metric ton (EIA 2016b), and ICF social cost of carbon scenarios reaching nearly 14 times this level by 2040 (ICF 2016: 3), the incentives to redeploy local capital stock and rail connections to non-federal coal in order to bypass the new rules seems quite strong.

Were non-federal acreage to substitute for declines in federal production from the PRB, our modeling conclusions regarding the adequacy of existing leases would be unchanged. However, the carbon benefits from the moratorium would be reduced, perhaps greatly so.

Some avoidance seems plausible. Erickson and Lazarus (2016: 20) point out large state and private coal reserves near the Otter Creek mine and Native American reserves adjacent to the Big Metal Mine, possibly reserves that could allow some bypass of higher costs on federal leases. Wood Mackenzie (2016: 7) also allows some intra-basin substitution, with some of the lost production from the closure of the larger PRB mines shifting to higher cost smaller mines).

However, the ownership patterns of coal reserves within the PRB, in combination with the large scale strip mining techniques deployed in the basin, make broad-based substitution extremely unlikely, a conclusion reached not only in the ICF/Vulcan study, but also by Headwaters Economics, a regional natural resource consulting firm specializing in western natural resource issues (Haggarty 2016), Erickson and Lazarus (2016) and Gerarden, Reeder and Stock (2016). The rationale can be seen in Figure 7 below, based on a 1998 USGS land survey (USGS 1998). Despite a great deal of non-federal ownership of surface rights to land within the PRB, federal ownership of the coal rights is extensive and non-federal parcels of the subsurface estate are small and segregated. More recent USGS data shows the same pattern of federal coal ownership, though without the same resolution on tribal lands and surface rights (Luppens and Scott 2015, 72).

Figure 7: Federal ownership of coal dominates PRB



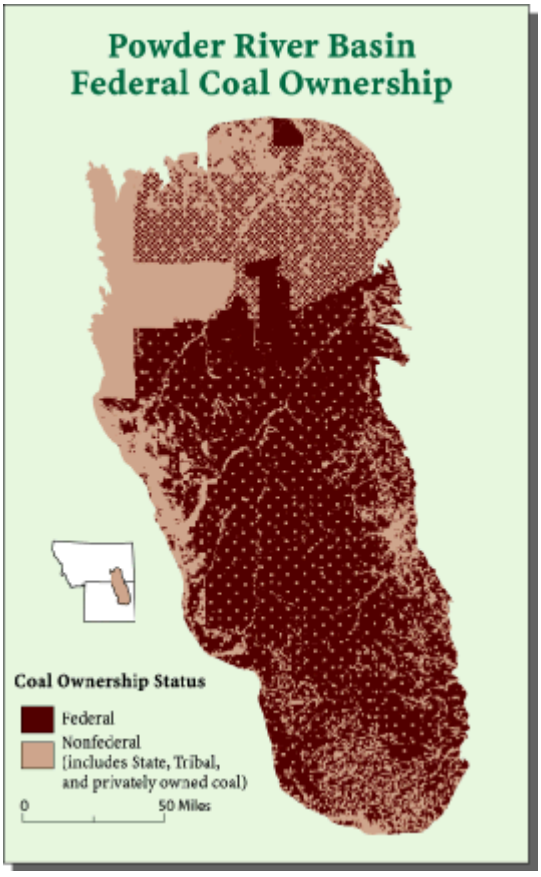


Figure 6

B. Could coal from other basins substitute for declines in federal PRB coal?

All of the modeling scenarios show that part of the loss of PRB coal due to higher lease payments or leasing restrictions will be made up via substitution from other US coal basins, though significant net carbon reductions remain (see below). Part will be offset by increased use of natural gas as well, which is generally considered lower-carbon than coal. Although there is also some increase in energy efficiency and renewables projected, these amounts are much smaller in the studies we examined. The range of substitutes will depend on the specific policies implemented, as opposed to our approach of looking at supply from already-aligned 2°C outcomes.

For example, PRB-specific cost-increasing policy modifications tend to trigger a much higher level of substitution from other coal basins than more broad-based changes. This is because the PRB-specific changes create a pricing disparity relative to other sources of coal. Not surprisingly, the more substantial modifications (high SCC adders and lease moratoria) result in a larger decline in PRB production levels. For example, ICF's leasing moratoria scenarios (50% or 100%, though with a multi-year phase-in) and high-cost SCC adders both result in almost a full cessation of federal PRB leases by

2040. As noted earlier, this conclusion assumes that shifts of mining activity to non-federal PRB land remain small due to highly fragmented non-federal ownership of the subsurface estate.

National constraints on carbon, such as the CPP, have a markedly lower impact on PRB production levels as the differential prices across coal basins are less affected.

Shifts to other basins in the face of higher prices for PRB coal are significant in all of the modeling exercises. While some of the decline in PRB production is associated with a shift to natural gas, much of the PRB supply is replaced by increased output from the Illinois Basin, which would see demand grow by as much as 37% (Wood Mackenzie 2016: 7).

Erickson and Lazarus (2016: 22) project most of the increased production in the Illinois Basin as well, though production also rises in Appalachia. Basin switching makes up about 60% of the coal lost from federal and adjacent lands due to leasing restrictions. In ICF's no new permits case (ICF 2016: 47), coal production on federal lands is assumed to end by 2037. The associated decline in US coal production overall is 315.7 Mt by 2040, with the decline in PRB production even higher, at 360.15 Mt. The largest gainer is the Illinois Basin (28.12 Mt) and Northern Appalachia (14.5 Mt).

Nonetheless, basin switching does not negate the carbon benefits of the policy reforms. Geraden, Reeder and Stock (2016: 3) estimate based on the ICF model that a carbon adder on federal royalties for PRB leases, set at the government estimate for the social cost of carbon, could achieve nearly three-quarters the national reductions in carbon as the CPP. Erickson and Lazarus (2016: 19) distilled from the many ICF model runs that under the CPP about one-third of PRB coal would be replaced by non-coal (lower carbon) energy supplies. Although scenarios with no CPP would have a smaller impact on national coal consumption than under the CPP, PRB-specific impacts would be larger due to greater coal price disparity across basins. Under the no-CPP scenarios, Erickson and Lazarus reported the shift away from PRB coal was roughly two-thirds.

IV. Policy scenarios for PRB coal leasing

In addition to the current lease moratorium on federal PRB lands, other policy shifts are being seriously considered at the federal level and examined in these other studies.[29]

A. Policies specific to PRB coal

- **Higher lease payment floors**. Minimum price – a flat royalty adder of $2.75 per ton to set a higher floor on taxpayer revenues from the sale of coal. Although competitive auctions for coal leases could in theory accomplish this goal, the vast majority of PRB lease sales are by application, initiated by the firm already active in the parcel and have no competing bidders.

[29] This list focuses on PRB-related policy changes modeled in the studies we evaluated, but is by no means an exhaustive list. For example, some have proposed a compensatory mitigation obligation for federal coal leases. The approach would work in tandem with environmentally-related surcharges (such as the social cost of carbon adder to royalties) to ensure resultant funds are earmarked to address the climate damage the federal coal sales are contributing to.

- **Higher royalty rates**. The percentage royalty on coal sales would increase from 12.5% to 18.75%. Changes in how the market value of the coal is calculated to reduce gaming would also increase the federal take.
- **A social cost of carbon (SCC) adder**. Applied as a royalty to PRB coal to at least partially internalize the global warming impacts of the sale, some scenarios show the SCC fee many multiples of the current price of PRB coal.
- **PRB lease moratoria**. Reduction (in part or in full) of new federal coal leases from the PRB.

B. Policies broader in scope

- **Clean Power Plan.** The CPP would set limits on domestic carbon emissions across all fuels affecting the power sector, not just coal and not just within the PRB. CPP scenarios sometimes allow trading to reduce the average compliance cost.
- **Improved reclamation bonding.** More stringent financial assurance for coal mine reclamation would eliminate self-bonding options entirely and implement more stringent rules on sureties and the allowed collateral.[30] These changes would reduce the probability of unfunded liabilities across the country, though also increase the operating costs of mining somewhat.

As discussed above, policy reforms specific to PRB-coal introduce potentially large price differentials between federal leases within the PRB and other coal deposits. Alternative supplies include coal deposits on private, tribal, or state land both within the PRB, as well as other US coal basins. PRB-specific modifications do reduce coal consumption nationally, but not by the full amount of PRB-declines due to some basin switching.

The CPP and improved reclamation bonding requirements would affect all coal reserves in the US, and therefore would trigger fewer dislocations within the PRB area than the basin-specific modifications. Because these changes increase the cost of coal operations, they would accelerate the shift to other fuels.

While the policies vary in the degree to which they affect coal demand nationally or within the PRB region, directionally they all increase cost pressures on coal and can be expected to suppress coal demand somewhat relative to a no-policy baseline. None of them would lead us to conclude that reserves at existing PRB federal leases would be less able to meet projected demand.

[30] See, for example, Cantwell (2016).

APPENDIX – IMPLICATIONS FOR CAPITAL EXPENDITURES ON NEW MINES

The Wood Mackenzie supply dataset contains estimated potential production and capex data for possible new mines in the PRB, covered in summary below. Bonus payments bid to secure leases represent capital expenditures from the perspective of the mining company, and are included in the below capex tallies.

Although the data does not include new lease awards for tracts that would be associated with existing mining sites, further capital spending (including bonus bid payments) on these would also be at risk as the economy decarbonizes. The figures presented below thus provide an indication of the scale of potential investment, but understate the full amount of possible capital expenditure.

US government decisions with respect to granting leases for new PRB coal mines will affect production from 10 possible future mines owned by eight companies. Table 5 illustrates this potential production by company and related capital expenditures (capex) for new mines should these projects move forward. The potential spend on new mines is shown over the timeframes 2016-2025 and 2016-2040.

Table 5 Potential production and capex related to new PRB thermal coal mines serving US domestic demand, 2016-2040

	Production (Mt)	**Capex (real 2016 million USD)**	
	2016-2040	2016-2025	2016-2040
Cloud Peak	223	0	714
County Coal	152	0	584
Peabody	113	0	325
Northern Cheyenne	94	0	318
Ramaco	60	0	157
Crow Nation	44	0	313
Terra Nova	44	0	313
Great Northern	13	0	211
Total	**745**	**0**	**2,935**

Source: CTI analysis of data from Wood Mackenzie Global Economic Model, 2016

Through 2025, there is no expected capex associated with new PRB mines. Through 2040, there is $2.9 billion of capex associated with new PRB mines, with capex exposure for individual companies ranging from $157-$714 million. In a 2°C demand scenario this capex is unneeded and, should it proceed, could represent a wasted and/or financially risky capital allocation.

It is worth reiterating that these figures represent potential capex on future mines, and will not have already been committed by the companies involved. Indeed, in our data (drawn from Wood Mackenzie's Global Economic Model), no capital spend takes place on any potential new mine before 2029. Thus, a continued moratorium would not put at risk the finances of the companies noted in Table 5. On the contrary, if this investment does go ahead, there is a substantial risk of stranded capital and value destruction as the world's energy complex transitions to a lower-carbon basis.

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