

# ASSESSING EMISSION AND OTHER IMPACTS ASSOCIATED WITH THE PROPOSED FEDERAL LEASING BAN IN WESTERN STATES

REPORT PREPARED BY ADVANCED RESOURCES INTERNATIONAL, INC.



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02 March 2021

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The Great State of Wyoming  
State Capitol  
200 West 24th Street  
Cheyenne, WY 82002

via email at [buck.mcveigh@wyo.gov](mailto:buck.mcveigh@wyo.gov)

**RE: *Assessing Emission and Other Impacts Associated with the Proposed Federal Leasing Ban in Western States.***

Dear Governor Gordon,

Pursuant to your E.O. 2021-01, The Wyoming Energy Authority (WEA), the University of Wyoming's School of Energy Resources (SER), and the Enhanced Oil Recovery Institute (EORI) jointly initiated a review of the impact of President Biden's E.O. 139990 and the potential impact on Wyoming oil and gas production, access to existing and future reserves, as well as state revenue.

The primary objective of the study is to assess the possible implications to GHG emissions associated with this proposed ban and to do so, estimate the drilling and production losses from policies to restrict oil and gas development on federal lands. From that estimate, the emissions impacts are assessed by examining the difference in emissions associated with possible makeup production, compared to the production loss resulting from the ban, or from higher natural gas drilling levels that may be required to make up for lost supplies.

The study reveals several impacts of the proposed ban that include:

- **Greenhouse gas emissions could increase** because of a federal leasing and/or drilling ban.
- Without an increase in **oil and/or gas prices, US oil and gas production could decrease by 21% to 34% by 2030.**
- A ban on future drilling on federal lands would **prohibit development of 600 to 850 million barrels of incremental oil potential from CO<sub>2</sub> EOR in Wyoming, that would facilitate potential geologic storage of 420 to 570 million metric tons of CO<sub>2</sub>.**
- Without an increase in oil and gas prices, **drilling levels** in the six western states **would drop by as much as 35%** due to federal leasing/drilling policies.

- In Wyoming, by 2030, drilling levels decline by 28%, growing to 43% by 2050.
- In Wyoming, **declines in expenditures** associated with oil and gas well drilling would reach **over \$800 million per year by 2030.**
- In Wyoming, **declines in state revenues** associated from oil and gas production could reach **over \$600 million per year by 2040.**

This study along with the recently completed study by Dr. Considine, UW School of Energy Resources Professor of Energy Economics entitled “The Fiscal and Economic Impacts of Federal Onshore Oil and Gas Lease Moratorium and Drilling Ban Policies” look only at unconventional production. Our alternative methodology is complimentary to Dr. Considine’s arriving at a similar conclusion, and further substantiating Wyoming’s position with respect to the impact of these federal policies.

If you or any member of your staff have any questions or require any further details or assistance, please do not hesitate to reach out to any of the undersigned.

Respectfully,



Dr. Steven M. Carpenter  
Director  
EORI



Dr. Holly Krutka  
Executive Director  
SER



Dr. Glen Murrell  
Executive Director  
WEA

Attachment: *Assessing Climate and Other Impacts Associated with the Proposed Federal Leasing Ban in Western States*, Advanced Resourced International, 3/1/2021

pc: Mr. Buck McVeigh, Chief of Staff, Wyoming Governor Mark Gordon  
Mr. Randall Luthi, Chief Energy Advisor, Wyoming Governor Mark Gordon  
Senator Jim Anderson, Senate Co-Chair, Joint Minerals Committee  
Representative Mike Greear, House Co-Chair, Joint Minerals Committee  
Senator Drew Perkins, Senate Co-Chair, Joint Appropriations Committee  
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Dr. Glen Murrell, Executive Director, Wyoming Energy Authority  
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Mr. Ken Hendricks, Chair, Enhanced Oil Recovery Commission  
Ms. Cindy Crane, Chair, Energy Resources Council  
Mr. Mark Stege, Chair, Wyoming Energy Authority Board  
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Mr. Adam Stewart, Staff, Senator Cynthia Lummis  
Ms. Kate Barlow, Staff, Senator Cynthia Lummis  
Ms. Esther Wagner, Sr. Policy Advisor for Energy and Lands, Representative Liz Cheney

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## ASSESSING CLIMATE AND OTHER IMPACTS ASSOCIATED WITH THE PROPOSED FEDERAL LEASING BAN IN WESTERN STATES

### SUMMARY

On January 27, 2021, President Biden issued an Executive Order (EO) that suspended new leasing for fossil fuel production from federal lands and waters. The acting Secretary of the Interior, responding to this direction, suspended indefinitely federal oil and gas leasing. Moreover, at least temporarily, decisions on the approval of permits for drilling and development on already-leased federal lands are being delayed. This EO can have a major impact on Wyoming and other western states where a significant portion of oil and gas development and production comes from federal lands.

This study was undertaken to evaluate the impact, in terms of lost production and associated economic impacts and corresponding implications on GHG emissions, associated with this proposed ban. This assessment considered the impact of two possible policy initiatives:

- A drilling ban on federal lands, including lands that have already been leased
- A ban on the issuance of new onshore federal leases in the future

Impacts of these possible policy initiatives were assessed for the state of Wyoming, as well as a collection of western states in the onshore Lower 48, including Wyoming, New Mexico, Colorado, Utah, Montana, and North Dakota. *While the scope of the EO applied to all federal lands in the U.S., onshore and offshore, this analysis was only focused on these western states.*

### IMPACTS

**Greenhouse gas emissions will likely increase because of a federal leasing and/or drilling ban.** The primary stated motivation for imposing a ban on leasing and/or drilling on federal lands is to reduce US emissions of greenhouse gases (GHGs). However, it warrants investigation as to whether reducing the supply of fossil fuels would have much impact relative to reducing their demand. Reducing domestic supplies, without reducing demand, would not reduce US emissions. In fact, negligible change or even an increase are likely occur because oil and gas production on federal lands have relatively low GHG emissions compared to other sources likely to replace decreased production on federal lands:

- For crude oil, GHG emissions resulting from a federal leasing and/or drilling ban would likely increase by 20 to 150 million metric tons annually by 2030. This assumes that oil imports increase to replace lost domestic supplies from federal lands, with the range depending on the sources of these increased imports.
- For natural gas, a significant decrease in GHG emissions associated with a leasing/drilling ban on federal lands is also unlikely. In response to the higher prices necessary to stimulate the lost supplies from federal lands, greater productivity (and higher emissions) horizontal wells from non-federal lands will, to some extent, displace lower productivity (and lower emissions) vertical wells not otherwise developed on federal lands, resulting in emissions reductions on the order of only 0.3 million metric tons annually by 2030.

**Without an increase in oil and/or gas prices, US oil and gas production would decrease by 21% to 34% by 2030.** Assuming the oil and gas price forecast in the Energy Information Administration's (EIA's) 2020 Annual Energy Outlook (AEO) Reference Case:

- Oil production from the six western states production would drop by 21% to 28% by 2030 (a decline of 1.1 to 1.5 million barrels per day)
- Natural gas production would drop by 23% to 34% by 2030 (a 6.0 to 8.7 Bcf per day reduction in production)
- In Wyoming, by 2030, oil production would drop by 9% to 16% (a reduction of 51,000 to 85,000 barrels per day)
- Natural gas production in Wyoming would drop by 18% to 28% by 2030 (declining by 0.5 Bcf to 0.8 Bcf per day)

**A ban on future drilling on federal lands would prohibit development of 600 to 850 million barrels of incremental oil potential from CO<sub>2</sub> EOR in Wyoming, that would facilitate potential geologic storage of 420 to 570 million metric tons of CO<sub>2</sub>.** Additional oil production potential from the application of CO<sub>2</sub> enhanced oil recovery (CO<sub>2</sub> EOR) operations in depleted oil fields in Wyoming could be forgone because of a ban on new drilling on federal leases. Even though these fields are already leased, a drilling ban would likely prohibit the development of all or a portion of these fields for CO<sub>2</sub> EOR, which offers a significantly lower GHG footprint. ARI estimates that 35 fields would be economically viable to pursue for CO<sub>2</sub> EOR at \$80 per barrel oil price and \$30 per metric ton for purchased CO<sub>2</sub>. From 72% to 74% of the total CO<sub>2</sub> EOR oil



production and CO<sub>2</sub> storage potential in Wyoming underlie federal lands. In other words, the drilling ban would prohibit the development of near carbon neutral oil in the state.

**Without an increase in oil and gas prices, drilling levels in the six western states would drop by as much as 35% due to federal leasing/drilling policies.** The result of new federal leasing/drilling policies on federal leases could result in a drop in oil and gas well drilling by 2030 by 35% (a reduction of 1,500 to 1,600 wells in the six western states). The extent of the impact is comparable whether a federal leasing ban or a federal drilling ban is imposed.

**In Wyoming, by 2030, drilling levels decline by 28%, growing to 43% by 2050.**

**Reduction in oil and gas drilling on federal lands would result in a \$14 billion per year decrease in expenditures associated with drilling activity by 2030 in the six western states.** Of course, such impacts would be felt earlier in the federal drilling ban scenario but would be significant in both the federal leasing ban and drilling ban cases. Decreases in drilling and the expenditures associated with drilling in the six western states would result in a proportional decrease in industry jobs.

**In Wyoming, declines in expenditures associated with oil and gas well drilling would reach over \$800 million per year by 2030.** And this represents just the lost expenditures associated with oil and gas well drilling, and not all spending associated with oil and gas development and production activity.

**Reductions in oil and gas oil and gas production on federal lands would result in a decrease in state revenues in the six states considered of over \$6 billion per year by 2030.** These revenues are critical to the states' fiscal well-being, and the reduction in expenditures continues to grow substantially after 2030. Again, such impacts would be felt earlier in the federal drilling ban scenario but would be significant in both the leasing ban and drilling ban cases.

**In Wyoming, declines in state revenues associated from oil and gas production could reach over \$600 million per year by 2040.**

## BACKGROUND

On January 27, 2021, President Biden issued an Executive Order (EO) that suspended new leasing for fossil fuel production from federal lands and waters. The acting Secretary of the Interior, responding to this direction, suspended indefinitely federal oil and gas leasing. Moreover, at least temporarily, decisions on the approval of permits for drilling and development on already-leased federal lands are being delayed.

This EO can have a significant impact on Wyoming and other western states where a significant portion of the oil and gas development and production in the state comes from federal lands. This includes an impact on state revenues, domestic oil and gas supplies, investment, and oil and gas prices. Moreover, given the fact that this EO impacts the supply of oil and gas, and not demand, it must be investigated as to whether this action can achieve the primary objective intended – that is, the reduction of greenhouse gas (GHG) emissions.

## OBJECTIVE

The primary objective of this study is to assess the possible implications on GHG emissions associated with this proposed ban. However, to do this, estimates of the drilling and production losses from policies to restrict oil and gas development on federal lands needed to be developed. From that, the climate impacts are assessed by examining the difference in emissions associated with possible makeup production, compared to the production loss resulting from the ban, or from higher natural gas drilling levels that may be required to make up for lost supplies.

This assessment considered the impact of two possible policy initiatives:

- A drilling ban on federal lands, including lands that have already been leased
- A ban on the issuance of future onshore federal leases

Impacts of these possible policy initiatives were assessed both for the state of Wyoming, as well as for a collection of western states in the onshore Lower 48: Wyoming, New Mexico, Colorado, Utah, Montana, and North Dakota. *While the scope of the EO applied to all federal lands in the U.S., onshore and offshore, this analysis was only focused on these western states.*

## SUMMARY OF PREVIOUS WORK

Section 604 of the Energy Policy and Conservation Act (EPCA) of 2000, as amended by Section 364 of the Energy Policy Act of 2005, required an inventory of all onshore Federal lands to estimate the oil and gas resources underlying these lands; and the extent and nature of any restrictions or impediments to the development of the resources...”

A report prepared by Advanced Resources International (ARI) entitled *Inventory of Onshore Federal Oil and Natural Gas Resources and Restrictions to Their Development* (the “EPCA Inventory”) implemented these requirements and showed that 279 million acres of Federal lands are within areas mapped as having oil and natural gas potential. These lands were estimated to contain 31 billion barrels of oil and 231 trillion cubic feet (Tcf) of natural gas. The report provided an inventory of the extent and nature of limitations to development of these resources but did not make any policy recommendations in response to its findings.<sup>1</sup>

In the EPCA Inventory, oil and natural gas resources underlying various categories of federal lands were characterized. BLM summarized these into three summary categories: inaccessible, accessible with restrictions, and accessible under standard lease terms.

In 2009, the original assessments of oil and gas resources underlying federal lands developed for the EPCA Inventory were cross walked by ARI to characterize the portion of resources in each of the unconventional gas plays that underlie federal lands that were known at the time. This characterization is summarized in **Table 1**.

Not all currently active unconventional resource basins, particularly new emerging shale oil and gas and tight oil basins, were evaluated as part of the EPCA Inventory, or in the ARI cross walk. To update this, assumptions were made about the portion of federal lands in various categories for basins not assessed previously by BLM. In this regard, analogous basins were chosen for those not included in the EPCA Inventory. Estimates of the portion of unconventional oil and gas resources (which now make up most of domestic oil and gas production) were updated by either analogy to original plays characterized, or by estimation by overlaying federal lands maps to basin maps.

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<sup>1</sup> <https://www.blm.gov/epca/>

**Table 1. Breakdown of Unconventional Gas Resources on Federal Lands by Resource Type, Basin, and Access Category as Reported in the BLM EPCA Assessment**

Basin	% of Basin Area on Federal Lands	% of Federal Land in Basin		
		Inaccessible	Accessible with Restrictions	Standard Leasing Terms
Tight Gas Basins				
Piceance	39%	31%	63%	6%
Uinta	26%	8%	18%	74%
San Juan	33%	13%	36%	51%
Green River	42%	20%	47%	34%
Denver/Julesburg	50%	95%	4%	1%
Appalachia	3%	40%	47%	13%
Coalbed Methane Basins				
Uinta	40%	23%	63%	15%
Piceance	43%	30%	51%	18%
Powder River	30%	15%	50%	36%
Green River	36%	22%	64%	14%
San Juan	33%	10%	29%	61%
Appalachia	2%	42%	25%	33%
Warrior	4%	57%	33%	10%
Shale Gas Basins				
San Juan	30%	15%	29%	56%
Appalachia	4%	46%	33%	21%

The assumed breakdown of oil and gas production by resource type and access category for all the basins considered in this assessment are summarized in **Table 2**.

**Table 2. Breakdown of Unconventional Gas Production on Federal Lands by Resource Type, Basin, and Access Category as Assumed in this Assessment**

State	Oil/Condensate Production Year 2019				Wet Gas Production Year 2019			
	Total State Production (MB/D)	% of Total from Federal Lands	Production from Federal Lands (MB/D)	Production from Non-Federal Lands (MB/D)	Total State Production (Bcfd)	% of Total from Federal Lands	Production from Federal Lands (Bcfd)	Production from Non-Federal Lands (Bcfd)
<b>Colorado</b>								
DJ Basin								
Shale	422	4%	17	405	2.3	4%	0.1	2.2
Tight	92	0%	0	92	0.4	0%	0.0	0.4
Piceance								
Tight	4	0%	0	4	1.4	85%	1.2	0.2
CBM	-	-	-	-	0.0	60%	0.0	0.0
San Juan								
Tight	0	60%	0	0	0.1	0%	0.0	0.1
CBM	-	-	-	-	0.8	60%	0.5	0.3
Raton (CBM)	-	-	-	-	0.2	20%	0.0	0.2
Unconventional Total	518		17	501	5.2		1.8	3.4
Conventional Total	8	29%	2	6	0.1	24%	0.0	0.1
Total MB/D, Bcfd	526		19	507	5.3		1.8	3.5
Total MMB/Yr, Bcf/Yr	192	4%	7	185	1935	34%	664	1.3
<b>Wyoming</b>								
Powder River								
Shale	15	10%	2	14	0.1	10%	0.0	0.1
Tight	113	20%	23	90	0.4	20%	0.1	0.3
CBM	-	-	-	-	0.3	100%	0.3	0.0
DJ Basin								
Shale	9	10%	1	8	0.0	10%	0.0	0.0
Tight	12	5%	1	11	0.0	5%	0.0	0.0
Green River								
Tight	20	95%	19	1	2.5	95%	2.4	0.1
CBM	-	-	-	-	0.0	100%	0.0	0.0
Wind River (Tight)	1	80%	0.8	0.2	0.1	80%	0.1	0.0
Unconventional Total	170		45	125	3.4		2.8	0.6
Conventional Total	109	79%	86	23	0.6	99%	0.6	0.0
Total MB/D, Bcfd	279		132	147	4.0		3.4	0.6
Total MMB/Yr, Bcf/Yr	102	47%	48	54	1460	86%	1255	205
<b>New Mexico</b>								
Delaware								
Shale	356	62%	221	135	1.3	62%	0.8	0.5
Tight	401	50%	201	201	1.4	50%	0.7	0.7
San Juan								
Shale	19	70%	13	6	0.1	70%	0.1	0.0
Tight	1	70%	1	0	0.9	70%	0.6	0.3
CBM	-	-	-	-	0.6	70%	0.4	0.2
Unconventional Total	777		435	342	4.3		2.6	1.7
Conventional Total	124	20%	25	99	0.5	48%	0.2	0.3
Total MB/D, Bcfd	901		460	441	4.8		2.9	1.9
Total MMB/Yr, Bcf/Yr	329	51%	168	161	1752	60%	1046	706
<b>North Dakota</b>								
Williston (Shale)	1386	9%	118	1268	2.2	9%	0.2	2.0
Unconventional Total	1386		118	1268	2.2		0.2	2.0
Conventional Total	29	19%	5	24	0.7	8%	0.1	0.6
Total MB/D, Bcfd	1415		123	1292	2.9		0.2	2.7
Total MMB/Yr, Bcf/Yr	516	9%	45	471	1059	8%	89	970

**Table 2. Breakdown of Unconventional Gas Production on Federal Lands by Resource Type, Basin, and Access Category as Assumed in this Assessment (Cont'd)**

State	Oil/Condensate Production Year 2019				Wet Gas Production Year 2019			
	Total State Production (MB/D)	% of Total from Federal Lands	Production from Federal Lands (MB/D)	Production from Non-Federal Lands (MB/D)	Total State Production (Bcfd)	% of Total from Federal Lands	Production from Federal Lands (Bcfd)	Production from Non-Federal Lands (Bcfd)
<b>Montana</b>								
Williston (Shale)	33	0%	0	33	0.0	0%	0.0	0.0
Unconventional Total	33		0	33	0.0		0.0	0.0
Conventional Total	35	23%	8	27	0.1	30%	0.0	0.1
<b>Total MB/D, Bcfd</b>	68		8	60	0.1		0.0	0.1
<b>Total MMB/Yr, Bcf/Yr</b>	25	12%	3	22	37	30%	11	26
<b>Utah</b>								
Unita								
Tight	6	60%	4	2	0.6	60%	0.4	0.2
CBM	-	-	-	-	0.1	20%	0.0	0.1
Unconventional Total	6		4	2	0.7		0.4	0.3
Conventional Total	95	19%	18	77	0.1	25%	0.0	0.1
<b>Total MB/D, Bcfd</b>	101		22	79	0.8		0.4	0.4
<b>Total MMB/Yr, Bcf/Yr</b>	37	22%	8	29	292	51%	148	144

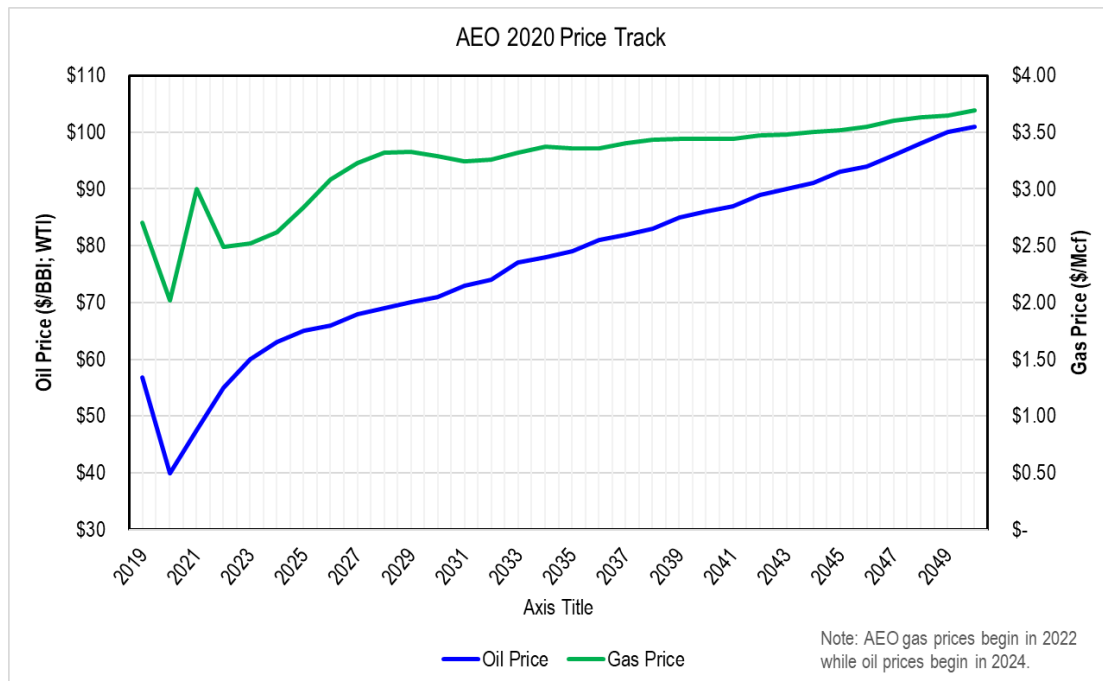
ARI has assembled a high-quality data base on shale oil and gas, tight oil and gas, and coalbed methane resources in the US. This data base, along with forecasts of potential supplies from conventional sources, is linked with ARI's Model for Unconventional Gas and Oil Supply (MUGS)<sup>2</sup> to estimate economically viable conventional and unconventional gas and oil resources and their future rates of development and production, on a basin and play level. MUGS incorporates data related to the resource base/proved reserves, costs and well performance, economic considerations, and the impact of technological progress as it relates to unconventional oil and gas production. The US unconventional gas and oil data base includes 21 basins (with 110 plays) for shale; 14 basins (with 75 plays) for tight oil and gas; and 11 basins (with 30 plays) for coalbed methane. This includes plays currently under development, as well as prospective plays that could be developed in the future.

The estimated proportions of domestic oil and gas resources underlying federal lands were incorporated into the MUGS forecasting system to assess, based on oil and gas prices forecast in the Energy Information Administration (EIA) 2020 Annual Energy Outlook (AEO) in their Reference Case (**Figure 1**) to estimate the future supplies that would be lost if the specific federal lands policy initiatives are implemented.

<sup>2</sup> [https://adv-res.com/model\\_of\\_unconventional\\_gas\\_and\\_oil\\_supply\\_mugs.php](https://adv-res.com/model_of_unconventional_gas_and_oil_supply_mugs.php)



**Figure 1. Oil and Gas Prices Assumed in this Assessment**



MUGS is a geologic/engineering-based supply model, in contrast to more econometric models such as those used by Considine<sup>3</sup> and RFF.<sup>4</sup> However, it is only a supply model; and not an integrating model that balances domestic supply and demand like the National Energy Modeling System that develops EIA's Annual Energy Outlook.<sup>5</sup>

Relative to a reference case, assuming no changes in federal leasing policies, the impacts are characterized in terms of the reduction in oil and gas well drilling that takes place, the oil and gas production lost over time due to the policy initiatives (assuming no change in prices), and, in the case of natural gas, the increase in prices that would be required to make up for the supply lost from federal lands from other sources.

Assuming these lost supplies from federal lands will likely need to be replaced by other sources to meet demand, estimates of the implications of these policies on GHG emissions are developed.

3 Considine, Dr. Timothy J., "The Fiscal and Economic Impacts of Federal Onshore Oil and Gas Lease Moratorium and Drilling Ban Policies," report prepared for the Wyoming Energy Authority, December 14, 2020

4 Prest, Brian, "Supply-Side Reforms to Oil and Gas Production on Federal Lands: Modeling the Implications for Climate Emissions, Revenues, and Production Shifts," Resources for the Future Working Paper 20-16, September 2020

5 [https://www.eia.gov/outlooks/aeo/info\\_nems\\_archive.php](https://www.eia.gov/outlooks/aeo/info_nems_archive.php)



Finally, based on the lost drilling and lost production from federal lands, impacts on government revenues lost from this shortfall (both state and federal), and from the drop in investment in oil and gas drilling activities, can then be estimated.

## OVERVIEW OF METHODOLOGY

For this assessment, additional basins needed to be included to represent the tight oil and other unconventional plays that have emerged since 2009, or that may emerge and be developed in the future. This characterization, summarized in Table 2, incorporates estimates for the breakdown of unconventional gas resources on federal lands by resource type, basin, and access category. In addition, some adjustments were also made to ensure that 2019 production totals from federal lands in the model in each state were comparable to reported values.

As stated above, this assessment considers the impact of two possible policy initiatives:

- A drilling ban on federal lands, including lands that have already been leased
- A ban on the issuance of future onshore federal leases

The impacts are assessed two ways. The first focuses primarily on the loss of production and associated economic activity that would otherwise have resulted from the development of oil and gas resources underlying federal lands. This is related to lost drilling and associated capital expenditures on drilling, and lost state revenues from forgone royalties and severance taxes.

The second focuses on the implications associated with that lost production if the federal leasing/drilling ban has no impact on oil and gas demand. In the case of oil, it is assumed that imports increase to make up for the production foregone from federal lands. In the case of natural gas, the analysis assumes that natural gas prices in the US would need to increase to make up the difference corresponding to the lost production from federal lands.

## IMPACT OF POLICY INITIATIVES ON OIL AND GAS DRILLING AND PRODUCTION

### Ban on All New Drilling on Federal Leases (New and Existing)

For this scenario, it is assumed that the current “pause” on approving new drilling permits is temporary lifted, and that drilling would be allowed to work off the current backlog of applications submitted, permitting drilling through 2021 and half of 2022, at which point, all drilling is assumed to then cease. This assumption is somewhat less impactful than a potential ban on drilling effective immediately.<sup>6</sup>

For the six western states considered, the result of a ban on all new drilling on federal leases would result in a substantial drop in oil and gas well drilling (quantity of decrease shown in parentheses):

- By 2025, drilling levels drop by 31% (1,327 fewer wells drilled)
- By 2030, drilling levels drop by 35% (1,506 fewer wells)
- By 2050, drilling levels decline by 43% (a drop of 1,307 wells)

Similarly, oil production from these six states drops significantly:

- By 2025, production declines by 20% (amounting to a decline of 823,000 barrels per day)
- By 2030, production drops by 28% (or 1,475,000 barrels per day)
- By 2050, production is reduced by 32% (a reduction of 1,170,000 barrels per day)

And natural gas production (wet) impacts are comparable:

- By 2025, gas production drops by 19% (by 3.8 billion cubic feet (Bcf) per day)
- By 2030, gas production is reduced by 34% (a decline of 8.7 Bcf per day)
- By 2050, production of natural gas declines by 49% (a reduction of 10.8 Bcf per day)

For just Wyoming, the result of a ban on all new drilling on federal leases would result in a comparable percentage reduction in activity. For example, in the case of oil and gas well drilling:

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<sup>6</sup> Based on a letter send from Wyoming Governor Mark Gordon to Acting Secretary of the Interior Scott de la Vega, it appears that every action currently related to federal lands in Wyoming requires senior level “sign off.” nearly all actions related to drilling activities on federal lands appear to be currently stalled. Thus, this assumption is somewhat less impactful than a potential ban on drilling effective immediately.

- By 2025, drilling levels drop by 20% (a decline of 132 wells)
- By 2030, drilling levels decline by 28% (187 less wells are drilled)
- By 2050, drilling levels are reduced by 43% (219 wells less wells)

Similarly, oil production from Wyoming drops:

- By 2025, production declines by 12% (56,000 barrels per day less production in the state)
- By 2030, production drops by 16% (a decline of 85,000 barrels per day)
- By 2050, production declines by 21% (74,000 barrels per day less are produced)

For natural gas production, impacts are comparable:

- By 2025, gas production drops by 11% (by 0.3 Bcf per day)
- By 2030, production is reduced by 28% (by 0.8 Bcf per day)
- By 2050, production declines by 58% (a reduction of 1.4 Bcf per day)

### **Ban on New Federal Leases**

For this scenario, it is assumed that well drilling will be allowed on federal leases in place as of the beginning of 2021, but that no new federal leases are issued. It is assumed that these current leases are developed to their full extent over their 10-year term, on a constant rate per year. The impacts in this case are delayed compared to the no new drilling case, but eventually reach a comparable level of impact in the later years.

For the six western states considered (with corresponding decreases in parentheses):

- By 2025, drilling levels drop by 13% (553 less wells)
- By 2030, drilling levels drop by 35% (1,636 fewer wells)
- By 2050, drilling levels drop by 45% (a decline of 1,380 wells)

Similarly, oil production declines significantly:

- By 2025, oil production declines by 7% (a reduction of 279,000 barrels per day).
- By 2030, production drops by 21% (1,082,000 barrels per day less production).
- By 2050, production is reduced by 35% (1,310,000 fewer barrels per day).

Natural gas production impacts are as follows:

- By 2025, gas production drops by 6% (a drop in 1.2 Bcf per day)
- By 2030, production is reduced by 23% (6.0 Bcf per day less natural gas supplies)
- By 2050, production declines by 45% (a reduction of 11.9 Bcf per day)

Oil production from Wyoming declines as follows:

- By 2025, production declines by 4% (19,000 barrels per day less production in Wyoming)
- By 2030, production drops by 9% (by 51,000 barrels per day in the state)
- By 2050, production is reduced by 17% (dropping by 60,000 barrels per day)

Natural gas production also declines:

- By 2025, gas production drops by 4% (0.1 Bcf per day less production)
- By 2030, production is reduced by 18% (a drop in production of 0.5 Bcf per day)
- By 2050, production declines by 43% (1.2 Bcf per day less production)

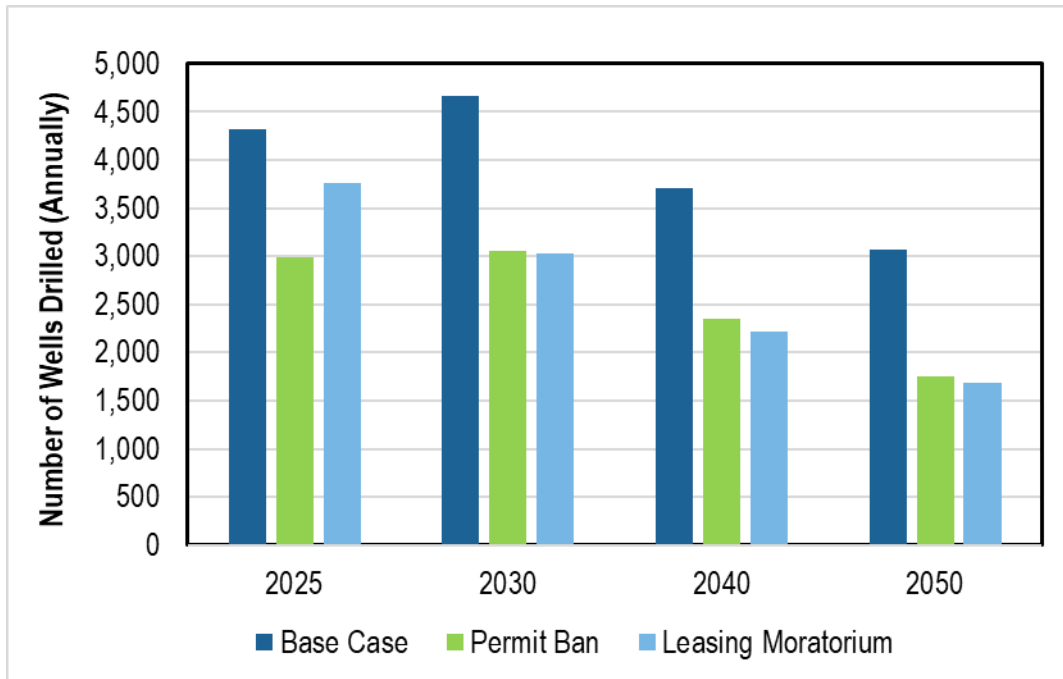
### **Comparison of Impacts for the Two Federal Leasing Policy Initiatives Considered**

For the six western states, **Figure 2** summarizes the impacts for the two federal leasing policy initiatives considered on drilling, **Figure 3** summarizes the impacts on crude oil production, and **Figure 4** summarizes the impacts on natural gas production.

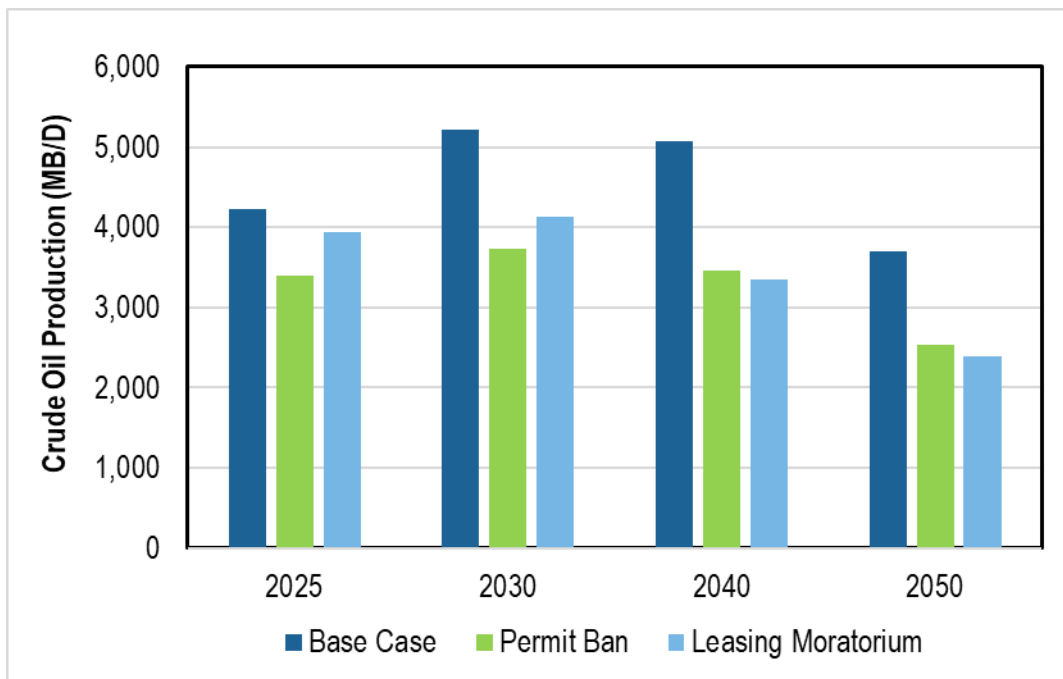
Similarly, for Wyoming, **Figure 5** summarizes the impacts for the two federal leasing policy initiatives considered on drilling, **Figure 6** summarizes the impacts on crude oil production, and **Figure 7** summarizes the impacts on natural gas production.



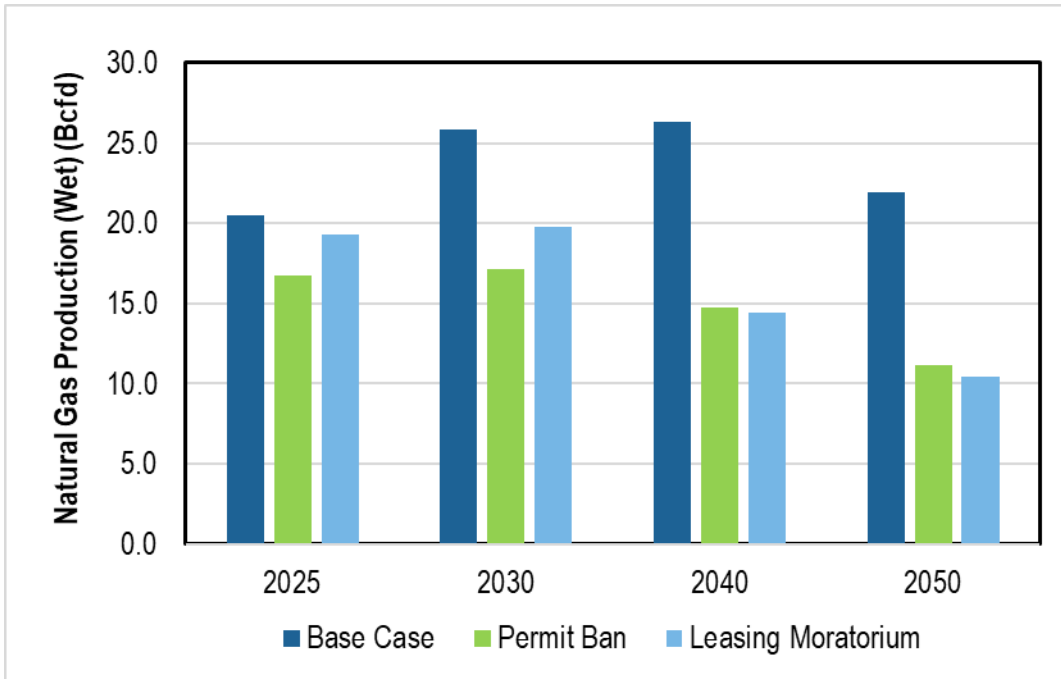
**Figure 2. Forecast Levels of Drilling in Six Western States for the Three Scenarios**



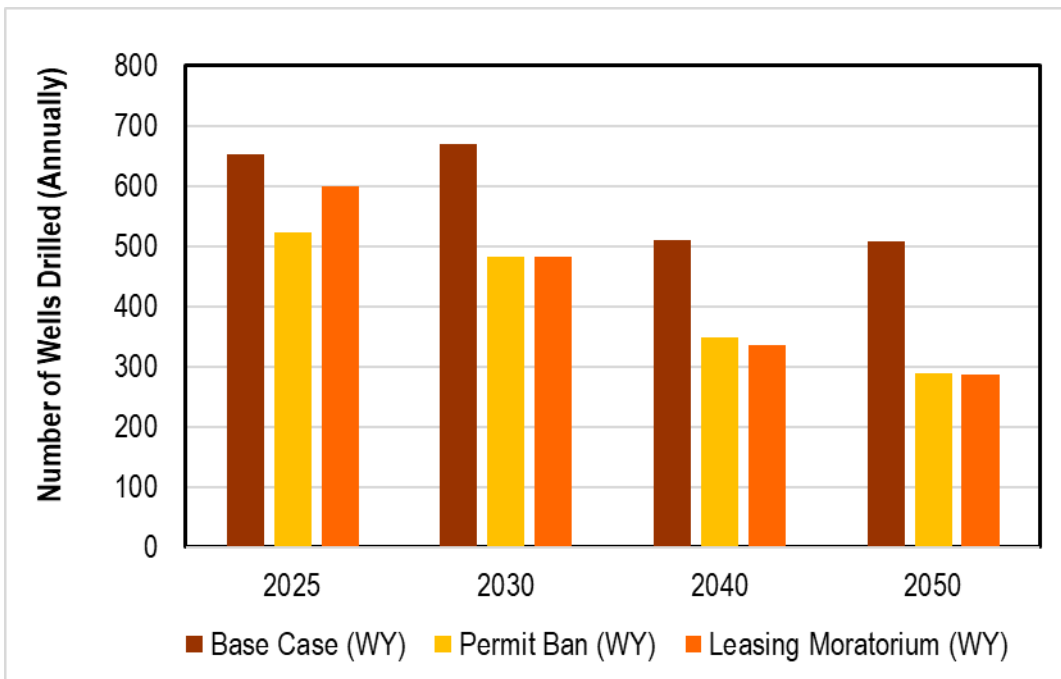
**Figure 3. Forecast Crude Oil Production in Six Western States for the Three Scenarios**



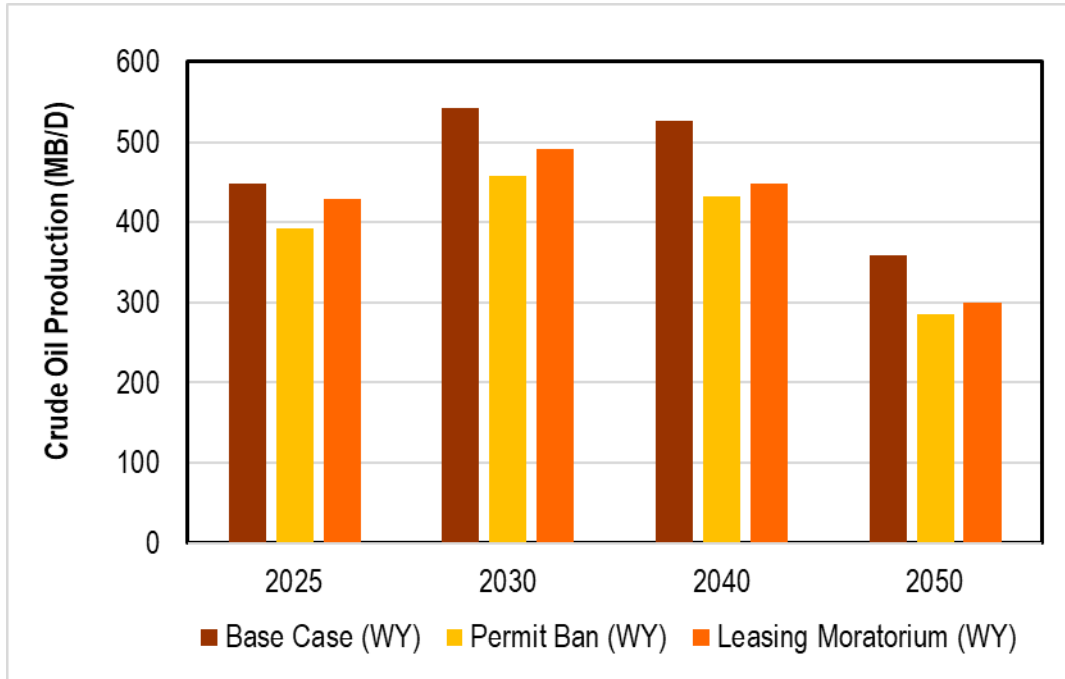
**Figure 4. Forecast Wet Natural Gas Production in Six Western States for the Three Scenarios**



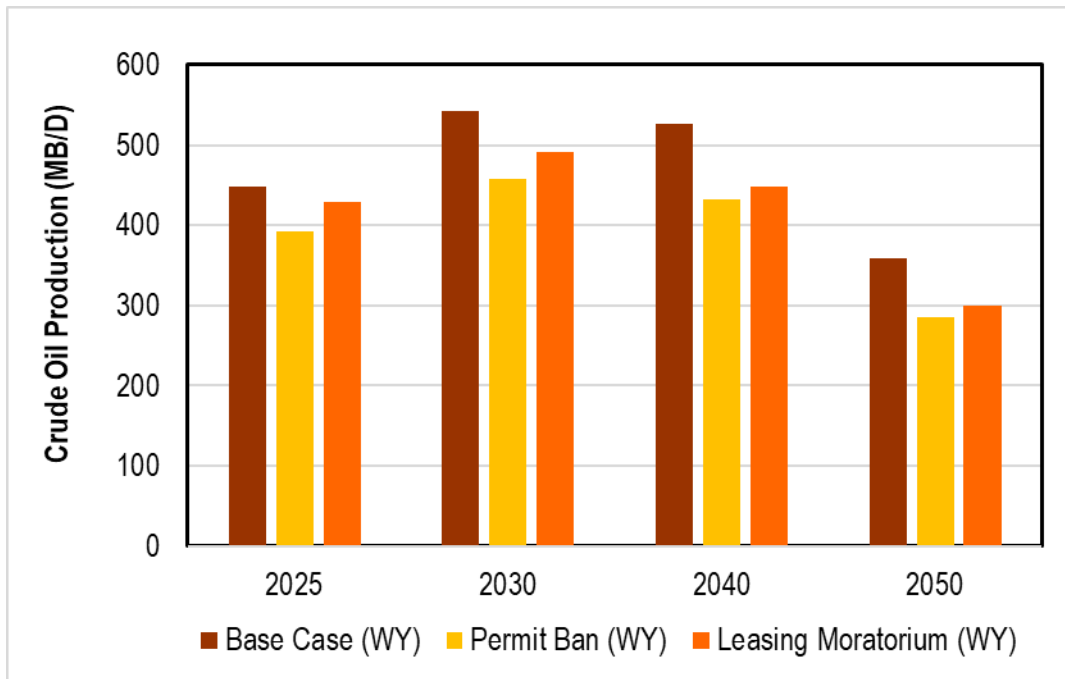
**Figure 5. Forecast Levels of Drilling in Wyoming for the Three Scenarios**



**Figure 6. Forecast Crude Oil Production in Wyoming for the Three Scenarios**



**Figure 7. Forecast Wet Natural Gas Production in Wyoming for the Three Scenarios**



## Impact of a Ban on All New Drilling on Federal Leases on Wyoming's Enhanced Oil Recovery Potential

Additional oil production potential from the application of CO<sub>2</sub> enhanced oil recovery (CO<sub>2</sub> EOR) operations on depleted oil fields in Wyoming could also be forgone because of a ban on all new drilling on federal leases. New drilling of injection and production wells is generally required to develop a field to allow for EOR development. Even though these fields are already leased, a drilling ban would likely prohibit the proper development of all or a portion of these fields for CO<sub>2</sub> EOR. A drilling ban would not allow the additional drilling that would be necessary to allow a viable CO<sub>2</sub> EOR project to be deployed. Notably, CO<sub>2</sub> EOR offers a significantly reduced GHG footprint.

ARI estimates that a total of 35 oil fields could be economically viable to pursue at an \$80 per barrel oil price and a \$30 per metric ton cost to purchase CO<sub>2</sub> for CO<sub>2</sub> EOR. Given data provided by EORI on the portion of oil fields with EOR potential on federal lands in Wyoming, 72% to 74% of the total CO<sub>2</sub> EOR oil production and CO<sub>2</sub> storage potential in Wyoming is on federal lands, per the table below.

Wyoming CO <sub>2</sub> EOR Resource Potential	CO <sub>2</sub> EOR Oil (MMbbl)	CO <sub>2</sub> Storage (Bcf)	CO <sub>2</sub> Storage (MMmt)
Oil Fields Economically Viable for CO <sub>2</sub> EOR	846	10,709	567
Potential Resource on Federal Lands	607	7,873	417
Portion of Those Oil Fields on Federal Lands	72%	74%	74%

Depending on whether the drilling ban prohibits CO<sub>2</sub> EOR development on all or just the federal portion of these fields, it could prohibit the production of 600 to 850 million barrels of total incremental oil in Wyoming and would also prohibit the potential storage of 420 to 570 million metric tons of CO<sub>2</sub> that would occur because of CO<sub>2</sub> EOR. In other words, the drilling ban would prohibit the development of near carbon neutral oil in the state.

## ECONOMIC AND GOVERNMENT REVENUE IMPACTS

Reduction in oil and gas drilling on federal lands would result in a decrease in expenditures associated with oil and gas drilling. As shown in **Table 3**, overall reductions in annual drilling expenditures would exceed \$14 billion per year by 2030. Of course, such impacts would be felt earlier in the federal drilling ban scenario but would be significant in both the leasing ban and permit ban cases. In Wyoming, declines in expenditures associated with just oil and gas well drilling in the state would reach over \$800 million per year by 2030.

**Table 3. Impact of Federal Policies on Investments in Oil and Gas Drilling**

(Shown in Revenue Decrease in Millions of Dollars Per Year)

PERMIT BAN				
State	2025	2030	2040	2050
Colorado	-\$296	-\$533	-\$460	-\$595
Wyoming	-\$623	-\$803	-\$681	-\$565
New Mexico	-\$9,945	-\$10,786	-\$7,436	-\$4,809
North Dakota	-\$1,474	-\$1,476	-\$1,331	-\$1,019
Montana	-\$45	-\$58	-\$69	-\$68
Utah	\$0	-\$66	-\$194	-\$339
<b>Total</b>	<b>-\$12,384</b>	<b>-\$13,720</b>	<b>-\$10,171</b>	<b>-\$7,395</b>

LEASING BAN				
State	2025	2030	2040	2050
Colorado	-\$121	-\$521	-\$501	-\$620
Wyoming	-\$260	-\$832	-\$754	-\$597
New Mexico	-\$4,152	-\$11,128	-\$8,554	-\$5,422
North Dakota	-\$626	-\$1,627	-\$1,524	-\$1,135
Montana	-\$18	-\$55	-\$74	-\$73
Utah	\$0	-\$60	-\$195	-\$343
<b>Total</b>	<b>-\$5,178</b>	<b>-\$14,225</b>	<b>-\$11,601</b>	<b>-\$8,189</b>

Importantly, these figures represent only the lost expenditures associated with well drilling, and not all expenditures associated with oil and gas development and production activity in these states.

One of the most significant impacts from a federal leasing/drilling ban could be on the revenues received by state governments from oil and gas production on federal lands in the state. This revenue is critical to these state governments, contributing significantly to supporting budgets for schools, infrastructure, research, and many other publicly financed programs.

The estimated impact on government revenues received from oil and gas production from federal lands was estimated based on the AEO 2020 oil and gas prices, the lost oil and gas production due to potential changes to federal policies, and the estimated revenues that would be received by the states from state production taxes and a 50% share of federal royalties. The rates assumed by state are shown in **Table 4**. These rates do not assume any offsets that may result of additional drilling on non-federal lands in these states.

**Table 4. Assumed Production and Effective Royalty Rates for Oil and Gas Production on Federal Lands**

State	Estimated Effective State Production Tax Rate (%) <sup>#</sup>	Estimated Effective Tax/Royalty Rate Directly Paid to the State (%) <sup>*</sup>
Colorado	5.91%	12.16%
Montana	6.04%	12.29%
New Mexico	6.82%	13.07%
North Dakota	7.20%	13.45%
Utah	5.60%	11.85%
Wyoming	7.41%	13.66%

<sup>#</sup> Considine, Timothy J., "The Fiscal and Economic Impacts of Federal Onshore Oil and Gas Lease Moratorium and Drilling Ban Policies," report prepared for the Wyoming Energy Authority, December 14, 2020.

<sup>\*</sup>Includes 1/2 of federal royalties (assuming 12.5% plus state production taxes).

As shown in **Table 5**, overall reductions in annual state revenues from oil and gas production from federal lands in the six states considered would be over \$6 billion per year by 2030, growing substantially thereafter. Again, such impacts would be felt earlier in the federal drilling ban scenario but would be significant in both the leasing ban and drilling ban cases. In Wyoming, declines in state revenues associated with just oil and gas well production in the state would reach over \$600 million per year by 2040.



**Table 5. Estimated Loss in State Revenues from Oil and Gas Production on Federal Lands**  
(in millions of dollars per year)

PERMIT BAN				
State	2025	2030	2040	2050
Colorado	-\$53	-\$170	-\$295	-\$376
Wyoming	-\$226	-\$437	-\$623	-\$634
New Mexico	-\$2,369	-\$5,014	-\$6,588	-\$5,434
North Dakota	-\$408	-\$714	-\$931	-\$890
Montana	-\$13	-\$23	-\$38	-\$47
Utah	-\$12	-\$31	-\$81	-\$161
<b>TOTAL Revenues</b>	<b>-\$3,081</b>	<b>-\$6,389</b>	<b>-\$8,557</b>	<b>-\$7,542</b>

LEASING BAN				
State	2025	2030	2040	2050
Colorado	-\$18	-\$121	-\$303	-\$392
Wyoming	-\$76	-\$266	-\$538	-\$550
New Mexico	-\$791	-\$3,675	-\$7,090	-\$6,165
North Dakota	-\$136	-\$528	-\$1,036	-\$1,017
Montana	-\$6	-\$16	-\$37	-\$49
Utah	-\$7	-\$20	-\$76	-\$158
<b>TOTAL Revenues</b>	<b>-\$1,033</b>	<b>-\$ 4,627</b>	<b>-\$9,080</b>	<b>-\$8,331</b>

## IMPACTS ON GREENHOUSE GAS EMISSIONS FROM OIL AND GAS DEVELOPMENT AND PRODUCTION

The primary stated motivation for imposing a ban on leasing and/or drilling on federal lands is to reduce US emissions of GHGs. However, it warrants investigation as to whether reducing the supply of fossil fuels would have much impact relative to reducing the demand for fossil fuels. Reducing domestic supplies, without reducing demand commensurately, would likely not reduce US GHG emissions. Instead, it would simply lead to increased production at other locations, some of which may have higher GHG emissions than oil and gas produced on federal lands.

### Crude Oil

In this study, the impact is assessed in terms of the total GHG emissions from that which

would have been associated with the oil supplies not produced from federal lands, compared to that which would be associated with potential sources of oil supply to make up that shortfall.

For this, the alternative potential supply sources that could most likely make up this supply shortfall are considered. This assumes that the US is not a price setter, and that decreases in domestic oil supplies from federal lands would have a negligible impact on world oil prices, and that other domestic supplies or oil imports would make up the supplies lost due to the federal leasing and/or drilling ban. In addition to other domestic supplies, based on imports in 2019, the sources of imports considered (in order based on import levels) most likely to replace lost domestic supplies due to a federal leasing or drilling ban are Canada, Mexico, Saudi Arabia, and Russia.<sup>7</sup> These four countries made up 67% of the imports into the United States in 2019

The estimated emissions (wells-to-wheels) associated with various sources of imported oil, compared to sources of oil from New Mexico and Wyoming, are shown in **Table 6**. Also shown is the relative change in wells-to-wheels compared to the benchmark, represented by the Eagle Ford shale in Texas.

**Table 6. Wells-to-Wheels Life Cycle Emissions for Selected Crude Oils**

	Well-to-wheels emissions (tonnes CO <sub>2</sub> /bbl)	Difference in Emissions Relative to Eagle Ford (tonnes CO <sub>2</sub> /bbl)	Source
US Texas Eagle Ford	0.458	0.000	Ref. 1
Wyoming Light	0.467	0.009	Ref. 1
Russia Samotlor	0.499	0.041	Ref. 1
Mexico Maya	0.599	0.141	Ref. 2
Saudi Arabia Ghawar	0.491	0.033	Ref. 1
Canada Athabasca FC-HC SCO	0.729	0.271	Ref. 1
Canada SAGD	0.644	0.186	Ref. 2

1. Carnegie Oil Index Report (<https://oci.carnegieendowment.org/#total-emissions>)

2. AERI/Jacobs (2009), Life Cycle Assessment Comparison of North American and Imported Crudes, Jacobs Consultancy and Life Cycle Associates, prepared for the Alberta Energy Research Institute.

Important to note is that in 2019, 72% of the imports coming from the top four countries

<sup>7</sup> [https://www.eia.gov/dnav/pet/pet\\_move\\_impcus\\_a2\\_nus\\_ep00\\_im0\\_mbbi\\_a.htm](https://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbbi_a.htm)

(and almost half of all imports) come from Canada, where the wells-to-wheels GHG emission intensity is considerably higher than the other sources.

If the supplies forgone from federal leases are supplemented from other sources in the US, the impact on GHG emissions is likely to be negligible. However, the most likely sources of supplemental imported oil impose a larger wells-to-wheels impact on GHG emissions compared to that foregone from the federal ban.

Given this scenario and set of assumptions, depending on which sources of imported oil replace these lost domestic supplies from federal lands, global GHG emissions from oil supplies would increase as follows:

- By 2025, GHG emissions increase by 10 to 80 million metric tons of CO<sub>2</sub> equivalent (CO<sub>2E</sub>) annually
- By 2030, GHG emissions increase by 15 to 150 million metric tons CO<sub>2E</sub> annually
- By 2050, GHG emissions increase by 15 to 120 million metric tons CO<sub>2E</sub> annually

Similarly, if no new federal leases are issued, the impact on global GHG emissions associated with incremental oil imports is as follows:

- By 2025, GHG emissions increase by 5 to 30 million metric tons CO<sub>2E</sub> annually
- By 2030, GHG emissions increase by 15 to 110 million metric tons CO<sub>2E</sub> annually
- By 2050, GHG emissions increase by 15 to 130 million metric tons CO<sub>2E</sub> annually

These estimates assume that ALL foregone oil production from federal lands is supplemented by imports, but the range representing uncertainty depends on where those imports will be sourced. However, as mentioned above, the highest proportion of imports come from Canada, with the highest wells-to-wheels GHG emission intensity of major importers.

## Natural Gas

For natural gas, banning activities on federal lands would shift development to non-federal lands, raising prices, and/or increasing natural gas imports (or decreasing exports). This analysis concludes that if resources on federal land are not available for drilling and development, natural gas prices must increase by 10% to 12%, with development shifting to non-federal areas. Natural gas development activity will shift some development focus from more mature, lower productivity basins in Western states (where some drilling of vertical wells still takes place) to

emerging, higher productivity areas in eastern states, where nearly all wells are fractured horizontal wells. The result is that fewer, higher productivity wells displace more lower productivity wells; however, even though GHG emissions associated with horizontal wells are significantly higher than for vertical wells, in aggregate, this shift does not significantly reduce GHG emissions associated with natural gas development in the US.

Thus, even though GHG emissions associated with horizontal wells are significantly higher than for vertical wells, in aggregate, this shift does not significantly reduce GHG emissions associated with natural gas development in the US. Total GHG emissions decrease by only about 0.3 million metric tons annually, on average. This is nearly 1,000 times less than the increase in GHG emissions associated with the increased volumes of imported oil.

The assumptions, approach, and key results associated with this analysis for natural gas are described in more detail in the Appendix.

## APPENDIX

### IMPACT OF FEDERAL LEASING BAN ON NATURAL GAS DEVELOPMENT AND PRODUCTION IN THE UNITED STATES

For natural gas, banning activities on federal lands would shift development to non-federal lands, raising prices, and/or increasing natural gas imports (or decreasing exports). Assuming a federal permit ban, total domestic wet natural gas production (not just that from the western states summarized above) decreases by 8.4 Bcf per day by 2030, respectively. In the long-term, natural gas production losses exceed 10 Bcf per day after 2035 through 2050.

Much of these declines in production can be attributed to reduced drilling two resource areas: 1) vertical non-associated tight gas sand basins primarily in the Rockies; and 2) horizontal “tight oil” / associated gas wells in the New Mexico portion of the Delaware Basin.

To evaluate the impact of GHG emissions related to the increased natural gas-focused drilling, ARI ran an additional “elasticity case” to evaluate what natural gas prices would be required to replace the lost production, as well as the additional gas-focused drilling that would result from the higher natural gas prices. In this case, increasing AEO 2020 natural gas prices by 10% from 2023 through 2028, and by 11% to 12% thereafter, were sufficient to add supplies that would be lost because of a drilling ban on federal lands.

While the 10% to 12% higher natural gas prices were sufficient to replace the losses in wet gas production that were observed the original federal permit ban case, total drilling activity in the elasticity federal permit ban case remains well below that of the Base Case. As shown in **Table A-1**, the Original Federal Permit Ban resulted in nearly 1,600 less well completed in 2030. In contrast, well drilling under the elasticity case with higher natural gas prices still results in 900 less wells completed in 2030 in comparison to the Base Case.

**Table A-1. Reduction in Drilling Activity under the Federal Permit Ban versus Base Case**  
**Drilling Activity**

Year	Difference in Well Drilling Activity from the Base Case
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	Original Federal Permit Ban	Elasticity Federal Permit Ban Case
	(Difference in Wells Drilled)	(Difference in Wells Drilled)
2025	-1,310	-880
2030	-1,590	-900
2040	-1,340	-820
2050	-1,370	-880

In **Table A-2**, vertical tight gas sand (TGS) wells in the Green River and Piceance Basins were used to demonstrate the impact of well drilling activity under the federal permit ban as well as the elasticity run. An average vertical TGS well in the Green River Basin has an estimated ultimate recovery (EUR) of 2.9 Bcf per well. In the Base Case, 143 vertical TGS wells in the Green River Basin were forecast to be completed in 2030. Due to the federal leasing ban restricting access to these vertical wells, only 13 vertical wells were forecast to be completed in the Green River under the original federal permit ban scenario.

**Table A-2. Comparison between Vertical TGS Wells and HZ Shale Gas Well Performance**

Basin/Play	EUR / Well	Number of Wells	Total Gas Supply
	(Bcf)	(# of Wells)	(Bcf)
Avg Green River TGS Vt	2.9	143	415
Avg Marcellus Shale Horizontal	17.4	24	418
Avg Piceance TGS Vt	1.3	324	421
Avg Eagle Ford Horizontal*	8.8	48	422

\*Average Eagle Ford HZ in Dry Gas and Wet Gas Partitions.

In the elasticity case with 12% higher natural gas prices, the number of vertical wells completed in the Green River increases to 17 wells, representing an additional 4 vertical wells in response to the higher gas price. This point is emphasized because these relatively low-cost basins in the Rockies that are developed with vertical wells have essentially been eliminated under the federal permit ban scenario. As a result, additional volumes of wet gas production must come from elsewhere in the US and will likely lead to increased activity in some of the premier, low-cost natural gas basins such as the Marcellus and Haynesville.



As shown in Table A-2, only 24 Marcellus Shale horizontal wells, with an EUR of 17.4 Bcf per well, would be required to replace the lost natural gas volumes that came from the 143 vertical wells in the Green River Basin. Similarly, even in a less productive shale gas basin such as the dry and wet gas portions of the Eagle Ford Shale, which has an average EUR of 8.8 Bcf per well, only 48 Eagle Ford horizontal wells are required to replace the lost production from 324 vertical wells in the Piceance Basin. This shift from vertical TGS wells in the Rockies to highly productive horizontal shale gas wells represent one of the primary reasons for the lower drilling totals in the elasticity case than in the Base Case.

The second explanation for the reduced drilling activity under the elasticity case focuses on the associated gas production that is lost in the New Mexico portion of the Delaware Basin under the federal permit ban case. In the elasticity case, higher natural gas prices are not sufficient to materially impact the level of drilling activity in the “tight oil” formations of the Delaware Basin. A typical Delaware Wolfcamp horizontal well has an associated wet gas EUR of 2.2 Bcf per well, with over 590 of these horizontal wells completed in the Base Case in 2030. The total gas supply lost from these Delaware Wolfcamp wells is equal to 1,305 Bcf. With higher natural gas prices, only 62 Haynesville Shale horizontals would be required to more than offset the production losses from the Delaware Wolfcamp, representing a 90% reduction in wells drilled, as shown in **Table A-3**. When comparing associated gas volumes coming from the Bone Spring horizontals in the Delaware with an average dry gas well in the Stack/Scoop (Meramec and Cana-Woodford horizontals), 86 Stack/Scoop horizontals are sufficient to offset the production losses from the 455 horizontal Bone Spring “tight oil wells.”

**Table A-3. Comparison between "Tight Oil" Associated Gas and HZ Shale Gas Well Performance**

Basin/Play	EUR / Well	Number of Wells	Total Gas Supply
	(Bcf)	(# of Wells)	(Bcf)
Avg Delaware Wolfcamp (Associated)	2.2	593	1,305
Avg Haynesville Shale Hz	21.1	62	1,308
Avg Delaware Bone Spring Hz (Associated)	2.7	455	1,229
Avg Stack/Scoop Hz*	14.3	86	1,230

\*Average Anadarko Basin (Stack/Scoop) Meramec and Cana-Woodford Dry Gas Wells.

However, even though fewer wells are drilled in the price elasticity case, the emissions estimated to be associated with horizontal wells are substantially higher than those assumed for vertical wells. The estimates assumed in this analysis for the emissions associated with gas well completions are based on those assumed by the EPA for its National Greenhouse Gas Emissions Inventory.<sup>8</sup> Prior to 2011, EPA did not differentiate between completions/workovers with and without hydraulic fracturing. Emission factors before 2011 were assumed to be 733 standard cubic feet per completion and 2,454 standard cubic feet per workover. Workovers were estimated to be 4.35% of total well numbers for each year.

However, the 1996 study upon which these original estimates were based was not representative of hydraulically fractured wells, which now represent most wells drilled, and hydraulically fractured well completions have greater emissions than other types of completions. As a result, EPA has updated its assumed emission factor for hydraulically fractured gas wells to be 9,175 Mcf of methane per completion. This is equivalent to 121 tonnes methane per completion, or 3,385 tonnes of CO<sub>2</sub> equivalent per completion, assuming a ratio of 28 as the difference in global warming potential (GWP) of methane relative to CO<sub>2</sub>.

However, this represents "potential" emissions from hydraulically fractured wells. EPA also estimates that due to emissions reductions resulting from state regulations and from voluntary emissions reduction programs implemented by many companies, actual emissions are estimated to be only 14% of "potential" emissions accounting for these reductions. As a result, effective emissions from hydraulically fractured wells are estimated in the National Inventory to

<sup>8</sup> [https://www.epa.gov/sites/production/files/2016-03/documents/epa-well\\_completions\\_and\\_workovers\\_with\\_hydraulic\\_fracturing.pdf](https://www.epa.gov/sites/production/files/2016-03/documents/epa-well_completions_and_workovers_with_hydraulic_fracturing.pdf)

be 1,296 Mcf of methane per completion, or 17 tonnes methane per completion, or 478 tonnes of CO<sub>2</sub> equivalent per completion. This is the emissions estimate assumed in this analysis. This represents emissions per well for hydraulically fractured to be orders of magnitude higher than for traditional vertical wells.

However, even though GHG emissions associated with horizontal wells are significantly higher than for vertical wells, in aggregate, this shift does not significantly reduce GHG emissions associated with natural gas development in the US. Total GHG emissions decrease by only about 0.3 million metric tons annually, on average. This is 1,000 times less than the increase in GHG emissions associated with the increased volumes of imported oil.