Regulatory Impact Analysis for the Proposed Reconsideration of the Oil and Natural Gas Sector Emission Standards for New, Reconstructed, and Modified Sources

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Regulatory Impact Analysis for the Proposed Reconsideration of the Oil and Natural Gas Sector Emission Standards for New, Reconstructed, and Modified Sources

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1 EXECUTIVE SUMMARY

1.1 Background

The action analyzed in this regulatory impact analysis (RIA) accompanies the proposed reconsideration of certain aspects of the Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources published in the Federal Register on June 3, 2016 ("2016 NSPS OOOOa"). In the 2016 NSPS OOOOa, new source performance standards (NSPS) were established to reduce greenhouse gas emissions and volatile organic compound (VOC) emissions from the oil and natural gas sector. The emission sources covered in the rule include hydraulically fractured oil and natural gas well completions and fugitive emissions from well sites and compressor stations, and pneumatic pumps. EPA has granted reconsideration of three requirements: the fugitive emissions requirements, well site pneumatic pump standards, and requirements for certification of closed vent system design and capacity by a professional engineer. In addition, EPA is reconsidering additional issues to streamline implementation and cost-effectiveness of compliance, including clarifying definitions.

For purposes of this RIA, we focus on the proposed amendments that result in quantifiable cost or emissions changes compared to an updated baseline. These provisions are those related to the fugitive emissions requirements and certification by a professional engineer. For details on the other provisions included in this proposed reconsideration that are not analyzed in this RIA, see the preamble to the Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Reconsideration, found in the docket.[1] We do not analyze all provisions included in the preamble because we either do not have the data to do so (for example, we do not have the data to analyze how the proposed exemption for fugitive components including and downstream of the custody meter assembly will increase emissions), or because we do not think the provision will lead to meaningful cost savings or emission changes (for example, clarifying the circumstances for pneumatic pump infeasibility determinations).

One of the requirements EPA is proposing to amend is monitoring frequency for fugitive emissions requirements at certain well sites and at compressor stations. Under the proposed

[1] Found on http://www.regulations.gov under Docket ID No. EPA-HQ-OAR-2017-0483

amendments, the monitoring frequency for a specific well site or compressor station will depend on the production of the well site or on the location of the well site or compressor station. In the 2016 NSPS OOOOa, all NSPS affected well sites are required to perform semiannual monitoring, and all NSPS affected compressor stations are required to perform quarterly monitoring. On March 12, 2018, EPA finalized a package containing amendments to the 2016 NSPS OOOOa ("Amendments package") to address immediate concerns regarding implementation challenges related to the reliability of emission monitoring equipment during extended periods of extreme cold temperatures on the Alaskan North Slope.[2] These amendments reduce monitoring frequency at NSPS affected well sites on the Alaskan North Slope from semiannual to annual. In this reconsideration, EPA is proposing to change monitoring frequency at NSPS affected low production well sites (well sites with less than 15 barrels of oil equivalent (BOE) per well per day) to biennial (every other year), and proposing to change monitoring frequency at all other NSPS affected well sites to annual. EPA is also proposing to reduce monitoring frequency at NSPS affected compressor stations from quarterly to annual for those on the Alaskan North Slope and co-proposing to reduce fugitive emissions monitoring frequency at all other compressor stations to either semiannual or annual. The results in this RIA focus on the estimates assuming semiannual fugitive emissions monitoring at compressor stations. For the cost savings and emission increases under the co-proposed option assuming annual fugitive emissions monitoring at compressor stations, see section 2.5.2.

In the 2016 NSPS OOOOa, EPA finalized a requirement for closed vent systems (CVS) on NSPS affected storage vessels, pneumatic pumps, reciprocating compressors and centrifugal compressors to be certified by a professional engineer, if applicable. In addition, EPA finalized a requirement that a "qualified professional engineer" would have to certify technical infeasibility for sources claiming that routing emissions from a pneumatic pump at a well site to a control device is technically infeasible. The costs for those certifications by a professional engineer were not considered in the 2016 NSPS OOOOa regulatory impact analysis (2016 NSPS RIA).[3] This RIA estimates those costs in the updated baseline and the impact of proposing to change the requirement to allow certification by an in-house engineer as well.

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[2] 83 FR 10628

[3] Found under Docket ID No. EPA-HQ-OAR-2010-0505, and at https://www3.epa.gov/ttn/ecas/docs/ria/oilgas_ria_nsps_final_2016-05.pdf

This analysis estimates the impacts of the proposed changes as compared to an updated baseline, explained in section 1.2, for the analysis years 2019 through 2025. All monetized impacts of these amendments are presented in 2016 dollars. This analysis also includes a presentation of the impacts in a present value (PV) framework. All sources that are affected by the 2016 NSPS OOOOa, starting at the promulgation of the 2016 NSPS OOOOa, are called "NSPS affected sources." The subset of these sources that experience a change in their requirements due to this proposed action, are called "reconsideration affected sources." The universe of reconsideration affected sources varies across the options being considered. This will be explained more in section 1.3, below.

1.2 Summary of Updates from the Final 2016 NSPS RIA

This section summarizes the updates made to data, assumptions, source counts, projections and state and local regulations that have been revised or promulgated since the promulgation of the 2016 NSPS OOOOa that affect the impacts of the proposed actions quantified in this RIA. These updates were combined with unchanged assumptions and methods from the 2016 NSPS RIA to estimate an updated, 2018 baseline. This 2018 baseline represents the current state of the industry. The cost and emission impacts estimated as a result of the three options analyzed in this RIA are compared to this updated 2018 baseline. The updates and revisions that affect the estimated impacts include:

- **Annual Energy Outlook:** In the 2016 NSPS OOOOa, we used the 2015 Annual Energy Outlook. For the purposes of this analysis, we are using the most recent publication of the Annual Energy Outlook (AEO), published February 2018.[4] The estimates of drilling activity published in the AEO are used to estimate projections of NSPS affected sources over time, and the estimates of natural gas prices are used to estimate the value of product recovery.
- **U.S. Greenhouse Gas Inventory updates:** Since the promulgation of the 2016 NSPS OOOOa, the U.S. Greenhouse Gas Inventory (GHGI) has been updated.[5] The data from the updated GHGI was used in the projection of NSPS affected sources over time.
- **DrillingInfo:** This RIA uses a more recent version of the DrillingInfo dataset than was used for the 2016 NSPS OOOOa.[6] The DrillingInfo dataset is used to characterize oil and

[4] The 2018 AEO can be found at: https://www.eia.gov/outlooks/aeo/

[5] The updated GHGI data used is from the April 2018 release. For information on the inventory, visit https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

[6] DrillingInfo is a private company that provides information and analysis to the energy sector. More information is available at: http://info.drillinginfo.com

natural gas wells and completion activity in the base year. The base year is 2014 in this analysis, updated from 2012 in the 2016 NSPS RIA.

- **State and Local Regulations:** Since the promulgation of the 2016 NSPS OOOOa, additional state and local requirements affecting the oil and natural gas sector have been published, namely regulations in California and general permits in Pennsylvania. In this analysis, we take the requirements from California, Colorado, Ohio, Pennsylvania, and Utah into account. The requirements in these states are expected to result in broadly similar overall emissions reductions to those expected from the 2016 NSPS OOOO and this reconsideration, though the particular program designs in each of these states differs from the 2016 NSPS OOOOa and the reconsideration requirements. In the 2016 NSPS RIA, Wyoming's program was included as a program expected to result in broadly similar overall emissions reductions. The requirements in Wyoming were reexamined and are no longer considered to be equivalent for purposes of the RIA because they are basin specific permit requirements, and are not applicable to the entire state.[7]

- **Fugitive Emissions Requirements**: Since the promulgation of the 2016 NSPS OOOOa, EPA has published a final package which amends the fugitive emissions monitoring and repair requirements for NSPS affected oil and natural gas well sites on the Alaskan North Slope. The Amendments package reduces the fugitive emissions monitoring frequency for NSPS affected well sites on the Alaskan North Slope from semiannual, as promulgated in the 2016 NSPS OOOOa, to annual.

- **Professional Engineer Certification**: The 2016 NSPS OOOOa requires closed vent systems and pneumatic pump technical infeasibility be certified by a professional engineer. The cost of this provision was not quantified in the 2016 NSPS RIA analysis. In this analysis, we are including the cost of the requirement for professional engineer certifications in the baseline.

- **Social Cost of Methane:** In the 2016 NSPS OOOOa, EPA used an estimate of the global social cost of methane to monetize the climate related benefits associated with reductions in methane emissions. Since the promulgation of the 2016 NSPS OOOOa, Executive Order (E.O.) 13783 has been signed, which directs agencies to ensure that estimates of the social cost of greenhouse gases used in economic analyses are consistent with the guidance contained in the Office of Management and Budget (OMB) Circular A-4, "including with respect to the consideration of domestic versus international impacts and the consideration of appropriate discount rates" (E.O. 13783, Section 5(c)). Thus, for this reconsideration, we are using an interim estimate of the domestic social cost of methane to estimate the forgone climate benefits resulting from the increase in methane emissions due to the proposed action.

- **Model Plants:** The model plants used to estimate the emissions from a well site, and emission reductions due to the fugitive emissions monitoring requirements, have been updated. The update includes the addition of fugitive emissions components, namely storage vessels. By adding storage vessels to the model plant, base emissions from a

[7] For information on additional states that were examined and why they are not considered equivalent, see the TSD and the State memo, both of which are available in the docket.

wellsite are estimated to be larger, and the reductions due to the monitoring and repair requirements have also increased compared to the base emissions and emission reduction estimates used in the 2016 NSPS OOOOa RIA.[8]

- **Other**: In the 2016 NSPS OOOOa, all costs and benefits were presented in 2012 dollars. In this analysis, all estimated costs are presented in 2016 dollars per E.O. 13771 implementation guidance.[9] In addition, in the 2016 NSPS RIA, we present annualized compliance costs and the benefits resulting from emission reductions occurring in 2020 and 2025. For this analysis, we estimate cost savings and forgone benefits resulting from changes in compliance activities and emissions occurring in each year from 2019 through 2025.[10] We also discount the annual cost savings and forgone benefits to 2016, and present total PV and equivalent annualized value (EAV) over the analysis period.

Table 1-1 below shows the number of NSPS affected facilities, methane emission reductions, VOC emission reductions and the total annualized costs including the value of product recovery, in 2020 and in 2025 for the fugitive emissions requirements of the 2016 NSPS OOOOa as estimated in the 2016 NSPS RIA, and under the 2018 updated baseline. The emission reductions presented here are the emission reductions assuming the affected sources were not performing compliance activities prior to the 2016 NSPS OOOOa. The only difference in the requirements between the two estimates stems from the change to the fugitive emissions requirements for well sites on the Alaskan North Slope, as explained above. Also as mentioned above, the 2016 NSPS RIA estimates did not include the cost of professional engineer certification. To be consistent, the estimates presented in this table for the 2018 baseline also exclude the cost of professional engineer certification. In addition to the updates related to the Amendments package, it should be noted that the assumptions used to estimate the 2018 baseline values have been updated from those used to estimate the 2016 NSPS RIA values as explained above (for example, projections, state and local regulations and model plants). The 2016 NSPS OOOOa costs presented here do not match the cost estimates for the fugitive emissions requirements as presented in the 2016 NSPS RIA. This is because costs in the 2016 NSPS RIA are presented in 2012 dollars, and they have been updated to 2016 dollars in this table.

[8] For more information on the model plants, see the TSD.

[9] Costs were adjusted to 2016 dollars using the seasonally adjusted annual Gross Domestic Product: Implicit Price Deflator released by the Federal Reserve on January 26, 2018.

[10] In this analysis, the DrillingInfo base year was updated from 2012 to 2014, therefore, the source projection estimates are based on reconsideration affected facilities established starting in 2014 and it goes through 2025.

Table 1-1 Estimated Cost and Emission Reductions of the 2016 NSPS OOOOa Fugitive Emissions Requirements: 2016 NSPS RIA and Updated 2018 Baseline Comparison

	2016 NSPS RIA		2018 Baseline	
	2020	**2025**	**2020**	**2025**
Counts of NSPS Affected Fugitive Emissions Sources	94,100	192,300	44,000	87,000
Methane Emission Reductions (short tons)	169,600	346,200	120,000	240,000
VOC Emission Reductions (tons)	46,300	94,500	32,000	62,000
Total Annualized Cost, with Product Recovery (7%, millions, 2016$)	$199	$407	$115	$219

1.3 Regulatory Options Analyzed in this RIA

In this RIA, we examine the effect of the proposed actions relative to the updated 2018 baseline. The sources affected by this proposed reconsideration (termed "reconsideration affected sources" in this RIA) are a subset of the NSPS affected sources. The universe of reconsideration affected sources includes sources of the types affected by this reconsideration that are considered new or modified starting in 2019, as well as sources that were affected by the 2016 NSPS OOOOa before 2019 and are expected to change compliance activity as a result of this action. For example, a low production well site that became an NSPS affected source in 2016 is also a reconsideration affected source under Option 2 and Option 3, because they are expected to change compliance activities (reduce monitoring frequency from semiannual to annual or biennial). In addition, the estimates of new low production well sites starting in 2019 are also reconsideration affected sources since the proposed action is different than the 2016 NSPS OOOOa action they would be performing otherwise. However, projected new affected well sites on the Alaskan North Slope are not reconsideration affected sources, since they are not changing compliance activities as a result of this action. The change in compliance activities (from semiannual as promulgated under the 2016 NSPS OOOOa to annual fugitive emissions monitoring frequency) at those well sites is attributed to the Amendments package. As we assume certifications only happen once, the only affected sources for the proposed certification requirements are those that become affected starting in 2019. We also examine the effect of two alternative suites of options. The universe of reconsideration affected sources is different under the different options. Table 1-2 shows the affected sources, points and controls for the 2016 NSPS OOOOa, the updated 2018 baseline and the three options that are analyzed in this RIA.

The bolded entries in the table represent the sources that are considered reconsideration affected sources under each option.

Table 1-2 Emissions Sources and Controls Evaluated for the Regulatory Alternatives

Emissions Point	2016 NSPS OOOOa	2018 Baseline	Option 1	Option 2	Option 3 (Co-Proposed)[1]
Fugitive Emissions - Planning, Monitoring and Maintenance					
Natural Gas and Oil Well Sites	Semiannual	Semiannual	Semiannual	**2 Yrs. Semiannual, then Annual**	**Annual**
Low Production Well Sites (<15 BOE/day)	Semiannual	Semiannual	Semiannual	**Annual**	**Biennial**
Natural Gas and Oil Well Sites on the Alaskan North Slope	Semiannual	Annual	Annual	Annual	Annual
Compressor Stations in Gathering and Boosting, Transmission and Storage	Quarterly	Quarterly	Quarterly	Quarterly	**Semiannual**
Compressor Stations in Gathering and Boosting, Transmission and Storage on the Alaskan North Slope[2]	Quarterly	Quarterly	Quarterly	**Annual**	**Annual**
Certifications					
Closed Vent Systems on Pneumatic Pumps, Reciprocating Compressors, Centrifugal Compressors, and Storage Vessels; and Pneumatic Pump Technical Infeasibility	Professional Engineer	Professional Engineer	**In-House Engineer**	**In-House Engineer**	**In-House Engineer**

[1] In the preamble, we are co-proposing the option listed here with an option where all requirements remain the same, with the exception of fugitive monitoring frequency at compressor stations. In the alternative co-proposed option, fugitive monitoring at compressor stations is reduced to annual.
[2] We do not currently have the data to estimate the effects of the proposed amendments pertaining to compressors stations on the Alaskan North Slope. All other provisions presented in this table are analyzed in this RIA. Additional provisions included in the preamble are not analyzed because we either do not have the data to do so or because we do not think the provision will lead to meaningful cost savings or emission changes.

The 2016 NSPS OOOOa requires fugitive emissions survey and repair programs be performed semiannually (twice per year) at the NSPS affected newly drilled or refractured well sites, and quarterly at new or modified gathering and boosting stations and new or modified transmission and storage compressor stations. Closed vent systems and pneumatic pump technical infeasibility have to be certified by a professional engineer.

The updated 2018 baseline reflects that fugitive emissions survey and repair programs are now required to be performed only annually at NSPS affected well sites in the Alaskan North Slope (as promulgated in the final Amendments package), semiannually at all other NSPS affected newly drilled or refractured gas well sites, and quarterly at new or modified gathering and boosting stations and new or modified transmission and storage compressor stations. Closed vent systems and pneumatic pump technical infeasibility have to be certified by a professional engineer.

Option 1 is the most stringent option considered. Under this analysis, fugitive emissions monitoring frequencies are unchanged. The certification requirement for closed vent systems and pneumatic pump technical infeasibility is changed to allow companies the option of using an in-house engineer as opposed to requiring a professional engineer. This option results in reduced regulatory burden related to the certification requirements, but is unlikely to affect realized emission reductions.[11] This option has the smallest universe of affected sources.

Option 2 reduces the monitoring frequency for all well sites outside of the Alaskan North Slope, and all compressor stations on the Alaskan North Slope. Low production well sites producing less than 15 barrels of oil equivalent (BOE) per day are required to perform fugitive emissions survey and repair programs annually. Well sites on the Alaskan North Slope retain the annual survey and repair requirement. All other NSPS affected well sites retain the semiannual survey and repair requirement for two years, stepping down to annual monitoring thereafter. Fugitive emissions survey and repair programs at compressor stations on the Alaskan North Slope are also reduced to annual frequency, while monitoring frequency at all other NSPS affected compressor stations remains at quarterly.[12] The certification requirement for closed vent systems and pneumatic pump technical infeasibility is changed to allow companies the option of using an in-house engineer as opposed to requiring a professional engineer. This option leads to reduced regulatory burden, as well as greater emissions compared to the 2018 baseline. The universe of reconsideration affected sources under this option is greater than that of Option 1.

The co-proposed Option 3 is the least stringent option analyzed. It retains annual monitoring and repair frequency for well sites on the Alaskan North Slope, reduces monitoring frequency for all compressor stations on the Alaskan North Slope and all non-low production

[11] Emissions should not be affected by this change in certification requirements as long as the use of an in-house engineer does not result in any change in the quality of closed vent systems being certified or the number of pneumatic pump technical infeasibility determinations. We do not have any information to estimate the potential for these types of technical changes, if any, when moving from professional engineer certifications to in-house engineer certifications.

[12] For an analysis of the costs of the proposed option under alternative monitoring frequencies at compressor stations, see section 2.5.2.

well sites outside of the Alaskan North Slope to annual, and reduces the frequency at all low production well sites to biennial monitoring (every other year). Fugitive emissions monitoring and repair frequency at compressor stations outside of the Alaskan North Slope is reduced to semiannual. The certification requirement is updated to allow companies the choice of using an in-house engineer as opposed to requiring a professional engineer. This option leads to the largest universe of reconsideration affected sources, the largest impact on costs and benefits compared to the 2018 baseline, as well as the greatest increase in emissions.[13]

1.4 Summary of Results

A summary of the key results of the co-proposed Option 3 of this RIA follow. All dollar estimates are in 2016 dollars. Also, all costs, emissions changes, and benefits are estimated relative to the updated 2018 baseline.

- **Emissions Analysis:** This proposed amendment to the 2016 NSPS OOOOa is expected to lead to an increase in emissions compared to the 2018 baseline. Methane emissions are estimated to increase by between 32,000 short tons per year (in 2019) and 76,000 short tons per year (in 2025) for a total of 380,000 short tons over 2019 through 2025. VOC emissions are expected to increase by between 8,500 tons per year and 20,000 tons per year, for a total of 100,000 tons over the same period. HAP emissions are expected to increase by between 320 and 760 tons per year, with an estimated total of 3,800 more tons of HAP emissions over 2019 through 2025 under the proposed amendments compared to the 2018 baseline.
- **Benefits Analysis:** The proposed option is expected to result in climate related dis-benefits compared to the 2018 baseline. The PV of the domestic share of forgone benefits, using an interim estimate of the domestic social cost of methane (SC-CH_4) discounting at a 7 percent rate is estimated to be $13.5 million from 2019 through 2025; the EAV is estimated to be $2.3 million per year. Using the interim SC-CH_4 estimate based on the 3 percent rate, the PV of the forgone domestic climate benefits is estimated to be $54 million; the EAV is estimated to be $8.3 million per year.
- **Compliance Cost Analysis:** The proposed option is expected to result in compliance cost savings to the affected firms compared to the 2018 baseline. The PV of these cost savings, discounted at a 7 percent rate and not including the forgone value of product recovery (about $48 million) is estimated to be about $429 million dollars. When the forgone value of product recovery is included, the PV of the cost savings is about $380 million. This is associated with an EAV of cost savings of about $74 million per year without including the forgone value of product recovery (about $8.4 million per year), or $66 million per year when the value of product recovery is included. Under a 3 percent

[13] The alternative co-proposed option, assuming annual monitoring at compressor stations is slightly less stringent and leads to a larger cost savings, forgone benefits and increase in emissions compared to the 2018 baseline.

discount rate, the PV of cost savings, accounting for the forgone value of product recovery (about $62 million) is $484 million, with an associated EAV of $75 million per year after accounting for the forgone value of product recovery (about $9.6 million per year).

- **Energy Markets Impacts Analysis:** The 2016 NSPS RIA estimated small (less than 1 percent) impacts on energy production and markets as a result of the final regulation. EPA expects that this deregulatory action, if finalized, would partially ameliorate the impacts estimated for the final NSPS in the 2016 NSPS RIA.
- **Distributional Impacts:** The compliance cost savings and forgone benefits presented in this analysis are not expected to be felt uniformly across the population, and may not accrue to the same individuals or communities. EPA did not conduct a quantitative assessment of the distributional impacts of the proposed reconsideration, but a qualitative discussion of the distributional aspects of the compliance cost savings and the forgone health benefits of this deregulatory action are provided in section 4.3.
- **Small Entity Impacts Analysis:** EPA expects that this deregulatory action, if finalized as proposed, would ameliorate the impacts estimated for the final 2016 NSPS OOOOa in the 2016 NSPS RIA. We have therefore concluded that this action will relieve regulatory burden for all directly regulated small entities and that this action, if finalized as proposed, will not have a Significant Impact on a Substantial Number of Small Entities (SISNOSE).
- **Employment Impacts Analysis:** EPA expects slight reductions in labor associated with compliance-related activities relating to the proposed fugitive emissions requirements and the inspections of closed vent systems compared to the 2016 NSPS OOOOa. However, due to uncertainties associated with how the proposed reconsideration will influence the portfolio of activities associated with fugitive emissions-related requirements, EPA is unable to provide quantitative estimates of compliance-related labor changes.

Table 1-3 presents the estimated annualized costs accounting for product recovery and the emission reductions for the updated 2018 baseline, as well as the three options analyzed in this RIA for 2020 and 2025. The rest of this document details the changes estimated as a result of this reconsideration. These changes are estimated as the difference between the 2018 baseline and the option being analyzed.

Table 1-3 Costs and Emissions Reductions of the 2016 NSPS OOOOa under the Updated 2018 Baseline and the Regulatory Alternatives Evaluated in the RIA

	Facilities Affected	Methane Emission Reductions (short tons)	VOC Emission Reductions (short tons)	Total Annualized Cost, w/ Product Recovery (7%, millions 2016$)
		2020		
2018 Baseline	58,000	120,000	32,000	$123
Option 1	58,000	120,000	32,000	$120
Option 2	58,000	102,000	26,000	$90
Option 3	58,000	83,000	22,000	$62
		2025		
2018 Baseline	102,100	240,000	62,000	$228
Option 1	102,100	240,000	62,000	$225
Option 2	102,100	200,000	51,000	$165
Option 3	102,000	160,000	42,000	$113

Table 1-4 through Table 1-6 present the PV and EAV, estimated using discount rates of 7 and 3 percent, of the changes in benefits, costs, and net benefits, as well as the increase in emissions compared to the 2018 baseline for all three options. These values are estimated for the universe of reconsideration affected sources under each option over the 2019 through 2025 analysis period, discounted to 2016, and are in 2016 dollars. When discussing net benefits, both here and in section 5, we modify the relevant terminology to be more consistent with traditional net benefits analysis. In the following tables, we refer to the cost savings as presented in section 2 as the "benefits" of this proposed action and the forgone benefits as presented in section 3 as the "costs" of this proposed action. The net benefits are the benefits (cost savings) minus the costs (forgone benefits). As explained in the following sections, all costs and benefits outlined in this RIA are estimated as the change from the updated baseline.

As can be seen in Table 1-4 through Table 1-6, Option 1 results in the smallest estimated impact on costs and emissions, and the proposed Option 3 results in the largest estimated impacts.[14] It should be noted that the estimated costs (forgone benefits) of Options 2 and 3 only include the monetized climate effects of the increase in methane emissions as a result of the

[14] Option 1 is unlikely to result in any changes in emissions, because it does not affect fugitive emissions requirements. Emissions should not be affected by the change in certification requirements under Option 1 as long as the use of an in-house engineer does not result in any change in the quality of closed vent systems being certified or the number of pneumatic pump technical infeasibility determinations. We do not have any information to estimate the potential for these types of technical changes, if any, or when moving from professional engineer certifications to in-house engineer certifications.

option under consideration, though there are increases in VOC and HAP emissions as well. While we expect that the forgone VOC emission reductions may also degrade air quality and adversely affect health and welfare effects associated with exposure to ozone, $PM_{2.5}$, and HAP, data limitations prevent us from quantifying forgone VOC-related health benefits. This omission should not imply that these forgone benefits may not exist; rather, it reflects the difficulties in modeling the direct and indirect impacts of the reductions in emissions for this industrial sector with the data currently available. A broader explanation of forgone benefits can be read in section 3 of this RIA. For a summary of the cost savings and increase in emissions from the co-proposed option, assuming annual fugitive emissions monitoring frequency at compressor stations, see section 2.5.2.

Table 1-4 Cost Savings, Forgone Benefits and Increase in Emissions of Option 1 Compared to the 2018 Baseline, 2019 through 2025 (millions 2016$)

	7%		3%	
	Present Value	**Equivalent Annualized Value**	**Present Value**	**Equivalent Annualized Value**
Benefits (Total Cost Savings)	$17	$2.9	$21	$3.3
Cost Savings	*$17*	*$2.9*	*$21*	*$3.3*
Forgone Value of Product Recovery	*$0*	*$0*	*$0*	*$0*
Costs (Forgone Domestic Climate Benefits)[1]	$0	$0	$0	$0
Net Benefits[2]	$17	$2.9	$21	$3.3
Emissions	**Total Change**			
Methane (short tons)	0			
VOC	0			
HAP	0			
Methane (million metric tons CO2E)	0			

[1] The forgone benefits estimates are calculated using estimates of the social cost of methane (SC-CH_4). SC-CH_4 values represent only a partial accounting of domestic climate impacts from methane emissions. This option is unlikely to affect emissions, therefore there are no monetized forgone benefits as a result of this option.
[2] Estimates may not sum due to independent rounding.

Table 1-5 Cost Savings, Forgone Benefits and Increase in Emissions of Option 2 Compared to the 2018 Baseline, 2019 through 2025 (millions 2016$)

	7%		3%	
	Present Value	**Equivalent Annualized Value**	**Present Value**	**Equivalent Annualized Value**
Benefits (Total Cost Savings)	$209	$36	$265	$41
Cost Savings	*$234*	*$41*	*$299*	*$47*
Forgone Value of Product Recovery	*$26*	*$4.5*	*$33*	*$5.2*
Costs (Forgone Domestic Climate Benefits)[1]	$7.2	$1.2	$28	$4.4
Net Benefits[2]	$201	$35	$237	$37
Emissions	**Total Change**			
Methane (short tons)	200,000			
VOC	56,000			
HAP	2,100			
Methane (million metric tons CO2E)	4.5			

[1] The forgone benefits estimates are calculated using estimates of the social cost of methane (SC-CH_4). SC-CH_4 values represent only a partial accounting of domestic climate impacts from methane emissions. See Section 3.3 for more discussion.

[2] Estimates may not sum due to independent rounding.

Table 1-6 Cost Savings, Forgone Benefits and Increase in Emissions of the Co-Proposed Option 3 Compared to the 2018 Baseline, 2019 through 2025 (millions 2016$)

	7%		3%	
	Present Value	**Equivalent Annualized Value**	**Present Value**	**Equivalent Annualized Value**
Benefits (Total Cost Savings)	$380	$66	$484	$75
Cost Savings	*$429*	*$74*	*$546*	*$85*
Forgone Value of Product Recovery	*$48*	*$8.4*	*$62*	*$9.6*
Costs (Forgone Domestic Climate Benefits)[1]	$13.5	$2.3	$54	$8.3
Net Benefits[2]	$367	$64	$431	$67
Emissions	**Total Change**			
Methane (short tons)	380,000			
VOC	100,000			
HAP	3,800			
Methane (million metric tons CO2E)	8.5			

[1] The forgone benefits estimates are calculated using estimates of the social cost of methane (SC-CH_4). SC-CH_4 values represent only a partial accounting of domestic climate impacts from methane emissions. See Section 3.3 for more discussion.

[2] Estimates may not sum due to independent rounding.

1.5 Organization of this Report

This analysis follows much of the same methods used to estimate costs of the 2016 NSPS OOOOa. The remainder of this report outlines some of that methodology, with further explanations of where the underlying data, assumptions or methods diverge, as well as the estimated results. For details on the methodology that is unchanged from the 2016 NSPS OOOOa, please see the 2016 NSPS RIA.[15] Section 2 describes the emissions and compliance cost analysis of the proposed action compared to the 2018 baseline. Section 2 also describes the cost savings compared to the 2018 baseline in a PV framework, as well as presents the associated EAV. Section 3 describes the forgone benefits of this rule compared to the 2018 baseline, including the PV and EAV over the 2019 through 2025-time frame. Section 4 describes the economic impacts expected as a result of this proposed action. Section 5 presents a comparison of forgone benefits and cost savings of this proposed reconsidered rule, as well as the net benefits compared to the updated 2018 baseline.

[15] Found at: https://www3.epa.gov/ttn/ecas/docs/ria/oilgas_ria_nsps_final_2016-05.pdf

2 COMPLIANCE COST SAVINGS AND FORGONE EMISSION REDUCTIONS

2.1 Introduction

This chapter describes the emissions and compliance cost analysis for the proposed reconsideration of the 2016 NSPS OOOOa. Incremental changes in emissions and costs as a result of this proposal are estimated with respect to a current policy baseline. Section 2.2 discusses the updates to data and the approach used in this analysis with respect to the RIA analysis for the 2016 NSPS OOOOa. Section 2.3 describes the steps in the emissions and compliance cost analysis of the requirements that are being reconsidered and presents an overview of results. Section 2.4 presents detailed tables describing the impacts for each source affected by this proposed reconsideration for the analyzed. Section 2.5 presents the present value and equivalent annualized value of the cost savings. Please see the Background Technical Support Document (TSD) located at Docket ID No. EPA-HQ-OAR-2017-0483 for more detail.

2.2 Emissions Points and Pollution Controls assessed in the RIA

This RIA estimates impacts associated with reconsidered requirements for fugitive emissions monitoring, and certifications of closed vent system design and technical infeasibility of routing pneumatic pump emissions to an existing control device. In addition, EPA is proposing reconsidered requirements related to pneumatic pumps and oil well completions, as well as technical corrections and clarifications, although this RIA does not quantify any changes in emissions or costs resulting from those proposed amendments. This section provides a basic description of the emissions sources and controls considered, and which aspects of the reconsideration proposals have quantified impacts in this RIA. For more detailed information on the requirements that are being reconsidered, see the Preamble.[16] For the other emission sources and controls evaluated in the 2016 NSPS OOOOa, see the 2016 NSPS RIA.[17]

Fugitive Emissions Requirements: Fugitive emissions occur when connection points are not fitted properly or when seals and gaskets start to deteriorate. Pressure, changes in pressure, or

[16] Found on regulations.gov under Docket ID No. EPA-HQ-OAR-2017-0483

[17] Found under Docket ID No. EPA-HQ-OAR-2010-0505, and at https://www3.epa.gov/ttn/ecas/docs/ria/oilgas_ria_nsps_final_2016-05.pdf

mechanical stresses can also cause components or equipment to leak. Potential sources of fugitive emissions include valves, connectors, pressure relief devices, open-ended lines, flanges, closed vent systems, and thief hatches or other openings on a controlled storage vessel. These fugitive emissions do not include devices that vent as part of normal operations.

In the 2016 NSPS RIA, EPA estimated costs and emission reductions assuming the use of a leak monitoring program based on the use of optical gas imaging (OGI) leak detection combined with leak correction. In addition, alternative frequencies for fugitive emissions surveys were considered: annual, semiannual, and quarterly. This RIA estimates the changes in impacts from reducing fugitive emissions monitoring frequency from the requirements promulgated in the 2016 NSPS OOOOa on NSPS affected oil and natural gas facilities.

Professional Engineer Certifications: Closed vent systems can be used to route emissions from various equipment at oil and natural gas facilities including storage vessels, compressors, and pneumatic pumps to control devices or processes. Closed vent systems must be designed to properly handle the particular configuration and flow rates of different facilities.

For the 2016 NSPS OOOOa, EPA requires closed vent systems be certified by a professional engineer. In addition, the 2016 NSPS OOOOa requires that facilities claiming technically infeasibility in routing emissions from well site pneumatic pumps to an existing control device must get that technical infeasibility certified by a professional engineer. The cost impact of the professional engineer certification requirements was not evaluated in the 2016 NSPS RIA. In this analysis, EPA evaluates the impact of the certification requirements, and the effects of allowing facilities to choose either a professional engineer or an in-house engineer to perform the required certifications.

Additional Reconsideration Topics Not Quantified in this RIA: The reconsideration preamble and proposed regulatory text includes discussion and proposals of a number of technical issues for which this analysis does not estimate impacts. These include, but are not limited to, the issues described below.[18]

- Pneumatic Pumps: EPA is proposing changes in the circumstances for which it may be infeasible to control emissions from well site pneumatic pumps by

[18] See the Preamble for more information, at Docket ID No. EPA-HQ-OAR-2017-0483.

removing the distinctions between greenfield and non-greenfield sites. These changes are intended to better characterize the circumstances under which control may be infeasible, and thus would not necessarily lead to a change in actual emissions.

- Well Completions: EPA is proposing changes and clarifications related to the location of separators during flowback operations, recordkeeping requirements for reduced emission completions, and the definition of flowback (e.g., to exclude screenouts, coil tubing cleanouts, and plug drill out processes). Some of these changes could increase cost savings (e.g., by lowering the burden of recordkeeping requirements) or be associated with increases in emissions relative to the 2018 baseline, but EPA does not have sufficiently specific information to quantify these changes.
- Fugitive Emissions: In addition to the quantified issues described above, EPA is proposing changes to fugitive emissions requirements with respect to the definitions of modification, third party equipment, and more, as well as the characterization of production levels for the purposes of well site fugitive emissions monitoring. In addition, EPA is proposing changes to the repair of leaking fugitive emissions components that were put on a delay of repair list. Some changes may result in cost savings (e.g., aligning pneumatic pump closed vent system requirements with storage vessel closed vent system requirements), and some may result in increased emissions (e.g., exempting fugitive components downstream of the custody meter assembly), but EPA does not have the information necessary to quantify these changes.
- Gas Processing Plants: EPA is proposing to exempt equipment from LDAR at gas processing plants that has been in service less than 300 hours per year when the equipment is only used during emergencies, as a backup, or is only in service during startup and shutdown. This may increase costs savings and emissions due to reduced LDAR requirements, but EPA does not have the data necessary to quantify these changes.
- Alternative Means of Emission Limitation provision: EPA is making changes to

the Alternative Means of Emission Limitation (AMEL) provision. Though the changes, as outlined in the preamble, may lead to lower costs (for example, due to streamlining regulatory efforts), we do not have any information on specifically when, or how, costs or emissions may change.

2.3 Compliance Cost Analysis

In this section, we provide an overview of the compliance cost analysis used to estimate the difference in the private expenditures to the industry when complying with the proposed reconsidered rule compared to the 2016 NSPS OOOOa, under the updated 2018 baseline. Updates to the data and analysis approach from the 2016 NSPS RIA are described in section 1.2 of this RIA. A detailed discussion of the methodology, data and assumptions used to estimate the compliance cost impacts of this reconsideration that have been updated since the 2016 NSPS RIA is presented in the TSD.[19] The methodology, data and assumptions that are not discussed here are the same as were used in the 2016 NSPS RIA, and can be found in the 2016 NSPS Final TSD for that action.[20]

The following sections describe each step in the compliance cost analysis. First, representative facilities are established for each affected source category, including baseline emissions and the control options. Second, the number of incrementally affected facilities under the 2018 baseline for each type of equipment or facility are projected, and the reconsideration affected sources are estimated. The change in national emissions and cost estimates are calculated by multiplying representative factors from the first step, by the estimated number of reconsideration affected facilities in each projection year from the second step. In addition to emissions reductions, some control options result in natural gas recovery, which can then be combusted for useful processes or sold. The change in national cost estimates include the change in estimated revenue from product recovery where applicable.

In this section, we present the effect of this proposal on costs and emissions from 2019 through 2025, under the assumption that 2019 is the first year the reconsidered requirements will be in effect. We chose to analyze through 2025 due to limited information, as explained in

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[19] Docket ID No. EPA-HQ-OAR-2017-0483

[20] Docket ID No. EPA-HQ-OAR-2010-0505-7631.

section 2.3.3. In addition, in this section, we are providing analysis for 2020 and 2025, which allows the reader to draw comparisons to the 2016 NSPS RIA. Comparing the 2016 NSPS RIA results to this analysis should be done with caution. The baseline of affected sources has been updated in this analysis, as explained in section 2.3.3, and results in this RIA are presented in 2016 dollars, while the 2016 NSPS RIA results are presented in 2012 dollars.

2.3.1 Regulatory Options

For each reconsideration affected emission source, point, and control option, the TSD develops a representative facility. The characteristics of this facility include typical equipment, operating characteristics, and representative factors including baseline emissions and the costs, emissions reductions, and product recovery resulting from each control option. In this RIA, we examine three broad regulatory options. Table 2-1 shows the emissions sources, points, and controls for 2016 NSPS OOOOa, the updated 2018 baseline, the co-proposed Option 3 and two alternative options being considered for the sources affected under this reconsideration proposal.

Table 2-1 Emissions Sources and Controls Evaluated for the Regulatory Alternatives

Emissions Point	2016 NSPS OOOOa	2018 Baseline	Option 1	Option 2	Option 3 (Co-Proposed)[1]
Fugitive Emissions - Planning, Monitoring and Maintenance					
Natural Gas and Oil Well Sites	Semiannual	Semiannual	Semiannual	**2 Yrs. Semiannual, then Annual**	**Annual**
Low Production Well Sites (<15 BOE/day)	Semiannual	Semiannual	Semiannual	**Annual**	**Biennial**
Natural Gas and Oil Well Sites on the Alaskan North Slope	Semiannual	Annual	Annual	Annual	Annual
Compressor Stations in Gathering and Boosting, Transmission and Storage	Quarterly	Quarterly	Quarterly	Quarterly	**Semiannual**
Compressor Stations in Gathering and Boosting, Transmission and Storage on the Alaskan North Slope[2]	Quarterly	Quarterly	Quarterly	**Annual**	**Annual**
Certifications					
Closed Vent Systems on Pneumatic Pumps, Reciprocating Compressors, Centrifugal Compressors, and Storage Vessels; and Pneumatic Pump Technical Infeasibility	Professional Engineer	Professional Engineer	**In-House Engineer**	**In-House Engineer**	**In-House Engineer**

[1] In the preamble, we are co-proposing the option listed here with an option where all requirements remain the same, with the exception of fugitive monitoring frequency at compressor stations. In the alternative co-proposed option, fugitive monitoring at compressor stations is reduced to annual.
[2] We do not currently have the data to estimate the effects of the proposed amendments pertaining to compressors stations on the Alaskan North Slope. All other provisions presented in this table are analyzed in this RIA. Additional provisions included in the preamble are not analyzed because we either do not have the data to do so or because we do not think the provision will lead to meaningful cost savings or emission changes.

In addition to the requirements listed above, the 2016 NSPS OOOOa contains well completion requirements for a subset of newly completed oil wells that are hydraulically fractured or refractured. The 2016 NSPS OOOOa also requires reductions from centrifugal compressors, reciprocating compressors, and pneumatic controllers throughout the oil and natural gas source category. These requirements are not analyzed in this RIA because the proposed reconsideration does not include amendments that change the cost or emissions from those achieved under the 2016 NSPS OOOOa requirements.

2.3.2 Unit Level Cost Savings and Emission Increases

The requirements affecting fugitive emissions requirements and certifications of technical infeasibility and closed vent systems are the only sources where changes in cost and emissions resulting from proposed reconsideration requirements have been quantified. Facility level costs and emission reductions for the fugitive emission requirements for each of the model plants is in Volume 1 of the TSD. For this reconsideration, the TSD and RIA results are based on a more disaggregated set of model plants used to analyze the changes in monitoring requirements among subsets of oil and natural gas well sites than the set used in the 2016 NSPS OOOOa analysis. Whereas the previous analysis included three model plants reflecting either oil, oil with associated gas, or natural gas well sites, this analysis is based on six model plants: non-low production natural gas well sites, non-low production oil-only well sites, non-low production oil with associated gas well sites, low-production natural gas well sites, low-production oil-only well sites, and low-production oil with associated gas well sites. The facility level cost savings and emission increases from the proposed requirements in this reconsideration were calculated by subtracting the costs and emissions of the model plants under the proposed option (and the alternative options) from the costs and emissions of the model plants under the 2018 baseline. Detailed descriptions of what is included in the cost estimates is also provided in Volume 1 of the TSD.

The cost of certifications being performed by a professional engineer was not included in the analysis of the 2016 NSPS OOOOa rule. This analysis updates baseline cost estimates to include professional engineer certification costs, as well as estimates the savings from allowing the certifications to be performed by an in-house engineer. The cost of a certification by a professional engineer is estimated to be just under $550 per certification, and the cost of the same certification performed by an in-house engineer is estimated to be about $358 per certification. Therefore, the cost savings per certification is estimated to be about $190 per certification. [21]

2.3.3 Projection of Affected Facilities

The second step in estimating national costs and emissions impacts of the proposed rule is projecting the number of NSPS and reconsideration affected facilities. We first update the number of NSPS affected facilities under the updated 2018 baseline. Then, we estimate the projection of reconsideration affected facilities, which are facilities that would be expected to

[21] The costs of certification being performed by a professional engineer and by an in-house engineer are explained fully in the TSD.

change their control activities as a result of this reconsideration. Facilities in states with similar state-level requirements and facilities with only recordkeeping requirements are not included within the estimates of affected facilities.

We analyze the effects of this proposal on cost and emissions compared to the 2018 baseline. The 2018 baseline includes the costs and emissions of the projected NSPS affected facilities, after accounting for updated assumptions and data. NSPS affected facilities include facilities that are new or modified since the 2015 NSPS OOOOa proposal, and were/are expected to change control activities as a result of the 2016 NSPS OOOOa, starting from a baseline of a world without the 2016 NSPS OOOOa. Over time, more facilities are newly established or modified in each year, and to the extent the facilities remain in operation in future years, the total number of facilities subject to the 2016 NSPS OOOOa accumulates. As in the final 2016 NSPS RIA, this analysis assumes that all new equipment and facilities established from 2015 through 2024 are still in operation in 2025.

The reconsideration affected facilities are estimated as the subset of the NSPS affected facilities that are expected to change control activities as a result of this reconsideration. These facilities include sources that became affected facilities under the 2016 NSPS OOOOa, prior to the effective date of this action and are assumed to still be in operation, as well as those that are projected to become newly affected sources in the future, and are expected to change what their monitoring frequency would have been as a result of this action. For the proposed option, these sources include fugitive emissions sources at well sites outside of the Alaskan North Slope and compressor stations both outside of and on the Alaskan North Slope.[22] Reconsideration affected sources that require a certification are only affected under the projection of newly affected sources. Sources that have already completed professional engineer certifications are not counted as reconsideration affected sources.

EPA has projected affected facilities using a combination of historical data from the U.S. GHG Inventory (GHGI), DI Desktop, and projected activity levels taken from the Energy Information Administration (EIA) AEO. EPA derived typical counts for new gathering and boosting, and transmission and storage compressor stations by averaging the year-to-year

[22] We do not quantify any emissions or cost changes associated with new compressor stations on the Alaskan North Slope. See Volume 2 of the TSD for details.

changes over the past ten years in the GHGI. New and modified well sites are based on the count of wells in 2014 from DI Desktop, and projections and growth rates consistent with the drilling activity in the AEO. For this proposed RIA, the projections have been updated from the 2016 NSPS RIA to reflect the projection estimates in the 2018 AEO.

The 2018 AEO (along with historical year information from previous AEOs) reflects a significant drop in oil and gas drilling between 2014 and 2016, followed by projected increases from 2016 through 2025. While the 2018 AEO projects that oil and gas well drilling will more than double from about 14 thousand wells in 2016 to about 30 thousand wells in 2025, this projection is about 40 percent lower than was projected in the 2015 AEO, which was previously used. In comparison to the 2015 AEO, the 2018 AEO shows about 11 percent lower crude oil production and about 17 percent higher dry natural gas production, indicating an increase in estimated production per well.

This RIA includes an enhanced analysis with respect to previous oil and gas NSPS RIA analyses by including year-by-year results over the 2014 to 2025 analysis period and better disaggregating facilities by vintage and production levels. While it is desirable to analyze impacts beyond 2025 in this RIA, EPA has chosen not to, largely because of the limited information available to model long-term dynamics in practices and equipment in the oil and gas industry. For example, EPA has limited information on how practices, equipment, and emissions at new facilities evolve as they age or may be shut down. The current analysis assumes that newly established facilities remain in operation for the entire analysis period, which would be less realistic for longer-term analysis. In addition, in a dynamic industry like oil and natural gas, technological progress in control technology is also likely to change significantly over a longer time horizon. For example, the current analysis does not include potential fugitive emissions controls utilizing remote sensing technologies currently under development.

We also reviewed state regulations and permitting requirements which require mitigation measures for many emission sources in the oil and natural gas sector. Detailed information is included in section 3.2.2 of the TSD and in the memorandum *Equivalency of State Fugitive Emissions Programs for Well Sites and Compressor Stations to Proposed Standards at 40 CFR Part 60, Subpart OOOOa* (“State memo”), located at Docket ID No. EPA-HQ-OAR-2017-

0483.[23] This analysis was done for the 2016 NSPS RIA, with the states of Colorado, Utah, Ohio and Wyoming expected to result in broadly similar overall emissions reductions. For this RIA, state regulations and permitting requirements were reexamined. While the particular program designs in each of the states examined differs from the 2016 NSPS OOOOa, for the purpose of this RIA analysis, the current requirements in Colorado, Utah, Ohio, Pennsylvania, and California are expected to result in broadly similar overall emissions reductions. California and Pennsylvania have been added as states with similar requirements for this analysis because the requirements in the states have been finalized since the promulgation of the 2016 NSPS OOOOa. The requirements in Wyoming are no longer considered to be equivalent for purposes of the RIA because they are basin specific permit requirements, and are not applicable to the entire state. Requirements in Texas are not included as broadly equivalent requirements in this analysis because they include a permit by rule, which we do not consider equivalent in terms of overall emissions reductions.[24] For more information on the states that were examined and why they are or are not considered equivalent, see the TSD and the State memo, both of which are available in the docket.[25]

Applicable facilities in these five states are not included in the estimates of incrementally affected facilities presented in the RIA, as sources in those states would be expected to control emissions at a comparable level regardless of the reconsidered federal standards. This means that any additional costs and benefits incurred by facilities in these states to comply with the federal standards beyond the state requirements (e.g., recordkeeping or verification requirements) are not reflected in this RIA.

Table 2-2 presents the number of reconsideration affected sources for each year of analysis after generally accounting for state regulations. In addition to the caveats regarding facilities affected by state regulations described above, facilities with only recordkeeping requirements are also not included within incrementally affected facilities.

[23] For a more detailed explanation of state programs, see section 3.2.2 of the TSD, as well as the memo Equivalency of State Fugitive Emissions Programs for Well Sites and Compressor Stations to Proposed Standards at 40 CFR Part 60, Subpart OOOOa, located at Docket ID No. EPA-HQ-OAR-2017-0483.

[24] We do not consider the permit by rule in Texas as equivalent for RIA purposes because they are self-certified permits and we currently have a lack of certainty on the degree of enforcement of these rules.

[25] Docket ID No. EPA-HQ-OAR-2017-0483

Table 2-2 Reconsideration Affected Source Counts of the Co-Proposed Option 3 Compared to the 2018 Baseline

Year	Incrementally Affected Sources[1]	Total Affected Sources[2]
2019	21,000	49,000
2020	22,000	58,000
2021	23,000	66,000
2022	23,000	75,000
2023	24,000	84,000
2024	24,000	93,000
2025	24,000	100,000

Note: Affected source counts are the same under the alternative co-proposed option.
[1] Incrementally reconsideration affected sources includes sources that are newly affected in each year.
[2] Total reconsideration affected sources includes sources that have to change their control activity as a result of the rule in each year. These include sources that are newly affected in each year plus the sources from previous years that experience a change in their compliance activity as a result of this proposal compared to the 2018 baseline. The table does not include estimated counts of a) affected facilities in states with similar state-level requirements to the proposed option, b) NSPS affected facilities whose controls are unaffected by the reconsideration.

The estimates for affected well sites are based on the count of new and modified wells in 2014 from DI Desktop, and then projected using year by year growth rates from the AEO. The estimates for other affected sources are based upon projections of new sources alone, and do not include replacement or modification of existing sources. While some of these sources are unlikely to be modified, particularly pneumatic pumps and controllers, the impact estimates may be under-estimated due to the focus on new sources. Newly constructed affected facilities are estimated based on averaging the year-to-year changes in the past 10 years of activity data in the Greenhouse Gas Inventory for compressor stations, pneumatic pumps, compressors, and pneumatic controllers. The approach averages the number of newly constructed units in all years. In years when the total count of equipment decreased, there were assumed to be no newly constructed units.

2.3.4 Emissions Increases

Table 2-3 summarizes the national increase in emissions associated with the proposed Option 3 compared to the updated 2018 baseline as described in Section 2.2. This increase in emissions is estimated by multiplying the unit-level increase in emissions from the updated baseline associated with each applicable control and facility type by the number of incrementally affected sources of that facility type. In this analysis, closed vent system and technical infeasibility certification requirements are not associated with any direct emission reductions;

therefore, all emissions increases are attributed to the changes in the fugitive emissions monitoring program. Please note that all results have been rounded.

Table 2-3 Increase in Emissions under the Co-Proposed Option 3 Compared to the 2018 Baseline, by year

	Emission Changes			
	Methane (short tons)	VOC (short tons)	HAP (short tons)	Methane (metric tons CO_2 Eq.)
2019	32,000	8,500	320	730,000
2020	39,000	10,000	390	890,000
2021	46,000	12,000	460	1,000,000
2022	54,000	14,000	530	1,200,000
2023	61,000	16,000	610	1,400,000
2024	69,000	18,000	690	1,600,000
2025	76,000	20,000	760	1,700,000
Total	380,000	100,000	3,800	8,500,000

2.3.5 Forgone Product Recovery

The estimated decrease in costs presented below include the forgone revenue from the reductions in natural gas recovery under the co-proposed Option 3 compared to the 2016 NSPS OOOOa. Fugitive emissions monitoring and repair is assumed to increase the capture of methane and VOC emissions that would otherwise be vented to the atmosphere with no fugitive emissions program, and we assume that a large proportion of the averted methane emissions can be directed into natural gas production streams and sold. In the 2016 NSPS OOOOa, we based the estimated revenues from those averted natural gas emissions on an estimate of the amount of natural gas that would not be emitted during one year. In this analysis, we estimate the forgone revenue associated with the decrease in natural gas recovery due to this proposed action. Reducing the frequency of the survey and repair program leads to a reduction in the amount of natural gas that is assumed to be captured and sold, leading to forgone revenue in Option 2 and the co-proposed Option 3, as well as the alternative co-proposed option, as compared to the 2018 baseline.[26]

Table 2-4 summarizes the decrease in natural gas recovery and the associated forgone revenue included in the cost savings calculations. When including the decrease in natural gas

[26] The co-proposed option is also associated with forgone revenue associated with a decrease in natural gas recovery.

recovery in the cost savings analysis, we use the projections of natural gas prices provided in the EIA's 2018 AEO reference case. The AEO projects Henry Hub natural gas prices between $3.40 and $4.07 in $/MMBtu in 2017 dollars.[27] We adjust those prices to be between $3.09 and $3.70 in $/Mcf (using the conversion of 1 MMBtu = 1.028 Mcf) in 2016 dollars (using the GDP-Implicit Price Deflator) at the wellhead.[28]

Operators in the gathering and boosting, and transmission and storage parts of the industry do not typically own the natural gas they transport; rather, the operators receive payment for the transportation service they provide. As a result, the unit-level cost and emission reduction analyses supporting best system of emission reduction (BSER) decisions presented in Volume 1 of the TSD do not include estimates of revenue from natural gas recovery as offsets to compliance costs. From a social perspective, however, the increased financial returns from natural gas recovery accrues to entities somewhere along the natural gas supply chain and should be accounted for in the national impacts analysis. An economic argument can be made that, in the long run, no single entity is going to bear the entire burden of the compliance costs or fully receive the financial gain of the additional revenues associated with natural gas recovery. The change in economic surplus resulting from natural gas recovery is going to be spread out amongst different agents via price mechanisms. Therefore, the simplest and most transparent option for allocating these revenues would be to keep the compliance costs and associated revenues together in a given source category and not add assumptions regarding the allocation of these revenues across agents. This is the approach followed in Volume 2 of the TSD, as well as in the 2016 NSPS RIA.

[27] Available at: http://www.eia.gov/forecasts/aeo/tables_ref.cfm.

[28] An EIA study indicated that the Henry Hub price is, on average, about 11 percent higher than the wellhead price. See http://www.eia.gov/oiaf/analysispaper/henryhub/.

Table 2-4 Estimated Decrease in Natural Gas Recovery (Mcf) for the Co-Proposed Option 3 Compared to the 2018 Baseline (millions 2016$)

Year	Decrease in Gas Recovery (Mcf)	Forgone Revenue
2019	1.85	$5.7
2020	2.3	$7.6
2021	2.7	$8.9
2022	3.1	$10
2023	3.5	$12
2024	4.0	$14
2025	4.4	$16

2.3.6 Compliance Cost Savings

Table 2-5 summarizes the cost savings and foregone revenue from product recovery for the evaluated emissions sources and points. What we call planning costs in this analysis are a part of what were included in the capital cost estimates in the 2016 NSPS RIA, however, in this RIA we assume there are no capital equipment purchases. Instead, the analogous costs in this RIA include the cost of creating the survey monitoring plan for the fugitives monitoring requirement and completing the required certifications. The annual operating and maintenance cost savings are all attributed to the fugitives monitoring requirement, and include the cost of performing the surveys, as well as the costs of performing repairs. The planning cost savings in the table represents savings in the total planning cost expenditures associated with affected units, including the change in planning cost expenditures made by sources affected prior to the analysis year. The cost savings are estimated by multiplying the unit level cost savings from the updated baseline associated with applicable control and facility type, as explained in section 2.3.2, by the number of incrementally affected sources of that facility type. In addition, the cost savings from the streamlining of recordkeeping and reporting are included in the annualized cost savings totals.[29] These cost savings are described more below.

[29] See preamble section 60.5420a for details on the proposed amendments to the recordkeeping and reporting requirements.

Table 2-5 Compliance Cost Savings Estimates for Co-Proposed Option 3 Compared to the 2018 Baseline (millions 2016$)

Year	Compliance Cost Savings				
	Planning Cost Savings[1]	Operating and Maintenance Cost Savings	Annualized Cost Savings (w/o Forgone Product Revenue)[2]	Forgone Revenue from Product Recovery	Nationwide Annualized Cost Savings with Forgone Revenue
2019	$2.9	$54	$58	$5.7	$52
2020	$3.1	$66	$69	$7.6	$62
2021	$3.1	$78	$82	$8.9	$73
2022	$3.2	$90	$94	$10	$84
2023	$3.7	$102	$107	$12	$94
2024	$3.5	$115	$119	$14	$105
2025	$3.7	$128	$132	$16	$116

[1] The planning cost savings include the cost savings incurred by the newly affected sources for both fugitive emissions monitoring and certifications in each year, as well as the cost savings of fugitive emissions sources that renew survey monitoring plans after 8 years.
[2] These cost savings include the planning cost savings for all fugitive emissions requirements annualized over 8 years at an interest rate of 7 percent, plus the annual operating and maintenance cost savings for the fugitive emissions requirements every year, plus the cost savings of certifications in each year, plus the cost savings from streamlined recordkeeping and reporting.
Sums may not total due to independent rounding.

The cost of designing, or redesigning, the fugitive emissions monitoring program occurs every 8 years to comply with the 2016 NSPS OOOOa requirements. The lifetime of the monitoring program does not change in this reconsideration. The reduction in planning costs in each year outlined in Table 2-5 includes the estimated reduction in the costs of designing a fugitive emissions monitoring program for the new reconsideration affected sources in that year, plus the reduction in the cost of redesigning an existing program for sources that became affected previously. The first year a redesign cost is included in the planning cost calculation is 2023, as we assume the first NSPS affected sources completed monitoring plans in 2016, the first year the 2016 NSPS OOOOa affected sources completed compliance activities. The decrease in these program design costs were added to the cost savings of closed vent system and technical infeasibility certifications in each year to get the total planning cost savings for each year.

The fugitive emissions monitoring program design cost savings annualized over the expected lifetime of 8 years at an interest rate of 7 percent, is added to the annual cost savings of implementing the fugitive emissions monitoring program, the cost savings of in house certifications in each year, and the cost savings from streamlined recordkeeping and reporting to get the annualized cost savings in each year compared to the 2018 baseline. The forgone value of product recovery is then added to estimate the total annualized cost savings in each year.

Table 2-6 illustrates the sensitivity of compliance cost and emissions analysis results of the proposed Option 3 to choice of discount rate. We present costs using discount rates of 7 percent and 3 percent based on the OMB Circular A-4.[30] The table shows that the choice of discount rate has minor effects on the nationwide annualized cost savings of the proposed rule.

Table 2-6 Estimated Cost Savings of the Co-Proposed Option 3, 2019-2025, using 3 and 7 Percent Discount Rates (millions 2016$)

Year	7 Percent			3 Percent		
	Annualized Cost Savings (without Product Recovery)	Forgone Revenue from Product Recovery	Nationwide Annualized Cost Savings with Product Recovery	Annualized Cost Savings (without Product Recovery)	Forgone Revenue from Product Recovery	Nationwide Annualized Cost Savings with Product Recovery
2019	$58	$5.7	$52	$58	$5.7	$52
2020	$69	$7.6	$62	$69	$7.6	$62
2021	$82	$8.9	$73	$82	$8.9	$73
2022	$94	$10	$84	$94	$10	$84
2023	$107	$12	$94	$107	$12	$94
2024	$119	$14	$105	$119	$14	$105
2025	$132	$16	$116	$132	$16	$116

The choice of discount rate has a very small effect on nationwide annualized cost savings. Discount rate generally affects estimates of annualized costs for controls with high planning or capital costs relative to annual costs. In this analysis, the planning cost savings related to fugitive emissions surveys, plus the cost savings of closed vent system design and technical infeasibility certifications, are small relative to the annual cost savings related to fugitive emissions surveys, so the interest rate has little impact on annualized cost savings for these sources.

Reporting and recordkeeping costs were drawn from the information collection requirements (ICR) in this final rule that have been submitted for approval to the OMB under the Paperwork Reduction Act (see Preamble for more detail). The reporting and recordkeeping cost savings in this RIA are estimated to be constant at about $810,000 every year. These recordkeeping and recordkeeping cost savings are estimated for the selected Option 3 for all new

[30] Found at: https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/#e

and modified affected facilities regardless of whether they are in states with regulatory requirements similar to the final 2016 NSPS OOOOa. While these cost savings may differ across regulatory options as a result of the varying frequency of the fugitive emissions program across the options, we do not have the information to estimate the ICR burden for the unselected Option 1 and 2. As a result, we assume all options have the same recordkeeping and reporting cost burden. Note also that the total reporting and recordkeeping cost savings from streamlining the requirements is mitigated by the estimated cost of reading the proposed rule.

2.3.7 Comparison of Regulatory Alternatives

Table 2-7 presents a comparison of the regulatory alternatives through each step of the emissions analysis in 2020 and 2025. The options vary with respect to the fugitive emissions requirements at well sites. The co-proposed Option 3 reduces monitoring at low production wells to biennial (every other year), retains annual monitoring at well sites on the Alaskan North Slope, and requires annual monitoring for all other affected, non-low production wells sites. Monitoring frequency for compressor stations on the Alaskan North Slope is reduced to annual monitoring, while compressor stations located elsewhere require semiannual fugitive emissions monitoring.[31] Option 3 results in greater increases in emissions and cost savings compared to the presented alternative options. The most stringent option, Option 1, would finalize no changes in the fugitive emissions requirements from the 2016 NSPS OOOOa requirements, but amends the requirement for closed vent systems and pneumatic pump technical infeasibility to allow the use of an in-house engineer. There are no changes in emissions compared to the 2018 baseline, and the cost savings are smaller than under the both Option 2 and the co-proposed Option 3. We assume biennial, annual, stepped, semiannual, and quarterly fugitive emissions surveys result in reductions in emissions of 30 percent, 40 percent, 45 percent, 60 percent and 80 percent, respectively.[32] Natural gas recovery also varies as a result of survey frequency. The different survey frequencies, as shown in Table 2-1, also affect the count of reconsideration affected

[31] See section VI.B.1 of the preamble, section 2 of the TSD and section 2.5.2 below for further discussion on choice of fugitive emissions monitoring frequency, including the alternative co-proposed option of annual fugitive emissions monitoring at compressor stations outside of the Alaskan North Slope.

[32] For the Option 2, the fugitives monitoring survey frequency is stepped from semiannual for two years down to annual thereafter. The emission reductions for the stepped option averages out to 45 percent per year over the eight-year lifetime of the fugitive emissions monitoring plan. See the TSD for more details on this and the estimate for emission reductions under a biennial fugitive monitoring survey frequency.

sources, which leads to variations in the natural gas recovery, and therefore the value of natural gas recovery, as well as planning and annualized costs.

Table 2-7 Comparison of Regulatory Alternatives to 2018 Baseline, 2020 and 2025

	Regulatory Alternative		
	Option 1[1]	**Option 2**	**Option 3 (Co-Proposed)[2]**
Total Impacts, 2020			
Increase in Emissions			
Methane Emissions (short tons/year)	0	21,000	39,000
VOC Emissions (short tons/year)	0	5,700	10,000
Decrease in Natural Gas Recovery (Mcf) (millions)	0	1.2	2.3
Cost Savings			
Planning Cost Savings	$2.7	$3.0	$3.1
Annualized Cost Savings w/o Forgone Revenue	$3.5	$38	$69
Annualized Cost Savings with Forgone Revenue	$3.5	$34	$62
Total Impacts, 2025			
Increase in Emissions			
Methane Emissions (short tons/year)	0	41,000	76,000
VOC Emissions (short tons/year)	0	11,000	20,000
Decrease in Natural Gas Recovery (Mcf) (millions)	0	2.4	4.4
Cost Saving			
Planning Cost Savings	$2.9	$3.5	$3.7
Annualized Cost Savings w/o Forgone Revenue	$3.7	$72	$132
Annualized Cost Savings with Forgone Revenue	$3.7	$64	$116

[1] The small difference between the planning cost savings and the annualized cost savings values for option 1 are due to the cost savings from proposed amendments to the recordkeeping and reporting requirements.
[1] The cost savings and increase in emission of the co-proposed option can be found in section 2.5.2.

As can be seen in Table 2-7, the most stringent Option 1 results in the smallest decrease in annualized costs ($3.5 million in 2020 and $3.7 million in 2025), as well as the smallest increase in emissions (at 0 tons). Option 2 results in a decrease of about $34 million in annualized costs in 2020 and $64 million in 2025, after accounting for the value of the decrease in product recovery. Option 2 also results in an estimated increase of about 21,000 short tons per year of methane emissions and 5,700 tons per year in VOC emissions in 2020, and 41,000 short tons per year methane emissions and 11,000 tons per year in VOC emissions in 2025. The co-proposed Option 3 results in the largest decrease in costs, as well as the largest increase in emissions. Option 3 is associated with an estimated decrease of about $62 million in annualized costs in 2020 and $116 million in 2025, after accounting for the value of the decrease in product recovery. Option 3 also results in an estimated increase of about 39,000 short tons per year methane emissions and 10,000 tons per year in VOC emissions in 2020, and 76,000 short tons per year methane emissions and 20,000 tons per year in VOC emissions in 2025.

2.4 Detailed Impacts Tables

The following tables show the full details of the cost savings and increase in emissions by emissions sources for each regulatory option in 2020 and 2025.

Table 2-8 Incrementally Affected Sources, Emissions Increases and Cost Savings, Option 1, 2020

Source/Emissions Point	Projected No. of Reconsideration Affected Sources	Total Increase in Emissions: Methane (short tons)	VOC (short tons)	HAP (short tons)	Methane (metric tons CO2e)	National Cost Savings: Planning Cost Savings	Operating and Maintenance	Forgone Product Recovery	Total Annualized Cost Savings with Forgone Revenues
Fugitive Emissions									
Well sites	0	0	0	0	0	$0	$0	$0	$0
Gathering and Boosting Stations	0	0	0	0	0	$0	$0	$0	$0
Transmission Compressor Stations	0	0	0	0	0	$0	$0	$0	$0
Certifications									
CVS and Technical Infeasibility	14,000	0	0	0	0	$2.7	$0	$0	$2.7
Reporting and Recordkeeping	All	0	0	0	0	$0	$0	$0	$0.81
TOTAL	**14,000**	**0**	**0**	**0**	**0**	**$2.7**	**$0**	**$0**	**$3.5**

Table 2-9 Incrementally Affected Sources, Emissions Increases and Cost Savings, Option 1, 2025

Source/Emissions Point	Projected No. of Reconsideration Affected Sources	Total Increase in Emissions: Methane (short tons)	VOC (short tons)	HAP (short tons)	Methane (metric tons CO2e)	National Cost Savings: Planning Cost Savings	Operating and Maintenance	Forgone Product Recovery	Total Annualized Cost Savings with Forgone Revenues
Fugitive Emissions									
Well sites	0	0	0	0	0	$0	$0	$0	$0
Gathering and Boosting Stations	0	0	0	0	0	$0	$0	$0	$0
Transmission Compressor Stations	0	0	0	0	0	$0	$0	$0	$0
Certifications									
CVS and Technical Infeasibility	15,000	0	0	0	0	$2.9	$0	$0	$2.9
Reporting and Recordkeeping	All	0	0	0	0	$0	$0	$0	$0.81
TOTAL	**15,000**	**0**	**0**	**0**	**0**	**$2.9**	**$0**	**$0**	**$3.7**

Table 2-10 Incrementally Affected Sources, Emissions Increases and Cost Savings, Option 2, 2020

Source/Emissions Point	Projected No. of Reconsideration Affected Sources	Total Increase in Emissions: Methane (short tons)	VOC (short tons)	HAP (short tons)	Methane (metric tons CO2e)	National Cost Savings: Planning Cost Savings	Operating and Maintenance	Forgone Product Recovery	Total Annualized Cost Savings with Forgone Revenues
Fugitive Emissions									
Well sites	42,000	21,000	5,700	220	470,000	$0.27	$34	$4.0	$30
Gathering and Boosting Stations	0	0	0	0	0	$0	$0	$0	$0
Transmission Compressor Stations	0	0	0	0	0	$0	$0	$0	$0.0
Certifications									
CVS and Technical Infeasibility	14,000	0	0	0	0	$2.7	$0	$0	$2.7
Reporting and Recordkeeping	All	0	0	0	0	$0	$0	$0	$0.81
TOTAL	**56,000**	**21,000**	**5,700**	**220**	**470,000**	**$3.0**	**$34**	**$4.0**	**$34**

Table 2-11 Incrementally Affected Sources, Emissions Increases and Cost Savings, Option 2, 2025

Source/Emissions Point	Projected No. of Reconsideration Affected Sources	Total Increase in Emissions: Methane (short tons)	VOC (short tons)	HAP (short tons)	Methane (metric tons CO2e)	National Cost Savings: Planning Cost Savings	Operating and Maintenance	Forgone Product Recovery	Total Annualized Cost Savings with Forgone Revenues
Fugitive Emissions									
Well sites	84,000	41,000	11,000	430	930,000	$0.57	$68	$8.8	$63
Gathering and Boosting Stations	0	0	0	0	0	$0	$0	$0	$0
Transmission Compressor Stations	0	0	0	0	0	$0	$0	$0	$0
Certifications									
CVS and Technical Infeasibility	15,000	0	0	0	0	$2.9	$0	$0	$2.9
Reporting and Recordkeeping	All	0	0	0	0	$0	$0	$0	$0.81
TOTAL	**99,000**	**41,000**	**11,000**	**430**	**930,000**	**$3.5**	**$68**	**$8.8**	**$64**

Table 2-12 Incrementally Affected Sources, Emissions Increases and Cost Savings, Co-Proposed Option 3, 2020

		Total Increase in Emissions				National Cost Savings			
Source/Emissions Point	**Projected No. of Reconsideration Affected Sources**	**Methane (short tons)**	**VOC (short tons)**	**HAP (short tons)**	**Methane (metric tons CO2e)**	**Planning Cost Savings**	**Operating and Maintenance**	**Forgone Product Recovery**	**Total Annualized Cost Savings with Forgone Revenues**
Fugitive Emissions									
Well sites	42,000	28,000	7,800	290	640,000	$0.37	$47	$5.5	$42
Gathering and Boosting Stations	1,300	8,900	2,500	94	200,000	$0	$16	$1.7	$14
Transmission Compressor Stations	230	2,100	58	1.7	47,000	$0	$2.9	$0.36	$2.5
Certifications									
CVS and Technical Infeasibility	14,000	0	0	0	0	$2.7	$0	$0	$2.7
Reporting and Recordkeeping	All	0	0	0	0	$0	$0	$0	$0.81
TOTAL	**58,000**	**39,000**	**10,000**	**390**	**890,000**	**$3.1**	**$66**	**$7.6**	**$62**

Table 2-13 Incrementally Affected Sources, Emissions Increases and Cost Savings, Co-Proposed Option 3, 2025

		Total Increase in Emissions				National Cost Savings			
Source/Emissions Point	**Projected No. of Reconsideration Affected Sources**	**Methane (short tons)**	**VOC (short tons)**	**HAP (short tons)**	**Methane (metric tons CO2e)**	**Planning Cost Savings**	**Operating and Maintenance**	**Forgone Product Recovery**	**Total Annualized Cost Savings with Forgone Revenues**
Fugitive Emissions									
Well sites	84,000	56,000	16,000	590	1,300,000	$0.78	$94	$12	$83
Gathering and Boosting Stations	2,300	16,000	4,600	170	370,000	$0	$29	$3.5	$25
Transmission Compressor Stations	420	3,800	110	3.1	87,000	$0	$5.3	$0.73	$4.5
Certifications									
CVS and Technical Infeasibility	15,000	0	0	0	0	$2.9	$0	$0	$2.9
Reporting and Recordkeeping	All	0	0	0	0	$0	$0	$0	$0.81
TOTAL	**100,000**	**76,000**	**20,000**	**760**	**1,700,000**	**$3.7**	**$128**	**$16**	**$116**

2.5 Analysis of the Present Value of Cost Savings

This section presents the economic cost impacts of the proposed action in a present value (PV) framework in compliance with E.O. 13771, Reducing Regulation and Controlling Regulatory Costs. The proposed action, if finalized, would be considered a deregulatory action as it has total costs that are less than zero. The stream of the estimated cost savings for each year from 2019 through 2025 is discounted back to 2016 using both a 7 and 3 percent discount rate, and summed to estimate the PV of the cost savings. This PV represents the sum of the total annual cost savings over the 2019 to 2025-time horizon as a result of this proposed action. The PV is then used to estimate the equivalent annualized value (EAV) of the cost savings. The EAV is the annualized PV of the cost savings. In other words, the EAV takes the "lumpy" stream of cost savings and converts them into a single annual value that, when added together, equals the original stream of values in PV terms.

As above, all costs are cost savings, and are presented as the change in costs of the analyzed option compared to the 2018 baseline, and are in 2016 dollars. Section 2.4 above presents the annualized cost savings of the co-proposed Option 3, however the cost savings used to estimate the PV are the un-annualized cost savings in each year. In the case of this analysis, using the annualized values would return results very similar to using the unannualized values because the portion of the total cost savings that is annualized (the planning cost savings) is very small.

2.5.1 Present Value and Equivalent Annualized Value of the Cost Savings

For this RIA, EPA evaluates the change in costs for each year where reconsideration affected sources are expected to change their compliance activities from the 2016 NSPS OOOOa requirements as a result of this reconsideration, through 2025. In the case of this proposed action, the change in compliance activities lead to cost savings. EPA has chosen not to evaluate impacts beyond 2025 in part due to the limited information available to model long-term dynamics in practices and equipment in the oil and gas industry. In addition, the oil and natural gas industry is dynamic, and technological progress in control technology is likely to change significantly over a longer time horizon.

Table 2-14 shows the stream of cost savings for each year from 2019 through 2025.

Planning cost savings are estimated as the sum of the difference in costs of the design of fugitive emissions monitoring plans for new reconsideration affected facilities, the difference in costs of the redesign of fugitive emissions monitoring plans for reconsideration affected facilities that were affected by the 2016 NSPS OOOOa at least 8 years prior, and the difference in costs of certification for closed vent system design and pneumatic pump technical infeasibility for new reconsideration affected sources compared to the updated baseline. Total cost savings are the sum of the planning cost savings and annual operating cost savings. The forgone revenue from the decrease in product recovery is estimated using the AEO 2018 projected natural gas price, as described in section 2.4.4. Total cost savings with forgone revenue is the total cost savings minus the forgone revenue. Over time, with the addition of new reconsideration affects sources, the planning cost savings, annual operating cost savings and forgone revenue increase.

Table 2-14 Estimated Cost Savings for the Co-Proposed Option 3, 2019-2025 (millions 2016$)

Year	Planning Cost Savings[1]	Operating and Maintenance Cost Savings	Total Cost Savings Without Forgone Revenue	Forgone Revenue from Product Recovery	Total Cost Savings with Forgone Revenue[2]
2019	$2.9	$54	$58	$5.7	$52
2020	$3.1	$66	$70	$7.6	$62
2021	$3.1	$78	$82	$8.9	$73
2022	$3.2	$90	$94	$10	$84
2023	$3.7	$102	$107	$12	$95
2024	$3.5	$115	$119	$14	$105
2025	$3.7	$128	$132	$16	$116

[1] The planning cost savings include the cost savings incurred by the newly affected sources for both fugitive emissions monitoring and certifications in each year, as well as the cost savings of fugitive emissions sources that renew survey monitoring plans after 8 years.
[2] Total cost savings include the planning cost savings for all fugitive emissions, plus the annual operating and maintenance cost savings for the fugitive emissions requirements every year, plus the cost savings of certifications in each year, plus the cost savings from streamlined recordkeeping and reporting.
Sums may not total due to independent rounding.

Table 2-15 shows the stream of cost savings discounted to 2016 using a 7 percent discount rate. The table also shows the PV and the EAV of planning cost savings, annual operating cost savings, forgone revenue from decreased product recovery and the total cost savings (after accounting for the forgone product recovery). The PV of total cost savings is $380 million, and the EAV of total cost savings is about $66 million per year.

Table 2-15 Discounted Cost Savings Estimates for Co-Proposed Option 3 Compared to the 2018 Baseline Using a 7 Percent Discount Rate (millions 2016$)

	Discounted Compliance Cost Savings			
Year	**Planning Cost Savings[1]**	**Operating and Maintenance Cost Savings**	**Forgone Revenue from Product Recovery**	**Total Cost Savings with Forgone Revenue[2]**
2019	$2.3	$44	$4.7	$42
2020	$2.3	$50	$5.8	$47
2021	$2.2	$55	$6.3	$52
2022	$2.1	$60	$6.9	$56
2023	$2.3	$64	$7.6	$59
2024	$2.1	$67	$8.2	$61
2025	$2.0	$69	$8.8	$63
PV	**$15**	**$410**	**$48**	**$380**
EAV	**$2.7**	**$71**	**$8.4**	**$66**

The cost savings in each year are discounted to 2016. Sums may not total due to independent rounding.
[1] The planning cost savings include the cost savings incurred by the newly affected sources for both fugitive emissions monitoring and certifications in each year, as well as the cost savings of fugitive emissions sources that renew survey monitoring plans after 8 years discounted to 2016.
[2] Total cost savings include the planning cost savings for all fugitive emissions, plus the annual operating and maintenance cost savings for the fugitive emissions requirements every year, plus the cost savings of certifications in each year, plus the cost savings from streamlined recordkeeping and reporting discounted to 2016.

Table 2-16 shows the discounted cost savings of the co-proposed Option 3, as well as the two alternative options, over 2019 through 2025 compared to the 2018 baseline, along with the PV and EAV of those cost savings, estimated using a 7 percent discount rate. Option 1 does not affect the fugitive emissions monitoring requirements, and therefore product recovery is not affected. Option 1 results in a savings of about $17 million in the PV, or $2.9 million per year in the EAV. Option 2 results in a larger decrease: about $209 million in the PV of total cost savings, after accounting for the forgone value of the decrease in product recovery, or about $36 million per year in the EAV. Option 3 leads to a PV of about $380 million in savings than the 2018 baseline, after accounting for the forgone value of the decrease in product recovery, or about $66 million per year in the EAV.

Table 2-16 Comparison of Regulatory Alternatives to 2018 Baseline Using a 7 Percent Discount Rate

	Regulatory Alternatives		
	Option 1	**Option 2**	**Option 3 (Co-Proposed)[1]**
Present Value of Cost Savings			
Compliance Cost Savings (millions 2016$)			
Planning Cost Savings	$13	$15	$15
Total Cost Savings w/o Forgone Revenue	$17	$234	$429
Total Cost Savings with Forgone Revenue	$17	$209	$380
EAV of Cost Savings			
Compliance Cost Savings (millions 2016$)			
Planning Cost Savings	$2.3	$2.6	$2.7
Total Cost Savings w/o Forgone Revenue	$2.9	$41	$74
Total Cost Savings with Forgone Revenue	$2.9	$36	$66

[1] The alternative co-proposed option leads to larger cost savings, as can be seen in table 2-18.

Table 2-17 shows how the choice of discount rate affects the PV and EAV estimates. A lower discount rate results in the higher cost savings in later years having a greater impact on the PV and EAV than would results under a higher discount rate. Therefore, the PV and EAV for the cost savings are higher when using a 3 percent discount rate than when using a 7 percent discount rate. Using a 3 percent discount rate increases the PV of the cost savings by between 27 and 28 percent from the estimates using a 7 percent discount rate. For the EAV, using a 3 percent discount rate increases the cost savings by between 14 and 15 percent from the estimates using a 7 percent discount rate.

Table 2-17 Discounted Cost Savings for the Co-Proposed Option 3 using 7 and 3 Percent Discount Rates Compared to the 2018 Baseline (millions 2016$)

	7 Percent			3 Percent		
Year	**Total Annual Cost Savings (without forgone revenue)**	**Forgone Revenue from Product Recovery**	**Total Cost Savings (with forgone revenue)[1]**	**Total Annual Cost Savings (without forgone revenue)**	**Forgone Revenue from Product Recovery**	**Total Cost Savings (with forgone revenue) [1]**
2019	$47	$4.7	$42	$53	$5.2	$48
2020	$53	$5.8	$47	$62	$6.7	$55
2021	$58	$6.3	$52	$70	$7.7	$63
2022	$63	$6.9	$56	$79	$8.7	$70
2023	$67	$7.6	$59	$87	$10	$77
2024	$69	$8.2	$61	$94	$11	$83
2025	$72	$8.8	$63	$101	$12	$89
PV	**$429**	**$48**	**$380**	**$546**	**$62**	**$484**
EAV	**$74**	**$8.4**	**$66**	**$85**	**$9.6**	**$75**

The cost savings in each year are discounted to 2016. Sums may not total due to independent rounding.
[1] Total cost savings include the planning cost savings for all fugitive emissions, plus the annual operating and maintenance cost savings for the fugitive emissions requirements every year, plus the cost savings of certifications in each year, plus the cost savings from streamlined recordkeeping and reporting discounted to 2016.

2.5.2 Sensitivity of Cost Savings to Fugitive Emissions Monitoring Frequency at Compressor Stations

The requirements under the co-proposed Option 3 were chosen individually and are based on the information we have available. This analysis was performed for the 2016 OOOOa NSPS, and revisited for this action. Section VI.B.1 of the preamble and section 2 of the TSD contain discussions of the different fugitive emissions monitoring frequencies, as well as a discussion of why we are co-proposing to reduce fugitive emissions monitoring frequency at compressor stations from quarterly to semiannual or annual. Section VI.B.1 of the preamble also contains solicitations for specific information we need in order to reevaluate monitoring frequencies further.

In this section, we provide an analysis of the total cost savings of the action under alternative monitoring frequencies for compressor stations, including the alternative co-proposed annual monitoring frequency. Table 2-18 contains the PV and EAV of the total cost savings and the total increase in emissions under each alternative frequency. All other aspects of the requirements remain as outlined under the co-proposed Option 3. The cost savings and increase in emissions are measured as changes from the 2018 baseline, and cost savings are discounted to

2016 using a 7 percent discount rate, and are in millions of 2016$. The total emissions are the sum of the increase in emissions from 2019 through 2025.

Table 2-18 Total Cost Savings and Increase in Emissions of the Co-Proposed Options Under Alternative Monitoring Frequencies at Compressor Stations

	Quarterly	Semiannual (Co-Proposed Option)	Annual (Alternative Co-Proposed Option)
Present Value			
Total Cost Savings	$277	$380	$424
Cost Savings	*$312*	*$429*	*$485*
Forgone Value of Product Recovery	*$35*	*$48*	*$61*
Equivalent Annualized Cost			
Total Cost Savings	$48	$66	$73
Cost Savings	*$54*	*$74*	*$84*
Forgone Value of Product Recovery	*$6.1*	*$8.4*	*$11*
Total Emissions Increase (2019 through 2025)			
Methane (short tons)	270,000	380,000	480,000
VOC (short tons)	76,000	100,000	120,000
HAP (short tons)	2,900	3,800	4,700
Methane (million metric tons CO_2 Eq.)	6.2	8.5	11

[1] Total cost savings include the planning cost savings for all fugitive emissions, the annual operating and maintenance cost savings for the fugitive emissions requirements every year, the cost savings of certifications in each year, the cost savings from streamlined recordkeeping and reporting, and the forgone revenue from the decrease in product recovery, discounted to 2016.
Totals may not sum due to independent rounding.

Table 2-18 presents a comparison of the co-proposed Option 3, which requires semiannual monitoring at compressor stations, with the alternative co-proposed option, which requires annual monitoring at compressor stations, and a third alternative that requires quarterly monitoring at compressor stations, that vary only with respect to the frequency of the fugitive emissions monitoring requirements for compressor stations. All other requirements are those of the co-proposed Option 3, as shown in Table 2-1. The cost savings, forgone value of product recovery, and total emissions decrease compared to the co-proposed Option 3 under quarterly monitoring and increase under the alternative co-proposed option (annual monitoring).

Assuming a 7 percent discount rate, and including the forgone value of product recovery, the present value of the total cost savings from 2019 through 2025 are about $43 million greater under the co-proposed option assuming annual monitoring than under the co-proposed option assuming semiannual monitoring. This is associated with an increase in the equivalent annualized value of total cost savings of about $7.5 million per year in comparison to the co-proposed option under semiannual monitoring.

Decreasing fugitive emissions monitoring frequency at compressor stations from semiannual to annual also results in a greater increase in total emissions. Over 2019 through 2025, the increase in fugitive emissions under the co-proposed option assuming annual monitoring compared to the 2018 baseline are about 100,000 short tons greater for methane, 24,000 tons greater for VOC, and 890 tons greater for HAP than those under the co-proposed option assuming semiannual fugitive emissions monitoring.

3 ESTIMATED FORGONE BENEFITS

3.1 Introduction

The 2016 NSPS OOOOa regulated methane and VOC emissions in the oil and natural gas sector. For the 2016 NSPS OOOOa, EPA predicted climate and ozone benefits from methane reductions, ozone and fine particulate matter ($PM_{2.5}$) health benefits from VOC reductions, and health benefits from ancillary HAP emission reduction. These benefits were expected to occur because the control techniques to meet the standards simultaneously reduce methane, VOC, and HAP emissions.[33] Under the updated assumptions and data as described above, the sources that are affected by this reconsideration would have prevented an estimated 120,000 tons of methane, and 32,000 tons of VOC from new sources in 2020 assuming no changes to the regulation. In 2025, the affected sources would have prevented an estimated 240,000 tons of methane and 62,000 tons of VOC. The estimated CO_2-equivalent (CO_2 Eq.) methane emission reductions would have been about 2.8 million metric tons in 2020 and 5.4 million metric tons in 2025. As described in the subsequent sections of this chapter, these pollutants are associated with substantial climate, health, and welfare effects.

As in the 2016 NSPS RIA, the only estimated forgone benefits monetized in this RIA are methane-related climate impacts. The co-proposed Option 3 is estimated to increase emissions compared to the 2018 baseline. The total increase in emissions over 2019 through 2025 is estimated to be about 380,000 short tons of methane, 100,000 tons of VOC and 3,800 tons of HAP. The associated increase in CO_2 Eq. methane emissions is estimated to be 8.5 million metric tons. The PV of the forgone methane-related climate benefits are estimated to be $14 million from 2019 through 2025 using an interim estimate of the domestic social cost of methane (SC-CH_4) discounting at a 7 percent rate. The associated EAV is estimated to be $2.3 million per year. Using the interim SC-CH_4 estimate based on the 3 percent rate, the PV of the forgone domestic climate benefits is estimated to be $54 million; the EAV is estimated to be $8.3 million per year.

[33] The specific control techniques for the 2016 NSPS OOOOa were also anticipated to have minor disbenefits resulting from secondary emissions of carbon dioxide (CO_2), nitrogen oxides (NO_X), PM, carbon monoxide (CO), and total hydrocarbons (THC)), and emission changes associated with the energy markets impacts. This proposed action is anticipated to reduce these minor secondary emissions.

While we expect that the forgone VOC emission reductions may also degrade air quality and adversely affect health and welfare effects associated with exposure to ozone, $PM_{2.5}$, and HAP, data limitations prevent us from quantifying forgone VOC-related health benefits. This omission should not imply that these forgone benefits may not exist; rather, it reflects the difficulties in modeling the direct and indirect impacts of the reductions in emissions for this industrial sector with the data currently available.[34] With these data currently unavailable, we are unable to estimate forgone health benefits estimates for this rule due to the differences in the locations of oil and natural gas emission points relative to existing information and the highly localized nature of air quality responses associated with HAP and VOC reductions.[35] In this chapter, we qualitatively assess the forgone health benefits associated with reducing exposure to these pollutants, as well as visibility impairment and forgone ecosystem benefits. Table 3-1 summarizes the quantified and unquantified forgone benefits in this analysis.

Table 3-1 Climate and Human Health Effects of Forgone Emission Reductions from this Proposed Rule

Category	Specific Effect	Effect Has Been Quantified	Effect Has Been Monetized	More Information
Improved Environment				
Reduced climate effects	Climate impacts from methane (CH_4) and carbon dioxide (CO_2)	—[1]	✓	Section 3.3
	Other climate impacts (e.g., ozone, black carbon, aerosols, other impacts)	—	—	IPCC, Ozone ISA, PM ISA[2]
Improved Human Health				
Reduced incidence of premature mortality from exposure to $PM_{2.5}$	Adult premature mortality based on cohort study estimates and expert elicitation estimates (age >25 or age >30)	—	—	PM ISA[3]
	Infant mortality (age <1)	—	—	PM ISA[3]
Reduced incidence of morbidity from exposure to $PM_{2.5}$	Non-fatal heart attacks (age > 18)	—	—	PM ISA[3]
	Hospital admissions—respiratory (all ages)	—	—	PM ISA[3]
	Hospital admissions—cardiovascular (age >20)	—	—	PM ISA[3]
	Emergency room visits for asthma (all ages)	—	—	PM ISA[3]

[34] EPA is working on improving available data and our understanding of the effects of VOC emission reductions in the oil and natural gas sector.

[35] Previous studies have estimated the monetized benefits-per-ton of reducing VOC emissions associated with the effect those emissions have on ambient $PM_{2.5}$ levels and the health effects associated with $PM_{2.5}$ exposure (Fann, Fulcher, and Hubbell, 2009). While these ranges of benefit-per-ton estimates provide useful context, the geographic distribution of VOC emissions from the oil and natural gas sector are not consistent with emissions modeled in Fann, Fulcher, and Hubbell (2009). In addition, the benefit-per-ton estimates for VOC emission reductions in that study are derived from total VOC emissions across all sectors. Coupled with the larger uncertainties about the relationship between VOC emissions and $PM_{2.5}$ and the highly localized nature of air quality responses associated with VOC reductions, these factors lead us to conclude that the available VOC benefit-per-ton estimates are not appropriate to calculate monetized benefits of these rules, even as a bounding exercise.

Category	Specific Effect	Effect Has Been Quantified	Effect Has Been Monetized	More Information
	Acute bronchitis (age 8-12)	—	—	PM ISA[3]
	Lower respiratory symptoms (age 7-14)	—	—	PM ISA[3]
	Upper respiratory symptoms (asthmatics age 9-11)	—	—	PM ISA[3]
	Asthma exacerbation (asthmatics age 6-18)	—	—	PM ISA[3]
	Lost work days (age 18-65)	—	—	PM ISA[3]
	Minor restricted-activity days (age 18-65)	—	—	PM ISA[3]
	Chronic Bronchitis (age >26)	—	—	PM ISA[3]
	Emergency room visits for cardiovascular effects (all ages)	—	—	PM ISA[3]
	Strokes and cerebrovascular disease (age 50-79)	—	—	PM ISA[3]
	Other cardiovascular effects (e.g., other ages)	—	—	PM ISA[2]
	Other respiratory effects (e.g., pulmonary function, non-asthma ER visits, non-bronchitis chronic diseases, other ages and populations)	—	—	PM ISA[2]
	Reproductive and developmental effects (e.g., low birth weight, pre-term births, etc.)	—	—	PM ISA[2,4]
	Cancer, mutagenicity, and genotoxicity effects	—	—	PM ISA[2,4]
Reduced incidence of mortality from exposure to ozone	Premature mortality based on short-term study estimates (all ages)	—	—	Ozone ISA[3]
	Premature mortality based on long-term study estimates (age 30–99)	—	—	Ozone ISA[3]
Reduced incidence of morbidity from exposure to ozone	Hospital admissions—respiratory causes (age > 65)	—	—	Ozone ISA[3]
	Hospital admissions—respiratory causes (age <2)	—	—	Ozone ISA[3]
	Emergency department visits for asthma (all ages)	—	—	Ozone ISA[3]
	Minor restricted-activity days (age 18–65)	—	—	Ozone ISA[3]
	School absence days (age 5–17)	—	—	Ozone ISA[3]
	Decreased outdoor worker productivity (age 18–65)	—	—	Ozone ISA[3]
	Other respiratory effects (e.g., premature aging of lungs)	—	—	Ozone ISA[2]
	Cardiovascular and nervous system effects	—	—	Ozone ISA[2]
	Reproductive and developmental effects	—	—	Ozone ISA[2,4]
Reduced incidence of morbidity from exposure to HAP	Effects associated with exposure to hazardous air pollutants such as benzene	—	—	ATSDR, IRIS[2,3]
Improved Environment				
Reduced visibility impairment	Visibility in Class 1 areas	—	—	PM ISA[3]
	Visibility in residential areas	—	—	PM ISA[3]
Reduced effects from PM deposition (organics)	Effects on Individual organisms and ecosystems	—	—	PM ISA[2]
Reduced vegetation and ecosystem effects from exposure to ozone	Visible foliar injury on vegetation	—	—	Ozone ISA[3]
	Reduced vegetation growth and reproduction	—	—	Ozone ISA[3]
	Yield and quality of commercial forest products and crops	—	—	Ozone ISA[3]
	Damage to urban ornamental plants	—	—	Ozone ISA[2]

Category	Specific Effect	Effect Has Been Quantified	Effect Has Been Monetized	More Information
	Carbon sequestration in terrestrial ecosystems	—	—	Ozone ISA[3]
	Recreational demand associated with forest aesthetics	—	—	Ozone ISA[2]
	Other non-use effects			Ozone ISA[2]
	Ecosystem functions (e.g., water cycling, biogeochemical cycles, net primary productivity, leaf-gas exchange, community composition)	—	—	Ozone ISA[2]

[1] The climate and related impacts of CO_2 and CH_4 emissions changes, such as sea level rise, are estimated within each integrated assessment model as part of the calculation of the domestic SC-CO_2 and SC-CH_4. The resulting monetized damages, which are relevant for conducting the benefit-cost analysis, are used in this RIA to estimate the domestic welfare effects of quantified changes in CH_4 emissions.
[2] We assess these benefits qualitatively because we do not have sufficient confidence in available data or methods.
[3] We assess these benefits qualitatively due to data limitations for this analysis, but we have quantified them in other analyses.
[4] We assess these benefits qualitatively because current evidence is only suggestive of causality or there are other significant concerns over the strength of the association.

3.2 Forgone Emissions Reductions

Oil and natural gas operations in the U.S. include a variety of emission points for methane, VOC, and HAP, including wells, well sites, processing plants, compressor stations, storage equipment, and transmission and distribution lines. These emission points are located throughout much of the country with significant concentrations in particular geographic regions. For example, wells and processing plants are largely concentrated in the South Central, Midwest, and Southern California regions of the U.S., whereas natural gas compressor stations are located all over the country. Distribution lines to customers are frequently located within areas of high population density.

Implementing this rule may result in forgone reductions in ambient $PM_{2.5}$ and ozone concentrations in areas attaining and not attaining the National Ambient Air Quality Standards (NAAQS). Due to the high degree of variability in the responsiveness of ozone and $PM_{2.5}$ formation to VOC emission reductions, we are unable to determine how this rule might affect attainment status without modeling air quality changes.[36] Because the NAAQS RIAs also calculate ozone and $PM_{2.5}$ benefits, there are important differences worth noting in the design and analytical objectives of each impact analysis. The NAAQS RIAs illustrate the potential costs and benefits of attaining new nationwide air quality standards based on an array of emission

[36] The responsiveness of ozone and $PM_{2.5}$ formation is discussed in greater detail in sections 3.4.1 and 3.5.1 of this RIA.

control strategies for different sources.[37] By contrast, the emission reductions for implementation rules, including this rule, are generally from a specific class of well-characterized sources. In general, EPA is more confident in the magnitude and location of the emission reductions for implementation rules rather than illustrative NAAQS analyses. Emission changes realized under these and other promulgated rules will ultimately be reflected in the baseline of future NAAQS analyses, which would affect the incremental costs and benefits associated with attaining future NAAQS.

Table 3-2 shows the total increase in direct emissions, compared to the 2018 baseline, anticipated for this proposed rule across the regulatory options examined for 2019 through 2025. It is important to note that these emissions accrue at different spatial scales. HAP emissions increase exposure to carcinogens and other toxic pollutants primarily near the emission source. VOC emissions are precursors to secondary formation of $PM_{2.5}$ and ozone on a broader regional scale. Climate effects associated with long-lived greenhouse gases like methane generally do not depend on the location of the emission of the gas, and have global impacts. Methane is also a precursor to global background concentrations of ozone (Sarofim 2015). Section 2.4.3 describes the emission increases for the co-proposed Option 3 estimated in each year.

Table 3-2 Total Direct Increases in Emissions Compared to the 2018 Baseline across Regulatory Options, 2019 through 2025

Pollutant	Option 1	Option 2	Option 3 (Co-Proposed)
Methane (short tons)	0	200,000	380,000
VOC (short tons)	0	56,000	100,000
HAP (short tons)	0	2,100	3,800
Methane (metric tons)	0	180,000	340,000
Methane (million metric tons CO_2 Eq.)	0	4.5	8.5

Table 3-3 shows the methane, VOC and HAP emissions increases for Option 2 and Option 3 for each year, compared to the 2018 baseline. Option 1 is not included in this table, as there are no estimated changes in emissions under Option 1 (as seen in Table 3-2).

[37] NAAQS RIAs hypothesize, but do not predict, the control strategies States may choose to enact when implementing a NAAQS. The setting of a NAAQS does not directly result in costs or benefits, and as such, the NAAQS RIAs are merely illustrative and are not intended to be added to the costs and benefits of other regulations that result in specific costs of control and emission reductions. However, some costs and benefits estimated in this RIA may account for the same air quality improvements as estimated in an illustrative NAAQS RIA.

Table 3-3 Annual Direct Increases in Methane, VOC and HAP Emissions Compared to the 2018 Baseline, Options 2 and 3, 2019 through 2025

	Option 2			Option 3 (Co-Proposed)		
Year	**Methane (metric tons)**	**VOC**	**HAP**	**Methane (metric tons)**	**VOC**	**HAP**
2019	15,000	4,700	180	29,000	8,500	320
2020	19,000	5,700	220	35,000	10,000	390
2021	22,000	6,800	260	42,000	12,000	460
2022	26,000	7,900	300	49,000	14,000	530
2023	30,000	9,100	340	55,000	16,000	610
2024	33,000	10,000	380	62,000	18,000	690
2025	37,000	11,000	430	69,000	20,000	760
Total	**180,000**	**56,000**	**2,100**	**340,000**	**100,000**	**3,800**

3.3 Methane Climate Effects and Valuation

Methane is the principal component of natural gas. Methane is also a potent greenhouse gas (GHG) that, once emitted into the atmosphere, absorbs terrestrial infrared radiation, which in turn contributes to increased global warming and continuing climate change. Methane reacts in the atmosphere to form ozone, which also impacts global temperatures. Methane, in addition to other GHG emissions, contributes to warming of the atmosphere, which over time leads to increased air and ocean temperatures; changes in precipitation patterns; melting and thawing of global glaciers and ice sheets; increasingly severe weather events, such as hurricanes of greater intensity; and sea level rise, among other impacts.

According to the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5, 2013), changes in methane concentrations since 1750 contributed 0.48 W/m^2 of forcing, which is about 17 percent of all global forcing due to increases in anthropogenic GHG concentrations, and which makes methane the second leading long-lived climate forcer after CO_2. However, after accounting for changes in other greenhouse substances such as ozone and stratospheric water vapor due to chemical reactions of methane in the atmosphere, historical methane emissions were estimated to have contributed to 0.97 W/m^2 of forcing today, which is about 30 percent of the contemporaneous forcing due to historical greenhouse gas emissions.

The oil and natural gas sector emits significant amounts of methane. The public Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014 (published 2016) estimates 2014 methane emissions from Petroleum and Natural Gas Systems (not including petroleum refineries and petroleum transportation) to be 232 MMt CO_2 Eq. In 2014, total methane emissions from the oil and natural gas industry represented 32 percent of the total methane emissions from all sources and account for about 3 percent of all CO_2 Eq. emissions in the U.S., with the combined petroleum and natural gas systems being the largest contributor to U.S. anthropogenic methane emissions (U.S. EPA, 2016c).

The 2016 NSPS OOOOa was expected to result in climate-related benefits by reducing methane emissions. The proposed changes would therefore forgo climate-related benefits associated with these emissions reductions as discussed above. To give a sense of the magnitude of the emissions increases presented in Table 2-3, Table 3-2, and Table 3-3, the forgone methane reductions estimated for 2020 (0.89 million metric tons CO_2 Eq.) are equivalent to about 0.4 percent of the methane emissions for this sector reported in the U.S. GHGI for 2014 (about 232 million metric tons CO_2 Eq. are from petroleum and natural gas production and gas processing, transmission, and storage). Expected forgone emission reductions in 2025 (about 1.7 million metric tons CO_2 Eq.) are equivalent to around 0.7 percent of 2014 emissions. As it is expected that emissions from this sector would increase over time, the estimates compared against the 2014 emissions would likely overestimate the percent of total emissions in 2020 and 2025.

We estimate the forgone climate benefits from the proposal using an interim measure of the domestic social cost of methane (SC-CH_4). The SC-CH_4 is an estimate of the monetary value of impacts associated with marginal changes in CH_4 emissions in a given year. It includes a wide range of anticipated climate impacts, such as net changes in agricultural productivity and human health, property damage from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. It is typically used to assess the avoided damages as a result of regulatory actions (i.e., benefits of rulemakings that lead to an incremental reduction in cumulative global CH_4 emissions). The SC-CH_4 estimates used in this analysis focus on the direct impacts of climate change that are anticipated to occur within U.S. borders.

The SC-CH_4 estimates presented here are interim values developed under E.O. 13783 for use in regulatory analyses until an improved estimate of the impacts of climate change to the U.S. can be developed based on the best available science and economics. E.O. 13783 directed agencies to ensure that estimates of the social cost of greenhouse gases used in regulatory analyses "are based on the best available science and economics" and are consistent with the guidance contained in OMB Circular A-4, "including with respect to the consideration of domestic versus international impacts and the consideration of appropriate discount rates" (E.O. 13783, Section 5(c)). In addition, E.O. 13783 withdrew the technical support documents (TSDs) and the August 2016 Addendum to these TSDs describing the global social cost of greenhouse gas estimates developed under the prior Administration as no longer representative of government policy. The withdrawn TSDs and Addendum were developed by an interagency working group (IWG) that included EPA and other executive branch entities and were used in the 2016 NSPS RIA.

Regarding the two analytical considerations highlighted in E.O. 13783 – how best to consider domestic versus international impacts and appropriate discount rates – current guidance in OMB Circular A-4 is as follows. Circular A-4 states that analysis of economically significant proposed and final regulations "should focus on benefits and costs that accrue to citizens and residents of the United States." Because this action is economically significant as defined in E.O. 12866, section 3(f)(1), we follow this guidance by adopting a domestic perspective in our central analysis. Regarding discount rates, Circular A-4 states that regulatory analyses "should provide estimates of net benefits using both 3 percent and 7 percent." The 7 percent rate is intended to represent the average before-tax rate of return to private capital in the U.S. economy. The 3 percent rate is intended to reflect the rate at which society discounts future consumption, which is particularly relevant if a regulation is expected to affect private consumption directly. EPA follows this guidance below by presenting estimates based on both 3 and 7 percent discount rates in the main analysis. See the Appendix for a discussion the modeling steps involved in estimating the domestic SC-CH_4 estimates based on these discount rates.

The SC-CH_4 estimates developed under E.O. 13783 will be used in regulatory analysis until improved domestic estimates can be developed, which will take into consideration the recent recommendations from the National Academies of Sciences, Engineering, and Medicine[38] for a comprehensive update to the current methodology to ensure that the social cost of greenhouse gas estimates reflect the best available science. While the Academies' review

[38] See National Academies of Sciences, Engineering, and Medicine, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide, Washington, D.C., January 2017. http://www.nap.edu/catalog/24651/valuing-climate-changes-updating-estimation-of-the-social-cost-of

focused on the methodology to estimate the social cost of carbon (SC-CO_2), the recommendations on how to update many of the underlying modeling assumptions also pertain to the SC-CH_4 estimates since the framework used to estimate SC-CH_4 is the same as that used for SC-CO_2.

Table 3-4 presents the average domestic SC-CH_4 estimates across all the model runs for each discount rate for emissions occurring in 2019 to 2025. As with the global SC-CH_4 estimates, the domestic SC-CH_4 increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change, and because GDP is growing over time and many damage categories are modeled as proportional to gross GDP.

Table 3-4 Interim Domestic Social Cost of CH_4, 2019-2025 (in 2016$ per metric ton CH_4)*

	Discount Rate and Statistic	
Year	7% Average	3% Average
2019	$53	$170
2020	55	180
2021	58	180
2022	60	190
2023	63	190
2024	65	200
2025	68	200

* SC-CH_4 values are stated in $/metric ton CH_4 and rounded to two significant digits. The estimates vary depending on the year of CH_4 emissions and are defined in real terms, i.e., adjusted for inflation using the GDP implicit price deflator.

The SC-CH_4 estimates in Table 3-4 are used to monetize the forgone domestic climate benefits across regulatory options under consideration. Forecasted increases in methane emissions in a given year, expected as a result of the regulatory action, are multiplied by the SC-CH_4 estimate for that year. Under the co-proposed Option 3, the forgone climate benefits vary by discount rate and year, and range from about $1.6 million to approximately $4.7 million under a 7 percent discount rate, and from about $5 million to approximately $14 million under a 3 percent discount rate, as seen in Table 3-5.

Table 3-5 Estimated Forgone Domestic Climate Benefits of the Co-Proposed Option 3, 2019-2025 (millions, 2016$)

Year	7 percent	3 Percent
2019	$1.6	$5.0
2020	$2.0	$6.2
2021	$2.4	$7.6
2022	$2.9	$9.1
2023	$3.5	$11
2024	$4.1	$12
2025	$4.7	$14

Table 3-6 shows the forgone domestic climate benefits in each year discounted to 2016 using a 3 or 7 percent discount rate. The table also shows the PV and the EAV for the 2019 through 2025-time horizon under each discount rate. The PV of forgone benefits under a 7 percent discount rate is about $14 million, with an EAV of about $2.3 million per year. The PV of forgone benefits under a 3 percent discount rate of $54 million, with an EAV of about $8.3 million per year.

Table 3-6 Discounted Forgone Domestic Climate Benefits of the Co-Proposed Option 3, PV and EAV (millions, 2016$)

Year	7 percent	3 Percent
2019	$1.3	$4.6
2020	$1.5	$5.5
2021	$1.7	$6.6
2022	$1.9	$7.6
2023	$2.2	$8.7
2024	$2.4	$9.7
2025	$2.5	$11
PV	**$14**	**$54**
EAV	**$2.3**	**$8.3**

The forgone domestic climate benefits in each year are discounted to 2016.

Table 3-7 shows the total increase in emissions over the 2019 through 2025-time horizon as well as the PV and EAV of the forgone domestic climate benefits under 3 percent and 7 percent discount rates. This table shows how the different values of the climate benefits, as seen in Table 3-4, affect the PV and EAV of each option. The affected sources in Option 1 are all related to certification requirements, which do not affect emissions. The number of affected sources under the co-proposed Option 3 is slightly larger than under Option 2, which leads the increase in emissions, as well as the forgone benefits, to be slightly larger as well.

Table 3-7 Estimated Forgone Domestic Climate Benefits Across the Regulatory Options (millions, 2016$)

	Option 1	Option 2	Option 3 (Co-Proposed)
Total Increase in Emission, 2019-2025			
Forgone CH_4 reductions (metric tonnes)	0	180,000	340,000
Forgone CH_4 reductions (million metric tonnes of CO_2 Eq.)	0	4.5	8.5
Forgone Domestic Climate Benefits (millions 2016$)			
PV			
3% (average)	$0	$28	$54
7% (average)	$0	$7.2	$14
EAV			
3% (average)	$0	$4.4	$8.3
7% (average)	$0	$1.2	$2.3

The SC-CH_4 values are dollar-year and emissions-year specific. SC-CH_4 values represent only a partial accounting of climate impacts.

The limitations and uncertainties associated with the global SC-CH_4 estimates, which were discussed in detail in the 2016 NSPS RIA, likewise apply to the forgone domestic SC-CH_4 estimates presented in this analysis.[39] Some uncertainties are captured within the analysis, as discussed in detail in the Appendix, while other areas of uncertainty have not yet been quantified in a way that can be modeled. For example, as with the methodology used to calculate SC-CO_2 estimates, limitations include incomplete or inadequate representation in the integrated assessment models of several important factors: catastrophic and non-catastrophic impacts, adaptation and technological change, inter-regional and inter-sectoral linkages, uncertainty in the extrapolation of damages to high temperatures, and the relationship between the discount rate and uncertainty in economic growth over long time horizons. The science incorporated into these models understandably lags behind the most recent research, and the limited amount of research linking climate impacts to economic damages makes the modeling exercise even more difficult.

[39] The SC-CH_4 estimates presented in the 2016 NSPS RIA are the same as the SC-CH_4 estimates presented in EPA-HQ-OAR-2015-0827-5886, "Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide (August 2016)", except the estimates in the 2016 NSPS RIA were adjusted to 2012$. The estimates published in the 2016 NSPS RIA were labeled as "Marten *et al*. (2014)" estimates. In addition, EPA-HQ-OAR-2015-0827-5886 provides a detailed discussion of the limitations and uncertainties associated with the SC-GHG estimates.

There are several limitations specific to the estimation of SC-CH_4. For example, the SC-CH_4 estimates do not reflect updates from the IPCC regarding atmospheric and radiative efficacy.[40] Another limitation is that the SC-CH_4 estimates do not account for the direct health and welfare impacts associated with tropospheric ozone produced by methane (see the 2016 NSPS RIA for further discussion). In addition, the SC-CH_4 estimates do not reflect that methane emissions lead to a reduction in atmospheric oxidants, like hydroxyl radicals, nor do they account for impacts associated with CO_2 produced from methane oxidizing in the atmosphere. See EPA-HQ-OAR-2015-0827-5886 for more detailed discussion about the limitations specific to the estimation of SC-CH_4. These individual limitations and uncertainties do not all work in the same direction in terms of their influence on the SC-CH_4 estimates. In accordance with guidance in OMB Circular A-4 on the treatment of uncertainty, the Appendix provides a detailed discussion of the ways in which the modeling underlying the development of the SC-CH_4 estimates used in this analysis addresses quantified sources of uncertainty, and presents a sensitivity analysis to show consideration of the uncertainty surrounding discount rates over long time horizons.

Recognizing the limitations and uncertainties associated with estimating the social cost of greenhouse gases, the research community has continued to explore opportunities to improve estimates of SC-CO_2 and other greenhouse gases. Notably, the National Academies of Sciences, Engineering, and Medicine conducted a multi-discipline, multi-year assessment to examine potential approaches, along with their relative merits and challenges, for a comprehensive update to the IWG methodology. The task was to ensure that the SC-CO_2 estimates that are used in Federal analyses reflect the best available science, focusing on issues related to the choice of models and damage functions, climate science modeling assumptions, socioeconomic and emissions scenarios, presentation of uncertainty, and discounting. In January 2017, the Academies released their final report, *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide*,[41] and recommended specific criteria for future updates to the SC-

[40] The SC-CH_4 estimates used in the 2016 NSPS RIA served as the starting point to calculate the interim domestic estimates presented in this RIA. The 2016 NSPS RIA SC-CH_4 estimates were calculated in 2014 using atmospheric and radiative efficacy values that have since been updated by the IPCC

[41] National Academies of Sciences, Engineering, and Medicine. 2017. *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide.* National Academies Press. Washington, DC Available at <https://www.nap.edu/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of> Accessed May 30, 2017.

CO_2 estimates, a modeling framework to satisfy the specified criteria, and both near-term updates and longer-term research needs pertaining to various components of the estimation process (National Academies 2017). Since the framework used to estimate SC-CH_4 is the same as that used for SC-CO_2, the Academies' recommendations on how to update many of the underlying modeling assumptions also apply to the SC-CH_4 estimates.

The Academies' report also discussed the challenges in developing domestic SC-CO_2 estimates, noting that current IAMs do not model all relevant regional interactions—e.g., how climate change impacts in other regions of the world could affect the United States, through pathways such as global migration, economic destabilization, and political destabilization. The Academies concluded that it "is important to consider what constitutes a domestic impact in the case of a global pollutant that could have international implications that impact the United States. More thoroughly estimating a domestic SC-CO_2 would therefore need to consider the potential implications of climate impacts on, and actions by, other countries, which also have impacts on the United States." (National Academies 2017, pg 12-13). This challenge is equally applicable to the estimation of a domestic SC-CH_4.

In addition to requiring reporting of domestic impacts, Circular A-4 states that when an agency "evaluate[s] a regulation that is likely to have effects beyond the borders of the United States, these effects should be reported separately" (page 15). This guidance is relevant to the valuation of damages from methane and other GHGs, given that GHGs contribute to damages around the world independent of the country in which they are emitted. Therefore, in accordance with this guidance in OMB Circular A-4, the Appendix presents the forgone global climate benefits from the proposal using global SC-CH_4 estimates based on both 3 and 7 percent discount rates. Note that EPA did not quantitatively project the full impact of the 2016 NSPS OOOOa on international trade and the location of production, so it is not possible to present analogous estimates of global cost savings resulting from the proposed action. However, to the extent that affected firms have some foreign ownership, some of the cost savings accruing to entities outside U.S. borders is captured in the compliance cost savings presented in this RIA.

3.4 VOC as an Ozone Precursor

This rulemaking may forgo emission reductions of VOC, which are a precursor to ozone. Ozone is not emitted directly into the air, but is created when its two primary components, volatile organic compounds (VOC) and oxides of nitrogen (NO_x), react in the atmosphere in the presence of sunlight. In urban areas, compounds representing all classes of VOC are important for ozone formation, but biogenic VOC emitted from vegetation tend to be more important compounds in non-urban vegetated areas (U.S. EPA, 2013). Forgone emission reductions may increase ozone formation, human exposure to ozone, and the incidence of ozone-related health effects. However, we have not quantified the ozone-related forgone benefits in this analysis due to the complex non-linear chemistry of ozone formation, which introduces uncertainty to the development and application of a benefit-per-ton estimate, particularly for sectors with substantial new growth. In addition, the impact of forgone VOC emission reductions is spatially heterogeneous and highly dependent on local air chemistry. Urban areas with a high population concentration are often VOC-limited, which means that ozone is most effectively reduced by lowering VOC. Rural areas and downwind suburban areas are often NO_X-limited, which means that ozone concentrations are most effectively reduced by lowering NO_X emissions, rather than lowering emissions of VOC. Between these areas, ozone is relatively insensitive to marginal changes in both NO_X and VOC.

Due to data limitations regarding potential locations of new and modified sources affected by this rulemaking, we did not perform air quality modeling for this rule needed to quantify the forgone ozone benefits associated with forgone VOC emission reductions. Due to the high degree of variability in the responsiveness of ozone formation to VOC emissions and data limitations regarding the location of new and modified well sites, we are unable to estimate the effect that forgone VOC emission reductions will have on ambient ozone concentrations without air quality modeling[42].

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[42] EPA is working on improving our understanding of the effects of VOC emission reductions in the oil and natural gas sector.

3.4.1 Ozone Health Effects

Human exposure to ambient ozone concentrations is associated with adverse health effects, including premature mortality and cases of respiratory morbidity (U.S. EPA, 2010a). Researchers have associated ozone exposure with adverse health effects in numerous toxicological, clinical and epidemiological studies (U.S. EPA, 2013). When adequate data and resources are available, EPA has generally quantified several health effects associated with exposure to ozone (e.g., U.S. EPA, 2010a; U.S. EPA, 2011a). These health effects include: respiratory morbidity, such as asthma attacks; hospital and emergency department visits; lost school days; and premature mortality. The scientific literature is also suggestive that exposure to ozone is also associated with chronic respiratory damage and premature aging of the lungs.

EPA has previously estimated the ozone-related benefits of reducing VOC emissions from the industrial boiler sector (U.S. EPA, 2011b)[43] and in the RIA for the proposed Ozone NAAQS (U.S. EPA, 2014b). While the benefit-per-ton estimates used to quantify impacts for those rules may provide useful context, the geographic distribution of VOC emissions from the oil and natural gas sector is not consistent with emissions modeled in either analysis. Therefore, we do not believe that those estimates are representative of the monetized forgone benefits of this rule, even as a bounding exercise.

3.4.2 Ozone Vegetation Effects

Exposure to ozone has been found to be associated with a wide array of vegetation and ecosystem effects in the published literature (U.S. EPA, 2013). Sensitivity to ozone is highly variable across species, with over 66 vegetation species identified as "ozone-sensitive", many of which occur in state and national parks and forests. These effects include those that damage to, or impairment of, the intended use of the plant or ecosystem. Such effects are considered adverse to public welfare and can include reduced growth and/or biomass production in sensitive trees, reduced yield and quality of crops, visible foliar injury, changed to species composition, and changes in ecosystems and associated ecosystem services.

[43] While EPA has estimated the ozone benefits for many scenarios, most of those scenarios also reduce NO_2 emissions, which make it difficult to isolate the benefits attributable to VOC reductions.

3.4.3 Ozone Climate Effects

Ozone is a well-known short-lived climate forcing greenhouse gas (GHG) (U.S. EPA, 2013). Stratospheric ozone (the upper ozone layer) is beneficial because it protects life on Earth from the sun's harmful ultraviolet (UV) radiation. In contrast, tropospheric ozone (ozone in the lower atmosphere) is a harmful air pollutant that adversely affects human health and the environment and contributes significantly to regional and global climate change. Due to its short atmospheric lifetime, tropospheric ozone concentrations exhibit large spatial and temporal variability (U.S. EPA, 2009b). The IPCC AR5 estimated that the contribution to current warming levels of increased tropospheric ozone concentrations resulting from human methane, NOx, and VOC emissions was 0.5 W/m^2, or about 30 percent as large a warming influence as elevated CO_2 concentrations. This quantifiable influence of ground level ozone on climate leads to increases in global surface temperature and changes in hydrological cycles.

3.5 VOC as a $PM_{2.5}$ Precursor

This rulemaking may forgo emission reductions of VOC, which are a precursor to $PM_{2.5}$, thus possibly increasing human exposure to $PM_{2.5}$ and the incidence of $PM_{2.5}$-related health effects. Most VOC emitted are oxidized to CO_2 rather than to PM, but a portion of VOC emission contributes to ambient $PM_{2.5}$ levels as organic carbon aerosols (U.S. EPA, 2009a). Analysis of organic carbon measurements suggest only a fraction of secondarily formed organic carbon aerosols are of anthropogenic origin. The current state of the science of secondary organic carbon aerosol formation indicates that anthropogenic VOC contribution to secondary organic carbon aerosol is often lower than the biogenic (natural) contribution. Given that a fraction of secondarily formed organic carbon aerosols is from anthropogenic VOC emissions and the extremely small amount of VOC emissions from this sector relative to the entire VOC inventory, it is unlikely this sector has a large contribution to ambient secondary organic carbon aerosols. Photochemical models typically estimate secondary organic carbon from anthropogenic VOC emissions to be less than 0.1 $\mu g/m^3$. Therefore, we have not quantified the forgone $PM_{2.5}$-related benefits in this analysis.

Due to data limitations regarding potential locations of new and modified sources affected by this rulemaking, we were unable to perform air quality modeling of the ambient

$PM_{2.5}$ impacts of the proposed rule, which is needed to quantify forgone $PM_{2.5}$ benefits associated with forgone VOC emission reductions for this rule.[44] Due to the high degree of variability in the responsiveness of $PM_{2.5}$ formation to VOC emission reductions, we are unable to estimate the effect that reducing VOC will have on ambient $PM_{2.5}$ levels without air quality modeling. However, we provide the discussion below for context regarding findings from previous modeling.

3.5.1 $PM_{2.5}$ Health Effects

Increasing VOC emissions would increase secondary $PM_{2.5}$ formation, and, thus, the incidence of $PM_{2.5}$-related health effects. Increasing exposure to $PM_{2.5}$ is associated with significant human health detriments, including mortality and respiratory morbidity. Researchers have associated $PM_{2.5}$ exposure with adverse health effects in numerous toxicological, clinical and epidemiological studies (U.S. EPA, 2009a). These health effects include premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, and increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing (U.S. EPA, 2009a). These health effects result in hospital and ER visits, lost work days, and restricted activity days. When adequate data and resources are available, EPA has quantified the health effects associated with exposure to $PM_{2.5}$ (e.g., U.S. EPA (2011g).

When EPA quantifies $PM_{2.5}$-related benefits, the agency assumes that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type (U.S. EPA, 2009a). Based on our review of the current body of scientific literature, EPA estimates PM-related premature mortality without applying an assumed concentration threshold. This decision is supported by the data, which are quite consistent in showing effects down to the lowest measured levels of $PM_{2.5}$ in the underlying epidemiology studies.

Fann, Fulcher, and Hubbell (2009) examined how the monetized benefit-per-ton estimates of reducing ambient $PM_{2.5}$ varies by the location of the emission reduction, the type of

[44] EPA is working on improving our understanding of the effects of VOC emission reductions in the oil and natural gas sector.

source emitting the precursor, and the specific precursor controlled. This study employed a reduced-form air quality model to estimate changes in ambient $PM_{2.5}$ from reducing 12 different combinations of precursor emissions and emission sources, including reducing directly emitted carbonaceous particles, nitrogen oxides, sulfur oxides, ammonia, and VOCs for nine urban areas and nationwide. However, while these ranges of benefit-per-ton estimates provide general context, the geographic distribution of VOC emissions from the oil and natural gas sector are not consistent with emissions modeled in Fann, Fulcher, and Hubbell (2009). In addition, the benefit-per-ton estimates for VOC emission reductions in that study are derived from total VOC emissions across all sectors. Coupled with the larger uncertainties about the relationship between VOC emissions and $PM_{2.5}$, these factors have lead EPA to conclude that the available VOC benefit per ton estimates are not appropriate for use in monetizing the $PM_{2.5}$ benefits of this rule, even as a bounding exercise.

3.5.2 Organic PM Welfare Effects

According to the previous residual risk assessment that EPA performed for this sector (U.S. EPA, 2012a), persistent and bioaccumulative HAP reported as emissions from oil and natural gas operations include polycyclic organic matter (POM). POM defines a broad class of compounds that includes polycyclic aromatic hydrocarbon compounds (PAHs). Several significant ecological effects are associated with the deposition of organic particles, including persistent organic pollutants, and PAHs (U.S. EPA, 2009a). This summary is from section 6.6.1 of the 2012 PM NAAQS RIA (U.S. EPA, 2012c).

PAHs can accumulate in sediments and bioaccumulate in freshwater, flora, and fauna. The uptake of organics depends on the plant species, site of deposition, physical and chemical properties of the organic compound and prevailing environmental conditions (U.S. EPA, 2009a). PAHs can accumulate to high enough concentrations in some coastal environments to pose an environmental health threat that includes cancer in fish populations, toxicity to organisms living in the sediment and risks to those (e.g., migratory birds) that consume these organisms. Atmospheric deposition of particles is thought to be the major source of PAHs to the sediments of coastal areas of the U.S. Deposition of PM to surfaces in urban settings increases the metal and organic component of storm water runoff. This atmospherically-associated pollutant burden can then be toxic to aquatic biota. The contribution of atmospherically deposited PAHs to aquatic food webs was demonstrated in high elevation mountain lakes with no other anthropogenic contaminant sources.

The Western Airborne Contaminants Assessment Project (WACAP) is the most comprehensive database available on contaminant transport and the effects of PM deposition on sensitive ecosystems in the Western U.S. (Landers *et al.*, 2008). In this project, the transport, fate, and ecological impacts of anthropogenic contaminants from atmospheric sources were assessed from 2002 to 2007 in seven ecosystem components (air, snow, water, sediment, lichen, conifer needles, and fish) in eight core national parks. The study concluded that bioaccumulation of semi-volatile organic compounds occurred throughout park ecosystems, that an elevational gradient in PM deposition exists with greater accumulation in higher altitude areas, and that contaminants accumulate in proximity to individual agriculture and industry sources, which is counter to the original working hypothesis that most of the contaminants would originate from Eastern Europe and Asia.

3.5.3 Visibility Effects

Increasing secondary formation of $PM_{2.5}$ from VOC emissions could reduce visibility throughout the U.S. Fine particles with significant light-extinction efficiencies include sulfates, nitrates, organic carbon, elemental carbon, and soil (Sisler, 1996). Suspended particles and gases degrade visibility by scattering and absorbing light. Higher visibility impairment levels in the East are due to higher concentrations of fine particles, particularly sulfates, and higher average relative humidity levels. Visibility impairment has a direct impact on people’s enjoyment of daily activities and their overall sense of wellbeing. Good visibility increases the quality of life where individuals live and work, and where they engage in recreational activities. Previous analyses (U.S. EPA, 2006b; U.S. EPA, 2011a; U.S. EPA, 2011g; U.S. EPA, 2012c) show that visibility benefits are a significant welfare benefit category. However, without air quality modeling, we are unable to estimate forgone visibility related benefits, nor are we able to determine whether VOC emission would be likely to have a significant impact on visibility in urban areas or Class I areas.

3.6 Hazardous Air Pollutants (HAP)

When looking at exposures from all air toxic sources of outdoor origin across the U.S., we see that emissions declined by approximately 60 percent since 1990. However, despite this decline, the 2011 National-Scale Air Toxics Assessment (NATA) predicts that most Americans are exposed to ambient concentrations of air toxics at levels that have the potential to cause adverse health effects (U.S. EPA, 2015).[45] The levels of air toxics to which people are exposed vary depending on where they live and work and the kinds of activities in which they engage. In order to identify and prioritize air toxics, emission source types and locations that are of greatest potential concern, EPA conducts the NATA.[46] The most recent NATA was conducted for calendar year 2011 and was released in December 2015. NATA includes four steps:

1) Compiling a national emissions inventory of air toxics emissions from outdoor sources;

2) Estimating ambient concentrations of air toxics across the U.S. utilizing dispersion models;

3) Estimating population exposures across the U.S. utilizing exposure models; and

4) Characterizing potential public health risk due to inhalation of air toxics including both cancer and noncancer effects.

Based on the 2011 NATA, EPA estimates that less than 1 percent of census tracts nationwide have increased cancer risks greater than 100 in a million. The average national cancer risk is about 40 in a million. Nationwide, the key pollutants that contribute most to the overall cancer risks are formaldehyde and benzene. [47,48] Secondary formation (e.g., formaldehyde forming from other emitted pollutants) was the largest contributor to cancer risks, while

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[45] The 2011 NATA is available on the Internet at http://www.epa.gov/national-air-toxics-assessment/2011-national-air-toxics-assessment.

[46] The NATA modeling framework has a number of limitations that prevent its use as the sole basis for setting regulatory standards. These limitations and uncertainties are discussed on the 2011 NATA website. Even so, this modeling framework is very useful in identifying air toxic pollutants and sources of greatest concern, setting regulatory priorities, and informing the decision making process. U.S. EPA. (2015) 2011 National-Scale Air Toxics Assessment. <http://www.epa.gov/national-air-toxics-assessment/2011-national-air-toxics-assessment>.

[47] Details on EPA's approach to characterization of cancer risks and uncertainties associated with the 2011 NATA risk estimates can be found at <http://www.epa.gov/national-air-toxics-assessment/nata-limitations>.

[48] Details about the overall confidence of certainty ranking of the individual pieces of NATA assessments including both quantitative (e.g., model-to-monitor ratios) and qualitative (e.g., quality of data, review of emission inventories) judgments can be found at <http://www.epa.gov/national-air-toxics-assessment/nata-limitations>.

stationary, mobile, biogenics, and background sources contribute lesser amounts to the remaining cancer risk.

Noncancer health effects can result from chronic,[49] subchronic,[50] or acute[51] inhalation exposure to air toxics, and include neurological, cardiovascular, liver, kidney, and respiratory effects as well as effects on the immune and reproductive systems. According to the 2011 NATA, about 80 percent of the U.S. population was exposed to an average chronic concentration of air toxics that has the potential for adverse noncancer respiratory health effects. Results from the 2011 NATA indicate that acrolein is the primary driver for noncancer respiratory risk.

Figure 3-1 and Figure 3-2 depict the 2011 NATA estimated census tract-level carcinogenic risk and noncancer respiratory hazard from the assessment. It is important to note that increases in HAP emissions may not necessarily translate into significant increases in health risk because toxicity varies by pollutant, and exposures may or may not exceed levels of concern. For example, acetaldehyde mass emissions were more than seventeen times acrolein mass emissions on a national basis in EPA's 2011 National Emissions Inventory (NEI). However, the Integrated Risk Information System (IRIS) reference concentration (RfC) for acrolein is considerably lower than that for acetaldehyde. This results in 2011 NATA estimates of nationwide chronic respiratory noncancer risks from acrolein being over three times that of acetaldehyde.[52] Thus, it is important to account for the toxicity and exposure, as well as the mass of the targeted emissions.

[49] Chronic exposure is defined in the glossary of the Integrated Risk Information System (IRIS) database (<http://www.epa.gov/iris>) as repeated exposure by the oral, dermal, or inhalation route for more than approximately 10 of the life span in humans (more than approximately 90 days to 2 years in typically used laboratory animal species).

[50] Defined in the IRIS database as repeated exposure by the oral, dermal, or inhalation route for more than 30 days, up to approximately 10 of the life span in humans (more than 30 days up to approximately 90 days in typically used laboratory animal species).

[51] Defined in the IRIS database as exposure by the oral, dermal, or inhalation route for 24 hours or less.

[52] Details on the derivation of IRIS values and available supporting documentation for individual chemicals (as well as chemical values comparisons) can be found at <http://www.epa.gov/iris>.

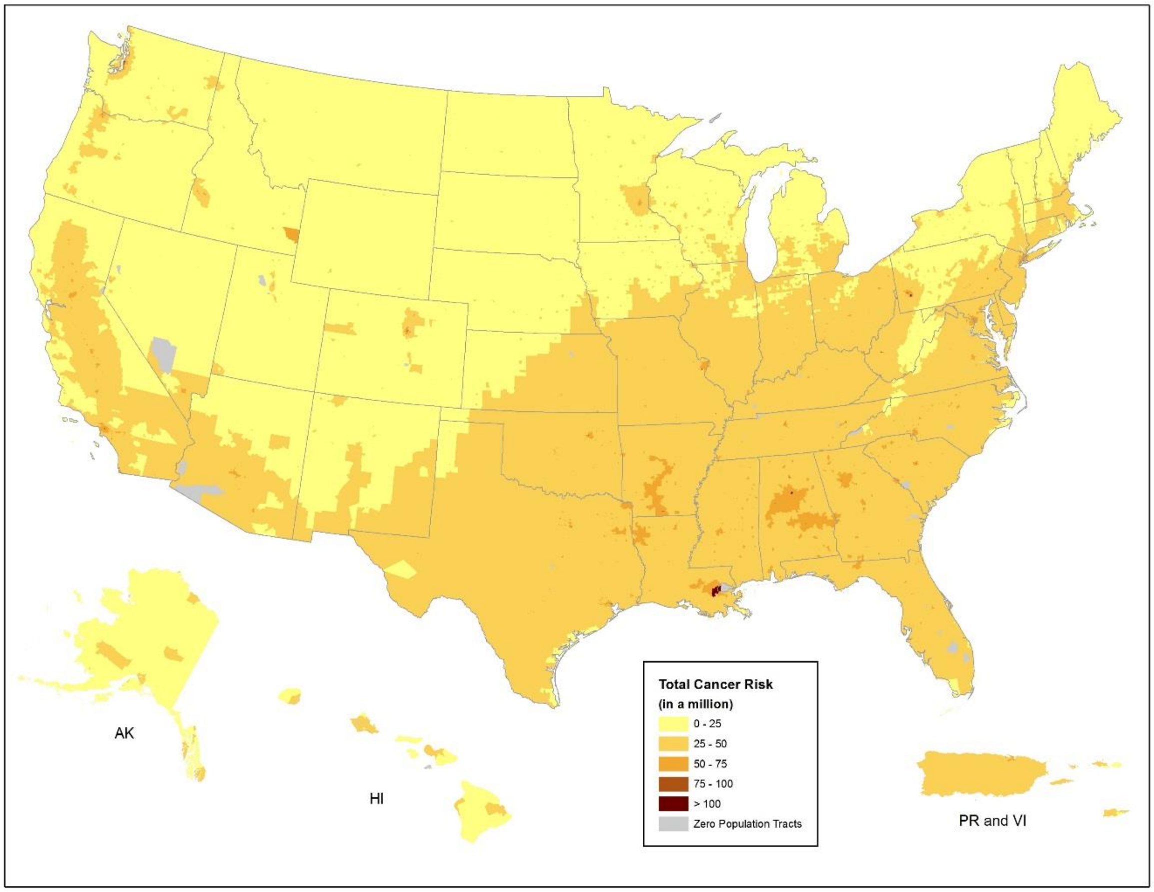

Figure 3-1 2011 NATA Model Estimated Census Tract Carcinogenic Risk from HAP Exposure from All Outdoor Sources based on the 2011 National Emissions Inventory

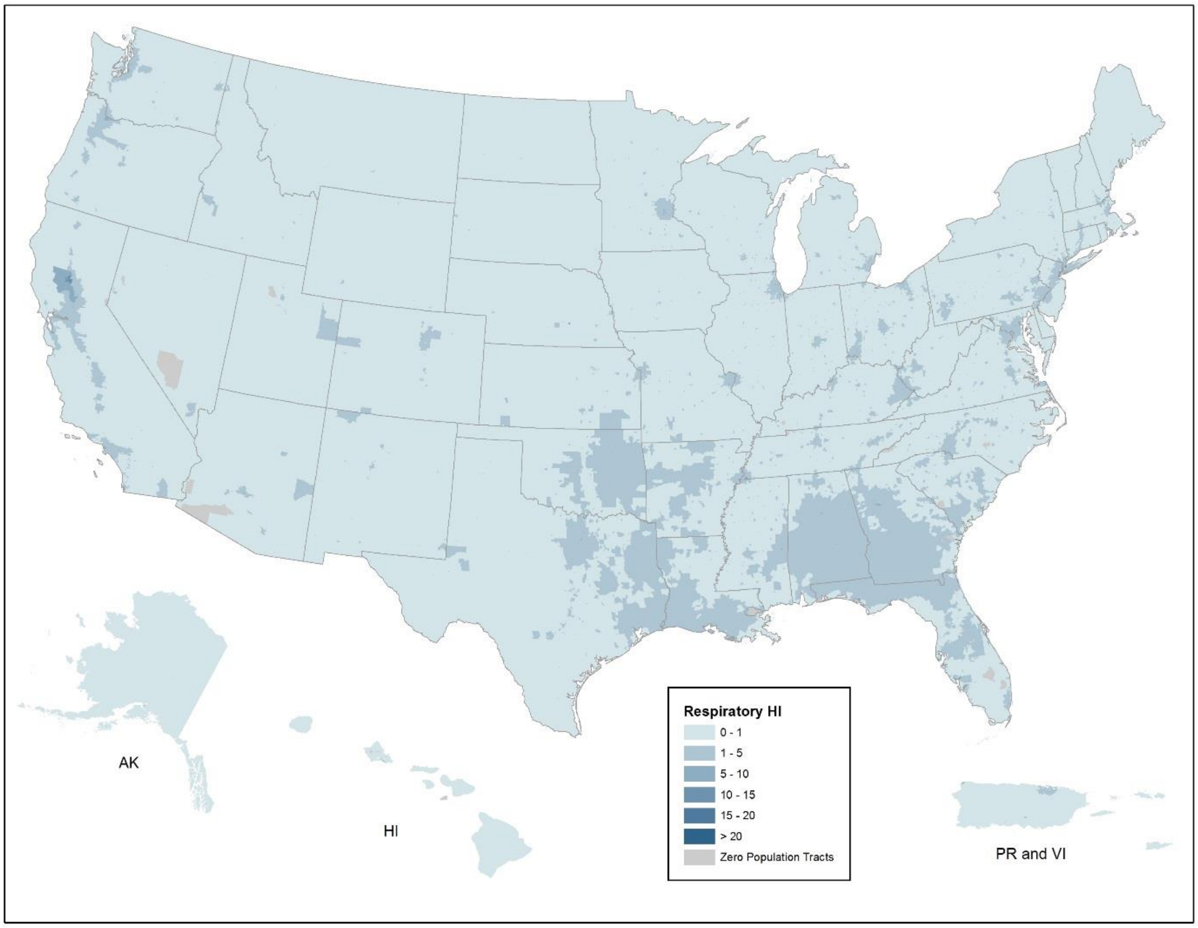

Figure 3-2 2011 NATA Model Estimated Census Tract Noncancer (Respiratory) Risk from HAP Exposure from All Outdoor Sources based on the 2011 National Emissions Inventory

Due to methodology and data limitations, we were unable to estimate the forgone benefits associated with the hazardous air pollutant emissions that would be forgone as a result of this rule. In a few previous analyses of the benefits of reductions in HAP, EPA has quantified the benefits of potential reductions in the incidences of cancer and noncancer risk (e.g., U.S. EPA, 1995). In those analyses, EPA relied on unit risk factors (URF) and reference concentrations (RfC) developed through risk assessment procedures. The URF is a quantitative estimate of the carcinogenic potency of a pollutant, often expressed as the probability of contracting cancer from a 70-year lifetime continuous exposure to a concentration of one $\mu g/m^3$ of a pollutant. These URFs are designed to be conservative, and as such, are more likely to represent the high end of the distribution of risk rather than a best or most likely estimate of risk. An RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious noncancer health effects during a lifetime. As the purpose of a forgone benefit analysis is to describe the benefits most likely to result from a forgone reduction in pollution, use of high-end, conservative risk estimates would overestimate the forgone benefits of the regulation. While we used high-end risk estimates in past analyses, advice from EPA's Science Advisory Board (SAB) recommended that we avoid using high-end estimates in benefit analyses (U.S. EPA-SAB, 2002). Since that time, EPA has continued to develop better methods for analyzing the benefits of reductions in HAP.

As part of the second prospective analysis of the benefits and costs of the Clean Air Act (U.S. EPA, 2011a), EPA conducted a case study analysis of the health effects associated with reducing exposure to benzene in Houston from implementation of the Clean Air Act (IEc, 2009). While reviewing the draft report, EPA's Advisory Council on Clean Air Compliance Analysis concluded that "the challenges for assessing progress in health improvement as a result of reductions in emissions of hazardous air pollutants (HAP) are daunting...due to a lack of exposure-response functions, uncertainties in emissions inventories and background levels, the difficulty of extrapolating risk estimates to low doses and the challenges of tracking health progress for diseases, such as cancer, that have long latency periods" (U.S. EPA-SAB, 2008).

In 2009, EPA convened a workshop to address the inherent complexities, limitations, and uncertainties in current methods to quantify the benefits of reducing HAP. Recommendations from this workshop included identifying research priorities, focusing on susceptible and vulnerable populations, and improving dose-response relationships (Gwinn *et al.*, 2011).

In summary, monetization of the forgone benefits of reductions in cancer incidences requires several important inputs, including central estimates of cancer risks, estimates of exposure to carcinogenic HAP, and estimates of the value of an avoided case of cancer (fatal and non-fatal). Due to methodology and data limitations, we did not attempt to monetize the forgone health benefits of forgone reductions in HAP in this analysis. Instead, we are providing a qualitative analysis of the health effects associated with the HAP anticipated to be forgone by this rule. EPA remains committed to improving methods for estimating HAP benefits by continuing to explore additional concepts of benefits, including changes in the distribution of risk.

Available emissions data show that several different HAP are emitted from oil and natural gas operations, either from equipment leaks, processing, compressing, transmission and distribution, or storage tanks. Emissions of eight HAP make up a large percentage of the total HAP emissions by mass from the oil and natural gas sector: toluene, hexane, benzene, xylenes (mixed), ethylene glycol, methanol, ethyl benzene, and 2,2,4-trimethylpentane (U.S. EPA, 2012a). In the subsequent sections, we describe the health effects associated with the main HAP of concern from the oil and natural gas sector: benzene, toluene, carbonyl sulfide, ethyl benzene, mixed xylenes, and n-hexane. This rule is anticipated to result an increase of a total of 3,800 tons of HAP emissions over 2019 through 2025. With the data available, it was not possible to estimate the change in emissions of each individual HAP.

3.6.1 Benzene

EPA's IRIS database lists benzene as a known human carcinogen (causing leukemia) by all routes of exposure, and concludes that exposure is associated with additional health effects, including genetic changes in both humans and animals and increased proliferation of bone marrow cells in mice.[53,54,55] EPA states in its IRIS database that data indicate a causal relationship between benzene exposure and acute lymphocytic leukemia and suggest a relationship between benzene exposure and chronic non-lymphocytic leukemia and chronic lymphocytic leukemia. The International Agency for Research on Carcinogens (IARC) has determined that benzene is a human carcinogen and the U.S. Department of Health and Human

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[53] U.S. Environmental Protection Agency (U.S. EPA). 2000. Integrated Risk Information System File for Benzene. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at: <http://www.epa.gov/iris/subst/0276.htm>.

[54] International Agency for Research on Cancer, IARC monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 29, Some industrial chemicals and dyestuffs, International Agency for Research on Cancer, World Health Organization, Lyon, France, p. 345-389, 1982.

[55] Irons, R.D.; Stillman, W.S.; Colagiovanni, D.B.; Henry, V.A. (1992) Synergistic action of the benzene metabolite hydroquinone on myelopoietic stimulating activity of granulocyte/macrophage colony-stimulating factor in vitro, Proc. Natl. Acad. Sci. 89:3691-3695.

Services has characterized benzene as a known human carcinogen.[56,57] A number of adverse noncancer health effects including blood disorders, such as preleukemia and aplastic anemia, have also been associated with long-term exposure to benzene.[58,59]

3.6.2 Toluene[60]

Under the 2005 Guidelines for Carcinogen Risk Assessment, there is inadequate information to assess the carcinogenic potential of toluene because studies of humans chronically exposed to toluene are inconclusive, toluene was not carcinogenic in adequate inhalation cancer bioassays of rats and mice exposed for life, and increased incidences of mammary cancer and leukemia were reported in a lifetime rat oral bioassay.

The central nervous system (CNS) is the primary target for toluene toxicity in both humans and animals for acute and chronic exposures. CNS dysfunction (which is often reversible) and narcosis have been frequently observed in humans acutely exposed to low or moderate levels of toluene by inhalation: symptoms include fatigue, sleepiness, headaches, and nausea. Central nervous system depression has been reported to occur in chronic abusers exposed to high levels of toluene. Symptoms include ataxia, tremors, cerebral atrophy, nystagmus (involuntary eye movements), and impaired speech, hearing, and vision. Chronic inhalation exposure of humans to toluene also causes irritation of the upper respiratory tract, eye irritation, dizziness, headaches, and difficulty with sleep.

Human studies have also reported developmental effects, such as CNS dysfunction, attention deficits, and minor craniofacial and limb anomalies, in the children of women who abused toluene during pregnancy. A substantial database examining the effects of toluene in

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56 International Agency for Research on Cancer (IARC). 1987. Monographs on the evaluation of carcinogenic risk of chemicals to humans, Volume 29, Supplement 7, Some industrial chemicals and dyestuffs, World Health Organization, Lyon, France.

57 U.S. Department of Health and Human Services National Toxicology Program 11th Report on Carcinogens available at: <http://ntp.niehs.nih.gov/go/16183>.

58 Aksoy, M. (1989). Hematotoxicity and carcinogenicity of benzene. Environ. Health Perspect. 82: 193-197.

59 Goldstein, B.D. (1988). Benzene toxicity. Occupational medicine. State of the Art Reviews. 3: 541-554.

60 All health effects language for this section came from: U.S. EPA. 2005. "Full IRIS Summary for Toluene (CASRN 108-88-3)" Environmental Protection Agency, Integrated Risk Information System (IRIS), Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH. Available on the Internet at <http://www.epa.gov/iris/subst/0118.htm>.

subchronic and chronic occupationally exposed humans exists. The weight of evidence from these studies indicates neurological effects (i.e., impaired color vision, impaired hearing, decreased performance in neurobehavioral analysis, changes in motor and sensory nerve conduction velocity, headache, and dizziness) as the most sensitive endpoint.

3.6.3 Carbonyl Sulfide

Limited information is available on the health effects of carbonyl sulfide. Acute (short-term) inhalation of high concentrations of carbonyl sulfide may cause narcotic effects and irritate the eyes and skin in humans.[61] No information is available on the chronic (long-term), reproductive, developmental, or carcinogenic effects of carbonyl sulfide in humans. Carbonyl sulfide has not undergone a complete evaluation and determination under U.S. EPA's IRIS program for evidence of human carcinogenic potential.[62]

3.6.4 Ethylbenzene

Ethylbenzene is a major industrial chemical produced by alkylation of benzene. The pure chemical is used almost exclusively for styrene production. It is also a constituent of crude petroleum and is found in gasoline and diesel fuels. Acute (short-term) exposure to ethylbenzene in humans results in respiratory effects such as throat irritation and chest constriction, and irritation of the eyes, and neurological effects such as dizziness. Chronic (long-term) exposure of humans to ethylbenzene may cause eye and lung irritation, with possible adverse effects on the blood. Animal studies have reported effects on the blood, liver, and kidneys and endocrine system from chronic inhalation exposure to ethylbenzene. No information is available on the developmental or reproductive effects of ethylbenzene in humans, but animal studies have reported developmental effects, including birth defects in animals exposed via inhalation. Studies in rodents reported increases in the percentage of animals with tumors of the nasal and oral

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[61] Hazardous Substances Data Bank (HSDB), online database. US National Library of Medicine, Toxicology Data Network, available online at http://toxnet.nlm.nih.gov/. Carbonyl health effects summary available at <http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@rn+@rel+463-58-1>.

[62] U.S. Environmental Protection Agency (U.S. EPA). 2000. Integrated Risk Information System File for Carbonyl Sulfide. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at <http://www.epa.gov/iris/subst/0617.htm>.

cavities in male and female rats exposed to ethylbenzene via the oral route.[63,64] The reports of these studies lacked detailed information on the incidence of specific tumors, statistical analysis, survival data, and information on historical controls, thus the results of these studies were considered inconclusive by the International Agency for Research on Cancer (IARC, 2000) and the National Toxicology Program (NTP).[65,66] The NTP (1999) carried out a chronic inhalation bioassay in mice and rats and found clear evidence of carcinogenic activity in male rats and some evidence in female rats, based on increased incidences of renal tubule adenoma or carcinoma in male rats and renal tubule adenoma in females. NTP (1999) also noted increases in the incidence of testicular adenoma in male rats. Increased incidences of lung alveolar/bronchiolar adenoma or carcinoma were observed in male mice and liver hepatocellular adenoma or carcinoma in female mice, which provided some evidence of carcinogenic activity in male and female mice (NTP, 1999). IARC (2000) classified ethylbenzene as Group 2B, possibly carcinogenic to humans, based on the NTP studies.

3.6.5 Mixed Xylenes

Short-term inhalation of mixed xylenes (a mixture of three closely-related compounds) in humans may cause irritation of the nose and throat, nausea, vomiting, gastric irritation, mild transient eye irritation, and neurological effects.[67] Other reported effects include labored breathing, heart palpitation, impaired function of the lungs, and possible effects in the liver and kidneys.[68] Long-term inhalation exposure to xylenes in humans has been associated with a

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[63] Maltoni C, Conti B, Giuliano C and Belpoggi F, 1985. Experimental studies on benzene carcinogenicity at the Bologna Institute of Oncology: Current results and ongoing research. Am J Ind Med 7:415-446.

[64] Maltoni C, Ciliberti A, Pinto C, Soffritti M, Belpoggi F and Menarini L, 1997. Results of long-term experimental carcinogenicity studies of the effects of gasoline, correlated fuels, and major gasoline aromatics on rats. Annals NY Acad Sci 837:15-52.

[65] International Agency for Research on Cancer (IARC), 2000. Monographs on the Evaluation of Carcinogenic Risks to Humans. Some Industrial Chemicals. Vol. 77, p. 227-266. IARC, Lyon, France.

[66] National Toxicology Program (NTP), 1999. Toxicology and Carcinogenesis Studies of Ethylbenzene (CAS No. 100-41-4) in F344/N Rats and in B6C3F1 Mice (Inhalation Studies). Technical Report Series No. 466. NIH Publication No. 99-3956. U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health. NTP, Research Triangle Park, NC.

[67] U.S. Environmental Protection Agency (U.S. EPA). 2003. Integrated Risk Information System File for Mixed Xylenes. Research and Development, National Center for Environmental Assessment, Washington, DC. This material is available electronically at <http://www.epa.gov/iris/subst/0270.htm>.

[68] Agency for Toxic Substances and Disease Registry (ATSDR), 2007. The Toxicological Profile for xylene is available electronically at <http://www.atsdr.cdc.gov/ToxProfiles/TP.asp?id=296&tid=53>.

number of effects in the nervous system including headaches, dizziness, fatigue, tremors, and impaired motor coordination.[69] EPA has classified mixed xylenes in Category D, not classifiable with respect to human carcinogenicity.

3.6.6 n-Hexane

The studies available in both humans and animals indicate that the nervous system is the primary target of toxicity upon exposure of n-hexane via inhalation. There are no data in humans and very limited information in animals about the potential effects of n-hexane via the oral route. Acute (short-term) inhalation exposure of humans to high levels of hexane causes mild central nervous system effects, including dizziness, giddiness, slight nausea, and headache. Chronic (long-term) exposure to hexane in air causes numbness in the extremities, muscular weakness, blurred vision, headache, and fatigue. Inhalation studies in rodents have reported behavioral effects, neurophysiological changes and neuropathological effects upon inhalation exposure to n-hexane. Under the Guidelines for Carcinogen Risk Assessment (U.S. EPA, 2005), the database for n-hexane is considered inadequate to assess human carcinogenic potential, therefore EPA has classified hexane in Group D, not classifiable as to human carcinogenicity.[70]

3.6.7 Other Air Toxics

In addition to the compounds described above, other toxic compounds might be affected by this rule, including hydrogen sulfide (H_2S). Information regarding the health effects of those compounds can be found in EPA's IRIS database.[71]

3.7 References

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[69] Agency for Toxic Substances and Disease Registry (ATSDR), 2007. The Toxicological Profile for xylene is available electronically at <http://www.atsdr.cdc.gov/ToxProfiles/TP.asp?id=296&tid=53>.

[70] U.S. EPA. 2005. Guidelines for Carcinogen Risk Assessment. EPA/630/P-03/001B. Risk Assessment Forum, Washington, DC. March. Available on the Internet at <http://www.epa.gov/ttn/atw/cancer_guidelines_final_3-25-05.pdf>.

[71] U.S. EPA Integrated Risk Information System (IRIS) database is available at: <www.epa.gov/iris>.

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4 ECONOMIC IMPACT ANALYSIS AND DISTRIBUTIONAL ASSESSMENTS

4.1 Introduction

This section includes four sets of discussion for the proposed reconsideration: energy markets impacts, distributional impacts, small business impacts, and employment impacts.

4.2 Energy Markets Impacts

As it is implemented, the 2016 NSPS OOOOa may have impacts on energy production and markets which would be reduced under the proposed reconsideration. The 2016 NSPS RIA used the National Energy Modeling System (NEMS) to estimate the impacts to drilling activity, price, and quantity changes in the production of crude oil and natural gas, and changes in international trade of crude oil and natural gas national energy markets as a result of the 2016 NSPS OOOOa.[72] In that analysis, EPA estimated the following impacts under the final 2016 NSPS OOOOa:

- Natural gas and crude oil drilling levels would decline slightly over the 2020 to 2025 period (by about 0.17 percent for natural gas wells and 0.02 percent for crude oil wells);
- Crude oil production would not change appreciably under the rule, while natural gas production would decline slightly over the 2020 to 2025 period (about 0.03 percent);
- Crude oil wellhead prices for onshore production in the lower 48 states were not estimated to change appreciably over the 2020 to 2025 period, while wellhead natural gas prices for onshore production in the lower 48 states were estimated to increase slightly over the 2020 to 2025 period (about 0.20 percent); and,
- Net imports of natural gas were estimated to increase slightly in 2020 (by about 0.12 percent) and in 2025 (by about 0.11 percent), while net imports of crude oil were not estimated to change appreciably over the 2020 to 2025 period.

As described earlier in this RIA, this proposed reconsideration includes proposing to reduce the stringency of the requirements on a substantial portion of the sources included in the 2016 NSPS OOOOa. The co-proposed Option 3 is expected to lead to total cost savings compared to the 2018 baseline. Relative to the baseline, the EAV of cost savings over the 2019-

[72] See Section 6.2 of the 2016 NSPS RIA

25 timeframe is about $74 million per year without including the forgone value of product recovery (about $8.4 million per year), or $66 million less per year when the forgone value of product recovery is included. As a result, EPA expects that this deregulatory action, if finalized, would partially ameliorate the impacts estimated for the final NSPS in the 2016 NSPS RIA.

4.3 Distributional Impacts

The compliance cost savings and forgone benefits presented above are not expected to be felt uniformly across the population, and may not accrue to the same individuals or communities. OMB recommends including a description of distributional effects, as part of a regulatory analysis, "so that decision makers can properly consider them along with the effects on economic efficiency [i.e., net benefits]. Executive Order 12866 authorizes this approach." (U.S. Office of Management and Budget 2003). Understanding the distribution of the compliance cost savings and forgone benefits can aid in understanding community-level impacts associated with this action.[73] This section discusses the general expectations regarding how compliance cost savings and forgone health benefits might be distributed across the population, relying on a review of recent literature. EPA did not conduct a quantitative assessment of these distributional impacts for the proposed reconsideration, but the qualitative discussion in this section provides a general overview of the types of impacts that could result from this action.

4.3.1 Distributional Aspects of Compliance Cost Savings

The compliance costs associated with an environmental action can impact households by raising the prices of goods and services; the extent of the price increase depends on if and how producers pass-through those costs to consumers. The literature evaluates the distributional effects of introducing a new regulation; as the literature relates to the proposed reconsideration, which is deregulatory, these effects can be interpreted in reverse. Expenditures on energy are usually a larger share of low-income household income than that of other households, and this share falls as income increases. Therefore, policies that increase energy prices have been found

[73] Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, directs agencies to address impacts on minority and low-income populations, particularly those that may be considered disproportionate. EPA developed guidance, both in its *Guidelines for Preparing Economic Analyses* (U.S. EPA 2010) and *Technical Guidance for Assessing Environmental Justice in Regulatory Analyses* (U.S. EPA 2016) to provide recommendations for how to consider distributional impacts of rules on vulnerable populations.

to be regressive, placing a greater burden on lower income households (e.g., Burtraw et al., 2009; Hassett et al., 2009; Williams et al. 2015). However, compliance costs will not be solely passed on in the form of higher energy prices, but also through lower labor earnings and returns to capital in the sector. Changes in employment associated with lower labor earnings can have distributional consequences depending on a number of factors (Section 6.5 discusses employment effects further). Capital income tends to make up a greater proportion of overall income for high income households. As result, the costs passed through to households via lower returns to capital tend to be progressive, placing a greater share of the burden on higher income households in these instances (Rausch et al., 2011; Fullerton et al., 2011).

The ultimate distributional outcome will depend on how changes in energy prices and lower returns to labor and capital propagate through the economy and interact with existing government transfer programs. Some literature using an economy-wide framework finds that the overall distribution of compliance costs could be progressive for some policies due to the changes in capital payments and the expectation that existing government transfer indexed to inflation will offset the burden to lower income households[74] (Fullerton et al., 2011; Blonz et al., 2012). However, others have found the distribution of compliance costs to be regressive due to a dominating effect of changes in energy prices to consumers (Fullerton 2011; Burtraw, et. al., 2009; Williams, et al., 2015). There may also be significant heterogeneity in the costs borne by individuals within income deciles (Rausch et al., 2011; Cronin et al., 2017). Different classifications of households, such as on the basis of lifetime income rather than contemporaneous annual income, may provide notably different results (Fullerton and Metcalf, 2002; Fullerton et al., 2011). Furthermore, there may be important regional differences in the incidence of regulations. There are differences in the composition of goods consumed, regional production methods, the stringency of a rule, as well as the location of affected labor and capital ownership (the latter of which may be foreign-owned) (e.g. Caron et. al 2017; Hassett et al. 2009).

[74] The incidence of government transfer payments (e.g., Social Security) is generally progressive because these payments represent a significant source of income for lower income deciles and only a small source for high income deciles. Government transfer programs are often, implicitly or explicitly, indexed to inflation. For example, Social Security payments and veterans' benefits are adjusted every year to account for changes in prices (i.e., inflation).

4.3.2 Distributional Aspects of the Forgone Health Benefits

This section discusses the distribution of forgone health benefits that result from the proposed reconsideration. EPA guidance directs analysts to first consider the distribution of impacts in the baseline, prior to any regulatory action (see U.S. EPA 2016). Often the baseline incidence of health outcomes is greater among low-income or minority populations due to a variety of factors, including a greater number of pollution sources located where low-income and minority populations live, work and play (Bullard, et al. 2007; United Church of Christ 1987); greater susceptibility to a given exposure due to physiology or other triggers (Akinbami 2012); and pre-existing conditions (Schwartz et al 2011). EPA (2016) then recommends analysts examine the distribution of health outcomes under the policy scenarios being considered. Finally, this can be followed by an examination of the change between the baseline and policy scenario, taking note of whether the action ameliorates or exacerbates any pre-existing disparities.

Because the manner in which the health benefits of a rulemaking are distributed is based on the correlation of housing and work locations to changes in atmospheric concentrations of pollutants, it is difficult to fully know the distributional impacts of a rule. Air dispersion models provide some information on changes in pollution, but it may be difficult to identify the characteristics of populations in those affected areas, as well as to perform local air dispersion modeling nationwide. Furthermore, the overall distribution of health benefits will depend on whether and how any households change their housing location choice in response to air quality changes (Sieg et al., 2004).

4.4 Small Business Impacts

The Regulatory Flexibility Act (RFA; 5 U.S.C. §601 et seq.), as amended by the Small Business Regulatory Enforcement Fairness Act (Public Law No. 104121), provides that whenever an agency publishes a proposed rule, it must prepare and make available an initial regulatory flexibility analysis (IRFA), unless it certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities (5 U.S.C. §605[b]). Small entities include small businesses, small organizations, and small governmental jurisdictions. An IRFA describes the economic impact of the rule on small entities and any significant alternatives to the rule that would accomplish the objectives of the rule while minimizing significant economic impacts on small entities.

An agency may certify that a rule will not have a significant economic impact on a substantial number of small entities if the rule relieves regulatory burden, has no net burden or otherwise has a positive economic effect on the small entities subject to the rule. As described in Section 2 of this RIA, this proposed reconsideration includes proposing to reduce the stringency of the requirements on a substantial portion of the sources included in the 2016 NSPS OOOOa. In addition, the three options being analyzed in this RIA would result in neutral or beneficial effects on the affected facilities, including small businesses. Where changes to the regulation are being proposed, they decrease burden to the industry through direct changes in the requirements (for example, reducing fugitive monitoring frequency at well sites and compressor stations, and excluding well sites without major production and processing equipment from fugitive emissions monitoring), increased clarity of requirements (for example, through more robust definitions), updating of the alternative means of limitation (for example specifying specific state level provisions as equivalent to the provisions being proposed in this reconsideration), and the streamlining of recordkeeping and reporting requirements. Relative to the baseline, the reduction in EAV of costs over the 2019-25 timeframe is about $74 million per year without including the forgone value of product recovery (about $8.4 million per year), or $66 million less per year when the forgone value of product recovery is included. As a result, EPA expects that this deregulatory action, if finalized as proposed, would lessen the impacts estimated for the final NSPS in the 2016 NSPS RIA. We have therefore concluded that this action will relieve regulatory burden for all directly regulated small entities.

4.5 Employment Impacts

In this section, EPA presents a qualitative discussion of the impacts of this rulemaking on employment.[75] E.O. 13777 directs federal agencies to consider a variety of issues regarding the characteristics and impacts of regulations, including the effect of regulations on jobs (Executive Order 13777). Employment impacts of environmental regulations are

[75] The employment analysis in this RIA is part of EPA's ongoing effort to "conduct continuing evaluations of potential loss or shifts of employment which may result from the administration or enforcement of [the Act]" pursuant to CAA section 321(a).

composed of a mix of potential declines and gains in different areas of the economy over time. Regulatory employment impacts can vary across occupations, regions, and industries; by labor demand and supply elasticities; and in response to other labor market conditions. Isolating such impacts is a challenge, as they are difficult to disentangle from employment impacts caused by a wide variety of ongoing, concurrent economic changes.

Environmental regulation "typically affects the distribution of employment among industries rather than the general employment level" (Arrow *et. al.* 1996). Even if they are mitigated by long-run market adjustments to full employment, many regulatory actions have transitional effects in the short run (OMB 2015). These movements of workers in and out of jobs in response to environmental regulation are potentially important distributional impacts of interest to policy makers. Transitional job losses experienced by workers operating in declining industries, exhibiting low migration rates, or living in communities or regions where unemployment rates are high are of particular concern.

A discussion of partial employment impacts for affected entities in the oil and gas industry was completed in the 2016 NSPS RIA using detailed engineering information on labor requirements for each of the control strategies identified in the rule.[76] These bottom-up, engineering-based estimates represented only one portion of potential employment impacts within the regulated industry, and did not represent estimates of the *net* employment impacts of the rule. Labor changes may be required as part of an initial effort to comply with a regulation or required as a continuous or annual effort to maintain compliance. In the 2016 analysis, EPA estimated up-front and continual annual labor requirements by estimating hours of labor required and converting this number to full-time equivalents (FTEs) by dividing by 2,080 (40 hours per week multiplied by 52 weeks). Overall, the 2016 NSPS OOOOa estimated the one-time labor requirement for the affected sector to be about 270 FTEs in 2020 and 2025, and the annual labor requirement was estimated to be about 1,100 FTEs in 2020 and 1,800 FTEs in 2025. Due to data and methodology limitations, other potential employment impacts in the affected industry and impacts in related industries were not estimated.

As the proposed reconsideration is likely to cause little change in oil and natural gas

[76] EPA did not estimate the labor required to perform the professional engineer certification requirements in the 2016 NSPS OOOOa.

exploration and production, and many aspects of the 2016 NSPS OOOOa requirements are not affected by the proposed reconsideration, demand for labor employed in exploration and production and associated industries is unlikely to change greatly. For the affected oil and natural gas entities, some reductions in labor from 2016 NSPS OOOOa related requirements may be expected under the proposed reconsideration. For the proposed reconsideration, EPA expects there will be slight reductions in the labor required for compliance-related activities associated with the 2016 NSPS OOOOa requirements relating to fugitive emissions and inspections of closed vent systems. However, due to uncertainties associated with how the proposed reconsideration will influence the portfolio of activities associated with fugitive emissions-related requirements, EPA is unable to provide quantitative estimates of compliance-related labor changes. EPA continues to explore the relevant theoretical and empirical literature and to seek public comments in order to ensure that the way EPA characterizes the employment effects of its regulations is valid and informative.

5 COMPARISON OF BENEFITS AND COSTS

5.1 Comparison of Benefits and Costs Across Regulatory Options

In this section, we present a comparison of the benefits and costs of this regulation. To be more consistent with traditional net benefits analysis, we modify the relevant terminology in the following tables, which present the costs, benefits and net benefits for this proposed action across regulatory options. In this section, we refer to the cost savings as presented in section 2 as the "benefits" of this proposed action and the forgone benefits as presented in section 3 as the "costs" of this proposed action. The net benefits are the benefits (cost savings) minus the costs (forgone benefits). As explained in the previous sections, all costs and benefits outlined in this RIA are estimated as the change from the updated baseline.

All benefits, costs, and net benefits shown in this section are presented as the PV of the costs and benefits of each option from 2019 through 2025 discounted back to 2016 under both a 7 percent and a 3 percent discount rate, and their associated EAV.

Table 5-1 shows the estimated benefits, costs and net benefits for Option 1, the most stringent option. Option 1 is associated with a decrease in costs due to in-house certifications compared to all certifications being performed by a professional engineer. There are no forgone benefits associated with this action. Therefore, the net benefits stem entirely from the cost savings (or benefits as presented in the table). The net benefits from this option are the smallest compared to Options 2 and 3.

Table 5-1 Summary of the Present Value (PV) and Equivalent Annualized Value (EAV) of Forgone Monetized Benefits, Cost Savings, and Net Benefits for Option 1 from 2019 through 2025 (millions, 2016$)

	7%		3%	
	PV	**EAV**	**PV**	**EAV**
Benefits (Total Cost Savings)	$17	$2.9	$21	$3.3
Cost Savings	*$17*	*$2.9*	*$21*	*$3.3*
Forgone Value of Product Recovery	*$0*	*$0*	*$0*	*$0*
Costs (Forgone Domestic Climate Benefits)[1]	$0	$0	$0	$0
Net Benefits[2]	$17	$2.9	$21	$3.3

[1] The forgone benefits estimates are calculated using estimates of the social cost of methane (SC-CH_4). SC-CH_4 values represent only a partial accounting of domestic climate impacts from methane emissions. This option is unlikely to affect emissions, therefore there are no monetized forgone benefits as a result of this option.
[2] Estimates may not sum due to independent rounding.

Table 5-2 shows the estimated benefits, costs and net benefits for Option 2. Option 2 results in net benefits greater than those of Option 1, but less than those of Option 3. In this option, we estimate the impact of in-house certifications, a step down in the fugitives monitoring frequency for all non-low production well sites to annual after two years, and an immediate reduction in monitoring frequency to annual for all low production well sites and all compressor stations on the Alaskan North Slope. The benefits (cost savings) are moderated by a decrease in the value of product recovery producers would have received under the 2016 NSPS OOOOa.

Table 5-2 Summary of the Present Value (PV) and Equivalent Annualized Value (EAV) of Forgone Monetized Benefits, Cost Savings, and Net Benefits for Option 2 from 2019 through 2025 (millions, 2016$)

	7%		3%	
	PV	**EAV**	**PV**	**EAV**
Benefits (Total Cost Savings)	$209	$36	$265	$41
Cost Savings	*$234*	*$41*	*$299*	*$47*
Forgone Value of Product Recovery	*$26*	*$4.5*	*$33*	*$5.2*
Costs (Forgone Domestic Climate Benefits)[1]	$7.2	$1.2	$28	$4.4
Net Benefits[2]	$201	$35	$237	$37

[1] [1] The forgone benefits estimates are calculated using estimates of the social cost of methane (SC-CH_4). SC-CH_4 values represent only a partial accounting of domestic climate impacts from methane emissions. See Section 3.3 for more discussion.
[2] Estimates may not sum due to independent rounding.

Table 5-3 shows the estimated benefits, costs and net benefits for Option 3. Option 3 results in the greatest cost savings, forgone benefits, and net benefits of the three options analyzed. Under Option 3, fugitive emissions monitoring frequency is annual at non-low production well sites not on the Alaskan North Slope, biennial at all low production well sites not on the Alaskan North Slope, and annual at all well sites and compressor stations on the Alaskan North slope. Fugitive emissions monitoring frequency at compressor stations not on the Alaskan North Slope is reduced from quarterly to semiannual.

Table 5-3 Summary of the Present Value (PV) and Equivalent Annualized Value (EAV) of Forgone Monetized Benefits, Cost Savings, and Net Benefits for the Co-Proposed Option 3 from 2019 through 2025 (millions, 2016$)

	7%		3%	
	PV	**EAV**	**PV**	**EAV**
Benefits (Total Cost Savings)	$380	$66	$484	$75
Cost Savings	*$429*	*$74*	*$546*	*$85*
Forgone Value of Product Recovery	*$48*	*$8.4*	*$62*	*$9.6*
Costs (Forgone Domestic Climate Benefits)[1]	$13.5	$2.3	$54	$8.3
Net Benefits[2]	$367	$64	$431	$67

[1] [1] The forgone benefits estimates are calculated using estimates of the social cost of methane (SC-CH_4). SC-CH_4 values represent only a partial accounting of domestic climate impacts from methane emissions. See Section 3.3 for more discussion.
[2] Estimates may not sum due to independent rounding.

Table 5-4 provides a summary of the direct increase in emissions for each regulatory option. As explained in section 3, there are no changes in emissions estimated as a result of Option 1. Option 2 results in an increase in emissions compared to both option 1, and the updated baseline. Option 3 results in the greatest increase in emissions compared to the baseline.

Table 5-4 Summary of Total Emissions Increases across Options, 2019 through 2025

Pollutant	**Option 1**	**Option 2**	**Option 3 (Co-Proposed)**
Methane (short tons)	0	200,000	380,000
VOC (short tons)	0	56,000	100,000
HAP (short tons)	0	2,100	3,800
Methane (metric tons)	0	180,000	340,000
Methane (million metric tons CO_2 Eq.)	0	4.5	8.5

5.2 Uncertainties and Limitations

Throughout the RIA, we considered a number of sources of uncertainty, both quantitatively and qualitatively, regarding emissions increases, forgone benefits, and cost savings of the proposed rule. We summarize the key elements of our discussions of uncertainty here:

- **Projection methods and assumptions:** As discussed in Section 2.4.2, over time, more facilities are newly established or modified in each year, and to the extent the facilities remain in operation in future years, the total number of facilities subject to the NSPS accumulates. The impacts of this rule are based on projections and growth rates consistent with the drilling activity in the 2018 Annual Energy Outlook. To the extent actual drilling activities diverge from the Annual Energy Outlook projections, the projected regulatory impacts estimated in this document will diverge. In addition, we assume one hundred percent compliance with the rule, starting from when the source becomes affected. If sources are not complying with the rule, at all or as written, the cost savings may be overestimated.
- **Years of analysis:** The years of analysis are 2019, to represent the first-year facilities are affected by this reconsideration, through 2025, to represent impacts of the rule over a longer period, as discussed in Section 2.4.2. While it is desirable to analyze impacts beyond 2025, in this RIA EPA has chosen not to do this largely because of the limited information available on the turnover rate of emissions sources and controls. Extending the analysis beyond 2025 would introduce substantial and increasing uncertainties in projected impacts of the proposed regulation.
- **State regulations in baseline:** In preparing the impacts analysis, EPA reviewed state regulations and permitting requirements, as discussed in Section 2.4.2. Applicable facilities in states with similar requirements to the proposed reconsideration are not included in the estimates of incrementally affected facilities presented in the RIA. This means that any additional costs and benefits incurred by facilities in these states to comply with the federal standards beyond the state requirements are not reflected in this RIA.
- **Wellhead natural gas prices used to estimate forgone revenues from natural gas recovery:** The compliance cost savings estimates presented in this RIA include the

forgone revenue associated with the decrease in natural gas recovery resulting from the decrease in emissions reductions. As a result, the national compliance cost savings depends on the price of natural gas. Natural gas prices used in this analysis are from the projection of the Henry Hub price in the 2018 AEO. To the extent actual natural gas prices diverge from the AEO projections, the projected regulatory impacts estimated in this document will diverge.

- **Monetized forgone methane-related climate benefits:** EPA considered the uncertainty associated with the social cost of methane (SC-CH_4) estimates, which were used to calculate the forgone domestic social benefits of the increase in methane emissions expected as a result of this reconsideration. Some uncertainties are captured within the analysis, while other areas of uncertainty have not yet been quantified in a way that can be modeled. Chapter 3 and the accompanying Appendix provides a detailed discussion of the ways in which the modeling underlying the development of the SC-CH_4 estimates used in this analysis addresses quantified sources of uncertainty, and presents a sensitivity analysis to show consideration of the uncertainty surrounding discount rates over long time horizons.
- **Non-monetized forgone benefits:** Numerous categories of forgone health, welfare, and climate benefits are not quantified and monetized in this RIA. These unquantified forgone benefits, including forgone benefits from increases in emissions of methane, VOCs and HAP, are described in detail in Chapter 3.

A. APPENDIX: UNCERTAINTY ASSOCIATED WITH ESTIMATING THE SOCIAL COST OF METHANE

A.1 Overview of Methodology Used to Develop Interim Domestic SC-CH_4 Estimates

The domestic SC-CH_4 estimates rely on the same ensemble of three integrated assessment models (IAMs) that were used to develop the IWG global SC-CH_4 (and SC-CO_2) estimates: DICE 2010, FUND 3.8, and PAGE 2009.[77] The three IAMs translate emissions into changes in atmospheric greenhouse concentrations, atmospheric concentrations into changes in temperature, and changes in temperature into economic damages. The emissions projections used in the models are based on specified socio-economic (GDP and population) pathways. These emissions are translated into atmospheric concentrations, and concentrations are translated into warming based on each model's simplified representation of the climate and a key parameter, equilibrium climate sensitivity. The effect of these Earth system changes is then translated into consumption-equivalent economic damages. As in the IWG exercise, these key inputs were harmonized across the three models: a probability distribution for equilibrium climate sensitivity; five scenarios for economic, population, and emissions growth; and discount rates.[78] All other model features were left unchanged. Future damages are discounted using constant discount rates of both 3 and 7 percent, as recommended by OMB Circular A-4.

The domestic share of the global SC-CH_4—i.e., an approximation of the climate change impacts that occur within U.S. borders[79]—is calculated directly in both FUND and PAGE. However, DICE 2010 generates only global estimates. Therefore, EPA approximates U.S. damages as 10 percent of the global values from the DICE model runs, based on the results from a regionalized version of the model (RICE 2010) reported in Table 2 of Nordhaus (2017).[80] Although the regional shares reported in Nordhaus (2017) are specific to SC-CO_2, they still

[77] The full models names are as follows: Dynamic Integrated Climate and Economy (DICE); Climate Framework for Uncertainty, Negotiation, and Distribution (FUND); and Policy Analysis of the Greenhouse Gas Effect (PAGE).

[78] See the IWG's summary of its methodology in the docket, document ID number EPA-HQ-OAR-2015-0827-5886, "Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide (August 2016)". See also National Academies (2017) for a detailed discussion of each of these modeling assumptions.

[79] Note that inside the U.S. borders is not the same as accruing to U.S. citizens, which may be higher or lower.

[80] Nordhaus, William D. 2017. Revisiting the social cost of carbon. *Proceedings of the National Academy of Sciences of the United States,* 114(7): 1518-1523.

provide a reasonable interim approach for approximating the U.S. share of marginal damages from methane emissions. Direct transfer of the domestic share from the SC-CO_2 may understate the U.S. share of the IWG global SC-CH_4 estimates based on DICE due to the combination of three factors: a) regional damage estimates are known to be highly correlated with output shares (Nordhaus 2017, 2014), b) the U.S. share of global output decreases over time in all five EMF-22 based socioeconomic scenarios used for the model runs, and c) the bulk of the temperature anomaly (and hence, resulting damages) from a perturbation in emissions in a given year will be experienced earlier for CH_4 than CO_2 due to the shorter lifetime of CH_4 relative to CO_2.

The steps involved in estimating the social cost of CH_4 are similar to that of CO_2. The three integrated assessment models (FUND, DICE, and PAGE) are run using the harmonized equilibrium climate sensitivity distribution, five socioeconomic and emissions scenarios, constant discount rates described above. Because the climate sensitivity parameter is modeled probabilistically, and because PAGE and FUND incorporate uncertainty in other model parameters, the final output from each model run is a distribution over the SC-CH_4 in year t based on a Monte Carlo simulation of 10,000 runs. For each of the IAMs, the basic computational steps for calculating the social cost estimate in a particular year t are: 1.) calculate the temperature effects and (consumption-equivalent) damages in each year resulting from the baseline path of emissions; 2.) adjust the model to reflect an additional unit of emissions in year t; 3.) recalculate the temperature effects and damages expected in all years beyond t resulting from this adjusted path of emissions, as in step 1; and 4.) subtract the damages computed in step 1 from those in step 3 in each model period and discount the resulting path of marginal damages back to the year of emissions. In PAGE and FUND step 4 focuses on the damages attributed to the US region in the models. As noted above, DICE does not explicitly include a separate US region in the model and therefore, EPA approximates U.S. damages in step 4 as 10 percent of the global values based on the results of Nordhaus (2017). This exercise produces 30 separate distributions of the SC-CH_4 for a given year, the product of 3 models, 2 discount rates, and 5 socioeconomic scenarios. Following the approach used by the IWG, the estimates are equally weighted across models and socioeconomic scenarios in order to consolidate the results into one distribution for each discount rate.

A.2 Treatment of Uncertainty in Interim Domestic SC-CH_4 Estimates

There are various sources of uncertainty in the SC-CH_4 estimates used in this analysis. Some uncertainties pertain to aspects of the natural world, such as quantifying the physical effects of greenhouse gas emissions on Earth systems. Other sources of uncertainty are associated with current and future human behavior and well-being, such as population and economic growth, GHG emissions, the translation of Earth system changes to economic damages, and the role of adaptation. It is important to note that even in the presence of uncertainty, scientific and economic analysis can provide valuable information to the public and decision makers, though the uncertainty should be acknowledged and when possible taken into account in the analysis (National Academies 2013).[81] OMB Circular A-4 also requires a thorough discussion of key sources of uncertainty in the calculation of benefits and costs, including more rigorous quantitative approaches for higher consequence rules. This section summarizes the sources of uncertainty considered in a quantitative manner in the domestic SC-CH_4 estimates.

The domestic SC-CH_4 estimates consider various sources of uncertainty through a combination of a multi-model ensemble, probabilistic analysis, and scenario analysis. We provide a summary of this analysis here; more detailed discussion of each model and the harmonized input assumptions can be found in the 2017 National Academies report. For example, the three IAMs used collectively span a wide range of Earth system and economic outcomes to help reflect the uncertainty in the literature and in the underlying dynamics being modeled. The use of an ensemble of three different models at least partially addresses the fact that no single model includes all of the quantified economic damages. It also helps to reflect structural uncertainty across the models, which stems from uncertainty about the underlying relationships among GHG emissions, Earth systems, and economic damages that are included in the models. Bearing in mind the different limitations of each model and lacking an objective basis upon which to differentially weight the models, the three integrated assessment models are given equal weight in the analysis.

Monte Carlo techniques were used to run the IAMs a large number of times. In each simulation the uncertain parameters are represented by random draws from their defined

[81] Institute of Medicine of the National Academies. 2013. Environmental Decisions in the Face of Uncertainty. The National Academies Press.

probability distributions. In all three models the equilibrium climate sensitivity is treated probabilistically based on the probability distribution from Roe and Baker (2007) calibrated to the IPCC AR4 consensus statement about this key parameter.[82] The equilibrium climate sensitivity is a key parameter in this analysis because it helps define the strength of the climate response to increasing GHG concentrations in the atmosphere. In addition, the FUND and PAGE models define many of their parameters with probability distributions instead of point estimates. For these two models, the model developers' default probability distributions are maintained for all parameters other than those superseded by the harmonized inputs (i.e., equilibrium climate sensitivity, socioeconomic and emissions scenarios, and discount rates). More information on the uncertain parameters in PAGE and FUND is available upon request.

For the socioeconomic and emissions scenarios, uncertainty is included in the analysis by considering a range of scenarios selected from the Stanford Energy Modeling Forum exercise, EMF-22. Given the dearth of information on the likelihood of a full range of future socioeconomic pathways at the time the original modeling was conducted, and without a basis for assigning differential weights to scenarios, the range of uncertainty was reflected by simply weighting each of the five scenarios equally for the consolidated estimates. To better understand how the results vary across scenarios, results of each model run are available in the docket.

The outcome of accounting for various sources of uncertainty using the approaches described above is a frequency distribution of the SC-CH_4 estimates for emissions occurring in a given year for each discount rate. Unlike the approach taken for consolidating results across models and socioeconomic and emissions scenarios, the SC-CH_4 estimates are not pooled across different discount rates because the range of discount rates reflects both uncertainty and, at least in part, different policy or value judgements; uncertainty regarding this key assumption is discussed in more detail below. The frequency distributions reflect the uncertainty around the input parameters for which probability distributions were defined, as well as from the multi-model ensemble and socioeconomic and emissions scenarios where probabilities were implied by the equal weighting assumption. It is important to note that the set of SC-CH_4 estimates obtained from this analysis does not yield a probability distribution that fully characterizes

[82] Specifically, the Roe and Baker distribution for the climate sensitivity parameter was bounded between 0 and 10 with a median of 3 °C and a cumulative probability between 2 and 4.5 °C of two-thirds.

uncertainty about the SC-CH_4 due to impact categories omitted from the models and sources of uncertainty that have not been fully characterized due to data limitations.

Figure 1 presents the frequency distribution of the domestic SC-CH_4 estimates for emissions in 2020 for each discount rate. Each distribution represents 150,000 estimates based on 10,000 simulations for each combination of the three models and five socioeconomic and emissions scenarios.[83] In general, the distributions are skewed to the right and have long right tails, which tend to be longer for lower discount rates. To highlight the difference between the impact of the discount rate on the SC-CH_4 and other quantified sources of uncertainty, the bars below the frequency distributions provide a symmetric representation of quantified variability in the SC-CH_4 estimates conditioned on each discount rate. The full set of SC-CH_4 results through 2050 is available as part of the RIA analysis materials.

[83] Although the distributions in Figure 1 are based on the full set of model results (150,000 estimates for each discount rate), for display purposes the horizontal axis is truncated with 0.001 to 0.013 percent of the estimates lying below the lowest bin displayed and 0.471 to 3.356 percent of the estimates lying above the highest bin displayed, depending on the discount rate.

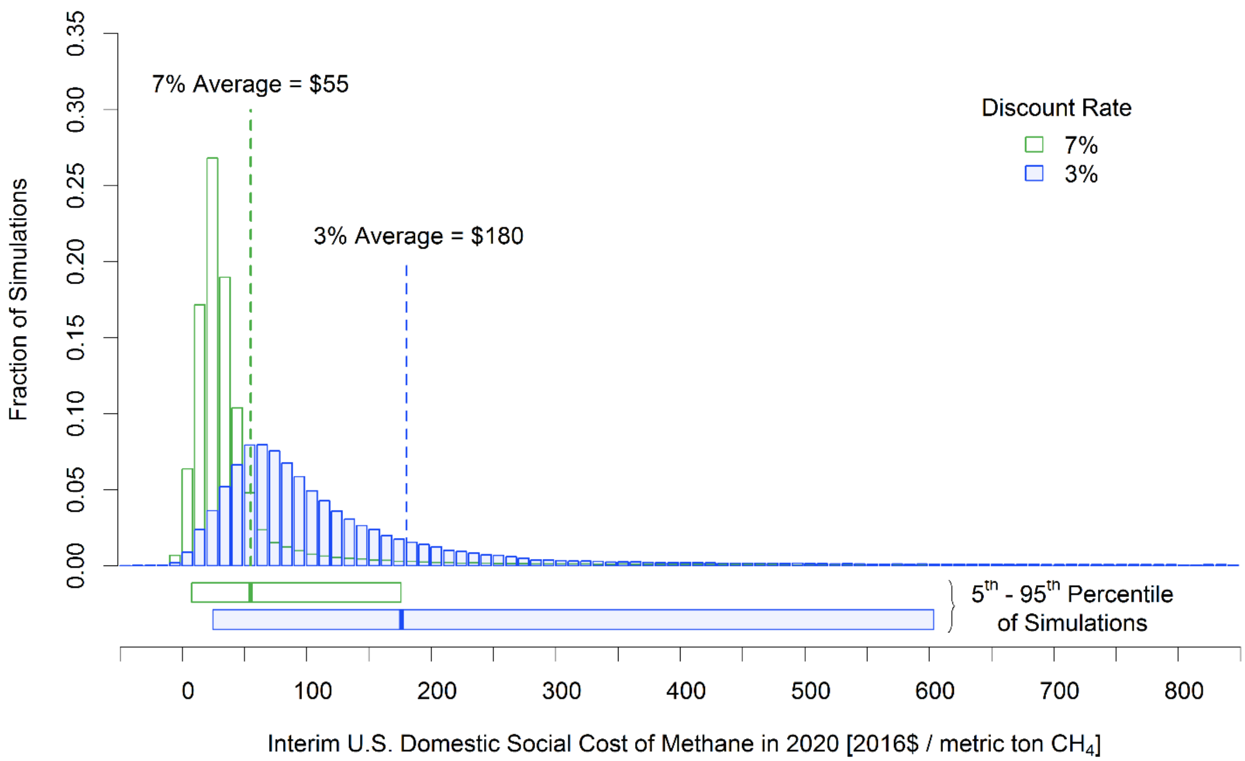

Figure 1. Frequency Distribution of Interim Domestic SC-CH_4 Estimates for 2020 (in 2016$ per metric ton CH_4)

As illustrated by the frequency distributions in Figure 1, the assumed discount rate plays a critical role in the ultimate estimate of the social cost of methane. This is because CH_4 emissions today continue to impact society far out into the future,[84] so with a higher discount rate, costs that accrue to future generations are weighted less, resulting in a lower estimate. Circular A-4 recommends that costs and benefits be discounted using the rates of 3 percent and 7 percent to reflect the opportunity cost of consumption and capital, respectively. Circular A-4 also recommends quantitative sensitivity analysis of key assumptions[85], and offers guidance on what sensitivity analysis can be conducted in cases where a rule will have important intergenerational benefits or costs. To account for ethical considerations of future generations and potential

[84] Although the atmospheric lifetime of CH_4 is notably shorter than that of CO_2, the impacts of changes in contemporary CH_4 emissions are also expected to occur over long time horizons that cover multiple generations. For more discussion, see document ID number EPA-HQ-OAR-2015-0827-5886, "Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide (August 2016)".

[85] "If benefit or cost estimates depend heavily on certain assumptions, you should make those assumptions explicit and carry out sensitivity analyses using plausible alternative assumptions." (OMB 2003, page 42).

uncertainty in the discount rate over long time horizons, Circular A-4 suggests "further sensitivity analysis using a lower but positive discount rate in addition to calculating net benefit using discount rates of 3 and 7 percent" (page 36) and notes that research from the 1990s suggests intergenerational rates "from 1 to 3 percent per annum" (OMB 2003). We consider the uncertainty in this key assumption by calculating the domestic SC-CH_4 based on a 2.5 percent discount rate, in addition to the 3 and 7 percent used in the main analysis. Using a 2.5 percent discount rate, the average domestic SC-CH_4 estimate across all the model runs for emissions occurring in 2019 is $220 per metric ton of CH_4 (2016$)[86]; in this case the forgone domestic climate benefits of the co-proposed Option 3 are $6.3 million in 2019 under a 2.5 percent discount rate. By 2025, the average domestic SC-CH_4 using a 2.5 percent discount rate is $250 per metric ton of CH_4 (2016$), and the corresponding forgone domestic climate benefits of the proposed action increase to $18 million. The PV of the forgone domestic climate benefits under a 2.5 percent discount rate is $69 million, with a corresponding EAV of $11 million per year.

In addition to the approach to accounting for the quantifiable uncertainty described above, the scientific and economics literature has further explored known sources of uncertainty related to estimates of the social cost of carbon and other greenhouse gases. For example, researchers have examined the sensitivity of IAMs and the resulting estimates to different assumptions embedded in the models (see, e.g., Hope 2013, Anthoff and Tol 2013, Nordhaus 2014, and Waldhoff et al. 2011, 2014). However, there remain additional sources of uncertainty that have not been fully characterized and explored due to remaining data limitations. Additional research is needed to expand the quantification of various sources of uncertainty in estimates of the social cost of carbon and other greenhouse gases (e.g., developing explicit probability distributions for more inputs pertaining to climate impacts and their valuation). On the issue of intergenerational discounting, some experts have argued that a declining discount rate would be appropriate to analyze impacts that occur far into the future (Arrow et al., 2013). However, additional research and analysis is still needed to develop a methodology for implementing a declining discount rate and to understand the implications of applying these theoretical lessons in practice. The 2017 National Academies report also provides recommendations pertaining to discounting, emphasizing the need to more explicitly model the uncertainty surrounding discount

[86] The estimates are adjusted for inflation using the GDP implicit price deflator and then rounded to two significant digits.

rates over long time horizons, its connection to uncertainty in economic growth, and, in turn, to climate damages using a Ramsey-like formula (National Academies 2017). These and other research needs are discussed in detail in the 2017 National Academies' recommendations for a comprehensive update to the current methodology, including a more robust incorporation of uncertainty.

A.3 Forgone Global Climate Benefits

In addition to requiring reporting of impacts at a domestic level, OMB Circular A-4 states that when an agency "evaluate[s] a regulation that is likely to have effects beyond the borders of the United States, these effects should be reported separately" (page 15).[87] This guidance is relevant to the valuation of damages from GHGs, given that most GHGs (including CH_4) contribute to damages around the world independent of the country in which they are emitted. Therefore, in this section we present the forgone global climate benefits from this rulemaking using the global SC-CH_4 estimates – i.e., reflecting quantified impacts occurring in both the U.S. and other countries—corresponding to the model runs that generated the domestic SC-CH_4 estimates used in the main analysis. The average global SC-CH_4 estimate across all the model runs for emissions occurring over the years analyzed in this RIA (2019-2025) range from $350 to $450 per metric ton of CH_4 emissions (in 2016 dollars) using a 7 percent discount rate, and $1,300 to $1,600 per metric ton of CH_4 using a 3 percent discount rate.[88] The domestic SC-CH_4 estimates presented above are approximately 15 percent and 13 percent of these global SC-CH_4 estimates for the 7 percent and 3 percent discount rates, respectively. Applying these estimates to the forgone CH_4 emission reductions results in estimated forgone global climate benefits ranging from $10 million in 2019 to $31 million in 2025, using a 7 percent discount rate. The PV of the

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[87] While Circular A-4 does not elaborate on this guidance, the basic argument for adopting a domestic only perspective for the central benefit-cost analysis of domestic policies is based on the fact that the authority to regulate only extends to a nation's own residents who have consented to adhere to the same set of rules and values for collective decision-making, as well as the assumption that most domestic policies will have negligible effects on the welfare of other countries' residents (EPA 2010; Kopp et al. 1997; Whittington et al. 1986). In the context of policies that are expected to result in substantial effects outside of U.S. borders, an active literature has emerged discussing how to appropriately treat these impacts for purposes of domestic policymaking (e.g., Gayer and Viscusi 2016, 2017; Anthoff and Tol, 2010; Fraas et al. 2016; Revesz et al. 2017). This discourse has been primarily focused on the regulation of greenhouse gases (GHGs), for which domestic policies may result in impacts outside of U.S. borders due to the global nature of the pollutants.

[88] The estimates are adjusted for inflation using the GDP implicit price deflator and then rounded to two significant digits.

forgone global climate benefits using a 7 percent discount rate is $89 million, with an associated EAV of $15 million per year. The estimated forgone global climate benefits are $39 million in 2019 and increase to $110 million in 2025 using a 3 percent rate. The PV of the forgone global climate benefits using a 3 percent discount rate is $421 million, with an associated EAV of $66 million per year. Under the sensitivity analysis considered above using a 2.5 percent discount rate, the average global SC-CH_4 estimate across all the model runs for emissions occurring in 2019-2025 ranges from $1,800 to $2,100 per metric ton of CH_4 (2016$). The forgone global climate benefits are estimated to be $52 million in 2019 and $144 million in 2025 using a 2.5 percent discount rate. The PV of the forgone global climate benefits using a 2.5 percent discount rate is $567 million, with an associated EAV of $87 million per year. All estimates are reported in 2016 dollars.

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