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

EPA-452/R-19-001
August 2019

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

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ACKNOWLEDGEMENTS

In addition to U.S. EPA staff from the Office of Air and Radiation, personnel from the U.S. EPA Office of Policy and SC&A contributed data and analysis to this document.

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1 EXECUTIVE SUMMARY

1.1 Background

The action analyzed in this regulatory impact analysis (RIA) accompanies the proposed Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Review. This action proposes regulatory changes based on a review 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 (GHG) emissions and volatile organic compound (VOC) emissions from the oil and natural gas sector. EPA received petitions to reconsider several provisions of the 2016 NSPS OOOOa. In response to those petitions, EPA has finalized one action and proposed a second.

First, 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.[1] These amendments reduce monitoring frequency at NSPS-affected well sites on the Alaskan North Slope from semiannual to annual.

Second, on October 15, 2018, EPA proposed the Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Reconsideration ("technical reconsideration").[2] The technical reconsideration proposed changes to the 2016 NSPS OOOOa addressing specific issues raised in petitions, including changes to fugitive emission requirements, certification requirements and clarifications of definitions, among other issues.

This proposed action is a result of EPA's commitment to review the 2016 NSPS OOOOa rule in response to Executive Order (E.O.) 13783, "Promoting Energy Independence and Economic Growth", issued on March 28, 2017. E.O. 13783 directs agencies to review existing regulations that potentially burden the development of domestic energy resources and

[1] 83 FR 10628
[2] 83 FR 52056

appropriately suspend, revise, or rescind regulations that unduly burden the development of U.S. energy resources beyond what is necessary to protect the public interest or otherwise comply with the law.

This proposed action reviews the inclusion of sources in transmission and storage as part of the source category and the inclusion of greenhouse gases, in the form of methane, as a regulated pollutant in the 2016 NSPS OOOOa. The proposed option of this action rescinds the requirements of the 2016 NSPS OOOOa for sources in the transmission and storage segment. The proposed option also rescinds methane requirements from sources in the production and processing segments, while leaving VOC regulations in place for the production and processing sources. As methane control options are redundant with VOC control options, there are no expected cost or emissions effects from removing the methane requirements in the production and processing segments. The alternative co-proposed option considered in this action is to rescind the methane requirements for all affected sources. There are no expected cost or emissions impacts for the alternative co-proposed option for the same reason as above: methane control options on all sources are redundant with VOC control options.

In this RIA, we present costs and benefits of the proposed action relative to two alternative baselines. As there are no expected cost or emissions impacts for the alternative proposed option, this RIA focuses analysis on the proposed option in which removing sources in transmission and storage will produce cost and emissions impacts. The first baseline for this analysis of the proposal includes the March 2018 final Amendments package and the October 2018 proposed technical reconsideration. The second baseline used in this RIA includes the March 2018 final Amendments package but excludes the potential impacts of the October 2018 proposed technical reconsideration. A more detailed description of the alternative baselines is presented in Section 1.2.2 below.

This RIA estimates impacts for the analysis years 2019 through 2025. All monetized impacts of these changes are presented in 2016 dollars. This analysis also includes a presentation of the impacts in a present value (PV) framework. All sources in the transmission and storage sector that are affected by the 2016 NSPS OOOOa, starting at the promulgation of the 2016 NSPS OOOOa, are sources that are affected by this proposed action.

The projected impacts of the proposed action being analyzed in this RIA pertain specifically to potential new, reconstructed, and modified sources under NSPS OOOOa. EPA recognizes that by rescinding the applicability of the NSPS, issued under CAA section 111(b), to methane emissions, existing sources of the same type in the source category will not be subject to regulation under CAA section 111(d). Analysis of potential impacts of removing the requirement to regulate existing sources under 111(d) is outside the scope of this RIA and would be speculative.

1.2 Summary of Analytical Updates from the Final 2016 NSPS RIA

1.2.1 Summary of Updates Presented in the Technical Reconsideration Proposal RIA

The updates to data, assumption, source counts, projections, and state and local regulations that were made for the technical reconsideration proposal apply to this analysis. These updates were combined with unchanged assumptions and methods from the 2016 NSPS RIA to estimate an updated baseline for the technical reconsideration proposal. The updates and revisions included:

- **Annual Energy Outlook:** In the 2016 NSPS OOOOa, we used the 2015 Annual Energy Outlook (AEO) from the U.S. Energy Information Administration (EIA). For the technical reconsideration RIA, we used the 2018 AEO, published February 2018.[3] 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.[4] The data from the updated GHGI was used in the projection of NSPS-affected sources over time.
- **DrillingInfo:** The technical reconsideration RIA used a more recent version of the DrillingInfo dataset than was used for the 2016 NSPS OOOOa.[5] The DrillingInfo dataset was used to characterize oil and 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. For this

[3] The 2018 AEO can be found at https://www.eia.gov/outlooks/archive/aeo18/

[4] 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.

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

proposed action, EPA reviewed state regulations and permitting requirements. We attempted to take the requirements from California, Colorado, Ohio, Pennsylvania, and Utah into account in the RIA. However, with the information we currently have available, we are unable to determine where newly affected sources in the transmission and storage segments are expected to locate. Applicable facilities in these states with similar requirements will still be expected to follow state regulations, and so this analysis likely overestimates the cost savings from sources in transmission and storage from this proposed action because it includes estimates of incrementally affected facilities with similar state-level requirements to those in the 2016 NSPS OOOOa.

- **Fugitive Emissions Requirements**: Since the promulgation of the 2016 NSPS OOOOa, EPA has published a final package that 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 cost analysis of the 2016 NSPS. In the technical reconsideration proposal, we included the cost of the requirement for professional engineer certifications in the alternative baselines.
- **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, 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 the technical reconsideration proposal RIA, we used 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 changes.
- **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 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 RIA.[6]
- **Other**: In the 2016 NSPS OOOOa, all costs and benefits were presented in 2012 dollars. In the technical reconsideration proposal RIA, all estimated costs were presented in 2016

[6] For more information on the model plants, see the Technical Support Document.

dollars per E.O. 13771 implementation guidance.[7] In addition, in the 2016 NSPS RIA, we presented annualized compliance costs and the benefits resulting from emission reductions occurring in 2020 and 2025. For the technical reconsideration proposal RIA, we estimated cost savings and forgone benefits resulting from changes in compliance activities and emissions occurring in each year from 2019 through 2025.[8] We also discounted the annual cost savings and forgone benefits to 2016, and present total PV and equivalent annualized value (EAV) over the analysis period.

1.2.2 The Alternative Baselines for this RIA

EPA generally only includes final actions in baseline estimates. However, the currently proposed technical reconsideration will likely be promulgated before this action is finalized and will become part of the industry landscape before this action is complete. As such, we believe including the proposed technical reconsideration in the baseline for this action results in a reasonable approximation of what the state of the industry will be at promulgation of this action. As a result, the "2018 Proposed Regulatory" baseline for the analysis of this proposed action assumes the requirements are those that reflect the proposed option of the technical reconsideration. This RIA also presents potential impacts of this action where the technical reconsideration proposal is excluded from the baseline, which we term the "Current Regulatory" baseline.

Compared to the 2016 NSPS RIA analysis, this analysis uses the same projection methodologies with updated data. Note that, although there are states with similar requirements to those of the 2016 NSPS OOOOa, we are unable to account for these requirements in this action.[9] Table 1-1 shows the number of NSPS-affected facilities, methane, VOC, and HAP emission reductions, and the total annualized costs including the value of product recovery in

[7] 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.

[8] 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 continuing through 2025.

[9] For this proposed action and for the technical reconsideration proposal, EPA projected affected facilities using a combination of historical data from the U.S. GHG Inventory, DI Desktop, and projected activity levels taken from the Energy Information Administration Annual Energy Outlook. Because oil and natural gas well locations are identified in DI Desktop, we can forecast well drilling activities by state. As a result, we can estimate the effects of state regulations on future affected facilities that draw upon state-specific information in their projection. However, projections of affected facilities that draw upon the U.S. GHG Inventory, such as sources in the transmission and storage segment, are national-scale and, hence, we are unable to account for state-level regulations in our projected impacts in this proposed RIA. More information on data and methods used to project potentially affected facilities, please see Section 2.3.2.

2020 and in 2025 for the sources in the transmission and storage sector as estimated in the 2016 NSPS RIA and relative to the alternative baselines for this proposed action. After updating facility projections for this analysis, there are likely more potentially affected facilities than we anticipated when performing the analysis for the 2016 NSPS.[10] Consequently, for the subset of 2016 NSPS provisions affected by this proposal, compliance cost and emissions impacts of the 2016 NSPS were likely underestimated in the 2016 NSPS-related analysis. Comparing baselines for this analysis, the Current Regulatory baseline reflects greater emissions reductions and compliance costs than the 2018 Proposed Regulatory baseline since fugitive monitoring requirements are more stringent in the former. The emission reductions presented here are the emission reductions assuming the affected sources were not performing compliance activities prior to the 2016 NSPS OOOOa.

Table 1-1 shows the number of NSPS-affected facilities, methane, VOC, and HAP emission reductions, and the total annualized costs including the value of product recovery in 2020 and in 2025 for the sources in the transmission and storage sector as estimated in the 2016 NSPS RIA and relative to the alternative baselines for this proposed action. After updating facility projections for this analysis, there are likely more potentially affected facilities than we anticipated when performing the analysis for the 2016 NSPS.[11] Consequently, for the subset of 2016 NSPS provisions affected by this proposal, compliance cost and emissions impacts of the 2016 NSPS were likely underestimated in the 2016 NSPS-related analysis. Comparing baselines for this analysis, the Current Regulatory baseline reflects greater emissions reductions and compliance costs than the 2018 Proposed Regulatory baseline since fugitive monitoring requirements are more stringent in the former. The emission reductions presented here are the

[10] Results from the 2016 NSPS RIA are generally not comparable to results in this analysis because they rely on different baselines. The higher count of affected facilities in transmission and storage results from higher growth in the historical period used to estimate new facilities, compared to the historical data used in 2016, which showed very little growth in transmission and storage. In general, projection methods such as are used here to estimate affected facilities in transmission and storage are sensitive to the historical data used. Changes in transmission and storage-related methane, VOC, and HAP emissions shown in Table 1-1 result from changes in the projected facilities, while the unit-level emissions characteristics are the same as in the 2016 analysis.

[11] Results from the 2016 NSPS RIA are generally not comparable to results in this analysis because they rely on different baselines. The higher count of affected facilities in transmission and storage results from higher growth in the historical period used to estimate new facilities, compared to the historical data used in 2016, which showed very little growth in transmission and storage. In general, projection methods such as are used here to estimate affected facilities in transmission and storage are sensitive to the historical data used. Changes in transmission and storage-related methane, VOC, and HAP emissions shown in Table 1-1 result from changes in the projected facilities, while the unit-level emissions characteristics are the same as in the 2016 analysis.

emission reductions assuming the affected sources were not performing compliance activities prior to the 2016 NSPS OOOOa.

Table 1-1 Projected Impacts of the 2016 NSPS OOOOa Transmission and Storage Requirements: Comparison of 2016 NSPS RIA and Alternative Baselines for this Analysis

	2016 NSPS RIA		Relative to the 2018 Proposed Regulatory Baseline[1]		Relative to the Current Regulatory Baseline[2]	
	2020	**2025**	**2020**	**2025**	**2020**	**2025**
NSPS-affected Sources in Transmission and Storage*						
Counts	690	1,400	2,600	4,800	2,600	4,800
Emissions Changes						
Methane Emission Reductions (short tons)	8,900	18,000	37,000	69,000	39,000	72,000
VOC Emission Reductions (tons)	250	490	1,000	1,900	1,100	2,000
HAP Emission Reductions (tons)	7	15	31	56	32	59
Annualized Compliance Costs (millions, 2016$)						
Annualized Compliance Cost (7 percent)	*$2.6*	*$5.3*	*$17*	*$32*	*$20*	*$37*
Product Recovery (millions, 2016$)	*$1.8*	*$3.6*	*$3.7*	*$7.5*	*$4.1*	*$8.2*
Total Annualized Cost, with Product Recovery	$0.81	$1.6	$14	$25	$16	$29

[1] The 2018 Proposed Regulatory baseline reflects updated assumptions and methods made since 2016, the impacts of the March 2018 Amendments final rule, and the requirements of the co-proposed option in the October 2018 technical reconsideration proposed rule that assumed semiannual fugitive emissions monitoring at compressor stations.
[2] The Current Regulatory baseline reflects updated assumptions and methods made since 2016 and the impacts of the March 2018 Amendments final rule.
* For more information on the projection of affected facilities, see Section 2.3.2.

As mentioned above, the 2016 NSPS RIA estimates did not include the cost of professional engineer certification. To be consistent, the estimates presented in Table 1-1 for the alternative baselines of this RIA also exclude the cost of certifications. It should be noted, however, that the assumptions used to estimate the alternative baselines for this analysis have been updated from those used to estimate the 2016 NSPS RIA values, as explained above. In addition, the 2016 NSPS OOOOa costs presented here do not match the cost estimates 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.

1.3 Regulatory Options Analyzed in this RIA

In this RIA, we estimate the effect of rescinding requirements on sources in the transmission and storage sector. We assume that increases in cost savings and emission due to rescinding those regulations are equal to what the costs and emission reductions would be if the requirements remained in place. The universe of affected sources includes all sources in the transmission and storage sector that are considered new or modified starting in 2019, as well as sources that were affected by the 2016 NSPS OOOOa before 2019 and would be complying with the 2016 NSPS OOOOa rule in the absence of this action.

For example, compressor stations in the transmission sector that become NSPS-affected sources in 2016 are also affected sources under this action because they are expected to cease activities related to the fugitive emissions monitoring and repair requirements. However, compressor stations in the gathering and boosting sector are not affected by this action because they are in the production and processing segment and are still required to comply with the semiannual fugitive emissions monitoring and repair requirements. As we assume certifications only happen once, the only affected sources for the purposes of this action are those that are in the transmission and storage sector and that become affected starting in 2019.

Table 1-2 outlines the sources that are affected by this action under the 2016 NSPS OOOOa and as they are relative to the alternative baselines for this analysis. The 2018 Proposed Regulatory baseline includes the sources and controls from the 2016 NSPS OOOOa that have not changed, as well as the updates to the sources and controls as proposed in the technical reconsideration. The differences between the 2018 Proposed Regulatory baseline and the Current Regulatory baseline is related to certifications on closed vent systems on centrifugal and reciprocating compressors and to fugitive emissions monitoring at transportation and storage compressor stations not on the Alaskan North Slope. This is because we currently estimate that there are no affected compressor stations on the Alaskan North Slope.

Table 1-2 Emissions Sources and Controls in the Transmission and Storage Sector

Emissions Point and Control	Relative to the 2018 Proposed Regulatory Baseline	Relative to the Current Regulatory Baseline
Fugitive Emissions - Planning, Monitoring and Maintenance		
Compressor Stations	Semiannual[1]	Quarterly
Compressor Stations on the Alaskan North Slope[2]	Annual	Annual
Pneumatic Controllers – Replace High Bleed with Low Bleed	X	X
Reciprocating Compressors – Replace Rod Packing Every ~3 Years[3]	X	X
Centrifugal Compressors – Route to Control	X	X
Certifications		
Closed Vent Systems on Centrifugal and Reciprocating Compressors and Storage Vessels[4]	In-House Engineer	Professional Engineer

[1] The technical reconsideration co-proposes semiannual and annual fugitive emission monitoring frequency at compressor stations not on the Alaskan North Slope.
[2] We do not currently have the data needed to estimate the effects of the proposed action pertaining to compressors stations on the Alaskan North Slope.
[3] Every 36 months, or 26,000 hours.
[4] We currently estimate that there are no affected storage vessels in the transmission and storage sector.

1.4 Summary of Results

A summary of the key results of this proposed action follow. All dollar estimates are in 2016 dollars. Also, all cost savings and emissions increases are estimated relative to the alternative baselines. These cost savings and emission increases are equal to the total costs and emission reductions that would be incurred if the requirements were left in place.

- **Emissions Analysis:** This proposed action is expected to lead to an increase in emissions compared to the emissions levels in both baselines used in this RIA.
  - ***Relative to the 2018 Proposed Regulatory Baseline****:* annual methane emissions are estimated to increase by between 31,000 short tons per year (in 2019) and 69,000 short tons per year (in 2025) for a total of 350,000 short tons over 2019 through 2025. Annual VOC emissions are expected to increase by between 860 tons per year and 1,900 tons per year for a total of 9,700 tons over the same period. HAP emissions are expected to increase by between 26 tons per year and 56 tons per year, with an estimated total of 290 more tons of HAP emissions over 2019 through 2025 under the proposed changes.
  - ***Relative to the Current Regulatory Baseline****:* annual methane emissions are estimated to increase by between 33,000 short tons per year (in 2019) and 72,000 short tons per year (in 2025) for a total of 370,000 short tons over 2019 through 2025. Annual VOC emissions are expected to increase by between 910 tons per year and 2,000 tons per year for a total of 10,000 tons over the same period. HAP emissions are expected to increase by between 27 tons per year and 59 tons per year, with an estimated total of 300 more tons of HAP emissions over 2019 through 2025 under the proposed changes.

- **Benefits Analysis:** This proposed action is expected to result in climate-related dis-benefits relative to both baselines used in this analysis.
  - ***Relative to the 2018 Proposed Regulatory Baseline****:* The PV of the domestic share of forgone benefits, using an interim estimate of the domestic social cost of methane (SC-CH_4) discounted at a 7 percent rate is estimated to be $13 million from 2019 through 2025; the EAV is estimated to be $2.2 million per year. Using the interim SC-CH_4 estimate based on the 3 percent discount rate, the PV of the forgone domestic climate benefits is estimated to be $49 million; the EAV is estimated to be $7.7 million per year.
  - ***Relative to the Current Regulatory Baseline****:* The PV of the domestic share of forgone benefits, using an interim estimate of the domestic social cost of methane (SC-CH_4) discounted at a 7 percent rate is estimated to be $13 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 discount rate, the PV of the forgone domestic climate benefits is estimated to be $52 million; the EAV is estimated to be $8.1 million per year.
- **Compliance Cost Analysis:** The proposed action is expected to result in compliance cost savings to the affected firms relative to the alternative baselines of this RIA.
  - ***Relative to the 2018 Proposed Regulatory Baseline****:* The PV of these cost savings, discounted at a 7 percent rate and not including the forgone value of product recovery, is estimated to be about $104 million dollars. When the forgone value of product recovery (about $23 million) is included, the PV of the cost savings is about $81 million. This is associated with an EAV of cost savings of about $18 million per year without including the forgone value of product recovery, or $14 million per year when the value of product recovery (about $4 million per year) is included. Under a 3 percent discount rate, the PV of cost savings, accounting for the forgone value of product recovery (about $29 million) is $103 million, with an associated EAV of $16 million per year after accounting for the forgone value of product recovery (about $4.6 million per year).
  - ***Relative to the Current Regulatory Baseline****:* The PV of these cost savings, discounted at a 7 percent rate and not including the forgone value of product recovery, is estimated to be about $122 million dollars. When the forgone value of product recovery (about $25 million) is included, the PV of the cost savings is about $97 million. This is associated with an EAV of cost savings of about $21 million per year without including the forgone value of product recovery, or $17 million per year when the value of product recovery (about $4.4 million per year) is included. Under a 3 percent discount rate, the PV of cost savings, accounting for the forgone value of product recovery (about $32 million) is $123 million, with an associated EAV of $19 million per year after accounting for the forgone value of product recovery (about $5 million per year).
- **Energy Markets Impacts Analysis:** The 2016 NSPS RIA estimated small (less than one percent) impacts on energy production and markets as a result of the 2016 NSPS. EPA expects that this deregulatory action, if finalized, would partially reduce the energy

market impacts estimated for the final NSPS in the 2016 NSPS RIA. This conclusion is independent of the choice of baseline used in this 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. This conclusion is independent of the choice of baseline used in this RIA. EPA did not conduct a quantitative assessment of the distributional impacts of the proposed action, 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 reduce 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 many 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). This conclusion is independent of the choice of baseline used in this analysis.
- **Employment Impacts Analysis:** EPA expects 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. This conclusion is independent of the choice of baseline used in this RIA. However, due to uncertainties associated with how the proposed action will influence the portfolio of activities associated with fugitive emissions-related requirements, EPA is unable to provide quantitative estimates of compliance-related labor changes.

The rest of this document details the annual changes estimated under this proposed action relative to two alternative baselines. Tables 1-3 and 1-4 presents the PV and EAV of the benefits, costs, and net benefits of this proposed action, estimated using discount rates of 7 and 3 percent. The tables also present the increase in emissions, estimated as a result of removing requirements from all affected sources in the transmission and storage sectors.

These cost, emissions, and benefit impacts are estimated for the universe of affected sources over the 2019 through 2025 analysis period, discounted to 2016, and are presented in 2016 dollars. When discussing net benefits, both here and in Section 5, we modify the 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).

Table 1-3 Quantified Costs, Benefits, and Emissions Changes Resulting from the Proposed Removal of Requirements in Transmission and Storage, 2019 through 2025, relative to the 2018 Proposed Regulatory Baseline (millions 2016$)*

	7 percent		3 percent	
	Present Value	**Equivalent Annualized Value**	**Present Value**	**Equivalent Annualized Value**
Benefits (Total Cost Savings)	$81	$14	$103	$16
Cost Savings	*$104*	*$18*	*$133*	*$21*
Forgone Value of Product Recovery	*$23*	*$4.0*	*$29*	*$4.6*
Costs (Forgone Domestic Climate Benefits)[1]	$13	$2.2	$49	$7.7
Net Benefits[2]	$69	$12	$54	$8.4
Emissions	**Total Change**			
Methane (short tons)	350,000			
VOC	9,700			
HAP	290			
Methane (million metric tons CO^2-Eq.)	7.9			

[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.
* These results assume semiannual fugitive emissions monitoring at compressors stations in absence of this action.

Table 1-4 Quantified Costs, Benefits, and Emissions Changes Resulting from the Proposed Removal of Requirements in Transmission and Storage, 2019 through 2025, relative to the Current Regulatory Baseline (millions 2016$)*

	7 percent		3 percent	
	Present Value	**Equivalent Annualized Value**	**Present Value**	**Equivalent Annualized Value**
Benefits (Total Cost Savings)	$97	$17	$123	$19
Cost Savings	*$122*	*$21*	*$155*	*$24*
Forgone Value of Product Recovery	*$25*	*$4.4*	*$32*	*$5.0*
Costs (Forgone Domestic Climate Benefits)[1]	$13	$2.3	$52	$8.1
Net Benefits[2]	$83	$14	$70	$11
Emissions	**Total Change**			
Methane (short tons)	370,000			
VOC	10,000			
HAP	300			
Methane (million metric tons CO^2-Eq.)	8.4			

[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 many of the same methods used to estimate costs of the 2016 NSPS OOOOa and the October 2018 proposed technical reconsideration. The remainder of this report outlines that methodology, with further explanations of where the underlying data, assumptions, or methods diverge, as well as the results. For details on the methodology that remains unchanged from the 2016 NSPS OOOOa, please see the 2016 NSPS RIA.[12]

Section 2 describes the emissions increases and compliance cost savings analysis of the proposed action. Section 2 also describes the cost savings in a PV framework and presents the associated EAV. Section 3 describes the forgone benefits of this rule compared to the alternative baselines for this analysis, including the PV and EAV over the 2019 to 2025 period. Section 4 describes the economic impacts expected from this proposed action. Section 5 presents a comparison of forgone benefits and cost savings of this proposed action, as well as the net benefits.

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

2 COMPLIANCE COST SAVINGS AND EMISSIONS INCREASES

2.1 Introduction

This chapter describes the emissions and compliance cost analysis for the proposed review of the 2016 NSPS OOOOa. We focus this section on estimating the incremental changes in emissions and costs of this proposed action with respect to the technical reconsideration proposal, which, as discussed in Section 1.2.2, reflects the current requirements in place, as well as the requirements of the October 2018 proposed technical reconsideration. 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 and the technical reconsideration proposal. Section 2.3 describes the steps in the emissions and compliance cost analysis of the requirements that are being reviewed and presents an overview of results. Section 2.4 presents detailed tables describing the impacts for each source affected by this proposed action relative to each of the alternative baselines discussed in Section 1. Section 2.5 illustrates the sensitivity of the results to an alternative baseline representing the co-proposed option from the technical reconsideration proposal. Section 2.6 presents the present value and equivalent annualized value of the cost savings. Please see the memorandum "Control Cost and Emission Changes under the Proposed Amendments to 40 CFR Part 60, subpart OOOOa Under Executive Order 13783" 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 removing the 2016 NSPS OOOOa requirements from affected sources in the transmission and storage segment. This section provides a basic description of the emissions sources and controls affected by this proposed action. For more detailed information on the requirements that are being reviewed, see the 2016 NSPS OOOOa and the 2016 NSPS RIA.[13,14] For the other emission sources and controls (those in the production and processing segments of the oil and natural gas industry) evaluated in the 2016 NSPS OOOOa, see the 2016 NSPS RIA.

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[13] Found on regulations.gov under Docket ID No. EPA-HQ-OAR-2017-0483.
[14] 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.

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 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. Under the proposed technical reconsideration, monitoring and repair frequency for low production well sites is set at biennial (every other year), and monitoring frequency for non-low production well sites is set at annual. At compressor stations, located in the gathering and boosting, transmission, and storage segments, the monitoring and repair frequency is set at semiannual.[15] This RIA estimates the impacts of removing the fugitive emission requirements from the compressor stations located in the transmission and storage segments.

Pneumatic Controllers: Pneumatic controllers are automated instruments used for maintaining a process condition such as liquid level, pressure, pressure differential, and temperature. In many situations across all segments of the oil and natural gas industry, pneumatic controllers make use of the available high-pressure natural gas to operate or control a valve. In these "gas-driven" pneumatic controllers, natural gas may be released with every valve movement and/or continuously from the valve control pilot. Not all pneumatic controllers are gas driven. These "non-gas driven" pneumatic controllers use sources of power other than pressurized natural gas. Examples include solar, electric, and instrument air. At oil and gas locations with electrical service, non-gas-driven controllers are typically used. Continuous bleed pneumatic controllers can be classified into two types based on their emissions rates: (1) high-bleed controllers and (2) low-bleed controllers. This RIA evaluates the impact of removing the requirement to replace high-bleed controllers with low-bleed controllers in the transmission and storage segments.

[15] Monitoring frequency for compressor stations on the Alaskan North Slope is set at annual, however, we do not estimate any compressor stations on the Alaskan North Slope. For all other compressor stations, in the technical reconsideration proposal, EPA co-proposed to reduce fugitive emissions monitoring to an annual basis.

Reciprocating and Centrifugal Compressors: Compressors are mechanical devices that increase the pressure of natural gas and allow the natural gas to be transported from the production site, through the supply chain, and to the consumer. The types of compressors that are used by the oil and gas industry as prime movers are reciprocating and centrifugal compressors. Centrifugal compressors use either wet or dry seals.

Emissions from compressors occur when natural gas leaks around moving parts in the compressor. In a reciprocating compressor, emissions occur when natural gas leaks around the piston rod when pressurized natural gas is in the cylinder. Over time, during operation of the compressor, the rod packing system becomes worn and will need to be replaced to prevent excessive leaking from the compression cylinder. This RIA estimates the impact of removing the requirements to replace the rod packing approximately every 3 years (26,000 hours, or 36 months) in reciprocating compressors in the transmission and storage segments.

Emissions from centrifugal compressors depend on the type of seal used: either "wet", which use oil circulated at high pressure, or "dry", which use a thin gap of high-pressure gas. The use of dry gas seals substantially reduces emissions. In addition, their use significantly reduces operating costs and enhances compressor efficiency. Limiting or reducing the emission from the rotating shaft of a centrifugal compressor using a mechanical dry seal system was evaluated. For centrifugal compressors equipped with wet seals, a flare was evaluated as an option for reducing emissions from centrifugal compressors. This RIA estimates the impact of removing requirements to capture and route emissions from a wet-seal centrifugal compressor to a control device in the transmission and storage segment.

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 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 requirements was not evaluated in the cost analysis for the

2016 NSPS. In the technical reconsideration proposal RIA, EPA evaluated the impact of amending the certification requirements to allow facilities to choose either a professional engineer or an in-house engineer to perform the required certifications. This RIA estimates the impact of removing the certification requirements from affected sources in the transmission and storage sectors.

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 action compared to the 2018 Proposed Regulatory baseline. Updates to the data and analysis approach from the 2016 NSPS RIA that are used in this action 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 is presented in the cost memo associated with this proposed action.[16]

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 for each affected source type. Second, the number of incrementally affected facilities for each type of equipment or facility are estimated. Unlike the technical reconsideration, where a subset of the type of equipment or facilities that are affected under the 2016 NSPS OOOOa are affected under the reconsideration, all NSPS-affected facilities in the transmission and storage sector are affected by this proposed action. Changes in national emissions and cost estimates are calculated by multiplying the representative factors from the first step by the estimated number of 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 estimates of national cost savings include the value of the forgone product recovery where applicable.

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

[16] US EPA. 2019. Memorandum: Control Cost and Emission Changes under the Proposed Amendments to 40 CFR Part 60, subpart OOOOa Under Executive Order 13783. Docket ID No. EPA-HQ-OAR-2017-0483.

Section 2.3.2. 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, and results in this RIA are presented in 2016 dollars, while the 2016 NSPS RIA presents results in 2012 dollars.

2.3.1 Proposed Requirements

EPA developed a representative or model plant for each affected emission source, point, and control option. The characteristics of the model plant include typical equipment, operating characteristics, and representative factors including baseline emissions and the costs, emissions reductions, and product recovery resulting from each control option. This source-level cost and emission information for the requirements affected by this action can be found in the cost memo associated with this action.

Table 2-1 shows the emissions sources, points, and controls in the transmission and storage segment for 2016 NSPS OOOOa, and the alternative baselines for this analysis.

Table 2-1 Emissions Sources and Controls in the Transmission and Storage Sector

Emissions Point and Control	Relative to the 2018 Proposed Regulatory Baseline	Relative to the Current Regulatory Baseline
Fugitive Emissions - Planning, Monitoring and Maintenance		
Compressor Stations	Semiannual[1]	Quarterly
Compressor Stations on the Alaskan North Slope[2]	Annual	Annual
Pneumatic Controllers – Replace High Bleed with Low Bleed	X	X
Reciprocating Compressors – Replace Rod Packing Every ~3 Years[3]	X	X
Centrifugal Compressors – Route to Control	X	X
Certifications		
Closed Vent Systems on Centrifugal and Reciprocating Compressors and Storage Vessels[4]	In-House Engineer	Professional Engineer

[1] The technical reconsideration co-proposes semiannual and annual fugitive emission monitoring frequency at compressor stations not on the Alaskan North Slope.
[2] We do not currently have the data to estimate the effects of the proposal on compressors stations on the Alaskan North Slope.
[3] Every 36 months, or 26,000 hours.
[4] We currently estimate that there are no affected storage vessels in the transmission and storage sector.

In addition to the requirements listed above, the 2016 NSPS OOOOa established recordkeeping and reporting requirements for the affected sources. This proposed action would relieve that burden as well, as explained further in Section 2.3.5.

2.3.2 Projection of Affected Facilities

To project the number of NSPS-affected facilities, we first updated the number of NSPS-affected facilities for this analysis using the GHG Inventory. We assumed that this average number of new affected sources is constant from 2019 through 2025. Though this may not be the case, we believe this assumption is our best approximation of the average number of new sources in each year.

For the purposes of this RIA, "NSPS-affected facilities" include facilities that are projected to change control activities as a result of this action. 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 facilities affected by this rule are estimated as the subset of the NSPS-affected facilities that are in the transmission and storage sector. 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. For the proposed option, these sources include fugitive emissions sources at compressor stations, pneumatic controllers, and centrifugal and reciprocating compressors.[17] Affected sources in transmission and storage 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 affected sources. EPA derived typical counts for affected sources in the transmission and storage segment by averaging the year-to-year changes for each source over the past ten years in the GHG Inventory.

[17] 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.

This RIA includes more analysis than previous oil and natural gas NSPS RIA analyses by including year-by-year results over the 2019 to 2025 analysis period and an increased level of disaggregation of facilities by vintage and production levels. While it would be desirable to analyze impacts beyond 2025, 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 natural gas industry. For example, EPA has limited information on how practices, equipment, and emissions at new facilities change 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.

Table 2-2 presents the number of NSPS-affected sources for each year of analysis. The estimates for 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 underestimated 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 GHG 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.

Table 2-2 NSPS-affected Source Counts in Transmission and Storage

Year	Incrementally Affected Sources[1]	Total Affected Sources[2]
2019	470	2,200
2020	470	2,700
2021	470	3,100
2022	470	3,500
2023	470	4,000
2024	470	4,400
2025	470	4,900

[1] Incrementally-affected sources include sources that are newly affected in each year. The source counts are equivalent relative to each of the alternative baselines.
[2] Total affected sources include the accumulation of sources over time. These include sources that are newly affected in each year plus the affected sources from previous years.

There have been multiple updates to the GHG Inventory and the data EPA uses to estimate the number of affected sources since the 2016 NSPS OOOOa was analyzed. One such update is that the period used to estimate the number of affected sources has been updated. The 2016 NSPS RIA used the ten-year period leading up to 2012, whereas this proposed action estimates the number of affected sources in the ten-year period leading up to 2014. The number of affected sources in the transmission and storage segments is sensitive to the year-to-year changes over the ten-year period used. For example, the 2016 NSPS RIA estimated four new transmission compressor stations a year, and this proposal estimates 36 new transmission compressor stations per year. Though the difference in the count of affected sources as estimated for the 2016 NSPS RIA and this proposed action seems large at first, when compared to the total number of transmission compressor stations nationally in 2014 (about 1,800), both totals are small: 0.2 percent and 2.0 percent, respectively.

In addition, since the 2016 NSPS RIA (which used 2015 GHG Inventory data), EPA has updated the GHG Inventory methodology that is used to develop station counts. This update had only a small impact on total national counts in the GHG Inventory.[18] The update also resulted in minor changes in year-to-year trends, which have impacted the affected source analysis. National estimates of other sources (e.g., compressors and pneumatic controllers) in the transmission and storage segment rely on station counts as an input and are therefore impacted by this change as well. As annual national counts of transmission and storage stations are not directly available

[18] For example, comparing year 2013 station count estimate, the 2018 GHG Inventory estimate is 5 percent lower for transmission stations and 12 percent lower for storage stations.

from any national-level data source, EPA applies a methodology to estimate the total national counts of transmission and storage stations. This method was updated between the 2015 GHG Inventory and the 2018 GHG Inventory. In the method used in the 2016 NSPS, transmission station counts were estimated by applying a factor of stations per mile of transmission pipeline to the total national transmission pipeline mileage. Storage station counts were developed by applying a factor of stations per unit of gas consumption to total national gas consumption. In the 2018 GHG Inventory, transmission stations are estimated based on scaling up GHGRP reporting data. Storage stations are estimated by applying a factor to total national storage fields. These methods were discussed through a stakeholder process and are an improvement over the previous methods.

2.3.3 Emissions Increases

Table 2-3 summarizes the national increase in emissions associated with the proposed action relative to the 2018 Proposed Regulatory baseline. This increase in emissions is estimated by multiplying the unit-level increase in emissions associated with each applicable control and facility type by the number of incrementally-affected sources of that facility type.[19] In this analysis, closed vent system certification requirements are not associated with any direct emission reductions.

[19] Because it uses updated baselines, results in this analysis are generally not comparable to those in the 2016 NSPS RIA. As explained in Section 2.3.2, the current baselines project more affected facilities in transmission and storage than the baseline used in 2016, resulting in higher emissions and cost changes than the previous analysis. Unit-level emissions characteristics for facilities in transmission and storage are unchanged since the 2016 analysis.

Table 2-3 Increase in Emissions Under the Proposed Action, by Year, relative to the 2018 Proposed Regulatory Baseline

	Emission Changes			
Year	Methane (short tons)	VOC (short tons)	HAP (short tons)	Methane (metric tons CO_2 Eq.)
2019	31,000	860	26	710,000
2020	37,000	1,000	31	850,000
2021	44,000	1,200	36	990,000
2022	50,000	1,400	41	1,100,000
2023	56,000	1,600	46	1,300,000
2024	62,000	1,700	51	1,400,000
2025	69,000	1,900	56	1,600,000
Total	**350,000**	**9,700**	**290**	**7,900,000**

Note: Estimates may not sum due to independent rounding.

The estimated increase in emissions is associated with forgone health and climate benefits that would have been achieved under the 2016 NSPS OOOOa absent this proposed action. In 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,[20] which are associated with climate, health, and welfare effects. In this reconsideration the predicted emission reductions and benefits from the 2016 NSPS OOOOa are considered forgone, including VOC emission reductions and health and welfare benefits associated with exposure to ozone, $PM_{2.5}$, and HAP.

2.3.4 Forgone Product Recovery

The estimated cost savings presented below include the forgone revenue from the reductions in natural gas recovery under the proposed option. Requirements on compressor stations, reciprocating compressors, and pneumatic controllers are assumed to increase the capture of methane and VOC emissions that would otherwise be vented to the atmosphere with

[20] The control techniques analyzed in 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 energy markets impacts. The proposed action is anticipated to reduce these minor secondary emissions.

no requirements, 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.

Error! Reference source not found. 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 recovery in the cost savings analysis, we use the projections of natural gas prices provided in the EIA's 2018 Annual Energy Outlook (AEO) reference case from 2019 through 2025. The AEO projects Henry Hub natural gas prices between $3.40 and $4.07 in $/MMBtu in 2017 dollars during the 2019 to 2025 period.[21] 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.[22]

Table 2-4 Estimated Decrease in Natural Gas Recovery, relative to the 2018 Proposed Regulatory Baseline

Year	Decrease in Gas Recovery (Mcf)	Forgone Revenue (millions 2016$)
2019	0.9	$2.8
2020	1.1	$3.7
2021	1.3	$4.3
2022	1.5	$4.9
2023	1.7	$5.8
2024	1.8	$6.6
2025	2.0	$7.5

Operators in the transmission and storage segments 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 2016 NSPS OOOOa TSD, and the technical reconsideration TSD do not include estimates of revenue from

[21] Available at https://www.eia.gov/outlooks/archive/aeo18/tables_ref.php.

[22] An EIA study indicated that the Henry Hub price is, on average, about 11 percent higher than the wellhead price. See https://www.researchgate.net/publication/265155970_US_Natural_Gas_Markets_Relationship_Between_Henry_Hub_Spot_Prices_and_US_Wellhead_Prices.

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 across 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 2016 NSPS OOOOa and technical reconsideration TSDs, as well as in the 2016 NSPS and technical reconsideration RIAs.

2.3.5 Compliance Cost Savings

Table 2-5 summarizes the cost savings and forgone revenue from product recovery for the evaluated emissions sources and points. Total cost savings consist of capital cost savings, annual operating and maintenance cost savings, and forgone revenue from product recovery. Capital cost savings include the capital cost savings from removing the requirements on newly affected controllers and compressors, the planning cost savings from removing the requirements on compressor stations to create survey monitoring plans for the fugitives monitoring requirement, the planning cost savings from removing the requirement to complete certifications of closed vent systems, as well as the cost savings of sources that would have had to renew survey monitoring plans or purchase new capital equipment at the end of their useful life. The annual operating and maintenance cost savings are attributed to the fugitives monitoring requirement, and the requirements on centrifugal compressors. The cost savings are estimated by multiplying the unit-level cost savings associated with each 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. These cost savings are described more below.

Table 2-5 Compliance Cost Savings Estimates relative to the 2018 Proposed Regulatory Baseline (millions 2016$)

	Compliance Cost Savings				
Year	Capital Cost Savings[1]	Operating and Maintenance Cost Savings	Annualized Cost Savings (w/o Forgone Revenue)[2]	Forgone Revenue from Product Recovery	Nationwide Annualized Cost Savings with Forgone Revenue
2019	$2.1	$13	$15	$2.8	$12
2020	$2.1	$15	$18	$3.7	$14
2021	$2.1	$18	$21	$4.3	$16
2022	$2.1	$20	$24	$4.9	$19
2023	$2.4	$23	$26	$5.8	$21
2024	$2.4	$25	$29	$6.6	$23
2025	$3.7	$28	$32	$7.5	$25

[1] The capital cost savings include the planning cost savings incurred by the newly affected sources for fugitive emissions monitoring, capital cost savings for newly affected controllers and compressors, and certifications in each year, as well as the cost savings of sources that renew survey monitoring plans and the purchasing of new capital requirements at the end of their useful life.
[2] These cost savings include the capital cost savings annualized over the requisite equipment lifetimes at an interest rate of 7 percent, plus the annual operating and maintenance cost savings for 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 eight years to comply with the 2016 NSPS OOOOa requirements. Pneumatic controllers are assumed to have a lifetime of ten years. Rod packing replacement is assumed to happen about every 3.8 years in the transmission segment and every 4.4 years in the storage segment, as discussed in Section 2.3.2 and in the cost memo. The lifetime of the sources affected by this action are unchanged from the assumptions in 2016 NSPS OOOOa. The reduction in capital costs in each year outlined in Table 2-5 includes the estimated reduction in the costs attributed to newly affected sources in that year, plus the reduction in the cost attributed to sources affected previously that have reached the end of their assumed lifetime.

The capital and planning cost savings for reciprocating compressors, centrifugal compressors, pneumatic controllers and fugitive emissions monitoring program design are annualized over their requisite expected lifetimes at an interest rate of 7 percent, and are added to the annual operating and maintenance cost savings of the requirements, the cost savings of the in-house certifications in each year, and the cost savings from streamlined recordkeeping and reporting to get the annualized cost savings in each year. The forgone value of product recovery is then subtracted to estimate the total annualized cost savings in each year.

Table 2-6 illustrates the sensitivity of the cost savings results of the proposed option to a given discount rate. We present cost savings using a discount rate of 7 percent and 3 percent based on the Office of Management and Budget (OMB) Circular A-4.[23]

Table 2-6 Estimated Cost Savings, 2019-2025, using 7 and 3 Percent Discount Rates, relative to the 2018 Proposed Regulatory Baseline (millions 2016$)

	7 percent			3 percent		
Year	**Annualized Cost Savings (w/o Forgone Revenue)**	**Forgone Revenue from Product Recovery**	**Nationwide Annualized Cost Savings with Forgone Revenue**	**Annualized Cost Savings (w/o Forgone Revenue)**	**Forgone Revenue from Product Recovery**	**Nationwide Annualized Cost Savings with Forgone Revenue**
2019	$15	$2.8	$12	$15	$2.8	$12
2020	$18	$3.7	$14	$17	$3.7	$14
2021	$21	$4.3	$16	$20	$4.3	$16
2022	$24	$4.9	$19	$23	$4.9	$18
2023	$26	$5.8	$21	$26	$5.8	$20
2024	$29	$6.6	$23	$29	$6.6	$22
2025	$32	$7.5	$25	$32	$7.5	$24

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 and capital cost savings are small relative to the annual operating and maintenance cost savings, so the interest rate has little impact on total annualized cost savings for these sources.

Reporting and recordkeeping costs were drawn from the information collection requirements (ICR) that have been submitted for approval to the Office of Management and Budget (OMB) under the Paperwork Reduction Act (see Preamble for more detail). The reporting and recordkeeping cost savings in this RIA are estimated to be about $0.28 million every year. These recordkeeping and recordkeeping cost savings are estimated for the proposed option for all new and modified affected facilities regardless of whether they are in states with regulatory requirements similar to the final 2016 NSPS OOOOa.[24]

[23] Found at: https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A4/a-4.pdf.
[24] Note that the cost savings associated with reduced reporting and recordkeeping pertain to all sources that would not be regulated under the proposed option, not just fugitive emissions monitoring requirements.

2.4 Detailed Impacts Tables

The following tables show the full details of the cost savings and increase in emissions by emissions sources relative to each of the alternative baselines in 2020 and 2025. The estimates for compressor stations do not include any impacts from compressor stations on the Alaskan North Slope because we do not currently have the data to estimate those effects of the proposal.

Two of the affected source types, reciprocating compressors and pneumatic controllers, have negative total cost savings under the proposal, meaning that the potential capital and annual cost savings from deregulating the transmission and storage segment may be outweighed by the forgone revenue from product recovery. This observation may typically lead to an assumption that operators would continue to perform the emissions abatement activity, regardless of whether a requirement is in place, because it is in their private self-interest to do so. However, as discussed in the 2016 RIA, operators in the gathering and boosting and transmission and storage segments 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, financial incentives to reduce emissions may be substantially reduced because of the inability of operators to recoup the financial value of captured natural gas that may otherwise be emitted. The assumption that the abatement activities for the transmission and storage emissions sources in question will continue absent regulation may not hold as readily as it might for other sources where operators own the natural gas. Based on this reasoning, this RIA includes the full negative cost savings for these affected source types, despite the estimate that indicates net compliance costs may increase under this deregulatory proposal.

Table 2-7 Incrementally Affected Units, Emissions Increases and Cost Savings, relative to the 2018 Proposed Regulatory Baseline, 2020

		Nationwide Emissions Increase				National Costs			
Source/Emissions Points in Transmission and Storage	Projected No. of Affected Sources	Methane (short tons)	VOC (short tons)	HAP (short tons)	Methane (metric tons CO2e)	Capital Cost Savings	Operating and Maintenance Savings	Forgone Product Recovery	Total Annualized Cost Savings with Forgone Revenue
Fugitive Emissions - Compressor Stations[1]	230	6,300	170	5.1	140,000	$0.23	$3.3	$1.1	$2.4
Reciprocating Compressors	460	9,900	270	8.1	220,000	$0.46	$0.0	$1.7	-$0.87
Centrifugal Compressors	110	16,000	440	13	360,000	$1.4	$12	$0.0	$13
Pneumatic Controllers	1,800	5,100	140	4.2	120,000	$0.07	$0.0	$0.9	-$0.85
Certifications on Closed Vent Systems	26	0	0	0	0	$0.01	$0.0	$0.0	$0.01
Reporting and Recordkeeping[2]	0	0	0	0	0	$0.0	$0.0	$0.0	$0.28
TOTAL	**2,700**	**37,000**	**1,000**	**31**	**850,000**	**$2.1**	**$15**	**$3.7**	**$14**

[1] Assumes semiannual fugitive emissions monitoring; includes reporting and recordkeeping pertaining to fugitive emissions monitoring.
[2] Applies to reporting and recordkeeping for requirements other than the fugitive emissions monitoring requirements.

Table 2-8 Incrementally Affected Units, Emissions Increases and Cost Savings, relative to the 2018 Proposed Regulatory Baseline, 2025

Source/Emissions Points in Transmission and Storage	Projected No. of Affected Sources	Nationwide Emissions Increase: Methane (short tons)	VOC (short tons)	HAP (short tons)	Methane (metric tons CO2e)	National Costs: Capital Cost Savings	Operating and Maintenance Savings	Forgone Product Recovery	Total Annualized Cost Savings with Forgone Revenue
Fugitive Emissions - Compressor Stations[1]	420	11,000	320	9.4	260,000	$0.45	$6.0	$2.2	$4.2
Reciprocating Compressors	840	18,000	500	15	410,000	$0.46	$0.0	$3.5	-$1.9
Centrifugal Compressors	200	29,000	820	24	670,000	$2.7	$22	$0.0	$24
Pneumatic Controllers	3,400	9,400	260	7.8	210,000	$0.07	$0.0	$1.8	-$1.7
Certifications on Closed Vent Systems	26	0	0	0	0	$0.01	$0.0	$0.0	$0.01
Reporting and Recordkeeping[2]	0	0	0	0	0	$0.0	$0.0	$0.0	$0.28
TOTAL	**4,900**	**69,000**	**1,900**	**56**	**1,600,000**	**$3.7**	**$28**	**$7.5**	**$25**

[1] Assumes semiannual fugitive emissions monitoring; includes reporting and recordkeeping pertaining to fugitive emissions monitoring.
[2] Applies to reporting and recordkeeping for requirements other than the fugitive emissions monitoring requirements.

Table 2-9 Incrementally Affected Units, Emissions Increases and Cost Savings, relative to the Current Regulatory Baseline, 2020

Source/Emissions Points in Transmission and Storage	Projected No. of Affected Sources	Nationwide Emissions Increase: Methane (short tons)	VOC (short tons)	HAP (short tons)	Methane (metric tons CO2e)	National Costs: Capital Cost Savings	Operating and Maintenance Savings	Forgone Product Recovery	Total Annualized Cost Savings with Forgone Revenue
Fugitive Emissions - Compressor Stations[1]	230	8,300	230	6.9	190,000	$0.23	$6.1	$1.5	$4.9
Reciprocating Compressors	460	9,900	270	8.1	220,000	$0.46	$0.0	$1.7	-$0.87
Centrifugal Compressors	110	16,000	440	13	360,000	$1.4	$12	$0.0	$13
Pneumatic Controllers	1,800	5,100	140	4.2	120,000	$0.07	$0.0	$0.9	-$0.85
Certifications on Closed Vent Systems	26	0	0	0	0	$0.01	$0.0	$0.0	$0.01
Reporting and Recordkeeping[2]	0	0	0	0	0	$0.0	$0.0	$0.0	$0.28
TOTAL	**2,700**	**39,000**	**1,100**	**32**	**890,000**	**$2.1**	**$18**	**$4.1**	**$17**

[1] Assumes semiannual fugitive emissions monitoring; includes reporting and recordkeeping pertaining to fugitive emissions monitoring.
[2] Applies to reporting and recordkeeping for requirements other than the fugitive emissions monitoring requirements.

Table 2-10 Incrementally Affected Units, Emissions Increases and Cost Savings, relative to the Current Regulatory Baseline, 2025

		Nationwide Emissions Increase				National Costs			
Source/Emissions Points in Transmission and Storage	Projected No. of Affected Sources	Methane (short tons)	VOC (short tons)	HAP (short tons)	Methane (metric tons CO2e)	Capital Cost Savings	Operating and Maintenance Savings	Forgone Product Recovery	Total Annualized Cost Savings with Forgone Revenue
Fugitive Emissions - Compressor Stations[1]	420	15,000	420	13	350,000	$0.45	$11	$2.9	$8.7
Reciprocating Compressors	840	18,000	500	15	410,000	$0.46	$0.0	$3.5	-$1.9
Centrifugal Compressors	200	29,000	820	24	670,000	$2.7	$22	$0.0	$24
Pneumatic Controllers	3,400	9,400	260	7.8	210,000	$0.07	$0.0	$1.8	-$1.7
Certifications on Closed Vent Systems	26	0	0	0	0	$0.01	$0.0	$0.0	$0.01
Reporting and Recordkeeping[2]	0	0	0	0	0	$0.0	$0.0	$0.0	$0.28
TOTAL	**4,900**	**72,000**	**2,000**	**59**	**1,600,000**	**$3.7**	**$33**	**$8.2**	**$29**

[1] Assumes semiannual fugitive emissions monitoring; includes reporting and recordkeeping pertaining to fugitive emissions monitoring.
[2] Applies to reporting and recordkeeping for requirements other than the fugitive emissions monitoring requirements.

2.5 Sensitivity of Results to Baseline Assuming Annual Fugitive Emissions Monitoring at Compressor Stations

The technical reconsideration preamble co-proposed two alternative options with respect to the fugitive emissions monitoring frequency at compressor stations. The first option proposed to reduce monitoring frequency from quarterly to semiannually (twice per year), and the second option reduced monitoring frequency from quarterly to annually. The analysis presented thus far using the 2018 Proposed Regulatory baseline assumes the first option (semi-annual monitoring at compressor stations). Cost savings of this proposed action will be smaller relative to an alternative baseline that assumes the second option (annual monitoring at compressor stations). This is because the costs of performing annual fugitive emissions monitoring are less than the costs of performing semiannual monitoring. Table 2-11 shows the costs and emissions impacts of this proposed action assuming compressor stations would be performing annual fugitive emissions monitoring in the absence of this proposed action.

The technical reconsideration preamble co-proposed two alternative options with respect to the fugitive emissions monitoring frequency at compressor stations. The first option proposed to reduce monitoring frequency from quarterly to semiannually (twice per year), and the second option reduced monitoring frequency from quarterly to annually. The analysis presented thus far relative to the 2018 Proposed Regulatory baseline assumes the first option (semi-annual monitoring at compressor stations). Cost savings of this proposed action will be smaller relative to an alternative baseline that assumes the second option (annual monitoring at compressor stations). This is because the costs of performing annual fugitive emissions monitoring are less than the costs of performing semiannual monitoring. Table 2-11 shows the costs and emissions impacts of this proposed action assuming compressor stations would be performing annual fugitive emissions monitoring in the absence of this proposed action.

Table 2-11 Estimated Cost Savings and Increase in Emissions of the Proposed Action relative to a Baseline Assuming Annual Fugitive Emission Monitoring at Compressor Stations

Year	Facilities Affected	Methane Emissions (short tons)	VOC Emissions (tons)	Total Annualized Cost Savings with Forgone Revenue (7 percent, millions, 2016$)
2020	2,700	35,000	980	$13
2025	4,900	65,000	1,800	$23

2.6 Analysis of the Present Value and Equivalent Annualized 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 annualized value that, when added together over the analysis time frame, equals the original stream of values in PV terms.

As above, all cost savings are presented as the costs of the proposed option compared to the 2018 Proposed Regulatory baseline for this analysis, in 2016 dollars. Section 2.3 above presents the annualized cost savings of the proposed action, 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 capital cost savings) is very small.

For this RIA, EPA evaluates the cost savings for 2019, the first year we assume requirements on the NSPS-affected sources in the transmission and storage sector are removed as a result of this proposed action, through 2025. 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 2-12 shows the stream of cost savings for each year from 2019 through 2025 relative to the 2018 Proposed Regulatory baseline. Capital cost savings are estimated as the total capital and planning costs of compliance with the 2016 NSPS OOOOa requirements that will not be incurred. Total cost savings are the sum of the capital 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 2.3.4. Total cost savings with forgone revenue is the total cost savings minus the forgone revenue. Over time, with the addition of new affected sources in each year, the capital cost savings, annual operating cost savings and forgone revenue increase.

Table 2-12 Estimated Cost Savings, 2019-2025, relative to the 2018 Proposed Regulatory Baseline (millions 2016$)

Year	Capital Cost Savings	Annual Operating Cost Savings	Total Cost Savings w/o Forgone Revenue	Forgone Revenue from Product Recovery	Total Cost Savings with Forgone Revenue
2019	$2.1	$13	$15	$2.8	$12
2020	$2.1	$15	$18	$3.7	$14
2021	$2.1	$18	$20	$4.3	$16
2022	$2.1	$20	$23	$4.9	$18
2023	$2.4	$23	$25	$5.8	$20
2024	$2.4	$25	$28	$6.6	$21
2025	$3.7	$28	$32	$7.5	$24

Table 2-13 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 capital 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 $81 million, and the EAV of total cost savings is about $14 million per year.

Table 2-13 Discounted Cost Savings Estimates Using a 7 Percent Discount Rate, relative to the 2018 Proposed Regulatory Baseline (millions 2016$)

	Discounted Compliance Cost Savings			
Year	**Capital Cost Savings**	**Annual Operating Cost Savings**	**Forgone Revenue from Product Recovery**	**Total Cost Savings with Forgone Revenue**
2019	$1.7	$10	$2.3	$10
2020	$1.6	$12	$2.8	$11
2021	$1.5	$13	$3.1	$11
2022	$1.4	$13	$3.3	$12
2023	$1.5	$14	$3.6	$12
2024	$1.4	$15	$3.8	$12
2025	$2.0	$15	$4.1	$13
PV	**$11**	**$92**	**$23**	**$81**
EAV	**$1.9**	**$16**	**$4.0**	**$14**

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

Table 2-14 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. 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 about 23 percent from the estimates using a 7 percent discount rate. For the EAV, using a 3 percent discount rate increases the cost savings by about 14 percent from the estimates using a 7 percent discount rate.

Table 2-14 Discounted Cost Savings for the Proposed Option using 7 and 3 Percent Discount Rates, relative to the 2018 Proposed Regulatory Baseline (millions 2016$)*

	7 Percent			3 Percent		
Year	**Total Annual Cost Savings (w/o Forgone Revenue)**	**Forgone Revenue from Product Recovery**	**Total Cost Savings (with Forgone Revenue)**	**Total Annual Cost Savings (w/o Forgone Revenue)**	**Forgone Revenue from Product Recovery**	**Total Cost Savings (with Forgone Revenue)**
2019	$12	$2.3	$10	$14	$2.6	$11
2020	$13	$2.8	$11	$16	$3.3	$12
2021	$14	$3.1	$11	$17	$3.7	$14
2022	$15	$3.3	$12	$19	$4.1	$15
2023	$16	$3.6	$12	$21	$4.7	$16
2024	$16	$3.8	$12	$22	$5.2	$17
2025	$17	$4.1	$13	$24	$5.7	$19
PV	**$100**	**$23**	**$81**	**$130**	**$29**	**$100**
EAV	**$18**	**$4.0**	**$14**	**$21**	**$4.6**	**$16**

*The cost savings in each year are discounted to 2016.

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.[25]

Under the updated assumptions and data as described above, the sources that are affected by this action would have prevented an estimated 37,000 tons of methane and 1,000 tons of VOC from new sources in 2020 assuming no changes to the regulation. In 2025, the affected sources would have prevented an estimated 69,000 tons of methane and 2,000 tons of VOC. The estimated CO_2-equivalent (CO_2 Eq.) methane emission reductions will be about 0.85 million metric tons in 2020 and 1.6 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 and the October 2018 proposed technical reconsideration RIA, the only estimated forgone benefits monetized in this RIA are methane-related climate impacts. By proposing to remove sources in the transmission and storage section from NSPS OOOOa, this proposed action is estimated to increase emissions compared to each of the alternative baselines. For example, using the 2018 Proposed Regulatory baseline, the total increase in emissions over 2019 through 2025 under the proposal of this action is estimated to be about 350,000 short tons of methane, 9,700 tons of VOC, and 290 tons of HAP. The associated increase in CO_2 Eq. methane emissions is estimated to be 7.9 million metric tons. The PV of the forgone methane-related domestic climate benefits are estimated to be $13 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 of forgone benefits is estimated to be $2.2

[25] 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.

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 $49 million; the EAV is estimated to be $7.7 million per year.

Under the proposal, EPA expects that the forgone VOC emission reductions will degrade air quality and are likely to adversely affect health and welfare associated with exposure to ozone, $PM_{2.5}$, and HAP, but we are unable to quantify these effects at this time. This omission should not imply that these forgone benefits may not exist, and to the extent that EPA were to quantify these ozone and PM impacts, it would estimate the number and value of avoided premature deaths and illnesses using an approach detailed in the Particulate Matter NAAQS and Ozone NAAQS Regulatory Impact Analyses (U.S. EPA, 2012; U.S. EPA, 2015).

When quantifying the incidence and economic value of the human health impacts of air quality changes, the Agency sometimes relies upon reduced-form techniques, often reported as "benefit-per-ton" values that relate air pollution impacts to changes in air pollutant precursor emissions (U.S. EPA, 2018). A small, but growing, literature characterizes the air quality and health impacts from the oil and natural gas sector but does not yet supply the information needed to derive a VOC benefit-per-ton value suitable for a regulatory analysis (Fann et al., 2018; Litovitz et al., 2013; Loomis and Haefele, 2017).[26] Moreover, the Agency is currently comparing various reduced-form techniques, including benefit-per-ton approaches, to quantifying air quality benefits. Over the last year and a half, EPA systematically compared the changes in benefits, and concentrations where available, from its benefit-per-ton technique and other reduced-form techniques to the changes in benefits and concentration derived from full-form photochemical model representation of a few different specific emissions scenarios.[27] The Agency's goal was to better understand the suitability of alternative reduced-form air quality modeling techniques for estimating the health impacts of criteria pollutant emissions changes in EPA's benefit-cost analysis, including the extent to which reduced form models may over- or underestimate benefits (compared to full-scale modeling) under different scenarios and air quality concentrations. The

[26] Fann, N., et al. (2018). "Assessing Human Health PM2.5 and Ozone Impacts from U.S. Oil and Natural Gas Sector Emissions in 2025." Environmental Science & Technology 52(15): 8095-8103.

[27] This analysis compared the benefits estimated using full-form photochemical air quality modeling simulations (CMAQ and CAMx) against four reduced-form tools, including: InMAP; AP2/3; EASIUR and EPA's benefit-per-ton.

scenario-specific emission inputs developed for this project are currently available online.[28] The study design and methodology will be thoroughly described in the final report summarizing the results of the project, which is planned to be completed by the end of 2019.

For these reasons, we did not quantify VOC-related health impacts in this RIA. 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. Rather, 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]
	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]

[28] The scenario-specific emission inputs developed for this project are currently available online at https://github.com/epa-kpc/RFMEVAL. Upon completion and publication of the final report, the final report and all associated documentation will be online and available at this URL.

Category	Specific Effect	Effect Has Been Quantified	Effect Has Been Monetized	More Information
	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]
	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 is likely to result in forgone reductions in ambient $PM_{2.5}$ concentrations and may result in forgone reductions in 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.[29] 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 control strategies for different sources.[30] 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

[29] The responsiveness of ozone and $PM_{2.5}$ formation is discussed in greater detail in Sections 3.4 and 3.5 of this RIA.
[30] 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.

rules will ultimately be reflected in the baselines 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 alternative baselines used in this RIA anticipated for this proposed rule from 2019 to 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).

Table 3-2 Total Direct Increases in Emissions, 2019 through 2025, using Alternative Baselines

Pollutant	Increase in Emissions Relative to the 2018 Proposed Regulatory Baseline	Increase in Emissions Relative to the Current Regulatory Baseline
Methane (short tons)	350,000	370,000
VOC (short tons)	9,700	10,000
HAP (short tons)	290	300
Methane (metric tons)	320,000	330,000
Methane (million metric tons CO_2 Eq.)	7.9	8.4

Table 3-3 shows the methane, VOC and HAP emissions increases for each year, compared to the alternative baselines for this analysis.

Table 3-3 Annual Direct Increases in Methane, VOC and HAP Emissions, 2019 through 2025, using Alternative Baselines

	Increase in Emissions Relative to the 2018 Proposed Regulatory Baseline			Increase in Emissions Relative to the Current Regulatory Baseline		
Year	Methane (metric tons)	VOC	HAP	Methane (metric tons)	VOC	HAP
2019	31,000	860	26	33,000	910	27
2020	37,000	1,000	31	39,000	1,100	32
2021	44,000	1,200	36	46,000	1,300	38
2022	50,000	1,400	41	53,000	1,500	43
2023	56,000	1,600	46	59,000	1,600	49
2024	62,000	1,700	51	66,000	1,800	54
2025	69,000	1,900	56	72,000	2,000	59
Total	**350,000**	**9,700**	**290**	**370,000**	**10,000**	**300**

Note: sums may note total due to independent rounding.

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 (0.85-0.89 million metric tons CO_2 Eq., depending on the baseline) 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 1.6 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 for the primary proposal of this action 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[31] 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 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

[31] 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

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)*

Year	Discount Rate and Statistic	
	7 Percent Average	3 Percent 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 of the proposed action. Forecasted increases in methane emissions in each year, expected as a result of the regulatory action, are multiplied by the SC-CH_4 estimate for that year. Under the proposed action and relative to the 2018 Proposed Regulatory baseline, the forgone climate benefits vary by discount rate and year, and range from about $1.5 million to approximately $4.2 million under a 7 percent discount rate, and from about $4.8 million to approximately $13 million under a 3 percent discount rate, as seen in Table 3-5. The forgone benefits are estimated to be slightly higher when using the Current Regulatory baseline are slightly larger.

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

Year	Relative to the 2018 Proposed Regulatory Baseline		Relative to the Current Regulatory Baseline	
	7 percent	3 percent	7 percent	3 percent
2019	$1.5	$4.8	$1.6	$5.1
2020	$1.9	$6.0	$2.0	$6.3
2021	$2.3	$7.2	$2.4	$7.6
2022	$2.7	$8.5	$2.9	$8.9
2023	$3.2	$9.8	$3.4	$10
2024	$3.7	$11	$3.9	$12
2025	$4.2	$13	$4.4	$13

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 $13 million, with an EAV of about $2.2 million per year. The PV of forgone benefits under a 3 percent discount rate of $49 million, with an EAV of about $7.7 million per year. Again, the forgone benefits are estimated to be slightly higher when using the Current Regulatory baseline are slightly larger.

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

	Relative to the 2018 Proposed Regulatory Baseline		Relative to the Current Regulatory Baseline	
Year	**7 percent**	**3 percent**	**7 percent**	**3 percent**
2019	$1.2	$4.4	$1.3	$4.7
2020	$1.4	$5.3	$1.5	$5.6
2021	$1.6	$6.2	$1.7	$6.5
2022	$1.8	$7.1	$1.9	$7.5
2023	$2.0	$8.0	$2.1	$8.4
2024	$2.1	$8.8	$2.3	$9.3
2025	$2.3	$9.7	$2.4	$10.2
PV	**$13**	**$49**	**$13**	**$52**
EAV	**$2.2**	**$7.7**	**$2.3**	**$8.1**

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 the proposed action.

Table 3-7 Estimated Forgone Domestic Climate Benefits of the Proposed Action (millions, 2016$)

		2018 Proposed Regulatory Baseline	Current Regulatory Baseline
Total Increase in Emission, 2019-2025			
Forgone CH_4 reductions (metric tonnes)		320,000	330,000
Forgone CH_4 reductions (million metric tonnes of CO_2 Eq.)		7.9	8.4
Forgone Domestic Climate Benefits (millions 2016$)			
PV			
	3 percent (average)	$49	$52
	7 percent (average)	$13	$13
EAV			
	3 percent (average)	$7.7	$8.1
	7 percent (average)	$2.2	$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-CH4 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.[32] 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 the most recent research, and the limited amount of research linking climate impacts to economic damages makes the modeling exercise even more difficult.

[32] 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.[33] 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,[34] and recommended specific criteria for future updates to the SC-

[33] 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.

[34] 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. <https://www.nap.edu/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of>. Accessed April 3, 2019.

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 is expected to result in forgone 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.

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 associated with chronic respiratory damage and premature aging of the lungs.

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.

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 is expected to result in forgone emission reductions of VOC, which are a precursor to $PM_{2.5}$, thus increasing human exposure to $PM_{2.5}$ and the incidence of $PM_{2.5}$-related health effects, although the magnitude of this effect cannot be quantified at this time. 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 and photochemical models typically estimate secondary organic carbon from anthropogenic VOC emissions to be less than 0.1 $\mu g/m^3$ (U.S. EPA, 2009a). Given that only a small fraction of secondarily formed organic carbon aerosols is from anthropogenic VOC emissions, it is unlikely that this sector has a large contribution to ambient secondary organic carbon aerosols. Therefore, we have not quantified the forgone $PM_{2.5}$-related benefits in this analysis.

3.5.1 $PM_{2.5}$ Health Effects

Increasing VOC emissions will 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. 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 (2011c)).

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.

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, 2011c; 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 2014 National-Scale Air Toxics Assessment (NATA) predicts that some Americans are still exposed to ambient concentrations of air toxics at levels that have the potential to cause adverse health effects.[35] 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

[35] The 2014 NATA is available on the Internet at http://www.epa.gov/nata.

and prioritize air toxics, emission source types and locations that are of greatest potential concern, EPA conducts the NATA.[36] The most recent NATA was conducted for calendar year 2014 and was released in August 2018. 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 2014 NATA, EPA estimates that less than 1 percent of census tracts nationwide have increased cancer risks greater than 100-in-1 million. The average national cancer risk is about 30-in-1 million. Nationwide, the key pollutants that contribute most to the overall cancer risks are formaldehyde and benzene.[37,38] Secondary formation (e.g., formaldehyde forming from other emitted pollutants) was the largest contributor to cancer risks, while stationary, mobile, biogenics, and background sources contribute lesser amounts to the remaining cancer risk.

Noncancer health effects can result from chronic,[39] subchronic,[40] or acute[41] 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 2014

[36] 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 2014 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. (2018) 2014 National-Scale Air Toxics Assessment. http://www.epa.gov/nata.

[37] Details on EPA's approach to characterization of cancer risks and uncertainties associated with the 2014 NATA risk estimates can be found at http://www.epa.gov/national-air-toxics-assessment/nata-limitations.

[38] 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.

[39] 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).

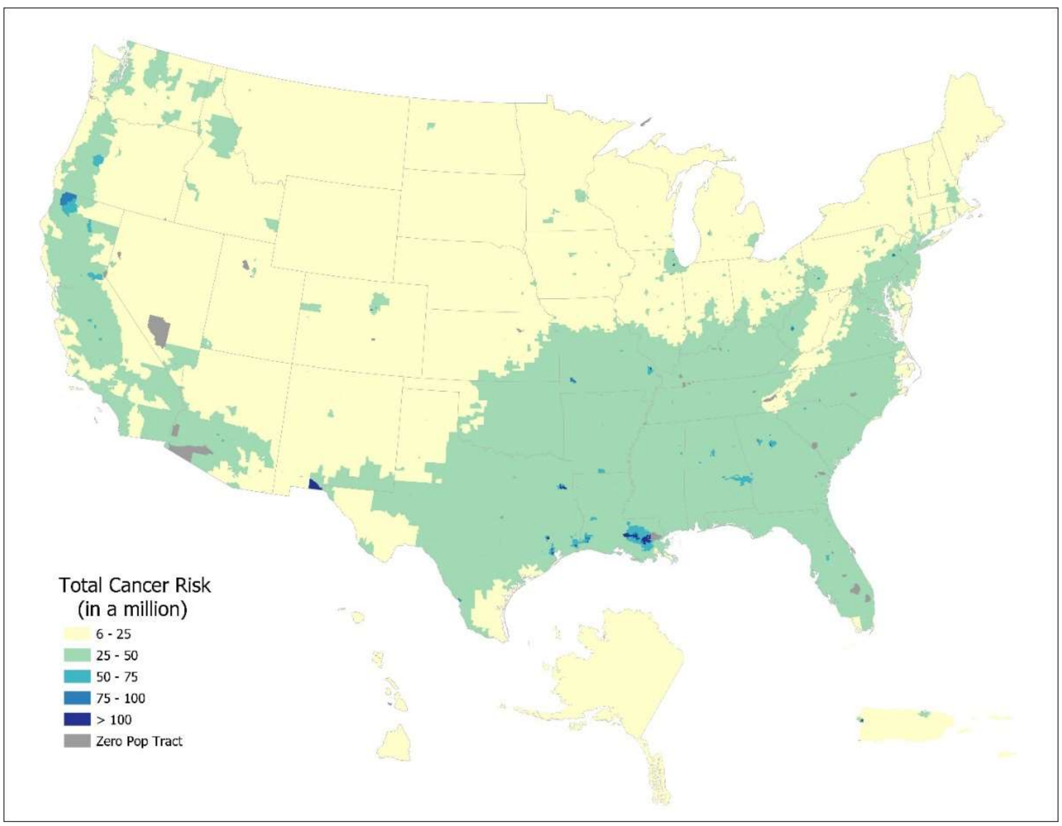
[40] Defined in the IRIS database as repeated exposure by the oral, dermal, or inhalation route for more than 30 days, up to approximately 10 of the life span in humans (more than 30 days up to approximately 90 days in typically used laboratory animal species).

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

NATA, less than 1 percent of the U.S. population was exposed to an average chronic concentration of air toxics that had the potential for adverse noncancer health effects. Results from the 2014 NATA indicate that acrolein is the primary respiratory driver for noncancer respiratory risk.

Figure 3-1 depict the 2014 NATA estimated census tract-level carcinogenic risk 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, just a few pounds of some metals (i.e., Hexavalent Chromium) is more toxic than a ton of benzene. However, the Integrated Risk Information System (IRIS) unit risk estimate (URE) for hexavalent chromium is considerably higher (more toxic) than that for benzene.[42] Thus, it is important to account for the toxicity and exposure, as well as the mass of the targeted emissions.

Figure 3-1 2014 NATA Model Estimated Census Tract Carcinogenic Risk from HAP Exposure from All Outdoor Sources based on the 2014 National Emissions Inventory



[42] 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.

Due to methodology and data limitations, we were unable to estimate the benefits or disbenefits associated with the hazardous air pollutant emissions changes that could occur 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 estimate (URE) and reference concentrations (RfC) developed through risk assessment procedures. The URE 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 UREs 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 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.[43,44,45] 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

[43] 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.

[44] 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.

[45] 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.

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 Services has characterized benzene as a known human carcinogen.[46,47] 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.[48,49]

3.6.2 Toluene[50]

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

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[46] 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.

[47] U.S. Department of Health and Human Services National Toxicology Program 11th Report on Carcinogens. Available at https://www.ncbi.nlm.nih.gov/pubmed/19826456.

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

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

[50] 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 at http://www.epa.gov/iris/subst/0118.htm.

abused toluene during pregnancy. A substantial database examining the effects of toluene in 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.[51] 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.[52]

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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[51] 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.

[52] 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.[53,54] 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).[55,56] 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.[57] Other reported effects include labored breathing, heart palpitation, impaired function of the lungs, and possible effects in the liver and kidneys.[58] Long-term inhalation exposure to xylenes in humans has been associated with a

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[53] 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.

[54] 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.

[55] 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.

[56] 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.

[57] 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 at http://www.epa.gov/iris/subst/0270.htm.

[58] Agency for Toxic Substances and Disease Registry (ATSDR), 2007. The Toxicological Profile for xylene is available 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.[59] 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.[60]

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.[61]

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

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

[61] 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 points of discussion for the proposed action: 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 action. 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.[62] 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 action includes removing the requirements in the 2016 NSPS OOOOa from the sources in the transmission and storage sector. The proposed option is expected to lead to total cost savings. The EAV of cost savings over the 2019-25 time frame is about $18 million per year without including the forgone value of product

[62] See Section 6.2 of the 2016 NSPS RIA

recovery (about $4 million per year), or $14 million 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]. E.O. 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.[63] 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 action, 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 action, 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 to be regressive, placing a greater burden on lower income households (e.g., Burtraw et al., 2009;

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[63] 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.

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 3.5 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 transfers indexed to inflation will offset the burden to lower income households[64] (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).

4.3.2 Distributional Aspects of the Forgone Health Benefits

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[64] 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).

This section discusses the distribution of forgone health benefits that result from the proposed action. 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 way 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 action proposes to remove requirements on all sources in the transmission and storage sector and will not change the stringency on the remaining sources affected by the 2016 NSPS OOOOa. Relative to the 2018 Proposed Regulatory baseline, the reduction in EAV over the 2019-25 time frame is about $18 million per year without including the forgone value of product recovery (about $4 million per year), or $14 million 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 be neutral or 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.[65] 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 (E.O. 13777). Employment impacts of environmental regulations are 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

[65] 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).

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 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.[66] 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 action is likely to cause little change in oil and natural gas exploration and production, and many aspects of the 2016 NSPS OOOOa requirements are not affected by the proposed action, 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 action. EPA expects there will be slight reductions in the labor required for compliance-related activities associated with the 2016 NSPS OOOOa requirements relating to sources in transmission and storage. However, due to uncertainties associated with how the proposed action 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

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

public comments to ensure that the way EPA characterizes the employment effects of its regulations is valid and informative.

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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 proposed regulation across the alternative baselines. 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. 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 alternative baseline.

All benefits, costs, and net benefits shown in this section are presented as the PV of the costs and benefits of the proposed action 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 the proposed action relative to the 2018 Proposed Regulatory baseline. Table 5-2 shows the estimated benefits, costs and net benefits for the proposed action relative to the 2018 Proposed Regulatory baseline.

Table 5-1 Summary of the Present Value (PV) and Equivalent Annualized Value (EAV) of Forgone Monetized Benefits, Cost Savings, and Net Benefits for the Proposed Option, 2019 through 2025, relative to the 2018 Proposed Regulatory Baseline (millions, 2016$)

	7 percent		3 percent	
	PV	**EAV**	**PV**	**EAV**
Benefits (Total Cost Savings)	$81	$14	$103	$16
Cost Savings	*$104*	*$18*	*$133*	*$21*
Forgone Value of Product Recovery	*$23*	*$4.0*	*$29*	*$4.6*
Costs (Forgone Domestic Climate Benefits)[1]	$13	$2.2	$49	$7.7
Net Benefits[2]	$69	$12	$54	$8.4

[1] The forgone benefits estimates are calculated using estimates of the social cost of methane ($SC\text{-}CH_4$). $SC\text{-}CH_4$ values represent only a partial accounting of domestic climate impacts from methane emissions.
[2] Estimates may not sum due to independent rounding.

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

	7 percent		3 percent	
	PV	**EAV**	**PV**	**EAV**
Benefits (Total Cost Savings)	$97	$17	$123	$19
Cost Savings	*$122*	*$21*	*$155*	*$24*
Forgone Value of Product Recovery	*$25*	*$4.4*	*$32*	*$5.0*
Costs (Forgone Domestic Climate Benefits)[1]	$13	$2.3	$52	$8.1
Net Benefits[2]	$83	$14	$70	$11

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

Table 5-3 provides a summary of the direct increase in emissions for the proposed action relative to both baselines.

Table 5-3 Summary of Total Increase in Emissions of the Proposed Action, 2019 through 2025, compared to Alternative Baselines

Pollutant	Increase in Emissions Relative to the 2018 Proposed Regulatory Baseline	Increase in Emissions Relative to the Current Regulatory Baseline
Methane (short tons)	350,000	370,000
VOC (short tons)	9,700	10,000
HAP (short tons)	290	300
Methane (metric tons)	320,000	330,000
Methane (million metric tons CO_2 Eq.)	7.9	8.4

5.2 Uncertainties and Limitations

Throughout the RIA, we considered several 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 2.3.2, 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. 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. In addition, the impacts of this rule are based on projections based on historical estimates in the Greenhouse Gas Inventory and do not account for modifications or turnover, just the estimated number of new sources.[67] To the extent actual counts of new facilities in transmission and storage diverge from the historical average annual increases, the projected regulatory impacts estimated in this document will diverge. It is possible that, though the number of sources remains constant over a time period, sources are retired at the same rate new sources subject to 2016 NSPS OOOOa are built. This means that the number of sources affected by 2016 NSPS OOOOa, and this proposed action, may be underestimated.

- **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 2.3.2. 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 the baselines for this analysis:** In preparing the impacts analysis, EPA reviewed state regulations and permitting requirements. With the information we currently have available, we are unable to determine where newly affected sources in the transmission and storage segments are expected to locate. Though there are states with similar requirements to those of the 2016 NSPS OOOOa, as amended in the technical reconsideration, we are unable to account for them in this action.[68] Applicable facilities in these states with similar requirements will still be expected to follow state regulations. This analysis likely overestimates the cost savings from sources in transmission and storage because it includes estimates of incrementally affected facilities with similar state

[67] As noted in the preamble of this proposed rule, EPA is interested in determining whether information in NSPS-related compliance reports may prove useful for estimating turnover rates of affected facilities. EPA will use this information in future analyses if it is useful and appropriate.

[68] For this proposed action and for the technical reconsideration proposal, EPA projected affected facilities using a combination of historical data from the U.S. GHG Inventory, DI Desktop, and projected activity levels taken from the Energy Information Administration's Annual Energy Outlook. Because oil and natural gas well locations are identified in DI Desktop, we can forecast well drilling activities by state. As a result, we can estimate the effects of state regulations on future affected facilities that draw upon state-specific information in their projection. However, projections of affected facilities that draw upon U.S. GHG Inventory, such as sources in the transmission and storage segment, are national-scale and, hence, we are unable to account for state-level regulations in our projected impacts in this proposed RIA.

level requirements to those in the 2016 NSPS OOOOa, as amended by the technical reconsideration.

- **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. As explained in Section 2.3.4, 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.[69] 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.[70] 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[71]—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).[72] Although the regional shares reported in Nordhaus (2017) are specific to SC-CO_2, they still provide a reasonable interim approach for approximating the U.S. share of marginal damages

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[69] The full model 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).

[70] 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.

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

[72] 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.

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 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).[73] 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 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.

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

Monte Carlo techniques were used to run the IAMs many times. In each simulation the uncertain parameters are represented by random draws from their defined 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.[74] 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

[74] 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.

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 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 A-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.[75] 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.

[75] Although the distributions in Figure A-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.

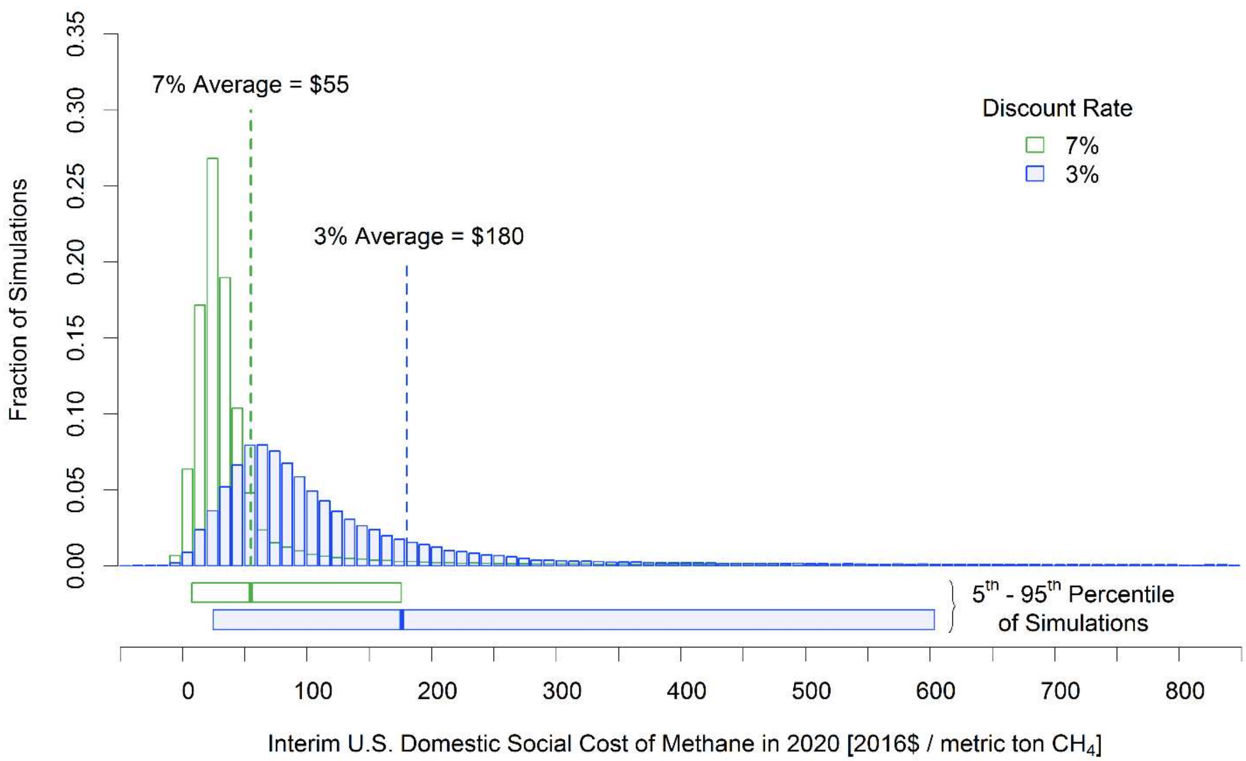

Figure A-1 Frequency Distribution of Interim Domestic SC-CH4 Estimates for 2020 (in 2016$ per metric ton CH4)

As illustrated by the frequency distributions in Figure A-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,[76] 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,[77] 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

[76] 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)".

[77] "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 $220 per metric ton of CH_4 (2016$);[78] in this case the forgone domestic climate benefits of the proposed action relative to the 2018 Proposed Regulatory Baseline are $5.7 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 $13 million. The PV of the forgone domestic climate benefits under a 2.5 percent discount rate is $64 million, with a corresponding EAV of $9.9 million per year. Using the same discount rate, the PV and EAV of the forgone domestic climate benefits of the proposed action relative to the Current Regulatory Baseline are $68 million and $10 million, respectively.

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

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

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 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).[79] 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.[80] The domestic SC-CH_4 estimates presented above are approximately 15 percent and 13 percent of these global SC-CH_4

[79] 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.

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

estimates for the 7 percent and 3 percent discount rates, respectively. Applying these estimates to the forgone CH_4 emission reductions relative to the 2018 Proposed Regulatory Baseline results in estimated forgone global climate benefits ranging from $8.1 million in 2019 to $15 million in 2025, using a 7 percent discount rate. The PV of the forgone global climate benefits using a 7 percent discount rate is $83 million, with an associated EAV of $14 million per year. The estimated forgone global climate benefits are $35 million in 2019 and increase to $76 million in 2025 using a 3 percent rate. The PV of the forgone global climate benefits using a 3 percent discount rate is $389 million, with an associated EAV of $61 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 $47 million in 2019 and $103 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 $525 million, with an associated EAV of $81 million per year. Using the same discount rate, the PV and EAV of the forgone global climate benefits of the proposed action relative to the Current Regulatory Baseline are $554 million and $85 million, respectively. All estimates are reported in 2016 dollars.

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United States Environmental Protection Agency	Office of Air Quality Planning and Standards Health and Environmental Impacts Division Research Triangle Park, NC	Publication No. EPA-452/R-19-001 August 2019