Regulatory Impact Analysis for the Proposed Industrial, Commercial, and Institutional Boilers and Process Heaters NESHAP Reconsideration

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Regulatory Impact Analysis of the Industrial, Commercial, and Institutional Boilers and Process Heaters NESHAP Reconsideration Proposed Rule

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
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1 INTRODUCTION

This report is the regulatory impact analysis (RIA) for the proposed reconsideration of the Industrial, Commercial, and Institutional (ICI) Boilers and Process Heaters NESHAP. The U.S. Environmental Protection Agency (EPA) is proposing national emission standards for hazardous air pollutants (NESHAP) for new and existing industrial, commercial, and institutional boilers and process heaters. On January 31, 2013, the EPA finalized amendments to the national emission standards for the control of hazardous air pollutants at major sources from new and existing industrial, commercial, and institutional boilers and process heaters. Subsequently, the U.S. Court of Appeals for the District of Columbia Circuit remanded several of the emission standards to the EPA based on the court's review of the EPA's approach to setting those standards. On July 29, 2016, the U.S. Court of Appeals for the District of Columbia Circuit issued its decision remanding emission standards where it held that the EPA had improperly excluded certain units in establishing the emission standards and remanded the use of carbon monoxide (CO) as a surrogate for organic HAP for further explanation. In March 2018, the court in a separate case remanded the EPA's decision to set a limit of 130 parts per million (ppm) CO as a minimum standard for certain subcategories for further explanation. In response to these remands, this action proposes to amend several numeric emission limits for new and existing boilers and process heaters and set compliance dates for these new emission limits.

The proposed revisions to the emission limits are solely to respond to the remands issued by the U.S. Court of Appeals for the District of Columbia Circuit. As part of its response, the EPA changed how co-fired (i.e., ICI boilers that can use more than one fuel type) units are ranked and assessed from previous Maximum Achievable Control Technology (MACT) rulemakings, changed how small datasets are assessed, and made decisions to propose certain emissions limits as beyond the MACT floor.[1] For the MACT-based emission limits calculated for this particular response to the remands, the revisions were very narrowly scoped. The EPA's response to the remands was to revise the rankings to address the co-firing issue, which required the EPA to identify a new set of best performing units, by including previously excluded co-fired units in the rankings and then re-calculate the limits based on the new set of best performer data

[1] We reviewed the recalculated MACT floor emission limits that were less stringent than those in the January 2013 final rule in order to assess whether a beyond-the-floor option was technically achievable and cost-effective. Further discussion is available in section III.B of the proposal preamble.

while using the existing data set (including any necessary corrections). Given the direction provided by the remand, the only available alternative standard was to select standards that were beyond the MACT floor, which the EPA selected in limited circumstances as discussed above and in more detail in the docketed memorandum.[2]

These changes yield 34 different emission limits that we are proposing to change. Of these 34 emission limits, 28 of the limits became more stringent. Six of the limits became modestly less stringent, with no more than a 25 percent decrease in the stringency of the emission limit compared to the 2013 ICI Boilers MACT standard. Twenty-one of these emissions limits change as a result of including previously excluded units (co-fired). The other seven emissions limits change as a result of the small dataset issue or adjustments to CO data. A complete list of all the proposed emission limits, for new and existing units, and with pollutant indicated for each emissions limit, and a summary of proposed changes to the current limits is shown in Table 1-1. We note that particulate matter (PM) and CO are the most common pollutants for these emissions limits, and these pollutants serve as surrogates for the HAPs that are regulated. More information on these emissions limits and the rationale for changes can be found in section IV.A of the proposal preamble.

Table 1-1 Summary of Changes to Emissions Limits In the Proposed Action

Subcategory	Pollutant	Current Emission Limit (lb/MMBtu of heat input or ppm @ 3 percent oxygen for CO)	Proposed Emission Limit (lb/MMBtu of heat input or ppm @ 3 percent oxygen for CO)
New-Solid	HCl	2.20E-02	3.00E-04
New-Dry Biomass Stoker	TSM8	4.00E-03	5.00E-03
New-Biomass Fluidized Bed	CO	230	130
New- Biomass Fluidized Bed	PM	9.80E-03	4.10E-03
	TSM	8.30E-05	8.40E-06
New-Biomass Suspension Burner	CO	2,400	220
New-Biomass Suspension Burner	TSM	6.50E-03	8.00E-03
New-Biomass Hybrid Suspension Grate	CO	1,100	180
New-Biomass Dutch Oven/Pile Burner	PM	3.20E-03	2.50E-03
New-Biomass Fuel Cell	PM	2.00E-02	1.10E-02
New- Wet Biomass Stoker	CO	620	590

[2] Eastern Research Group (ERG). Memorandum, Revised MACT Floor Analysis (2019) for the Industrial, Commercial, and Institutional Boilers and Process Heaters National Emission Standards for Hazardous Air Pollutants – Major Source. May, 2020.

New- Wet Biomass Stoker	PM	0.03	0.013
New-Liquid	HCl	4.40E-04	7.00E-05
New-Heavy Liquid	PM	1.30E-02	1.90E-03
	TSM	7.50E-05	6.40E-06
New-Process Gas	PM	6.70E-03	7.30E-03
Existing-Solid	HCl	2.20E-02	2.00E-02
Existing-Solid	Hg	5.70E-06	5.40E-06
Existing-Coal	PM	4.00E-02	3.90E-02
Existing-Coal Stoker	CO	160	150
Existing-Dry Biomass Stoker	TSM	4.00E-03	5.00E-03
Existing-Wet Biomass Stoker	CO	1,500	1,100
Existing- Wet Biomass Stoker	PM	3.70E-02	3.40E-02
	TSM	2.40E-04	2.00E-04
Existing-Biomass Fluidized Bed	CO	470	210
Existing-Biomass Fluidized Bed	PM	1.10E-01	2.10E-02
	TSM	1.20E-03	6.40E-05
Existing-Biomass Suspension Burners	PM	5.10E-02	4.10E-02
	TSM	6.50E-03	8.00E-03
Existing-Biomass Dutch Oven/Pile Burner	PM	2.80E-01	1.80E-01
Existing-Liquid	Hg	2.00E-06	7.30E-07
Existing-Heavy Liquid	PM	6.20E-02	5.90E-02
Existing-Non-continental Liquid	PM	2.70E-01	2.20E-01
Existing-Process Gas	PM	6.70E-03	7.30E-03

This rule affects a range of facilities in the ICI sector that are located at major sources of HAP and have a boiler or process heater as defined in the final Boiler MACT. The 2013 Emission Database for Boilers and Process Heaters estimated there were approximately 14,000 existing boilers and process heaters currently operating at 1,702 different facilities that are major sources of HAP and subject to the Boiler MACT. The vast majority of these combustion units (nearly 12,000 units) were gas-fired and in the Gas 1 subcategory, which are subject to the rule but are not subject to numeric emission limits.

To identify potentially affected facilities for this proposal, the EPA reviewed compliance data submitted to CEDRI and WebFIRE and data available from trade associations, such as the Council for Industrial Boiler Operators (CIBO). These data show 533 existing boilers and process heaters, of which 443 remain operational, belonging to one of the subcategories that are subject to numeric emission limits, the subject of this action.[3] We then reviewed the compliance data for hydrogen chloride (HCl), mercury (Hg), filterable particulate matter (PM), and CO emissions and compared these data to the proposed emission limits to evaluate which boilers were not currently meeting the more stringent proposed emission limits. Based on this effort, the EPA determined that this proposed regulation could likely affect 33 boilers, 28 boilers of which are classified as existing sources and five of which are classified as new sources. The EPA notes that 16 of these boilers (13 existing, 3 new) are not expected to incur any compliance costs associated with the proposal because they already meet the proposed emissions limits. After applying all these filters, the EPA expects that 17 boilers (15 existing, 2 new) would likely be affected by this proposed rule in that they would likely have to perform additional compliance actions to meet the new proposed limits.

The impacts estimated for this proposal are all additional to the reductions already accounted for in the January 2013 final ICI boiler rule for both new and existing sources. Thus, the baseline for this proposal includes the impacts, and hence the installation and operation of HAP control devices at ICI boilers associated with the 2013 boilers rule.

The proposed changes to the emissions limits shown in Table 1 will protect air quality and promote public health by reducing emissions of the HAP listed in section 112(b)(1) of the Clean Air Act. This action also addresses the two issues remanded to the EPA for further explanation and makes several technical clarifications and corrections.

In addition to controlling HAP, primarily metal HAP, this action yields co-benefits such as reduced emissions of fine particulate matter ($PM_{2.5}$) and sulfur dioxide (SO_2) that are co-benefits (that is, benefits from reductions of non-targeted emissions) of this action. There are also minimal increases in carbon dioxide (CO_2) emissions associated with this action, and these increases are treated as a co-disbenefit. Our estimate of benefits includes those monetized estimates for non-targeted emission reductions and increases. There are no monetized benefits from the targeted HAP reductions due to lack of necessary input data. More information on the benefits, ancillary co-benefits, and co-disbenefits can be found in Chapter 4 of the RIA.

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[3] This count excludes any shutdown boilers, boilers that have switched to the natural gas subcategory and are therefore no longer impacted by changes to emission limits, or boilers that are classified as small or limited use.

This proposed rule is economically significant according to Executive Order 12866 (i.e., an annual effect of $100 million or greater in any one year or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities), and the EPA is therefore required to develop a RIA. This RIA documents all methods and provides the results of the economic impact analysis (EIA), small business impacts analysis, and benefits analysis. With the purpose of this proposal being to provide necessary, non-discretionary changes in emissions limits to ICI boilers and process heaters in response to the decision by the U.S. Court of Appeals for the D.C. Circuit, the RIA presents an analysis of the regulatory impacts resulting from the changes in emissions limits.

1.1 Summary of RIA Results

This reconsideration will likely impose costs and economic impacts on several industries and their consumers, while producing beneficial improvements in air quality. The key results of this RIA are as follows:

- **Engineering Compliance Costs**: Total annual costs are those costs incurred by affected industries that include pollution control and administrative (monitoring, recordkeeping, and reporting) costs. The EPA estimates that the facilities that will need to implement compliance measures to meet the proposed limits will incur $83.7 million in total capital costs (2016). The facilities are also projected to incur about $14 million in annual operating and maintenance expenditures once the proposed limits are in effect. In addition, the PV of these costs is $103.7 million at a 7 percent discount rate, and $128.1 million at a 3 percent discount rate. Finally, consistent with the present value estimate, the annualized value of the costs, expressed as an equivalent annualized value (EAV), is $17.4 million at a 7 percent discount rate and $18.3 million at a 3 percent discount rate.
- **Economic Impacts and Small Businesses**: The EPA prepared an analysis of economic impacts in which the annualized costs for affected companies are compared to their annual revenues, and consider these results in light of market information (e.g., price elasticities of demand). We find that these impacts are relatively low, and minimal impacts are expected to affected companies and consumers of their products. In compliance with the Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness

Act (SBREFA), the EPA used the economic impact analysis to estimate impacts on affected small businesses by analyzing annual compliance costs as a share of annual ultimate parent company revenues. Of the 26 affected parent companies, only one is a small business according to Small Business Administration (SBA) small business size guidelines. The EPA estimates that the single potentially affected small business owns two affected ICI boilers subject to the requirements in this proposal but will not incur any compliance costs, so there are no small business impacts associated with this proposal. Therefore, the EPA can certify that this proposal will not have a significant economic impact on a substantial number of small entities (SISNOSE).

- **Emissions Impacts**: For targeted HAP emissions, the proposed amendments are expected to result in an additional 34 tons per year (tpy) of reductions in HCl emissions. The proposed amendments are also expected to have a modest effect on mercury, with an estimated additional reduction of 3.96 pounds per year. Emissions of non-mercury metals (i.e., antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, nickel, and selenium) would decrease by 2.3 tpy. For non-targeted emissions, filterable PM emissions would decrease by 333 tpy, of which 251 tpy is fine PM ($PM_{2.5}$), due to the proposed amendments. In addition, the proposed amendments are estimated to result in an additional 393 tpy of reductions in sulfur dioxide (SO_2) emissions. Finally, carbon dioxide (CO_2) emissions increase by 14,700 short tons as a result of operation of the additional control devices expected as a result of the proposal.
- **Benefits:** Benefits associated with reductions in the targeted HAP emission reductions are not estimated in this RIA due to lack of appropriate valuation estimates. Estimated monetized ancillary co-benefits of this proposal are from reduced mortality and morbidity attributed to lower emissions of from non-targeted pollutants such as $PM_{2.5}$ and SO_2 achieved with the operation of the compliance technologies associated with the proposed HAP standards.[4] The benefits estimates also account for ancillary climate co-disbenefits,

[4] To facilitate the estimation of the stream of potential ancillary co-benefits flowing from this rulemaking, we use available air quality modeling to estimate ancillary co-benefits in 2025, then assume that the level of impacts estimated for 2025 recurs annually during the years within the time horizon under analysis that facilities are expected to be in compliance and reducing emissions, or 2024 to 2028. The EPA estimates the ancillary co-benefits from reductions in non-targeted pollutants such as $PM_{2.5}$ and SO_2 in 2016 dollars of this proposed major source NESHAP are $110 million to $250 million at a 3 percent discount rate and $95 million to $210 million at a 7 percent discount rate for the snapshot year of 2025.

which result from increased emissions of CO_2.[5] The present value (PV) of the benefits in 2016 dollars and discounted to 2020, is $630 million to $1,100 million when using a 7 percent discount rate and $730 million to $1,650 million when using a 3 percent discount rate, all plus C to represent the present value of the unmonetized HAP benefits. The equivalent annualized values (EAV), an estimate of the annualized value of the net benefits considering ancillary co-benefits and co-disbenefits consistent with the present values, is $90 million to $180 million per year when using a 7 percent discount rate and $100 million to $240 million per year when using a 3 percent discount rate, all plus D to represent the equivalent annualized value of the unmonetized HAP benefits. The calculation of benefits as PV and EAV can be found in a set of spreadsheets available in the docket for this rulemaking.[6]

- **Cost-Benefit Comparison:** The present value (PV) of the net benefits considering ancillary co-benefits and co-disbenefits, in 2016 dollars and discounted to 2020, is $530 million to $1,000 million when using a 7 percent discount rate and $600 million to $1,520 million when using a 3 percent discount rate, all plus C to represent the present value of the unmonetized HAP benefits. The equivalent annualized values (EAV), an estimate of the annualized value of the net benefits considering ancillary co-benefits and co-disbenefits consistent with the present values, is $70 million to $160 million per year when using a 7 percent discount rate and $80 million to $220 million per year when using a 3 percent discount rate, all plus D to represent the equivalent annualized value of the unmonetized HAP benefits. Table 1-2 summarizes the costs, monetized co-benefits, and net benefits of the proposal, all of which are shown as PV and EAV. Estimates in the table are presented as rounded values.

[5] The annualized value of the ancillary climate co-disbenefits for 2025 from this proposed NESHAP is $0.09 million at a 3 percent discount rate and $0.01 million at a 7 percent discount rate.

[6] U.S. EPA. OAQPS. WorkbookICIboilersMACTrecon_BenefitsUpperbound3%_PVandEAV.xls, WorkbookICIboilersMACTrecon_BenefitsUpperbound7%_PVandEAV.xls, WorkbookICIboilersMACTrecon_BenefitsLowerbound3%_PVandEAV.xls, WorkbookICIboilersMACTrecon_BenefitsLowerbound7%_PVandEAV.xls,

Table 1-2 Summary of Present Values and Equivalent Annualized Values for Annual Costs, Monetized Ancillary Co-Benefits, and Monetized Net Co-Benefits (Including Co-Disbenefits) for the Proposed Rule (millions of 2016 dollars)[a,b]

		3% Discount Rate	7% Discount Rate
Present Value	Targeted Benefits[c]	C	C
	Ancillary Co-Benefits	$730 to $1,650	$630 to $1,100
	Ancillary Co-Disbenefits	<$1	<$1
	Cost[d]	$130	$100
	Net Benefits[e]	$600 to $1,520 + C	$530 to $1,000 + C
Equivalent Annualized Value	Targeted Benefits[f]	D	D
	Ancillary Co-Benefits	$100 to 240	$90 to 180
	Ancillary Co-Disbenefits	<$0.1	<$0.1
	Costs	$18	$17
	Net Benefits	$80 to 220 + D	$70 to 160 +D

[a] All estimates in this table are rounded to one decimal point, so numbers may not sum due to independent rounding.
[b] All estimates reflect the amendments to the ICI Boilers MACT standard included in this proposal from a baseline that includes the control technologies applied to meet the MACT standard.
[c] C represents the present value of unquantified benefits from reductions in targeted HAP emissions.
[d] The annualized present value of costs and benefits are calculated over an 8 year period from 2021 to 2028.
[e] The total monetized ancillary co-benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of directly emitted $PM_{2.5}$ and SO_2. Monetized ancillary co-benefits include many, but not all, health effects associated with $PM_{2.5}$ exposure. Co-benefits are shown as a range from Krewski *et al.* (2009) to Lepeule *et al.* (2012). We do not report the total monetized ancillary co-benefits by $PM_{2.5}$ species. The ancillary climate co-disbenefits from additional CO_2 emissions resulting from control device operations are included in the results given the rounding convention employed in this table as stated in footnote a. The net benefits calculation consists of the sum of the targeted benefits and ancillary co-benefits minus the costs and ancillary climate co-disbenefits.
[f] D represents the equivalent annualized value of unquantified benefits from reductions in targeted HAP emissions.

Given these results, the EPA expects that implementation of this proposed rule, based solely on an economic efficiency criterion, will provide society with a substantial net gain in welfare, notwithstanding the expansive set of health and environmental benefits and co-benefits or other impacts we were unable to quantify. Further quantification of directly emitted $PM_{2.5}$-, mercury-, acidification-, and eutrophication-related impacts would increase the estimated net co-benefits of the rule.

1.2 Organization of this Report

This report presents the EPA's analysis of the potential benefits, costs, and other economic effects of the proposed standards for ICI boilers. This RIA includes the following sections:

- Section 2 presents a profile of the affected industries, developed for the economic impact analysis.
- Section 3 describes the estimated costs and impacts of the regulation, providing a summary of the analysis inputs and methodology for assessing the economic impacts of the proposed

regulation. The section provides the analysis results, including impacts on industry overall and impacts on small businesses.

- Section 4 describes the benefits and ancillary co-benefits of this regulation for both targeted HAP and non-targeted emission reductions and the inputs and methods used for estimating and valuing reduced environmental and human exposure to air emissions. The section also describes the climate co-disbenefits of this proposed regulation.
- Section 5 presents the overall comparison of the benefits (including ancillary co-benefits and co-disbenefits) and costs.

2 INDUSTRY PROFILE

This proposed rule will affect facilities and companies using ICI boilers, based on the National Emission Standards for Hazardous Air Pollutants (NESHAP) source category (i.e., 40 CFR part 63, subpart D) standards. Of the 90 different emission limits included in the ICI boilers MACT standard, the EPA is proposing to revise 34 of them depending on the type of boilers and fuel used. Of these 34 emission limits, 28 of the limits became more stringent and six of the limits became less stringent. Facilities would have up to three years after the effective date of the final rule to demonstrate compliance with these revised emission limits.

ICI boilers are found in many manufacturing sectors and other industries. The EPA used the North American Industrial Classification System (NAICS) code identified for the parent company owning each facility using an impacted ICI boiler to conduct this brief industry profile. This section summarizes in a high-level fashion the profiles of these industries using the NAICS codes for the ultimate parent companies that own affected boilers. The proposed rule only affects a subset of facilities using ICI boilers within each industry identified. This proposal does not impact all types of ICI boilers. The ICI boilers identified as having impacts from this proposal fall in the following categories: existing biomass-fired, existing coal-fired, new biomass-fired, and new coal-fired. The EPA identified 28 existing ICI boilers that will be affected by this proposed rule and expects five new boilers to be added to the industry in the future, which are fired or expected to be fired by biomass (e.g., wood) or coal as fuels. None of the affected ICI boilers are oil-fired or gas-fired. Table 2-1 provides a list of the industries by NAICS code with source categories affected by the proposed rule.

Table 2-1 Source Categories Affected By This Proposed Action

NAICS code[1]	Examples of potentially regulated entities
221	Electric, gas, and sanitary services
321	Manufacturers of lumber and wood products
322	Pulp and paper mills
423	Merchant Trade, Durable Goods
424	Merchant Trade, Nondurable Goods
541	Professional, Scientific and Technical Services

[1] North American Industry Classification System.

The industry profile provided here is based on 2016 data from U.S. Census Bureau and U.S. Census Bureau American Fact Finder.[7] For some NAICS codes, 2016 data were not available, and in those instances the most up-to-date data available were used. This profile is not meant to serve as an exhaustive treatment for each affected industry and any subsectors of note, but is meant to serve as a high-level summary of useful information for these industries. It is important to note that only a small fraction of the facilities in each industry own ICI boilers. Thus, only a small fraction of facilities in these industries are impacted by this proposed regulation.

2.1 Electric, Gas, and Sanitary Services

Activities in this sector, NAICS 221, include providing electric power, natural gas, steam supply, water supply, and sewage removal through a permanent infrastructure of lines, mains, and pipes. This proposed rule is anticipated to affect four ultimate parent companies owning four boilers in this sector. According to the U.S. Census Bureau American Fact Finder, in 2016, NAICS 221 had 5,893 ultimate parent companies that own 18,159 establishments. The sector employed 638,917 people, with payroll of around $654 billion.

2.2 Sawmills and Wood Preservation

This sector includes establishments whose primary production process begins with logs or bolts that are transformed into boards, dimension lumber, beams, timbers, poles, ties, shingles, shakes, siding, and wood chips. This industry also includes establishments that cut and treat round wood and/or treat wood products to prevent rotting by impregnation with creosote or other chemical compounds.

This proposed rule is anticipated to affect nine ultimate parent companies owning 12 boilers in this sector. According to the U.S. Census Bureau American Fact Finder, in 2016, the sawmills and wood preservation industry (NAICS 321) was comprised of 3,213 establishments employing 77,200 people and had a payroll of around $3.7 billion. The total value of shipments and receipts for services from this sector was around $30.5 billion.

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[7] US Census Bureau, Dept. of Commerce, https://www.census.gov/eos/www/naics/, and US Census Bureau American Fact Finder, Dept. of Commerce, https://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t

2.3 Converted Paper Product Manufacturing

This industry includes establishments primarily engaged in converting paper or paperboard, but they do not manufacture paper or paperboard. According to the U.S. Census Bureau American Fact Finder, in 2016 the converted paper product manufacturing industry (NAICS 322) had 3,638 establishments employing 233,866 people, with a payroll of around $13 billion. The total value of shipments and receipts for services was around $105 billion.

Paper bag and coated and treated paper manufacturing, NAICS 322220, is a subsector in this industry. It includes establishments primarily engaged in cutting and coating paper and paperboard, and/or cutting and laminating paper, paperboard, and other flexible materials (except plastics film to plastics film). There are 13 boilers owned by 12 ultimate parent companies with this NAICS code anticipated to be affected by this proposal. In 2016, this industry employed 45,700 employees, and had a payroll of around $2.6 billion. The total value of shipments and receipts from this sector was around $20.6 billion.

2.4 Merchant Wholesalers, Durable Goods

Firms in this sector, NAICS 423, sell capital or durable goods to other businesses. Merchant wholesalers generally take title to the goods that they sell; in other words, they buy and sell goods on their own account. Durable goods are new or used items with a useful life of three years or more. Durable goods merchant wholesale trade establishments are engaged in wholesaling products, such as motor vehicles, furniture, construction materials, machinery and equipment (including household-type appliances), metals and minerals (except petroleum), sporting goods, toys and hobby goods, recyclable materials, and parts.

There are two boilers owned by two ultimate parent companies under this NAICS code identified as having impacts from this proposal. According to the American Fact Finder (U.S. Census Bureau), in 2016 the sector was comprised of 164,328 parent companies that own 237,789 establishments. The sector had 3,464,046 employees, with a payroll of around $257.6 billion.

2.5 Merchant Wholesales, Nondurable Goods

Firms in this sector, NAICS 424, sell nondurable goods to other businesses. Nondurable goods are items generally with a useful life of less than three years. Nondurable goods merchant wholesale trade establishments are engaged in wholesaling products, such as paper and paper products, chemicals and chemical products, drugs, textiles and textile products, apparel, footwear, groceries, farm products, petroleum and petroleum products, alcoholic beverages, books, magazines, newspapers, flowers and nursery stock, and tobacco products.

There is one boiler owned by an ultimate parent company under this NAICS code identified as having impacts from this proposal. According to the American Fact Finder (U.S. Census Bureau), in 2016 the sector had 96,817 parent companies that own 129,133 establishments. The sector had 2,341,135 employees, with a payroll of around $153.9 billion.

2.6 Professional, Scientific and Technical Services

Firms in this sector, NAICS 541, are engaged in processes where human capital is the major input. These establishments offer the knowledge and skills of their employees, often on an assignment basis, where an individual or team is responsible for the delivery of services to the client. The individual industries of this subsector are defined on the basis of the particular expertise and training of the services provider.

There is one boiler with an ultimate parent company under this NAICS identified as affected by this proposal. According to the American Fact Finder (U.S. Census Bureau), in 2016 the sector had 805,745 parent companies that own 903,534 establishments. The sector had 8,799,893 employees, with a payroll of around $720.3 billion.

3 EMISSION REDUCTIONS, ENGINEERING COST AND ECONOMIC IMPACT ESTIMATES

This section presents the EPA's estimates of the emission reductions and compliance costs associated with the proposed reconsideration NESHAP. As discussed in Section 1, this proposed reconsideration is expected to affect 33 boilers (28 existing, 5 new). The EPA notes that 16 of these boilers (13 existing, 3 new) are not expected to incur any compliance costs associated with the proposal because they are expected to meet the proposed emissions limits. As a result, the EPA expects that 17 boilers (15 existing, 2 new) would likely be affected by this proposed action in that they would likely have to perform additional compliance actions to meet the new proposed limits. The emission reductions are used to estimate the benefits and co-benefits shown in Chapter 4 of this RIA, and the costs are used to estimate the economic and small business impacts presently later in this RIA chapter.

The analysis in this RIA reflects proposed amendments to the current MACT standard, including revisions to emissions limits for a variety of different source types and other revisions to appropriately respond to the instructions within the U.S. Court of Appeals for the D.C. Circuit's decisions. This analysis presents incremental emission reductions and costs separate from those already accounted for in the January 2013 final ICI boilers MACT rule RIA. For existing units, the EPA conducted a review to see if the impacts of the control strategy expected to be necessary to meet the proposed emission limit had been used in the previous RIA. If so, the same control was not accounted for in this revised analysis to avoid double counting of the emission reductions and costs.

3.1 National Emissions Reductions and Other Emissions Changes

The EPA's estimates of emission reductions in tons per year (tpy) for the proposed reconsideration NESHAP are shown in Table 3-1 below. The baseline emissions are primarily based on compliance data available through two EPA databases: Compliance and Emissions Data Reporting Interface (CEDRI) and WebFIRE. Data are also sourced from reported emission test results collected for the previous industrial boilers MACT, and from fuel and control devices installed on affected units. The proposed reconsideration standard would result in reductions of HAP emissions. The HAP emissions reduced include hydrochloric acid (HCl), mercury (Hg), hydrogen fluoride (HF), and total non-mercury selected metals (TSM).[8] We show these targeted emission reductions by type of source and fuel type.

In addition, the proposed reconsideration standard will yield reductions in emissions of non-targeted pollutants such as fine particulate matter ($PM_{2.5}$) and sulfur dioxide (SO_2) that are concurrent with the HAP emission reductions. In each case where there is an exceedance of the HCl, Hg, or PM emissions limits, the compliance cost analysis compares the baseline emissions to the corresponding proposed emission limit for the unit's subcategory. The control device cost for a unit was estimated if its baseline emissions exceeded their applicable proposed emission limit for each pollutant requiring control. For PM and Hg, there is only one control technology that can be applied to meet the proposed emissions limits for each pollutant. For HCl, there is more than one control technology available.

Most of the Hg emissions reductions are expected to be achieved through the installation of new fabric filters. Where baseline Hg emissions are found to be greater than the MACT floor estimate, the cost of a fabric filter was estimated for an individual boiler or process heater unless the unit already had a fabric filter.

When baseline PM emissions exceeded the proposed emissions limits, reductions are expected to be achieved by the installation of new ESPs unless the unit already had a fabric filter in the analysis for Hg reduction or unless an ESP was already reported to be installed as a baseline control and the unit still required more than 5 percent PM emission reductions.

When HCl baseline emissions are greater than the MACT floor estimate, increasing the sorbent rate on an existing scrubber, adding a new scrubber, or installing a combination fabric filter and dry injection (DIFF) system is applied to achieve the necessary HCl emissions reductions. Of these options, Scrubbers and DIFF systems are estimated to attain similar levels of HCl control.

Our analysis of the costs of compliance options listed above finds that the choice of options is insensitive to nominal interest rates of 10% and 15%, which are much higher rates than that for our main cost analysis (5.5%). The discussion and presentation of these cost

[8] Metals include antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, nickel, and selenium.

sensitivity analysis results can be found in the Impacts and Cost Methodology memos for this proposal.[9]

In total, including existing and new ICI boilers, the emission controls listed above yield HAP emission reductions of about 34 tpy of HCl, 1 tpy of HF, and 0.002 tpy of Hg. Reductions in $PM_{2.5}$ from this proposal are estimated at 251 tpy (out of 333 tpy of total PM, which includes PM_{10}), and SO_2 reductions are estimated at 393 tpy.

Table 3-1 Nationwide Annual Emission Reductions from ICI Boilers affected by the Proposed Rule

	Annual Reductions, tons/year (tpy)						
Source Type	Hg	HCl	HF	SO_2	PM	$PM_{2.5}$	TSM
Existing-Biomass	1.80E-03	14.5	0.11	43.8	333	251	2.3
Existing-Coal	1.90E-04	9.8	0.67	336	0	0	0
Total Existing	1.80E-04	24.3	0.78	379.8	333	251	2.3
New-Biomass	0	9.8	0.21	13.2	0	0	0
Total	**1.80E-03**	**34.1**	**0.99**	**393**	**333**	**251**	**2.3**

This proposed rule is also expected to lead to an increase in the non-targeted pollutant carbon dioxide (CO_2) emissions incremental to the baseline for this proposal as a result of increased electricity consumption associated with operating existing and new control devices to meet the proposed standards. The EPA estimates an increase in CO_2 emissions of 14,550 tons from existing sources, and 190 tons from new sources, thus leading to a total increase in CO_2 emissions of 14,740 short tons per year.[10] These calculations use the same baseline as that for the

[9] The sensitivity analyses were done to explore the concept of hurdle rates as applied to investments in control technologies included in the cost analysis for this proposal. In this analysis, the limited effects of hurdle rate may be in part due to limited number of facilities that are affected by this decision variable. More discussion can be found in the cost methodology memo for this proposal.

[10] In order to calculate these values, it is necessary to convert tons (short) of emissions to metric tons. These values may be converted to $/short ton using the conversion factor 0.90718474 metric tons per short ton for application to the short ton CO_2 emissions impacts provided in this rulemaking. We note that these estimates become 13,200, 170, and 13,370 when converted from short tons to metric tons. Such conversion is needed to facilitate calculation of the climate-related co-disbenefits, as discussed in Chapter 4 of this RIA.

other analyses presented in this RIA, and are thus incremental from those already accounted for in the January 2013 final ICI boilers MACT rule RIA as mentioned earlier in this chapter.

Details on the emission reductions estimates and other emissions changes in this RIA, including emissions and control device data, can be found in the impacts methodology memorandum prepared by the Eastern Research Group (ERG).[11]

3.2 Compliance Costs

Estimated compliance costs associated with meeting the proposed requirements include the costs of pollution control capital as well as operating and maintenance costs, such as additional labor, materials, or energy used for compliance activities and monitoring. No testing costs are included because the proposed amendments do not change the requirements for testing.

Table 3-2 Pollution Control Costs by Technology Type ($2016)*

Cost type	Total Capital Investment	Operating and Maintenance (O&M)
Electrostatic Precipitators (ESP)	$7,623,000	$1,471,000
Fabric Filter and Dry Injection (DIFF)	$1,910,000	$951,000
Fabric Filter	$63,513,000	$9,304,000
Packed Bed Scrubber	$8,136,000	$2,181,000
Monitoring Costs	$1,790,000	$546,000
Total	**$83,750,000**	**$13,723,000***

*This value is the highest O&M estimate for any year for which an annual cost estimate is provided. See Table 3-3 and Appendix E for the impacts memorandum. The O&M value is equivalent to those for 2027 and 2028.

The present value (PV) is a single estimate of costs (or other impacts) that reflect a stream of annual compliance costs that are discounted to get an estimate for a specific date, which can be in the present, past, or future. Values are discounted to reflect the impact of time preferences. Guidance for E.O. 12866 requests impact estimates using a PV metric. To implement E.O. 12866, the U.S. Office of Management and Budget (OMB) has requested Federal agencies calculate the PV of the costs or cost savings of an action using both 7 percent

[11] Eastern Research Group (ERG). Prepared for the US EPA/OAQPS/SPPD. Revised (2019) Methodology for Estimating Impacts for Industrial, Commercial, Institutional Boilers and Process Heaters National Emission Standards for Hazardous Air Pollutants. August 2019.

and 3 percent end-of-period discount rates for those actions, including actions not deemed economically significant.[12]

For this analysis an eight-year time period was selected as a measure of the full duration of the expected effects of this action, as section 112 of the Clean Air Act (CAA) requires Maximum Achievable Control Technology (MACT) standards such as this one to be reviewed every eight years. We consider an eight-year time period for this analysis to be appropriate given the CAA statutory review requirement. Given a compliance period of three years from promulgation, compliance is projected to begin in 2021 as this rule is expected to be finalized in late 2020. The eight years over which these calculations are made thus includes 2021-2028.

Table 3-3 below shows the undiscounted stream of annual costs for the proposal, as well as their present values discounted to 2020. As seen below, the PV at a real discount rate of 3 percent is $128.1 million and $103.7 million at a real discount rate of 7 percent. Total capital costs are expected to be incurred up to the date of full implementation of the promulgated rule (late in 2023). Thus, we assumed total capital costs are incurred in equal shares across 2021, 2022, and 2023 as affected firms approach the compliance period. Additional capital requirements are incurred in 2025 and 2027 by affected new units that are expected to install pollution control devices and monitors.[13]

We assume operating and maintenance (O&M) costs are incurred beginning in 2024 and continue until the final year of this analysis (2028). These annual costs start at about $13.5 million in 2021 with increments in 2026 and 2028 that are associated with the pollution control devices and monitors expected to be installed in 2025 and 2027. More information on these costs can be found in the impacts memorandum[14] and the workbook for generating these estimates.[15]

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[12] U.S. Office of Management and Budget. Memorandum. Executive Order 12866, "Regulatory Planning and Review." September 30, 1993. Federal Register, Vol. 58, No. 190. Available on the Internet at https://www.archives.gov/files/federal-register/executive-orders/pdf/12866.pdf.

[13] Eastern Research Group (ERG). Revised (2019) Methodology for Estimating Costs for Industrial, Commercial, Institutional Boilers and Process Heaters National Emission Standards for Hazardous Air Pollutants. August 2019. Appendix E.

[14] ERG. Revised (2019) Methodology for Estimating Costs for Industrial, Commercial, Institutional Boilers and Process Heaters National Emission Standards for Hazardous Air Pollutants. August 2019.

[15] U.S. EPA. E.O. 13771WorkbookICIBoilerseconofficial8-1-19.xls. Available in the docket for the proposed rule.

Table 3-3 Undiscounted Costs, Discounted Costs, and 2020 Present Value Analysis for the Proposed Rule (2016$)*

	Undiscounted (Annual) Cost		Total Discounted Costs	
Year	Capital	O&M	3%	7%
2021	$27,789,600	$0	$25,431,400	$22,684,000
2022	27,789,600	0	24,690,700	21,201,000
2023	27,789,600	0	23,971,600	19,813,600
2024	0	13,499,100	11,305,300	8,995,000
2025	190,500	13,499,100	11,130,900	8,525,200
2026	0	13,601,900	10,744,600	7,921,700
2027	190,500	13,722,800	10,663,400	7,567,900
2028	0	13,722,800	10,211,000	6,976,000
	2020 Present Value		**128,148,900**	**103,684,500**

*Total estimates may differ due to rounding conventions. Estimates are for 2021 through 2028. EPA has assumed that capital for compliance purposes will be expended in an equal amount each year between promulgation and the implementation deadline (3 years) due to a lack of information on precisely when affected facilities could be expected to install control technologies and monitors in response to this proposal.

Table 3-4 summarizes the present value of the costs in 2016, accounting for the additional compliance costs to industry, as well as the equivalent annualized value (EAV) over the selected 8-year time frame. The EAV is the annualized present value of the costs. As seen below, the EAV for the proposal in 2016 dollars at a discount rate of 3 percent is approximately $18.3 million and $17.4 million at a discount rate of 7 percent.

Table 3-4 2020 Present Value (PV) of Costs and Equivalent Annualized Values (EAV) for the Proposed Rule for E.O. 12866 (2016$)*

	2020 Present Value of Costs	Equivalent Annualized Value of Costs
7% Discount Rate	$103,684,500	$17,363,800
3% Discount Rate	$128,148,000	$18,255,600

*PV and EAV are calculated over an eight-year period from 2021 to 2028.

3.3 Economic Impact and Small Business Analysis

Although facility-specific economic impacts (e.g. closures) cannot be estimated by this analysis, the EPA did conduct a screening analysis to quantify some economic impacts on individual firms. For economic impact analyses of rules that directly affect one or several industries, such as this proposal, the EPA often prepares a partial equilibrium analysis. In this type of economic analysis, the focus of the effort is on estimating impacts to a single affected industry or several affected industries, and all impacts of this rule to industries outside of those affected are assumed to be zero or inconsequential.[16] If the compliance costs, which are key inputs to an economic impact analysis, are small relative to the receipts of the affected industries, then the impact analysis could consist of a calculation of annual (or annualized) costs as a percent of sales for affected parent companies. This latter type of analysis is called a screening analysis and is applied when a partial equilibrium or more complex economic impact analysis approach is deemed unnecessary given the expected size of the impacts.

We conduct a screening analysis to estimate the economic impacts of this proposal, given that the annualized total compliance costs are about $23 million in 2016 dollars, a very small amount relative to the size of the affected industries listed in Section 2. This estimate of annual total compliance costs is much less than those of previous NESHAP rules for this source category.[17] The analysis employed here is a "sales test", which determines annualized compliance costs as a share of annual sales for each impacted parent company. The annualized cost per sales for a company represents the maximum price increase in the affected product or service needed for the company to completely recover the annualized costs imposed by the regulation.

The EPA prefers a "sales test" as the impact methodology in economic impact analyses as opposed to a "profits test", in which annualized compliance costs are calculated as a share of profits.[18] This is consistent with guidance published by the U.S. Small Business Administration (SBA)'s Office of Advocacy, which suggests that cost as a percentage of total revenues is a metric for evaluating cost impacts on small entities relative to large entities.[19] This is because revenues or sales data are commonly available for entities impacted by the EPA regulations and profits data are often private or tend to misrepresent true profits earned by firms after undertaking accounting and tax considerations. Firms and entities have incentive to minimize

[16] U.S. EPA. Guidelines for Preparing Economic Analyses. May 2016. p. 9-17. Available at https://www.epa.gov/sites/production/files/2017-09/documents/ee-0568-09.pdf.
[17] For example, the total annual compliance costs estimated by the EPA for the December 2012 final ICI boiler MACT reconsideration were $1.4 to $1.6 billion (2008 dollars). Adjusting to 2016 dollars would make the reduction in costs even larger in a real sense. See https://www3.epa.gov/ttn/ecas/docs/ria/ici-boilers_ria_reconsider-neshap_2012-12.pdf, p. 3 of cover memo for the RIA.
[18] More information on sales and profit tests as used in analyses done by U.S. EPA can be found at http://www.epa.gov/sbrefa/documents/rfaguidance11-00-06.pdf, pp. 32-33.
[19] U.S. SBA, Office of Advocacy. 2010. A Guide for Government Agencies, How to Comply with the Regulatory Flexibility Act, Implementing the President's Small Business Agenda and Executive Order 13272.

their reported profits; thus, using reported profits may generate misleading estimates of the economic impacts of a regulation on an affected firm or entity and their consumers.

While screening analyses are often employed to estimate impacts to small businesses or entities as part an analysis in compliance with the Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA), a screening analysis can also be employed in an economic impact analysis such as this one whose focus is on all regulated companies, big and small. In addition, we also include a brief discussion of measures of producer and consumer responsiveness to price changes (i.e., supply and demand elasticities) to further characterize the economic impacts of these rules.

It should be noted that the compliance costs for the proposal were estimated in 2016 dollars. Hence, we use 2016 revenues to the extent possible for affected firms in this report in order to be consistent in estimating economic impacts. We find that the great majority of the 26 companies affected are large, U.S.-owned multinational companies with substantial revenues from paper, timber, and milling operations. Among such companies impacted by this proposal are Louisiana Pacific, Weyerhaeuser, and Boise Cascade.

Using the current SBA small business size definitions, which is defined using employee size or annual revenues depending on the sector to which a given parent company belongs, only one of the affected companies is small according to the SBA small business size standards.[20] These small business size standards for the industries in which these boilers operate range from 200 to 1,250 employees, or $15.0 to $32.5 million in annual revenues, where appropriate. We generally find that the cost imposed on these companies is a very small fraction of the parent companies' revenues and should yield small economic impacts on wood products producers and the wood products market. The revenue estimate for these ultimate parent companies reflects all product sales worldwide. In turn, such small economic impacts should yield small impacts on customers (regardless of whether they are consumers of intermediate or end-use goods).

Based on the fact that the small businesses subject to this proposal will not incur any compliance costs, we can certify that there is no significant economic impact on a substantial

[20] SBA's small business size standards can be found on the Internet at https://www.sba.gov/document/support--table-size-standards. These standards were updated on October 1, 2017.

number of small entities (SISNOSE) for either option of this proposed rule. Details on the impacts by ultimate parent company can be found in the spreadsheet that accompanies the economic impact analysis report.[21] The annualized compliance costs are less than 0.7 percent of 2016 revenues for each impacted parent company. The median cost to sales ratio is 0.003 percent. Thus, the economic impacts should be minimal for these firms. A listing of affected ultimate parent businesses and their economic impacts is found in Table 3-5. More information on these impacts can be found in the spreadsheet for these calculations.[22] No confidential business information (CBI) was used in preparing these estimates.

Table 3-5 Impacts for Affected Ultimate Parent Businesses

Ultimate Parent Business	Total Annualized Costs (2016$)	Annualized Cost to Sales (%)
Koch Industries, Inc.	$0	0
Ameresco, Inc.	0	0
Anthony Timberlands, Inc	978,300	0.59
IHI Corp.	2,095,800	0.02
Coastal Forest Resources Company*	0	0
Hood Companies, Inc.	80,900	0.01
Resolute Forest Products	4,927,900	0.14
Kaluz, S.A. de C.V.	300,000	0.01
Packaging Corporation of America	3,982,100	0.07
Nine Dragons Paper	3,185,300	0.07
CMS Energy/Fortistar LLC	3,312,200	0.05
Louisiana Pacific Corp.	574,400	0.03
Hankins Lumber Company	0	0
International Paper	644,800	0.003
Paperweight Development Corp.	0	0
Marsh Furniture Company	651,200	0.70
P.H. Glatfelter Company	0	0
Domtar Corp.	702,400	0.01
Dominion Energy	0	0
WestRock	29,200	0.0002
Nippon Paper Industries Co., Ltd.	64,600	0.0007
Sonoco, Inc.	0	0
Weyerhaeuser Company	40,400	0.0006
West Fraser Timber Co., Ltd.	42,600	0.0014
Idaho Forest Group LLC	42,600	0.02
Boise Cascade	127,900	0.0033

*Small business.

[21] Ibid.

[22] U.S. EPA. IndBoilersMACTEconDataSheet.xls. Available in the docket for the proposed rule.

Regarding possible impacts to markets, it should be noted that available estimates of long-run responsiveness of price changes show that the price elasticity of demand for two of the most impacted industries, wood products (NAICS 321) is -0.81,[23] and for paper products (NAICS 322) is -0.85. The price elasticity of supply for wood products is 3.0 to 5.0,[24] and 0.28 to 1.65 for paper products.[25] Assuming the affected industries are imperfectly competitive, based on this information, one can conclude that demand will respond close to 1:1 to a change in output price, and that supply is fairly elastic (i.e., will respond more than 1:1) to a change in output price. The direct economic impact of this rule as measured by changes in price and output appears relatively minor based on the low annualized cost to sales estimates and these elasticities, and thus it is reasonable to infer that the price impacts on consumers from this proposed rule should also be relatively minor. In addition, any other economic impacts, such as changes in firm concentration within the affected industries, should be relatively minor.

3.4 Employment Impacts

Regarding employment impacts, environmental regulation may affect groups of workers differently, as changes in abatement and other compliance activities cause labor and other resources to shift. Standard benefit-cost analyses have not typically included a separate analysis of regulation-induced employment impacts.[26] In this section we discuss qualitatively the potential employment impacts of this proposed rule.

An environmental regulation affecting these sectors is expected to have a variety of transitional employment impacts, which may include reduced employment at facilities, as well as increased employment for the manufacture, installation, and operation of pollution control

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[23] ICF International. U.S. LNG Exports: Impacts on Energy Markets and the Economy. May 15, 2013. Submitted to the American Petroleum Institute. Table 3-4. Estimate is prepared for NAICS 321. Available on the Internet at https://fossil.energy.gov/ng_regulation/sites/default/files/programs/gasregulation/authorizations/2013/orders/Ex_Parte07_03_13.pdf. Accessed July 25, 2019.

[24] U.S. International Trade Commission. Hardwood Plywood from China. Investigation Nos. 701-TA-565 and 731-TA-1341 (Final). Publication 4747. December 2017. Available on the Internet at https://www.usitc.gov/publications/701_731/pub4747.pdf.

[25] U.S. EPA. Economic Impact Analysis. Proposed Revisions to the National Emissions Standards for Hazardous Air Pollutants, Subpart MM for the Pulp and Paper Industry. October 2016. p. 4-8. Available on the Internet at https://www.epa.gov/sites/production/files/2016-12/documents/subpart_mm_eia_10_31_2016_final.pdf.

[26] Labor costs associated with regulatory compliance activities are included as part of total costs in EPA's standard benefit-cost analyses. See Section 3.1 of this RIA, for a discussion of operating, supervisory, and maintenance labor hours for the operation of control devices, other labor costs associated with operation and maintenance, and labor expenses required for monitoring, reporting, and record keeping.

equipment.[27] Labor costs and the amount of labor needed for operation of control devices, and installation and operation of monitoring equipment and recordkeeping procedures can be found in the control cost memorandum and related appendices and reports for this proposal as discussed earlier in this RIA chapter. As one example of these impacts, the annual labor costs for operation and maintenance of monitoring and recordkeeping procedures is $180,000 (2016$), based on an estimate of 1,080 labor hours needed for these compliance categories.[28] For this proposed rule, the EPA expects some potential for small changes in the amount of labor needed in different parts of the affected sectors.[29] These employment impacts, both negative and positive, are likely to be small or *de minimus*, particularly when considering the relatively small economic impacts to affected sectors and firms as discussed earlier in Chapter 3 of this RIA.

3.5 Social Welfare Considerations

As stated in E.O. 12866, when a proposed regulatory action is deemed "significant", an estimate of the regulation's social cost is compared to its social benefits to determine whether the benefits justify the costs. The value of a regulatory action is traditionally measured by the change in economic welfare that it generates. The regulation's welfare impacts, or the social costs required to achieve environmental improvements, will extend to consumers and producers. Consumers experience welfare impacts due to changes in market prices and consumption levels associated with the rule. Producers experience welfare impacts resulting from changes in profits corresponding with the changes in production costs, output levels, and market prices. However, it is important to emphasize that these welfare impacts or social costs do not include benefits (or disbenefits) that occur outside markets directly impacted by this action, that is, the value of reduced or increased levels of air pollution with the regulation. These benefits are estimated separately, and those for this proposed action can be found in Chapter 4. The net benefits of this proposal account for both the social costs presented in this chapter and the social benefits (both

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[27] Schmalansee, R. and R. Stavins (2011). "A Guide to Economic and Policy Analysis for the Transport Rule." White Paper. Boston, MA. Exelon Corp.

[28] U.S. EPA. Information Collection Request for the Proposed National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters: Amendments. ICR #2028.10. January, 2020.

[29] 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).

ancillary co-benefits from reduced $PM_{2.5}$ and SO_2 emissions and co-disbenefits from increased CO_2 emissions) presented in Chapter 4. Net benefits are presented in Chapter 5.

4 BENEFITS ANALYSIS

Implementing emissions controls required by this NESHAP is expected to reduce HAP emissions, including emissions of mercury (Hg), hydrochloric acid (HCl), and other HAPs. The emission controls are also expected to reduce emissions of non-HAP pollutants, such as particulate matter (including $PM_{2.5}$) and SO_2. In this section, we provide the benefits analysis for this proposal. Data, resource, and methodological limitations prevented the EPA from monetizing the human health benefits from reduced exposure to mercury, HCl, and other HAP directly targeted by this proposal. In addition, the potential ancillary co-benefits from reduced ecosystem effects and reduced visibility impairment from the reduction in $PM_{2.5}$ and SO_2 emissions are also not monetized here. The EPA provides a qualitative discussion of mercury, HCl, and other HAP benefits later in this chapter. This discussion can also be found in section 4.7 of the recently promulgated Affordable Clean Energy (ACE) rule.[30]

In this section, we quantify the economic value of co-benefits of this proposal such as those associated with potential reduction in $PM_{2.5}$-related premature deaths and illnesses expected to occur as a result of implementing this rule. $PM_{2.5}$ and SO_2 emissions reductions occur as a result of implementing the proposed HAP emission controls described earlier in the RIA.

We estimate the total annual monetized co-benefits of the proposed rule to be $110 million to $250 million at a 3 percent discount rate and $95 million to $210 million at a 7 percent discount rate in 2025, a snapshot year used to approximate the impacts in 2023 (the year of full implementation).[31] All estimates are reported in 2016 dollars and reflect the co-benefits associated with reductions in both directly emitted $PM_{2.5}$ and SO_2. In addition, the climate co-disbenefits resulting from additional emissions of CO_2 are included in these monetized estimates. The climate co-disbenefits in 2025 are estimated at $0.09 million at a 3 percent discount rate and $0.01 million at a 7 percent discount rate.

[30] U.S. EPA. Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emissions Guidelines for Greenhouse Gases from Existing Electric Energy Generating Units. EPA-452/R-19-003. June 2019. Available at https://www.epa.gov/sites/production/files/2019-06/documents/utilities_ria_final_cpp_repeal_and_ace_2019-06.pdf.

[31] Benefit per ton estimates are available in five-year intervals (2020, 2025, 2030, and 2035). With 2025 as the closest year to the year of full implementation (2023), we apply benefit per ton estimates for that year to best approximate the monetized benefits of the proposal.

4.1 Approach to Estimating Human Health Benefits

This section summarizes the EPA's approach to estimating the incidence and economic value of the $PM_{2.5}$-related ancillary co-benefits estimated for this rule. The Regulatory Impact Analysis (RIA) for the Particulate Matter (PM) National Ambient Air Quality Standards (NAAQS)[32] and the user manual for the BenMAP-CE program[33] provide a full discussion of the EPA's approach for quantifying the incidence and value of estimated air pollution-related health impacts. In these documents, the reader can find the rationale for selecting the health endpoints quantified; the demographic, health and economic data applied in the environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE); modeling assumptions; and the EPA's techniques for quantifying uncertainty.

Implementing this rule will affect the distribution of $PM_{2.5}$ concentrations throughout the U.S.; this includes locations both meeting and exceeding the NAAQS for PM and ozone. This RIA estimates avoided $PM_{2.5}$--related health impacts that are distinct from those reported in the RIAs for the PM NAAQS.[34] The $PM_{2.5}$ NAAQS RIAs hypothesize, but do not predict, the benefits and costs of strategies that States may choose to enact when implementing a revised NAAQS; these costs and benefits are illustrative and cannot be added to the costs and benefits of policies that prescribe specific emission control measures.

4.2 Estimating $PM_{2.5}$, Ozone, and HAP Related Health Impacts

We estimate the quantity and economic value of air pollution-related effects by estimating counts of air pollution-attributable cases of adverse health outcomes, assigning dollar values to these counts, and assuming that each outcome is independent of one another. We construct these estimates by adapting primary research—specifically, air pollution epidemiology studies and economic value studies—from similar contexts. This approach is sometimes referred to as "benefits transfer." Below we describe the procedure we follow for: (1) selecting air pollution health endpoints to quantify; (2) calculating counts of air pollution effects using a

[32] U.S. EPA. 2012b. Regulatory Impact Assessment for the Particulate Matter National Ambient Air Quality Standards.
[33] U.S. EPA. 2018. User Manual for Environmental Benefits Mapping and Analysis Program (BenMAP).
[34] U.S. EPA. 2012a. Regulatory Impact Analysis for the Proposed Revisions to the National Ambient Air Quality Standards for Particulate Matter. Available at https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-pm_ria_final_2012-12.pdf.

health impact function; (3) specifying the health impact function with concentration-response parameters drawn from the epidemiological literature.

4.2.1 Selecting air pollution health endpoints to quantify

As a first step in quantifying $PM_{2.5}$-related human health impacts, the EPA consults the *Integrated Science Assessment for Particulate Matter* (PM ISA).[35] This document synthesizes the toxicological, clinical and epidemiological evidence to determine whether each pollutant is causally related to an array of adverse human health outcomes associated with either acute (i.e., hours or days-long) or chronic (i.e. years-long) exposure. For each outcome, the ISA reports this relationship to be causal, likely to be causal, suggestive of a causal relationship, inadequate to infer a causal relationship, or not likely to be a causal relationship.

The ISA for $PM_{2.5}$ found acute exposure to $PM_{2.5}$ to be causally related to cardiovascular effects and mortality (i.e., premature death), and respiratory effects as likely-to-be-causally related. The ISA identified cardiovascular effects and total mortality as being causally related to long-term exposure to $PM_{2.5}$ and respiratory effects as likely-to-be-causal; and the evidence was suggestive of a causal relationship for reproductive and developmental effects as well as cancer, mutagenicity and genotoxicity.

The EPA estimates the incidence of air pollution effects for those health endpoints listed above where the ISA classified the impact as either causal or likely-to-be-causal. Table 4-1 reports the effects we quantified and those we did not quantify in this RIA. The list of benefit categories not quantified shown in that table is not exhaustive. And, among the effects we quantified, we might not have been able to completely quantify either all human health impacts or economic values. The table below omits health effects associated with SO_2 and NO_2, and any welfare effects such as acidification and nutrient enrichment. These effects are described in Chapters 5 and 6 of the PM NAAQS RIA.[36] Table 4-1 includes health effects associated with HAP that were qualitatively evaluated: Hg, HCl, HF, and TSM.

[35] U.S. EPA. 2009. Integrated Science Assessment for Particulate Matter. EPA/600/R-08/139F.
[36] U.S. EPA. 2012b. Regulatory Impact Assessment for the Particulate Matter National Ambient Air Quality Standards.

4.2.2 Health Effects from exposure to HAP

4.2.2.1 Mercury

Mercury (Hg) in the environment is transformed into a more toxic form, methylmercury (MeHg). Because Hg is a persistent pollutant, MeHg accumulates in the food chain, especially the tissue of fish. When people consume these fish, they consume MeHg. In 2000, the NAS Study was issued which provides a thorough review of the effects of MeHg on human health (NRC 2000).[37] Many of the peer-reviewed articles cited in this section are publications originally cited in the Mercury Study.[38] In addition, the EPA has conducted literature searches to obtain other related and more recent publications to complement the material summarized by the NRC in 2000.

In its review of the literature, the NAS found neurodevelopmental effects to be the most sensitive and best documented endpoints and appropriate for establishing a reference dose (RfD) (NRC 2000); in particular NAS supported the use of results from neurobehavioral or neuropsychological tests. The NAS report noted that studies on animals reported sensory effects as well as effects on brain development and memory functions and supported the conclusions based on epidemiology studies. The NAS noted that their recommended endpoints for a RfD are associated with the ability of children to learn and to succeed in school. They concluded the following: "The population at highest risk is the children of women who consumed large amounts of fish and seafood during pregnancy. The committee concludes that the risk to that population is likely to be sufficient to result in an increase in the number of children who have to struggle to keep up in school."

The NAS summarized data on cardiovascular effects available up to 2000. Based on these and other studies, the NRC concluded that "Although the data base is not as extensive for cardiovascular effects as it is for other end points (i.e., neurologic effects), the cardiovascular system appears to be a target for MeHg toxicity in humans and animals." The NRC also stated that "additional studies are needed to better characterize the effect of methylmercury exposure on blood pressure and cardiovascular function at various stages of life."

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[37] National Research Council (NRC). 2000. *Toxicological Effects of Methylmercury*. Washington, DC: National Academies Press.
[38] U.S. Environmental Protection Agency (U.S. EPA). 1997. *Mercury Study Report to Congress*, EPA–HQ–OAR–2009–0234–3054. December. Available at http://www.epa.gov/hg/report.htm.

Additional cardiovascular studies have been published since 2000. The EPA did not develop a quantitative dose-response assessment for cardiovascular effects associated with MeHg exposures, as there is no consensus among scientists on the dose-response functions for these effects. In addition, there is inconsistency among available studies as to the association between MeHg exposure and various cardiovascular system effects. The pharmacokinetics of some of the exposure measures (such as toenail Hg levels) are not well understood. The studies have not yet received the review and scrutiny of the more well-established neurotoxicity data base.

The Mercury Study noted that MeHg is not a potent mutagen but is capable of causing chromosomal damage in a number of experimental systems. The NAS concluded that evidence that human exposure to MeHg caused genetic damage is inconclusive; they note that some earlier studies showing chromosomal damage in lymphocytes may not have controlled sufficiently for potential confounders. One study of adults living in the Tapajós River region in Brazil (Amorim et al. 2000) reported a direct relationship between MeHg concentration in hair and DNA damage in lymphocytes, as well as effects on chromosomes.[39] Long-term MeHg exposures in this population were believed to occur through consumption of fish, suggesting that genotoxic effects (largely chromosomal aberrations) may result from dietary and chronic MeHg exposures similar to and above those seen in the Faroes and Seychelles populations.

Although exposure to some forms of Hg can result in a decrease in immune activity or an autoimmune response (ATSDR 1999), evidence for immunotoxic effects of MeHg is limited (NRC 2000).[40] Based on limited human and animal data, MeHg is classified as a "possible" human carcinogen by the International Agency for Research on Cancer (IARC 1994)[41] and in IRIS (U.S. EPA 2002).[42] The existing evidence supporting the possibility of carcinogenic effects

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[39] Amorim, M.I.M., D. Mergler, M.O. Bahia, H. Dubeau, D. Miranda, J. Lebel, R.R. Burbano, and M. Lucotte. 2000. Cytogenetic damage related to low levels of methyl mercury contamination in the Brazilian Amazon. An. Acad. Bras. Ciênc. 72(4): 497-507.

[40] Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological Profile for Mercury. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA.

[41] International Agency for Research on Cancer (IARC). 1994. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans and their Supplements: Beryllium, Cadmium, Mercury, and Exposures in the Glass Manufacturing Industry. Vol. 58. Jalili, H.A., and A.H. Abbasi. 1961. Poisoning by ethyl mercury toluene sulphonanilide. Br. J. Indust. Med. 18(Oct.):303-308 (as cited in NRC, 2000).

[42] U.S. Environmental Protection Agency (EPA). 2002. Integrated Risk Information System (IRIS) on Methylmercury. National Center for Environmental Assessment. Office of Research and Development. Available at http://www.epa.gov/iris/subst/0073.htm.

in humans from low-dose chronic exposures is tenuous. Multiple human epidemiological studies have found no significant association between Hg exposure and overall cancer incidence, although a few studies have shown an association between Hg exposure and specific types of cancer incidence (e.g., acute leukemia and liver cancer) (NRC 2000).

There is also some evidence of reproductive and renal toxicity in humans from MeHg exposure. However, overall, human data regarding reproductive, renal, and hematological toxicity from MeHg are very limited and are based on either studies of the two high-dose poisoning episodes in Iraq and Japan or animal data, rather than epidemiological studies of chronic exposures at the levels of interest in this analysis.

4.2.2.2 Hydrogen Chloride

Hydrogen chloride (HCl) is a gas that forms corrosive hydrochloric acid when it comes into contact with water. It can cause irritation of the mucous membranes of the nose, throat, and respiratory tract. Brief exposure to 35 ppm causes throat irritation, and levels of 50 to 100 ppm are barely tolerable for 1 hour.[43] Concentrations in typical human exposure environments are much lower than these levels and rarely exceed the reference concentration.[44] The greatest impact is on the upper respiratory tract; exposure to high concentrations can rapidly lead to swelling and spasm of the throat and suffocation. Most seriously exposed persons have immediate onset of rapid breathing, blue coloring of the skin, and narrowing of the bronchioles. Exposure to HCl can lead to Reactive Airways Dysfunction Syndrome (RADS), a chemically, or irritant-induced type of asthma. Children may be more vulnerable to corrosive agents than adults because of the relatively smaller diameter of their airways. Children may also be more vulnerable to gas exposure because of increased minute ventilation per kg and failure to evacuate an area promptly when exposed. Hydrogen chloride has not been classified for carcinogenic effects.[45]

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[43]Agency for Toxic Substances and Disease Registry (ATSDR). Medical Management Guidelines for Hydrogen Chloride. Atlanta, GA: U.S. Department of Health and Human Services. Available at http://www.atsdr.cdc.gov/mmg/mmg.asp?id=758&tid=147#bookmark02.

[44]Table of Prioritized Chronic Dose-Response Values: http://www2.epa.gov/sites/production/files/2014-05/documents/table1.pdf.

[45]U.S. Environmental Protection Agency (U.S. EPA). 1995. "Integrated Risk Information System File of Hydrogen Chloride." Washington, DC: Research and Development, National Center for Environmental Assessment. This material is available at http://www.epa.gov/iris/subst/0396.htm.

4.2.2.3 Hydrogen Fluoride

Hydrogen fluoride (HF) is a gas that forms corrosive hydrofluoric acid when it comes in contact with water. HF can cause eye irritation and irritation and congestion of the nose, throat, and lungs.[46] Exposure to 0.5 ppm for one hour causes upper respiratory tract irritation. Brief inhalation exposure to high concentrations of gaseous HF can cause severe respiratory damage in humans, including severe irritation and lung edema. Severe eye irritation and skin burns may occur following eye or skin exposure in humans. Chronic (long-term) exposure in workers has resulted in skeletal fluorosis, a bone disease. Animal studies have reported effects on the lungs, liver, and kidneys from acute and chronic inhalation exposure to HF. Studies investigating the carcinogenic potential of HF are inconclusive. The EPA has not classified HF for carcinogenicity.

4.2.2.4. Total non-mercury selected metals (TSM)

TSM include antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, nickel, and selenium. The acute health effects associated with inhalation of these metals are primarily respiratory system effects that include respiratory irritation, shortness of breath, coughing and wheezing, inflammation of the lungs, pneumonia, lung congestion, lung edema, and hemorrhage of the lung.[47] Other organs and organ systems affected by acute inhalation exposure to some TSM include skin, eyes, gastrointestinal system, and central nervous system. Chronic effects of inhalation exposure to TSM include respiratory system effects such as respiratory irritation, inflammation of the lungs, chronic bronchitis, chronic emphysema, wheezing, asthma, and lung fibrosis. Effects of chronic inhalation exposure on other organs or organ systems include irritation of the skin and mucous membranes, central nervous system effects, kidney disease, and effects on the liver and immune system. Some TSM are also known to be human carcinogens or reasonably anticipated to be human carcinogens. Lead is a TSM that is of particular concern due to its developmental toxicity. While ingestion is usually the primary

[46] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Fluorides, Hydrogen Fluoride and Fluorine. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 2003. http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=212&tid=38

[47] The main sources of information for the TSM health effects information are EPA's Integrated Risk Information System (IRIS) the Agency for Toxic Substances and Disease Registry's (ATSDR's) Toxicological Profiles. Information on individual chemicals can be found at https://cfpub.epa.gov/ncea/iris_drafts/atoz.cfm?list_type=alpha and https://www.atsdr.cdc.gov/toxprofiledocs/index.html

route of exposure for children, the health effects are the same for both oral and inhalation routes of exposure. Early childhood and prenatal exposures to lead are associated with slowed cognitive development, learning deficits and other effects.

Table 4-1 Human Health Effects of Ambient $PM_{2.5}$, Ozone, and HAP

Category	Effect	Effect Quantified	Effect Monetized	More Information
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
	Infant mortality (age <1)	✓	✓	PM ISA
Morbidity from exposure to $PM_{2.5}$	Non-fatal heart attacks (age > 18)	✓	✓	PM ISA
	Hospital admissions—respiratory (all ages)	✓	✓	PM ISA
	Hospital admissions—cardiovascular (age >20)	✓	✓	PM ISA
	Emergency room visits for asthma (all ages)	✓	✓	PM ISA
	Acute bronchitis (age 8-12)	✓	✓	PM ISA
	Lower respiratory symptoms (age 7-14)	✓	✓	PM ISA
	Upper respiratory symptoms (asthmatics age 9-11)	✓	✓	PM ISA
	Exacerbated asthma (asthmatics age 6-18)	✓	✓	PM ISA
	Lost work days (age 18-65)	✓	✓	PM ISA
	Minor restricted-activity days (age 18-65)	✓	✓	PM ISA
	Chronic Bronchitis (age >26)	—	—	PM ISA[1]
	Emergency room visits for cardiovascular effects (all ages)	—	—	PM ISA[1]
	Strokes and cerebrovascular disease (age 50-79)	—	—	PM ISA[1]
	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[2,3]
	Cancer, mutagenicity, and genotoxicity effects	—	—	PM ISA[2,3]
Mortality from exposure to ozone	Premature mortality based on short-term study estimates (all ages)	—	—	Ozone ISA
	Premature mortality based on long-term study estimates (age 30–99)	—	—	Ozone ISA[1]
Morbidity from exposure to ozone	Hospital admissions—respiratory causes (age > 65)	—	—	Ozone ISA
	Emergency department visits for asthma (all ages)	—	—	Ozone ISA
	Exacerbated asthma (asthmatics age 6-18)	—	—	Ozone ISA
	Minor restricted-activity days (age 18–65)	—	—	Ozone ISA
	School absence days (age 5–17)	—	—	Ozone ISA
	Decreased outdoor worker productivity (age 18–65)	—	—	Ozone ISA[1]
	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[2,3]
Morbidity from exposure to methyl mercury	Neurologic effects – IQ loss	—	—	IRIS; NRC, 2000[1]
	Other neurologic effects (e.g., developmental delays, memory, behavior	—	—	IRIS; NRC, 2000[2]
	Cardiovascular effects	—	—	IRIS; NRC, 2000[2,3]

	Genotoxic, immunologic, and other toxic effects	—	—	IRIS; NRC, 2000[2,3]
Morbidity from exposure to hydrogen chloride	Upper respiratory tract irritation	—	—	ATSDR
	Asthma	—	—	ATSDR
Morbidity from exposure to hydrogen fluoride	Eye irritation	—	—	ATSDR
	Upper respiratory tract irritation and inflammation	—	—	ATSDR
	Bone disease	—	—	ATSDR
	Damage to liver, kidney, or lungs	—	—	ATSDR
Morbidity from exposure to total non-mercury selected metals (TSM)	Respiratory system effects such as irritation, inflammation of the lungs, chronic bronchitis, and pneumonia	—	—	IRIS; ATSDR
	Cancer – lung, nasal, and potentially other sites	—	—	IRIS; ATSDR
	Neurologic effects – learning disabilities, brain damage, other central nervous system effects	—	—	IRIS; ATSDR
	Effects on skin, eye, kidney, liver, and immune system	—	—	IRIS; ATSDR

[1] We assess these benefits qualitatively due to data and resource limitations for this analysis. In other analyses we quantified these effects as a sensitivity analysis.
[2] We assess these benefits qualitatively because we do not have sufficient confidence in available data or methods.
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.

4.3 Quantifying Cases of $PM_{2.5}$-Attributable Premature Death

For adult PM-related mortality, we use the effect coefficients from two epidemiology studies examining two large population cohorts: the American Cancer Society (ACS) cohort[48] and the Harvard Six Cities cohort).[49] The ISA concluded that the analyses of the ACS and Six Cities cohorts provide the strongest evidence of an association between long-term $PM_{2.5}$ exposure and premature mortality, with support from additional cohort studies. The Scientific Advisory Board's Health Effects Subcommittee (SAB-HES) also supported using effect estimates from these two analyses to estimate the benefits of PM reductions.[50] There are distinct attributes of both the ACS and Six Cities cohort studies that make them well-suited for use in

[48] Krewski D, Jerrett M, Burnett RT, Ma R, Hughes E, Shi Y, et al. 2009. Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality. Res Rep Health Eff Inst 5-114; discussion 115–36.
[49] Lepeule J, Laden F, Dockery D, Schwartz J. 2012. Chronic exposure to fine particles and mortality: an extended follow-up of the Harvard Six Cities study from 1974 to 2009. Environ Health Perspect 120:965–970; doi:10.1289/ehp.1104660.
[50] U.S. EPA-SAB. 2010. Review of EPA's Draft Health Benefits of the Second Section 812 Prospective Study of the CAA.

PM benefits (or co-benefits) assessments and thus we present $PM_{2.5}$ related effects derived using relative risk estimates from both cohorts.

The PM ISA, which was twice reviewed by the Clean Air Scientific Advisory Committee of the EPA's Science Advisory Board (SAB-CASAC), [51,52] concluded that there is a causal relationship between mortality and both long-term and short-term exposure to $PM_{2.5}$ based on the body of scientific evidence. The PM ISA also concluded that the scientific literature supports the use of a no-threshold log-linear model to portray the PM-mortality concentration-response relationship while recognizing potential uncertainty about the exact shape of the concentration-response function. The PM ISA, which informed the setting of the 2012 PM NAAQS, reviewed available studies that examined the potential for a population-level threshold to exist in the concentration-response relationship. Based on such studies, the ISA concluded that the evidence supports the use of a "no-threshold" model and that "little evidence was observed to suggest that a threshold exists." [53] Consistent with this evidence, the EPA historically has estimated health impacts above and below the prevailing NAAQS.[54]

Following this approach, we report the estimated $PM_{2.5}$-related benefits (in terms of both health impacts and monetized values) calculated using a log-linear concentration-response function that quantifies risk from the full range of simulated $PM_{2.5}$ exposures.[55] When setting the 2012 PM NAAQS, the Administrator also acknowledged greater uncertainty in specifying the "magnitude and significance" of PM-related health risks at PM concentrations below the NAAQS. As noted in the preamble to the 2012 PM NAAQS final rule, the "EPA conclude[d]

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[51] U.S. EPA-SAB. 2008. Review of EPA's Integrated Science Assessment for Particulate Matter (First External Review Draft, December 2008).
[52] U.S. EPA-SAB. 2009. Review of Integrated Science Assessment for Particulate Matter (Second External Review Draft, July 2009).
[53] U.S. EPA-SAB. 2009. Review of Integrated Science Assessment for Particulate Matter (Second External Review Draft, July 2009).
[54] The Federal Register Notice for the 2012 PM NAAQS notes that "[i]n reaching her final decision on the appropriate annual standard level to set, the Administrator is mindful that the CAA does not require that primary standards be set at a zero-risk level, but rather at a level that reduces risk sufficiently so as to protect public health, including the health of at-risk populations, with an adequate margin of safety. On balance, the Administrator concludes that an annual standard level of 12 ug/m3 would be requisite to protect the public health with an adequate margin of safety from effects associated with long- and short-term PM2.5 exposures, while still recognizing that uncertainties remain in the scientific information."
[55] U.S. EPA-SAB. 2009. Review of Integrated Science Assessment for Particulate Matter (Second External Review Draft, July 2009), and NRC. 2002. Estimating the Public Health Benefits of Proposed Air Pollution Regulations. Washington, D.C.

that it [was] not appropriate to place as much confidence in the magnitude and significance of the associations over the lower percentiles of the distribution in each study as at and around the long-term mean concentration."[56] The preamble separately noted that "[a]s both the EPA and CASAC recognize, in the absence of a discernible threshold, health effects may occur over the full range of concentrations observed in the epidemiological studies." [57] In general, we are more confident in the size of the risks we estimate from simulated $PM_{2.5}$ concentrations that coincide with the bulk of the observed PM concentrations in the epidemiological studies that are used to estimate the benefits. Likewise, we are less confident in the risk we estimate from simulated $PM_{2.5}$ concentrations that fall below the bulk of the observed data in these studies.[58] In the RIA developed for the recently promulgated Affordable Clean Energy (ACE) rule, the EPA reported the number of estimated PM-related premature death occurring at or above various concentration levels. As described further below, we lacked the air quality modeling simulations to perform such an analysis for this proposed rule and thus report the total number of avoided $PM_{2.5}$-related premature deaths using the traditional log-linear no-threshold model noted above.

4.4 Economic Valuation

After quantifying the change in adverse health impacts, we estimate the economic value of these avoided impacts. Reductions in ambient concentrations of air pollution generally lower the risk of future adverse health effects by a small amount for a large population. Therefore, the appropriate economic measure is willingness to pay (WTP) for changes in risk of a health effect. For some health effects, such as hospital admissions, WTP estimates are generally not available, so we use the cost of treating or mitigating the effect. These cost-of-illness (COI) estimates generally (although not necessarily in every case) understate the true value of reductions in risk of a health effect. They tend to reflect the direct expenditures related to treatment but not the

[56] 78 FR 3154, 15 January 2013.
[57] 78 FR 3149, 15 January 2013.
[58] The Federal Register Notice for the 2012 PM NAAQS indicates that "[i]n considering this additional population level information, the Administrator recognizes that, in general, the confidence in the magnitude and significance of an association identified in a study is strongest at and around the long-term mean concentration for the air quality distribution, as this represents the part of the distribution in which the data in any given study are generally most concentrated. She also recognizes that the degree of confidence decreases as one moves towards the lower part of the distribution."

value of avoided pain and suffering from the health effect. The unit values applied in this analysis are provided in Table 5-9 of the PM NAAQS RIA for each health endpoint.[59]

Avoided premature deaths account for 98 percent of monetized PM-related benefits. The economics literature concerning the appropriate method for valuing reductions in premature mortality risk is still developing. The value for the projected reduction in the risk of premature mortality is the subject of continuing discussion within the economics and public policy analysis community. Following the advice of the SAB's Environmental Economics Advisory Committee (SAB-EEAC), the EPA currently uses the value of statistical life (VSL) approach in calculating estimates of mortality benefits, because we believe this calculation provides the most reasonable single estimate of an individual's WTP for reductions in mortality risk (U.S. EPA-SAB, 2000).[60] The VSL approach is a summary measure for the value of small changes in mortality risk experienced by a large number of people.

The EPA continues work to update its guidance on valuing mortality risk reductions and consulted several times with the SAB-EEAC on the issue. Until updated guidance is available, the EPA determined that a single, peer-reviewed estimate applied consistently best reflects the SAB-EEAC advice it has received. Therefore, the EPA applies the VSL that was vetted and endorsed by the SAB in the *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2016) while the EPA continues its efforts to update its guidance on this issue.[61] This approach calculates a mean value across VSL estimates derived from 26 labor market and contingent valuation studies published between 1974 and 1991. The mean VSL across these studies is $6.3 million (2000$).[62]

The EPA is committed to using scientifically sound, appropriately reviewed evidence in valuing changes in the risk of premature death and continues to engage with the SAB to identify scientifically sound approaches to update its mortality risk valuation estimates. Most recently, the Agency proposed new meta-analytic approaches for updating its estimates which were

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[59] U.S. EPA. 2012a. Regulatory Impact Analysis for the Proposed Revisions to the National Ambient Air Quality Standards for Particulate Matter.
[60] U.S. EPA-SAB. 2000. An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction.
[61] U.S. EPA. Guidelines for Preparing Economic Analyses. 2016.
[62] In 1990$, this base VSL is $4.8 million. In 2016$, this base VSL is $10.7 million.

subsequently reviewed by the SAB-EEAC. The EPA is taking the SAB's formal recommendations under advisement (U.S. EPA 2017).[63]

4.5 Benefit-per-Ton Estimates

EPA did not conduct air quality modeling for this rule. Specifically, EPA believes that the emissions reductions due to this rule are small and EPA did not expect full air quality modeling to show a significant difference between the policy and baseline model runs. Instead, we used a "benefit-per-ton" (BPT) approach to estimate the co-benefits of this rulemaking. These BPT estimates provide the total monetized human health co-benefits (the sum of premature mortality and premature morbidity) of reducing one ton of $PM_{2.5}$ (or $PM_{2.5}$ precursor such as NOx or SO_2) from a specified source. Specifically, in this analysis, we multiplied the estimates from the "Industrial Point Sources" sector by the corresponding emission reductions. The method used to derive these estimates is described in the Technical Support Document (TSD) on estimating the benefits-per-ton of reducing $PM_{2.5}$ and its precursors from 17 sectors.[64] One limitation of using the BPT approach is an inability to provide estimates of the health benefits associated with exposure to HAP, CO, NO_2, or ozone.

As noted below in the characterization of uncertainty, all BPT estimates have inherent limitations. Specifically, all national-average BPT estimates reflect the geographic distribution of the modeled emissions, which may not exactly match the emission reductions that would occur due to rulemaking, and they may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors for any specific location. The photochemical modeled emissions of the industrial point source sector-attributable $PM_{2.5}$ concentrations used to derive the BPT values may not match the change in air quality resulting from the emissions controls described in Section 3. For this reason, the health co-benefits reported here may be larger, or smaller, than those realized through this rule. However, when choosing to utilize the EPA's BPT approach for this analysis, the spatial distribution of emissions for this particular sector is similar to that of the inventory used to derive the BPT. EPA confirmed that the spatial distribution of the industrial boiler facility locations were not

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[63] U.S. EPA. SAB Review of EPA's Proposed Methodology for Updating Mortality Risk Valuation Estimates for Policy Analysis. 2017.

[64] U.S. EPA. 2018. Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors. Technical Support Document.

unusually concentrated in one particular region of the country and tend to be located in areas with industrial point sources.

Thus, EPA assumed that although $PM_{2.5}$ emission reductions resulting from this rule are approximately 0.4% of the $PM_{2.5}$ annual emissions and 0.04% of the SO_2 emissions attributable to the BPT Industrial Point Sources category, the emission changes due to this rule scale linearly relative to the BPT Industrial Point Sources category. Combining the spatial representativeness of the sector with the small changes in emissions considered in this rulemaking, the difference in the quantified health benefits that result from the BPT approach compared with if EPA had used a full-form air quality model should be minimal. We are taking comment on the above assumptions as well as the utility of performing full-form modeling for the final rule.

Even though we assume that all fine particles have equivalent health effects, the BPT estimates vary across precursors depending on the location and magnitude of their impact on $PM_{2.5}$ levels, which drive population exposure. The sector-specific modeling does not provide estimates of the $PM_{2.5}$-related co-benefits associated with reducing VOC emissions, but these unquantified co-benefits are generally small compared to other $PM_{2.5}$ precursors.[65]

Over the last year and a half, the EPA systematically compared the changes in benefits, and concentrations where available, from its BPT technique and other reduced-form techniques to the changes in benefits and concentrations derived from full-form photochemical model representation of a few different specific emissions scenarios. Reduced form tools are less complex than the full air quality modeling, requiring less agency resources and time. That work, in which we also explore other reduced form models is referred to as the "Reduced Form Tool Evaluation Project" (Project), began in 2017, and the initial results were available at the end of 2018. The Agency's goal was to create a methodology by which investigators could better understand the suitability of alternative reduced-form air quality modeling techniques for estimating the health impacts of criteria pollutant emissions changes in the EPA's benefit-cost analysis, including the extent to which reduced form models may over- or under-estimate

[65] U.S. EPA. 2012a. Regulatory Impact Analysis for the Proposed Revisions to the National Ambient Air Quality Standards for Particulate Matter.

benefits (compared to full-scale modeling) under different scenarios and air quality concentrations. The EPA Science Advisory Board (SAB) recently convened a panel to review this report.[66] In particular, the SAB will assess the techniques the Agency used to appraise these tools; the Agency's approach for depicting the results of reduced-form tools; and, steps the Agency might take for improving the reliability of reduced-form techniques for use in future Regulatory Impact Analyses.

The scenario-specific emission inputs developed for this project are currently available online. The study design and methodology are described in the final report summarizing the results of the project, available here. Results of this project found that total $PM_{2.5}$ BPT values were within approximately 10 percent of the health benefits calculated from full-form air quality modeling when analyzing the Pulp and Paper sector. The ratios for individual species varied, and the report found that the ratio for the directly emitted $PM_{2.5}$ for the pulp and paper sector was 0.7 for the BPT approach compared to 1.0 for full air quality modeling combined with BenMAP. As the Pulp and Paper sector and the Industrial Boilers sector share a similar spatial distribution, we have greater confidence that this ratio reflected in the pulp and paper sector would also apply to the Boiler sector. This provides some initial understanding of the uncertainty which is associated with using the BPT approach instead of full air quality modeling.

4.6 $PM_{2.5}$-Co-benefits Results

Table 4-2 summarizes the monetized PM and SO_2-related health co-benefits, including the emission reductions and BPT estimates using discount rates of 3 percent and 7 percent. Table 4-3 presents the total health related co-benefits of reducing emissions of $PM_{2.5}$ and SO_2.

[66] 85 FR 23823. April 29, 2020.

Table 4-2 Estimated $PM_{2.5}$-related Ancillary Co-benefits of Proposed Reconsideration (2016$)

	Epidemiologic study used to quantify PM-related premature deaths			
	Krewski et al. (2009)		**Lepeule et al. (2012)**	
Pollutant	***Benefit per ton (3% discount rate)***	***Benefit per ton (7% discount rate)***	***Benefit per ton (3% discount rate)***	***Benefit per ton (7% discount rate)***
$PM_{2.5}$	$330,000	$300,000	$790,000	$690,000
SO_2	$52,000	$47,000	$120,000	$100,000

Table 4-3 Summary of Estimated $PM_{2.5}$ and SO_2-related Ancillary Co-benefits of Proposed Reconsideration (millions of 2016$)

	Epidemiologic study used to quantify PM and SO_2-related premature deaths			
	Krewski et al. (2009)		**Lepeule et al. (2012)**	
Pollutant	***Benefits (3% discount rate)***	***Benefits (7% discount rate)***	***Benefits (3% discount rate)***	***Benefits (7% discount rate)***
$PM_{2.5}$	$84	$76	$200	$170
SO_2	$21	$19	$49	$40
Total	**$110**	**$95**	**$250**	**$210**

*Columns may not sum due to rounding.

Characterizing Uncertainty in the Estimated $PM_{2.5}$ Co-Benefits

In any complex analysis using estimated parameters and inputs from a variety of models, there are likely to be many sources of uncertainty. This analysis is no exception. This analysis includes many data sources as inputs, including emission inventories, air quality data from models (with their associated parameters and inputs), population data, population estimates, health effect estimates from epidemiology studies, economic data for monetizing benefits, and assumptions regarding the future state of the world (i.e., regulations, technology, and human behavior). Each of these inputs are uncertain and generate uncertainty in the co-benefits estimate. When the uncertainties from each stage of the analysis are compounded, even small uncertainties can have large effects on the total quantified co-benefits. Therefore, the estimates of annual co-benefits should be viewed as representative of the magnitude of co-benefits expected, rather than the actual co-benefits that would occur every year.

This RIA does not include the type of detailed uncertainty assessment found in the 2012 PM NAAQS RIA because we lack the necessary air quality input and monitoring data. Also, emissions reductions were not significant enough to make performing an air quality model run worthwhile. As a result, we did not have the inputs to run the benefits model. However, the results of the uncertainty analyses presented in the PM NAAQS RIA can provide some information regarding the uncertainty inherent in the co-benefits results presented in this analysis. Sensitivity analyses conducted for the PM NAAQS RIA indicate that alternate cessation lag assumptions could change the $PM_{2.5}$-related mortality benefits discounted at 3 percent by between 10 percent and −27 percent and that alternate income growth adjustments could change the $PM_{2.5}$-related mortality benefits by between 33 percent and −14 percent.

4.7 Climate Co-Disbenefits

With the additional operation of control devices associated with the proposed rule, CO_2 emissions will be generated as a result of the additional electricity required to operate them. The estimate of additional CO_2 emissions is presented in Chapter 3. We calculate the co-disbenefit associated with these additional CO_2 emissions using an interim measure of the domestic social cost of carbon (SC-CO_2). The SC-CO_2 is an estimate of the monetary value of impacts associated with marginal changes in CO_2 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 CO_2 emissions). The SC-CO_2 estimates used in this analysis focus on the direct impacts of climate change that are anticipated to occur within U.S. borders.

The SC-CO_2 estimates presented here are interim values developed under E.O. 13783 for use in regulatory analyses until improved domestic estimates can be developed, which will take into consideration the recent recommendations from the National Academies of Sciences, Engineering, and Medicine (2017) for a comprehensive update to the current methodology to ensure that the social cost of greenhouse gas estimates reflect the best available science.[67] The

[67] 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 .

climate co-disbenefits associated with the additional 14,700 short tons of CO_2 emissions generated as a result of the requirements of this proposed rule are $93,600 at a 3 percent discount rate and $13,400 at a 7 percent discount rate, all in 2016 dollars.[68] These co-disbenefits are estimated for 2025 using the domestic social cost of carbon (SC-CO_2) ranging from $1/ metric ton and $7/metric ton (2016 dollars) to be consistent with the year for the $PM_{2.5}$ and SO_2 BPTs applied to generate those monetized co-benefits.[69,70, 71] The procedure for this calculation, background on its methodology, and a discussion of limitations and assumptions associated with the calculation of SC-CO_2 can be found in detail in Chapter 4 of the RIA for the recently promulgated ACE rule.[72]

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[68] In order to calculate these values, it is necessary to convert tons (short) of emissions to metric tons. These values may be converted to $/short ton using the conversion factor 0.90718474 metric tons per short ton for application to the short ton CO_2 emissions impacts provided in this rulemaking. Hence, 15,000 short tons of emissions becomes 13,300 metric tons of emissions.

[69] These SC-CO_2 values are stated in $/metric ton CO_2 and rounded to the nearest dollar. Such a conversion does not change the underlying methodology, nor does it change the meaning of the SC-CO_2 estimates. For both metric and short tons denominated SC-CO_2 estimates, the estimates vary depending on the year of CO_2 emissions and are defined in real terms, i.e., adjusted for inflation using the Gross Domestic Product (GDP) implicit price deflator.

[70] To account for ethical considerations of future generations and potential 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- CO_2 based on a 2.5 percent discount rate, in addition to the 3 and 7 percent used in the main analysis. Based on a 2.5 percent discount rate, the domestic climate co-disbenefits of the proposed action in 2025 is $ $0.14 million in 2016 dollars, with a value of $10/metric ton applied to generate the estimate. Additional discussion of discounting and other quantified sources of uncertainty is provided in the RIA for the recently promulgated ACE rule.

[71] 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 CO_2 and other GHGs, given that GHGs contribute to damages around the world independent of the country in which they are emitted. The global climate co-disbenefits of the proposed action in 2025 using global SC- CO_2 estimates based on both 3 and 7 percent discount rates are $0.08 million and 0.71 million in 2016 dollars, respectively.

[72] U.S. EPA. Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emissions Guidelines for Greenhouse Gases from Existing Electric Energy Generating Units. EPA-452/R-19-003. June 2019. Available at https://www.epa.gov/sites/production/files/2019-06/documents/utilities_ria_final_cpp_repeal_and_ace_2019-06.pdf.

5 BENEFIT-COST COMPARISON

In this section, we present a comparison of the benefits and costs of this regulation. As explained in the previous sections, all costs and benefits outlined in this RIA are estimated as the change from the baseline, which reflects the requirements already promulgated in the January 2013 final ICI boilers MACT standard. As stated earlier in this RIA, there is no monetized estimate of the benefits for the HAP emission reductions expected to occur as a result of this proposal. We do present monetized estimates for other impacts of this proposal, such as ancillary co-benefits from reductions in $PM_{2.5}$ and SO_2 emissions, and ancillary co-disbenefits from increases in CO_2 emissions.

5.1 Results

As shown in Chapter 4, the estimated monetized benefits from the HAP emission reductions of targeted pollutants are not quantified, but the total estimated monetized ancillary co-benefits due to reductions in non-targeted pollutants such as $PM_{2.5}$ and SO_2 from implementation of the proposed rule are approximately $110 million to $250 million in 2025 (2016 dollars) at a 3 percent discount rate, where 2025 is a year used to approximate impacts in the year of full MACT implementation (2023). Estimates of benefits including co-benefits and costs for 2025 and for co-benefits discounted at 3 percent and 7 percent are found in Table 5-1. The climate disbenefits from additional CO_2 emissions presented in section 4.7 are accounted for in these estimates.

The EPA presents estimates of the present value of the ancillary co-benefits (including co-disbenefits) and costs, assuming an eight year period from expected promulgation of the rule beginning in 2021. These estimates reflect that there is not an estimate of monetized benefits from affected HAP emission reductions that occur as a result of this proposal. The present value (PV) of the net benefits considering ancillary co-benefits and co-disbenefits, in 2016 dollars and discounted to 2020, is $530 million to $1,000 million when using a 7 percent discount rate and $600 million to $1,520 million when using a 3 percent discount rate. We represent the present value of unmonetized benefits from affected HAP emission reductions as a C, and this is part of the net benefits estimate. The equivalent annualized values (EAV), an estimate of the annualized value of the net benefits considering ancillary co-benefits and co-disbenefits consistent with the present values, is $70 million to $160 million per year when using a 7 percent discount rate and

$80 million to $220 million per year when using a 3 percent discount rate. We represent the equivalent annualized value of unmonetized benefits from affected HAP emission reductions as a D, and this is part of the net benefits estimate. The EAV represents a flow of constant annual values that, had they occurred in each year from 2021 to 2028, would yield an equivalent PV. The EAV represents the value of a typical cost or benefit (including ancillary co-benefits and co-disbenefits) for each year of the analysis, in contrast to the year-specific estimates mentioned earlier for the snapshot year of 2025. The comparison of benefits and costs in PV and EAVs terms can be found in Table 5-1. Estimates in the table are presented as rounded values.

Table 5-1 Summary of Present Values and Equivalent Annualized Values for Annual Costs, Monetized Ancillary Co-Benefits, and Monetized Net Benefits (Including Ancillary Co-Disbenefits) for the Proposed Rule (millions of 2016 dollars)[a,b]

		3% Discount Rate	7% Discount Rate
Present Value	Targeted Benefits[c]	C	C
	Ancillary Co-Benefits	$730 to $1,650	$630 to $1,100
	Cost[d]	$130	$100
	Net Benefits[e]	**$600 to $1,520 + C**	**$530 to $1,000 + C**
Equivalent Annualized Value	Targeted Benefits[f]	D	D
	Ancillary Co-Benefits	$100 to 240	$90 to 180
	Costs	18	17
	Net Benefits	**$80 to 220 + D**	**$70 to 160 + D**

[a] All estimates in this table are rounded to one decimal point, so numbers may not sum due to independent rounding.
[b] All estimates reflect the amendments to the ICI Boilers MACT standard included in this proposal from a baseline that includes the control technologies applied to meet the MACT standard.
[c] C represents the present value of unquantified benefits from reductions in targeted HAP emissions
[d] The annualized present value of costs and benefits are calculated over an 8 year period from 2021 to 2028.
[e] The total monetized ancillary co-benefits reflect the human health benefits associated with reducing exposure to $PM_{2.5}$ through reductions of directly emitted $PM_{2.5}$ and SO_2. Monetized ancillary co-benefits include many, but not all, health effects associated with $PM_{2.5}$ exposure. Co-benefits are shown as a range from Krewski *et al.* (2009) to Lepeule *et al.* (2012). We do not report the total monetized ancillary co-benefits by $PM_{2.5}$ species. The ancillary climate co-disbenefits from additional CO_2 emissions resulting from control device operations are included in the results given the rounding convention employed in this table as stated in footnote a. The net benefits calculation consists of the targeted benefits and ancillary co-benefits minus the social costs and ancillary climate co-disbenefits.
[f] D represents the equivalent annualized value of unquantified benefits from reductions in targeted HAP emissions.

Therefore, given these results, the EPA expects that implementation of this rule, based solely on an economic efficiency criterion, will provide society with a substantial net gain in welfare, notwithstanding the expansive set of health and environmental benefits and ancillary co-benefits or other impacts we were unable to quantify. Further quantification of directly emitted $PM_{2.5}$-, mercury-, acidification-, and eutrophication-related impacts would increase the estimated net benefits, including ancillary co-benefits, of the rule.

5.2 Uncertainties and Limitations

Throughout the RIA, we considered a number of sources of uncertainty, both quantitatively and qualitatively, regarding the benefits and co-benefits, and costs of the proposed rule. We summarize the key elements of our discussions of uncertainty here:

- **Projection methods and assumptions:** 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 proposed rule could change. We assume 100 percent compliance with the rule, starting from when the source becomes affected. If sources do not comply with the rule, at all or as written, the cost impacts may be overestimated. Additionally, new control technology may become available in the future at lower cost, and we are unable to predict exactly how industry will comply with the proposed standards in the future.
- **Years of analysis:** The years of the cost analysis are 2021, to represent the first-year facilities are affected by this reconsideration, through 2028, to represent impacts of the rule over a longer period, as discussed in Chapter 3. Extending the analysis beyond 2028 would introduce substantial and increasing uncertainties in projected impacts of the proposed regulation. We also note that the "snapshot" benefit estimates for 2025 are used as an approximation of such estimates in 2023, the year the rule will be fully implemented. This approximation is done because 2025 is the closest year to 2023 for which the EPA has benefits-per-ton estimates available to monetize the societal ancillary co-benefits of this action.
- **BPT estimates:** All national-average BPT estimates reflect the geographic distribution of the modeled emissions, which may not exactly match the emission reductions that would occur due to rulemaking, and they may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors for any specific location. Over the last year and a half, the EPA systematically compared the changes in benefits, and concentrations where available, from its BPT technique and other reduced-form techniques to the changes in benefits and concentrations derived from full-form photochemical model representation of a few different specific emissions scenarios. Reduced form tools are

less complex than the full air quality modeling, requiring less agency resources and time. That work, in which we also explore other reduced form models is referred to as the "Reduced Form Tool Evaluation Project" (Project), began in 2017, and the initial results were available at the end of 2018. 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 the EPA's benefit-cost analysis. The EPA continues to work to develop refined reduced-form approaches for estimating $PM_{2.5}$ benefits. The scenario-specific emission inputs developed for this project are currently available online. The study design and methodology are described in the final report summarizing the results of the project, available at https://www.epa.gov/sites/production/files/2019-11/documents/rft_combined_report_10.31.19_final.pdf.

- **Non-monetized benefits and ancillary co-benefits:** Numerous categories of health and welfare benefits and ancillary co-benefits are not quantified and monetized in this RIA. These unquantified benefits, including benefits from reductions in emissions of targeted pollutants such as mercury, HCl and other HAP, are described in detail in Chapter 4 of this RIA, various $PM_{2.5}$ NAAQS RIAs and in Chapter 4 of the RIA for the promulgated ACE rule.

- **PM health impacts**: In this RIA, we quantify an array of adverse health impacts attributable to emissions of $PM_{2.5}$. The Integrated Science Assessment for Particulate Matter ("PM ISA") (U.S. EPA, 2009) identifies the human health effects associated with ambient particles, which include premature death and a variety of illnesses associated with acute and chronic exposures.

- **Monetized climate co-disbenefits:** The EPA considered the uncertainty associated with the social cost of carbon (SC-CO_2) estimates, which were used to calculate the domestic climate co-disbenefits from the increase in CO_2 emissions projected under the proposed action. Some uncertainties are captured within the analysis, while other areas of uncertainty have not yet been quantified in a way that can be modeled.[73]

[73] For more information on the uncertainty associated with SC-CO_2 please see the RIA associated with the final ACE rule. Section 4.3 and Chapter 7 of the ACE RIA provides a detailed discussion of the ways in which the modeling underlying the development of the SC-CO_2 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.

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