Regulatory Impact Analysis for the Proposed Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Large Municipal Waste Combustors

EPA-452/R-24-007
January 2024

Regulatory Impact Analysis for the Proposed Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Large Municipal Waste Combustors

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ACKNOWLEDGEMENTS

In addition to U.S. Environmental Protection Agency staff, personnel from the Eastern Research Group (ERG) contributed research, data, and analysis to this document.

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1 EXECUTIVE SUMMARY

1.1 Introduction

The U.S. Environmental Protection Agency (EPA) is proposing amendments to the New Source Performance Standards (NSPS) and Emissions Guidelines (EG) for Large Municipal Waste Combustors (40 CFR Part 60, Subparts Cb, Ea, and Eb), as required by section 129 of the Clean Air Act (CAA). Section 129 of the CAA requires the EPA to establish NSPS and EG pursuant to sections 111 and 129 of the CAA for new and existing solid waste incineration units, including ‘‘incineration units with capacity greater than 250 tons per day combusting municipal waste.’’ This action amends the large MWC standards under such authority. In addition, CAA section 129(a)(5) specifically requires the EPA to periodically review and revise the standards and the requirements for solid waste incineration units, including large MWC units.

The North American Industry Classification System (NAICS) codes for the large municipal waste industry are 562213 and 924110. This list of categories and NAICS codes is not intended to be exhaustive, but rather provides a guide for readers regarding the entities that this proposed action is likely to affect. The proposed standards, once promulgated, will be directly applicable to the affected sources. A portion of large municipal waste combustors are owned and may be operated by local or municipal governments, and thus would be affected by this proposed action. Under Section 129(a)(1)(B) of the Clean Air Act Amendments of 1990 (see Pub. L 101-549, title III, §305(a), November 15, 1990, 104 Stat. 2577), the large municipal waste combustor source category comprises units with a capacity greater than 250 tons per day of municipal solid waste (MSW).

In accordance with E.O. 12866 (as amended by E.O. 14094) and E.O. 13563, the guidelines of OMB Circular A-4 and EPA's *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2016), the RIA analyzes the benefits and costs associated with the projected emissions reductions under the proposed requirements, a less stringent set of alternative requirements, and a more stringent set of alternative requirements to inform the EPA and the public about these projected impacts. The benefits and costs of the proposed rule and regulatory alternatives are presented for the 2025 to 2044 time period.

1.1.1 *Legal Basis for this Rulemaking*

Section 129 of the CAA requires the EPA to establish NSPS and EG pursuant to sections 111 and 129 of the CAA for new and existing solid waste incineration units, including ''incineration units with capacity greater than 250 tons per day combusting municipal waste.'' This action amends the large MWC standards under such authority. In addition, CAA section 129(a)(5) specifically requires the EPA to periodically review and revise the standards and the requirements for solid waste incineration units, including large MWC units.

The EPA has substantial discretion to distinguish among classes, types, and sizes of incinerator units within a category while setting standards. CAA section 129(a)(2) provides that standards "applicable to solid waste incineration units promulgated under . . . [section 111] and this section shall reflect the maximum degree of reduction in emissions of . . . [certain listed air pollutants] that the Administrator, taking into consideration the cost of achieving such emission reduction and any non-air quality health and environmental impacts and energy requirements, determines is achievable for new and existing units in each category." This level of control is referred to as a maximum achievable control technology, or MACT standard. CAA section 129(a)(4) further directs the EPA to set numeric emission limits for certain enumerated pollutants (Cd, CO, DF, HCl, Pb, Hg, NOX, PM, and SO_2). In addition, the standards "shall be based on methods and technologies for removal or destruction of pollutants." CAA section 129(a)(3).

In promulgating a MACT standard, the EPA must first calculate the minimum stringency levels for new and existing solid waste incineration units in a category, generally based on levels of emissions control achieved in practice by the subject units. The minimum level of stringency is called the MACT "floor," and there are different approaches to determining the floors for new and/or existing sources. For new (and reconstructed sources), CAA section 129(a)(2) provides that the "degree of reduction in emissions that is deemed achievable . . . shall not be less stringent than the emissions control that is achieved in practice by the best controlled similar unit, as determined by the Administrator." Emissions standards for existing units may be less stringent than standards for new units, but CAA section 129(a)(2) requires that the standards "shall not be less stringent than the average emissions limitation achieved by the best performing 12 percent of units in the category." The MACT floors form the least stringent regulatory option the EPA may consider in the determination of MACT standards for a source category. The EPA must also determine whether to control emissions "beyond-the-floor," after considering the costs, non-air quality health and environmental impacts, and energy requirements of such more stringent control.

In general, all MACT analyses involve an assessment of the emissions from the best performing units in a source category. The assessment can be based on actual emissions data, knowledge of the air pollution control in place in combination with actual emissions data, or on other information, such as state regulatory requirements, that enables the EPA to estimate the actual performance of the regulated units. For each source category, the assessment involves a review of actual emissions data with an appropriate accounting for emissions variability. Other methods of estimating emissions can be used provided that the methods can be shown to provide reasonable estimates of the actual emissions performance of a source or sources. Where there is more than one method or technology to control emissions, the analysis may result in several potential regulations (called regulatory options), one of which is selected as MACT for each pollutant. Each regulatory option the EPA considers must be at least as stringent as the minimum stringency "floor" requirements. The EPA must examine, but is not necessarily required to adopt, more stringent "beyond-the-floor" regulatory options to determine MACT. Unlike the floor minimum stringency requirements, the EPA must consider various impacts of the more stringent regulatory options in determining whether MACT standards are to reflect ''beyond-the-floor'' requirements. If the EPA concludes that the more stringent regulatory options have unreasonable impacts, the EPA selects the "floor-based" regulatory option as MACT. If the EPA concludes that impacts associated with "beyond-the-floor" levels of control are acceptable in light of additional emissions reductions achieved, the EPA selects those levels as MACT.

Under CAA section 129(a)(2), for new sources, the EPA determines the best control currently in use for a given pollutant and establishes one potential regulatory option at the emission level achieved by that control with an appropriate accounting for emissions variability. More stringent potential beyond-the-floor regulatory options might reflect controls used on other sources that could be applied to the source category in question. For existing sources, the EPA determines the average emissions limitation achieved by the best performing 12 percent of units to form the floor regulatory option. More stringent beyond-the-floor regulatory options reflect other or additional controls capable of achieving better performance.

As noted above, CAA section 129(a)(5) requires the EPA to conduct a review of the standards at 5-year intervals and, in accordance with CAA sections 129 and 111, revise the standards. In conducting periodic reviews under CAA section 129(a)(5), the EPA attempts to assess the performance of and variability associated with control measures affecting emissions performance at sources in the subject source category (including the installed emissions control equipment), along with recent developments in practices, processes, and control technologies, and determines whether it is appropriate to revise the NSPS and EG. This approach is consistent with the requirement that standards under CAA section 129(a)(3) “shall be based on methods and technologies for removal or destruction of pollutants before, during or after combustion.” We do not interpret CAA section 129(a)(5), together with CAA section 111, as requiring the EPA to recalculate MACT floors in connection with this periodic review. This general approach is similar to the approach taken by the EPA in periodically reviewing CAA section 111 standards, which, under CAA section 111(b)(1)(B), requires the EPA, except in specified circumstances, to review NSPS promulgated under that section every 8 years and to revise the standards if the EPA determines that it is appropriate to do so.

For major sources and any area source categories subject to MACT standards, the second stage in the standard-setting process focuses on identifying and addressing any remaining (*i.e.*, "residual") risk pursuant to CAA section 112(f) and concurrently conducting a technology review pursuant to CAA section 112(d)(6). The EPA is required under CAA section 112(f)(2) to evaluate residual risk within eight years after promulgating a NESHAP to determine whether risks are acceptable and whether additional standards beyond the MACT standards are needed to provide an ample margin of safety to protect public health or prevent adverse environmental effects.1 For area sources subject to GACT standards, there is no requirement to address residual risk, but technology reviews are required. Technology reviews assess developments in practices, processes, or control technologies and revise the standards as necessary without regard to risk, considering factors like cost and cost-effectiveness. The EPA is required to conduct a technology review every eight years after a NESHAP is promulgated. Thus, the first review after a NESHAP is promulgated is a residual risk and technology review (RTR) and the subsequent reviews are just technology reviews.

The EPA is also required to address regulatory gaps (*i.e.*, "gap-filling") when conducting NESHAP reviews, meaning it must establish missing standards for listed HAP that are known to be emitted from the source category. (*Louisiana Environmental Action Network v. EPA*, 955 F.3d 1088 (D.C. Cir. 2020) (*LEAN*)). Any new MACT standards related to gap-filling must be

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1 If risks are unacceptable, the EPA must determine the emissions standards necessary to reduce risk to an acceptable level without considering costs. In the second step of the approach, the EPA considers whether the emissions standards provide an ample margin of safety to protect public health in consideration of all health information as well as other relevant factors, including costs and economic impacts, technological feasibility, and other factors relevant to each particular decision.

established under CAA sections 112(d)(2) and (d)(3) or, in specific circumstances, under CAA sections 112(d)(4) or (h).

1.1.2 *Regulatory Background*

In December 1995, EPA adopted emission guidelines (40 CFR part 60, subpart Cb) and an NSPS (40 CFR part 60, subpart Eb)2 for large MWC units pursuant to CAA section 129. Large MWC units are units with a combustion capacity greater than 250 tons per day (tpd) of municipal type solid waste. Both the emission guidelines and NSPS require compliance with emission limitations that reflect the performance of maximum achievable control technology (MACT). The 1995 NSPS apply to new large MWC units for which construction commenced after September 20, 1994. The 1995 emission guidelines apply to existing large MWC units for which construction commenced on or before September 20, 1994. The 1995 emission guidelines required that emission control retrofits be completed by December 2000. Retrofits of controls at existing large MWC units were completed on time (December 2000) and were highly effective in reducing emissions of most CAA section 129 pollutants. Relative to a 1990 baseline, the emission guidelines reduced organic emissions (dioxin/furan) by more than 99 percent, metal emissions (cadmium, lead, and mercury) by more than 93 percent, and acid gas emissions (hydrogen chloride and sulfur dioxide) by more than 91 percent. While NOx is also regulated under the 1995 emission guidelines and NSPS, the emissions reductions for NOx were relatively modest compared to the other CAA section 129 pollutants. In this proposal, we are noting some

2 Note that on February 11, 1991, Subpart Ea was promulgated that applies Standards of Performance to MWCs which commenced construction after December 20, 1989 and on or before September 20, 1994.

significant potential improvements in performance of existing control technologies as well as new applications of different technology that could impact the NOx standards for existing and new large MWC units.

Following promulgation of the 2006 rulemaking, environmental groups filed a petition for review in the D.C. Circuit challenging the rulemaking. In relevant part, the petitioners challenged the MACT floor limits which the EPA promulgated in 1995, and which were kept in place in the 2006 rulemaking. In light of then-recent precedents casting doubt on the soundness of MACT floors derived in part from state-issued air permits, as the 1995 MACT floors for large municipal waste combustors were, the EPA sought a voluntary remand of the 2006 rule. In its remand motion, the EPA announced its intention to grant the environmental groups' administrative petition to revisit the 1995 MACT floors and re-evaluate the 2006 rule as necessary to comport with any revisions. This regulatory action is to fulfill the EPA's intention in its remand motion.

1.1.3 *Proposed Requirements*

These proposed amendments reflect the results from a reevaluation of the maximum achievable control technology (MACT) floor levels, a 5-year review, and remove startup, shutdown and malfunction exclusions and exceptions. These proposed amendments also streamline regulatory language, revise recordkeeping and electronic reporting requirements; re-establish new source and existing source applicability dates; clarify requirements for air curtain incinerators; correct certain typographical errors; make certain technical corrections and clarify certain provisions in the new source performance standards and emissions guidelines. These proposed amendments would revise eight or nine of the nine emission limits in the emission guidelines, depending on combustor subcategory, and all nine emission limits in the new source performance standards. The EPA is reevaluating the maximum achievable control technology floors in response to the EPA's voluntary remand of the large municipal waste combustion rules following a petitioner's request that the EPA review the maximum achievable control technology floors for large municipal waste combustion units in consideration of a D.C. Circuit Court decision on maximum achievable control technology floor issues. The 5-year technical review is required by the Clean Air Act.

1.2 Market Failure

Many regulations are promulgated to correct market failures, which otherwise lead to a suboptimal allocation of resources within a market. Air quality and pollution control regulations address "negative externalities" whereby the market does not internalize the full opportunity cost of production borne by society as public goods such as air quality are unpriced.

While recognizing that the optimal social level of pollution may not be zero, HAP, PM2.5, SO2, and NOx emissions impose costs on society, such as negative health and welfare impacts, that are not reflected in the market price of the output produced through the polluting process. If processes that burn MSW produce pollution emitted into the atmosphere, the social costs imposed by the pollution will not be borne by the polluting firms but rather by society as a whole. Thus, according to standard economic theory on the subject, the producers are imposing a negative externality, or a social cost from these emissions, on society. Those municipalities or other entities that are users of large MWCs and pay fees for their use may fail to incorporate the full opportunity cost in what is being paid for the burning of MSW. Consequently, absent a regulation or some other action to limit such emissions, owners of large MWCs will not internalize the negative externality of pollution due to emissions and social costs will be higher as a result. This proposed regulation will serve to address this market failure by causing affected producers to begin internalizing the negative externality associated with HAP and other emissions also affected by this proposal such as $PM_{2.5}$, SO_2, and NO_x.

1.3 Results for Proposed Action

1.3.1 *Baseline for the Regulation*

The impacts of regulatory actions are evaluated relative to a baseline that represents to the extent possible the world without the regulatory action. In addition to control technologies necessary to meet the current EG and NSPS for large MWCs, this baseline includes the impact of the Good Neighbor rule, a rule to reduce interstate transport of NOx emissions for purposes of implementing the current ozone (O_3) National Ambient Air Quality Standard (NAAQS), where NOx is an O_3 precursor. If a large MWC is subject to the Good Neighbor rule, then that unit is expected to not require additional NOx control to comply with the proposed NOx amendments to the large MWC EG and NSPS. In this RIA, the EPA presents analysis results for the proposed amendments to the large MWC EG and NSPS. Throughout this document, the EPA focuses the analysis on the proposed requirements that result in quantifiable compliance cost or emissions changes compared to the baseline as identified above. For each rule and most emissions sources, EPA assumed each facility achieved emissions control meeting current standards, and estimated emissions reductions and cost relative to this baseline. We calculate cost and emissions reductions relative to the baseline for the period 2025-2044. This time frame spans the time period from when the NSPS takes effective (given that the action should be finalized in 2024) through the lifetime of the typical capital equipment (20 years) expected to be installed as a result of the proposed EG and NSPS amendments if finalized.

The summaries of impact results below are for the proposed options. In accordance with OMB Circular A-4 (US OMB, 2003),3 we also present impact results for a more stringent and less stringent set of options as defined by that circular, which is the guidance for regulatory analysis to be followed by Federal agencies preparing an RIA such as this one. These alternatives are defined in section 3.

1.3.1.1 Overview of Costs and Benefits for the Proposed Options

The proposed amendments to the large MWC EG and NSPS constitute a significant regulatory action. This action is significant according to Executive Order 12866 as amended by Executive Order 14094, because it likely to have an annual effect on the economy of $200 million or more 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. The EPA monetized the projected benefits of reducing $PM_{2.5}$, SO_2,

3 U.S. Office of Management and Budget. Circular A-4, "Regulatory Analysis." September 17, 2003. Available at https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf.

and NOx emissions in terms of the value of avoided $PM_{2.5}$ and ozone-attributable deaths and illnesses, both short- and long-term.

Error! Reference source not found. also presents projected (benefits, compliance costs, and net benefits, and emission reductions from the proposed amendments to the EG and NSPS. Net compliance costs are calculated as total compliance costs minus product recovery credits. Monetized net benefits are projected using short- and long-term estimates of $PM_{2.5}$ and ozone health benefits and both 3 percent and 7 percent social discount rates. The unmonetized effects include benefits from HAP and dioxin/furan emission reductions. As mentioned earlier, we calculate cost and emissions reductions relative to the baseline for the period 2025-2044, with costs discounted to 2023. All estimates are in 2022 dollars.

Table 1-1: Projected Monetized Benefits, Compliance Costs, and Net Benefits of the Proposed Rule, 2025 to 2044[a,b,c,d] (millions of 2022$, discounted to 2023)

		3% Discount Rate	7% Discount Rate
Present Value	Health Benefits [c]	$5,100 and $16,000	$3,100 and $9,800
	Compliance Costs	$1,700	$1,200
	Net Benefits	**$3,400 and $14,000**	**$1,800 and $8,500**
Equivalent Annualized Value [b]	Health Benefits [c]	$340 and $1,100	$290 and $920
	Compliance Costs	$110	$120
	Net Benefits	**$230 and $970**	**$170 and $800**

[a] Values have been rounded to two significant figures. Rows may not appear to sum correctly due to rounding.
[b] The annualized present value of costs and benefits are calculated over the 20-year period from 2025 to 2044. The choice of this analysis period is explained in the proposal RIA.
[c] The projected monetized benefits include those related to public health associated with reductions in $PM_{2.5}$ and ozone concentrations that result from the reductions in PM, SO_2, and NOx emissions. The projected health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent.
[d] Several categories of benefits remain unmonetized and are thus not reflected in the table. Non-monetized benefits include important benefits from reductions in HAP including cadmium, lead and dioxin/furan emissions. In addition, benefits to provision of ecosystem services associated with reductions in N and S deposition and ozone concentrations are not monetized.

As shown in Table 1-1, at a 3 percent discount rate, this proposed rule is projected to reduce $PM_{2.5}$ and ozone concentrations, producing a projected PV of monetized health benefits of $5.1 billion to $16 billion, with an EAV of $340 million to $1.1 billion discounted at 3 percent. The PV of the projected compliance costs are $1,700 million, with an EAV of about $110 million discounted at 3 percent. Combining the projected benefits with the compliance costs yields a net benefit PV estimate of $3.4 billion to $14 billion and EAV of $230 to $970 million.

At a 7 percent discount rate, this proposed rule is expected to generate projected PV of monetized health benefits of $3.1 billion to $9.8 billion, with an EAV of about $290 million to $920 million. The PV of the projected compliance costs are $1,200 million, with an EAV of $120 million discounted at 7 percent. Combining the projected benefits with the projected compliance costs yields a net benefit PV estimate of $1.8 billion to $8.5 billion and an EAV of $170 million to $800 million.

The potential benefits from reducing Hg and non-Hg metal HAP were not monetized and are therefore not reflected in the benefit-cost estimates associated with this proposal. Potential benefits from dioxin/furan emission reductions and reduced nitrogen and sulfur deposition are not monetized in this analysis and are therefore not directly reflected in the quantified benefit-cost comparisons. We anticipate that taking these non-monetized effects into account would show the proposal to have a greater net benefit. Finally, results for a less stringent and a more stringent alternative are presented in section 6 of this RIA.

1.4 Organization of the Report

The remainder of this report details the methodology and the results of the RIA. Section 2 presents a profile of the large MWC source category. Section 3 describes emissions, emissions control options, and engineering costs. Section 4 presents the benefits analysis, including the monetized health benefits from $PM_{2.5}$, SO_2, NO_x, a qualitative discussion of the unmonetized benefits associated with HAP and dioxin/furan emissions reductions. Section 5 presents analyses of economic impacts, impacts on small entities, and a narrow analysis of employment impacts. Section 6 presents a comparison of the benefits and costs. Section 7 contains the references for this RIA.

2 INDUSTRY PROFILE

2.1 Introduction

This industry profile supports the regulatory impact analysis (RIA) of the proposed amendments to the EG and NSPS for MWCs. Regulation of emissions from MWCs directly impacts suppliers of combustion services as well as households, businesses, institutions, and communities that are either served by MWCs, would experience changes in landfill usage, or located where changes in emissions would be observed. This section begins with a discussion of the characterization of demand for MSW collection and disposal services. What follows is a discussion of the supply side of the market, including combustion technology and air pollution control technologies available to MWCs, characteristics of MWCs, and baseline flows to MWCs. The section concludes by introducing the inventory of MWCs used to analyze the impacts of the proposed regulation.

2.2 Generators

MSW generators require collection and disposal services resulting in them providing most of the potential demand for MWC services. This demand is a derived demand because the generators of MSW generally do not directly purchase MWC services; the purchase of MWC services is left to the collectors of MSW directly or indirectly contracted by MSW generators. MSW generators can be partitioned into four broad categories: residential, commercial, industrial, and a residual other. The residential category includes waste from single- and multiple-family homes. The commercial category includes waste from retail stores, shopping centers, office buildings, restaurants, hotels, airports, wholesalers, auto garages, and other commercial establishments. The industrial category includes waste such as corrugated boxes and other packaging, cafeteria waste, and paper towels from factories and other industrial buildings, but it does not include waste from industrial processes, whether hazardous or nonhazardous. The residual other category includes waste from public works such as street sweepings and tree/brush trimmings, and institutional waste from schools and colleges, hospitals, prisons, and similar public or quasi-public buildings. Infectious and hazardous waste from these residual generators are managed separately from MSW.

Households are the primary direct source of MSW, followed by the commercial sector. The commercial, industrial, and other sectors each directly generate smaller portions of MSW than households. The industrial sector manages most of its own solid residuals, whether MSW or industrial process waste, by recycling, reuse, or self-disposal. For this reason, industry directly contributes only a small share of the MSW flow, although some industrial process wastes do end up as MSW. Industries that are affected by this proposal are listed in Table 2-1.

Table 2-1: Industries Potentially Affected by Proposal

Category	NAICS Code	SIC Code	Examples of Potentially Regulated Entities
Industry: air and water resource and solid waste management	924110	9511	Solid waste landfills
Industry: refuse systems - solid waste landfills	562212	4953	Solid waste landfills

State, local, and tribal government agencies	562212 924110	4953	Solid waste landfills, air and water resource and solid waste management

Various underlying factors influence the trends in the quantity of MSW generated over time. These factors include changes in population, individual purchasing power and disposal patterns, trends in product packaging, and technological changes that affect disposal habits and the nature of materials disposed.

2.3 Collection and Disposal

Governments -local, state, and federal-continue to play a large role in regulating andoperating MSW management systems. Governmental influence, however, is limited. Material, engineering, geographic, cost, and other technical and economic conditions spell out some of the limits.

In addition, all MSW management systems ultimately involve private decision makers. Households and private firms generate most MSW, collect and transport MSW, build and operate MSW disposal systems, provide financing, and provide markets for recycled material. In some settings these private activities compete with public operations; in others, they provide factors of production and demand for outputs from public operations. Whatever the case, these technical and market relationships are important factors in conditioning the influence of local governments on MSW management generally.

Local governments, especially in more urbanized areas, often take the lead in organizing MSW management and, in many cases, providing collection and disposal services. This is particularly true in the Eastern United States (Chartwell, 1998). A wide variety of reasons explain this involvement: concern for the public health threat of uncollected or improperly disposed MSW, natural economies of scale in organizing and performing MSW collection and disposal, and a concern for the negative externalities-litter, noise, smells, traffic sometimes associated with private collection and disposal. These negative externalities are not necessarily unhealthy, but they are detractions from public welfare.

Four market structures for MSW collection predominate: public monopoly (public agency collects all MSW), private monopoly (private firm(s) collect(s) all MSW in a specific area under a franchise agreement and is (are) reimbursed by the local government), competitive (public agency and private firm(s) both collect MSW), and self-service (generators haul their MSW to disposal sites).

Most residential refuse is collected under the first three market structures A large fraction of private service is provided by contractors selected by local governments. In such cases, the government plays a role in selecting the private collection firm, specifying the terms and conditions of collection, and paying the private collector for the service.

Many factors justify the interest of government institutions, and local communities in playing a large role in leading MSW management. These factors include that MSW may pose a threat to the public health, improperly disposed waste may result in adverse environmental impacts, and problems such as noise, traffic, and odor may results from the disposal of MSW.

The most common owners of landfill facilities are county and city governments. State governments own less than one percent of landfills. The greatest proportion of public ownership is generally found in the Northeast, while the greatest proportion of private ownership is generally found in the West (Reason Public Policy Institute, 2000).

Fourty-eight percent of all U.S. landfills are now privately operated, a sign that privatization is becoming a common choice of governments in dealing with the operation of landfills. This is particularly true among communities with more than 100,000 residents. Larger facilities are generally more efficient, regardless of whether they are publicly or privately owned, and can utilize economies of scale that enable operators to charge lower tipping fees. Cost savings appears to be a clear reason for governments to move toward privatization. According to a 1998 R.W. Beck survey, forty-four percent of respondents said that cost savings was the major reason for privatizing a landfill; with efficiency being the choice of 19 percent of the respondents (Burgiel, 1998).

As of 2022, the largest landfill owner was Waste Management, Inc., which handles 30 percent of all intake volume for landfills nationwide. The next largest firm in terms of intake volume is Republic Services, with 19 percent of all intake volume nationally.[4] Revenue Generation

The costs of building and operating large MWCs are financed through various blends of debt and equity and public versus private investment. In the U.S., most facilities are built with

4 Statista, 2023. "Market Share of Landfill Waste Volume Managed in the U.S. in 2022, by Company." Available at https://www.statista.com/statistics/1098982/us-market-share-of-landfill-volume-by-company/

financial backing from municipal bonds, which is a form of debt security that has a low risk of defaulting. A few facilities with private partners also opt to partially finance facilities with private equity, but this is a less common practice. Overall, municipal waste combustors rely primarily on tipping fees and secondarily on electricity sales for revenues. As an example, the Palm Beach Country (FL) Solid Waste Authority, that operates the most recently built large MWC subject to the current EG/NSPS, is funded primarily through a system of user fees. The primary funding mechanism is a special assessment that is included on the annual property tax bill of all Palm Beach County property owners. Additional revenue sources include tipping fees, electric sales, recycling revenue and interest income.5 Covanta, which owns many of the large MWCs affected by this proposal, indicates in their 2020 Form 10-K filing with the Securities and Exchange Commission (SEC), that revenues for their MWCs (or WTE projects) come from the following three routes: (1) fees charged for operating facilities or processing waste received; (2) the sale of electricity and/or steam; and (3) the sale of ferrous and non-ferrous metals that are recovered from the waste stream as part of the WTE process.6 These revenue sources are from the communities that these large MWCs serve, which are the official service areas for each authority that manage the large MWCs. These official service areas can vary from a single city or municipality to a broader geographic scope.

5 Solid Waste Authority for Palm Beach County, FL. About Us | Solid Waste Authority of Palm Beach County, FL (swa.org). Accessed on July 27, 2023.

6 Covanta Corporation. Form 10-K, filed for the fiscal year ending December 31, 2020. p. 7. Available at https://app.quotemedia.com/data/downloadFiling?webmasterId=101533&ref=115653122&type=HTML&symbol=CVA&companyName=Covanta+Holding+Corporation&formType=10-K&dateFiled=2021-02-19&CK=225648. Accessed on July 27, 2023.

The costs of developing and operating MSW landfills are ultimately covered by tipping fees, general tax revenues, or a combination of the two. Tipping fees ultimately reflect many aspects of MSW disposal. Population and economic growth, recycling rates, operating and transportation costs, land values, and legislation all contribute to how much waste disposal facilities charge for the privilege of waste disposal (Chartwell, 1998). As of 2022, the nationwide average tipping fee for MSW landfills was $58.47/ton waste volume. This represents an increase of 8 percent compared to the nationwide average tipping fee from 2021. The range of average tipping fees is from a high of $75.92/ton in the Northeast to a low of $44.75/ton in the Southeast.7 This rate is more than that for materials recovery stations, but less than that charged by incinerators, mixed waste sites, and transfer stations. Approximately 30 percent of landfills receive all their revenues from tipping fees, and approximately 35 percent of landfills receive all their revenues from taxes. The remaining 35 percent of landfills cover the costs of waste disposal through a combination of tipping fees and taxes. The use of taxes as a revenue source rather than tipping fees has implications on waste disposal services. First, when disposal costs are included in taxes, most people are not aware of the actual costs involved. Without an effective mechanism for transmitting cost information, waste generators have no incentive to reduce their generation rates. Second, tax-supported facilities are typically underfunded relative to actual disposal costs, resulting in poorer operation than fully funded landfills supported by tipping fees (U.S. EPA, 1989).

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7 Waste Today, "EREF Study Shows MSW Tip Fees Rose Sharply In 2022," June 8, 2023. Available at https://www.wastetodaymagazine.com/news/eref-study-shows-msw-landfill-tip-fees-rose-sharply-in-2022/.

Factors that influence the choice of revenue sources include landfill size and ownership. Landfills receiving small quantities of waste are likely to rely heavily on taxes for their revenue while larger landfills rely on both taxes and tipping fees. Not surprisingly, private owners of landfills rely heavily on tipping fees relative to other landfill owners. It remains unclear whether private landfills rely on tipping fees because they are larger, or larger landfills rely heavily on tipping fees because they are private.

A distinction must be drawn between tipping fees and the actual costs of landfilling. Communities often set tipping fees to cover current operating costs without regard to amortization of capital expenditures (capital equipment, land, closure, and long-term care costs). Similarly, the cost of disposal for landfills supplementing tipping fee revenues with taxes is usually much higher than the fee charged.

In addition to tax subsidies, tipping fees do not cover the actual costs to society of disposal because landfill costs usually do not include three important social costs (U.S. EPA, 1991): depletion costs of existing landfills (i.e., discounted present value of the difference in landfill costs today and the future costs of a replacement landfill), opportunity costs of land used in landfills, and environmental costs (risk of environmental damage from landfills).

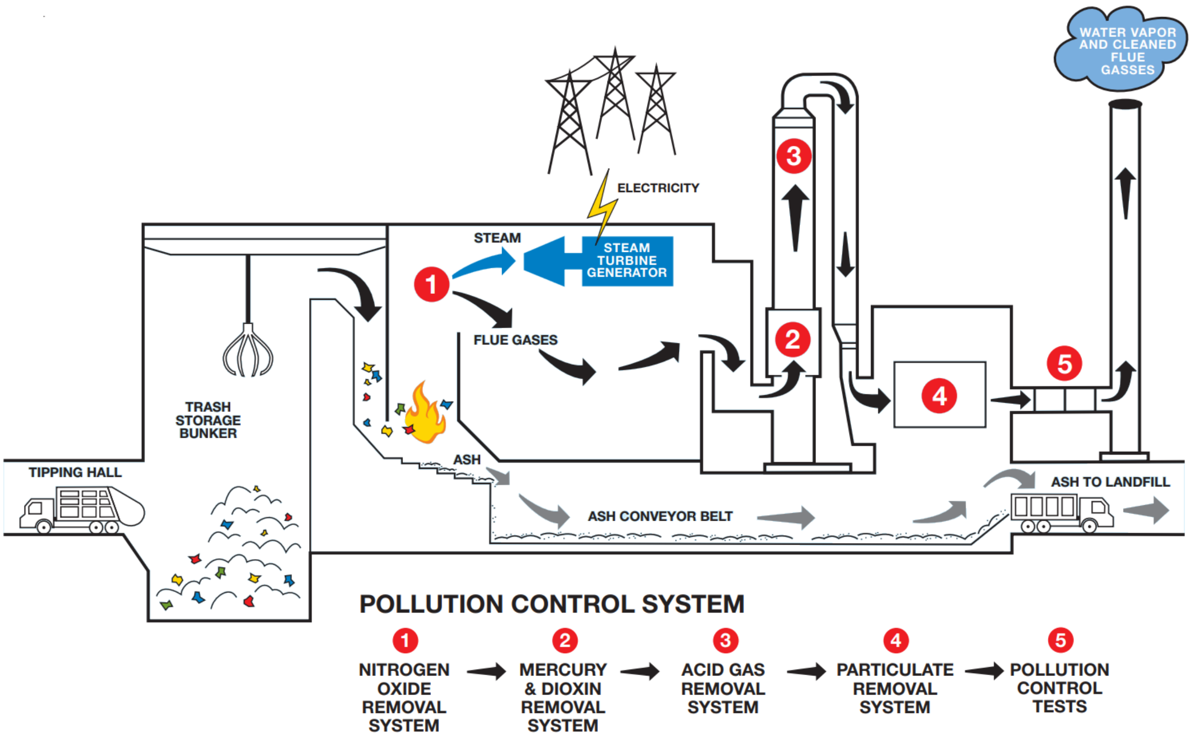
It is important to note that given the lesser amount of land normally needed to operate a bioreactor instead of a conventional landfill, the opportunity costs of land as reflected in its potential value for other purposes (e.g., real estate, commercial office buildings, etc.) becomes less of an issue for bioreactor siting and operation. According to an analysis of bioreactor costs done by ERG, “bioreactor landfills require 15 to 20 percent less land than standard landfills storing the same quantity of waste as a result of greater decay and compaction rates" (ERG, October 2001). Given the expense of land, particularly in large urban areas, this is an important and beneficial difference between these two types of MSW treatment. However, specific jurisdictions may experience little real competition for landfill services.

2.4 MSW Mass Burn Process

Mass burn facilities are the most common types of municipal solid waste combustion facilities in the United States, and they are fueled by waste that may or may not be sorted before it enters the combustion chamber as some municipalities separate the waste on the front end to extract recyclable products, while others do not. These units are designed to burn MSW in a single combustion chamber under conditions of excess air. This excess air must be used to promote mixing and turbulence to ensure that air can reach all parts of the waste, which is necessary due to the inconsistent nature of solid waste. This process is further encouraged by burning MSW on a sloping, moving grate that is vibrated or otherwise moved to agitate the waste and mix it with air.

At an MSW combustion facility, MSW is unloaded from collection trucks into a storage bunker, where an overhead crane is then used to sort the waste and lift it into a combustion chamber. The heat released from combustion is used to convert water to steam that is then sent to a turbine generator to produce electricity. The remaining ash is collected and taken to a landfill. Particulates are captured by a high-efficiency baghouse filtering system. As the gas stream travels through these filters, more than 99 percent of particulate matter is removed. Captured fly ash particles fall into funnel-shaped hopper receptacles and are transported by an enclosed conveyor system to the ash discharger where they are wetted to prevent dust and mixed with the bottom ash from the grate. This ash residue is then conveyed to an enclosed building where it is loaded into covered, leak-proof trucks to be taken to a landfill designed to protect against groundwater contamination. Ash residue from the furnace can be processed for removal of recyclable scrap metals. Figure 2-1 illustrates how this energy recovery process works.

Figure 2-1: Waste to Energy Plant Diagram



*From the EPA archive, supplied by ecomaine.

The amount of ash generated ranges from 15 to 25 percent by weight of the MSW processed and from 5 to 15 percent of the volume of the MSW processed.

2.5 MSW as Compared to Landfills

As an alternative to combustion by large MWCS, conventional landfills are typically operated as “dry tombs” by minimizing the infiltration of liquids into the landfill. This can be accomplished by placement of bottom and side liners and by placement of a low permeability final cap over the waste. In addition, many sites install and operate leachate collection systems to remove leachate and thus, minimize groundwater contamination. This method also results in a slower biodegradation process and a reduced rate of landfill gas generation. Some conventional landfills recirculate a portion of the collected leachate. A typical moisture content of the waste in a conventional landfill is approximately 20 percent, but it may be lower in arid areas or where all collected leachate is removed and infiltration.

A bioreactor is an MSW landfill or portion of an MSW landfill where any liquid other than leachate is added in a controlled fashion into the waste mass (often in combination with recirculating leachate) to reach a moisture content of 40 percent by weight to accelerate or enhance the anaerobic (without oxygen) biodegradation of the waste. This includes hybrid bioreactors, which are managed so that the waste undergoes a short (e.g., 60 day) aerobic stage, after which the waste is covered over and operated as an anaerobic bioreactor for several years. The long-term operation, emissions pattern, and applicable control techniques for hybrid bioreactors are similar to anaerobic bioreactors. The rapid biodegradation of waste in a bioreactor leads to more rapid generation of landfill gas compared to a conventional landfill. The vast majority of bioreactors are anaerobic or hybrid bioreactors.

Operating a landfill as a bioreactor extends the use of current sites and reduces the need for new sites, reducing land use, environmental impacts, and land purchase costs. Bioreactors improve the quality of leachate resulting in reduced environmental impacts if any groundwater contamination were to occur. Economic benefits include avoiding the costs of leachate treatment, transport, and disposal. In addition, because bioreactors emit a similar total amount of gas as conventional landfills but emit it more quickly over a shorter amount of time, owners and operators can convert landfill gas to energy more economically.

In aerobic bioreactors, air and liquids promote aerobic decomposition of waste. The waste decomposes rapidly due to the presence of oxygen and moisture. The aerobic decomposition produces large amounts of gases including carbon dioxide. Compared to conventional landfills, the increased temperature and increased air flow through the waste may result in increased emission rates of organic compounds (including organic HAP) soon after the aerobic bioreactor begins operation. However, aerobic landfill data is insufficient to characterize HAP emissions from this type of operation. The gas composition from aerobic bioreactors is expected to have higher levels of carbon dioxide, nitrogen, and oxygen, and significantly lower levels of methane. This may result in the gas being more difficult to safely combust. In addition, the lower levels of methane generated in aerobic bioreactors make them less economic compared to anaerobic bioreactors since methane gas can be easily used in waste-to-energy projects, while the gases formed in aerobic bioreactors cannot. Aerobic bioreactors are not included in the bioreactor subcategory in the supplemental proposal. EPA is not expecting a significant number of aerobic bioreactors to be built in the next several years. Concerns over the increased potential for landfill fires and added power costs have deterred use of this technology. Some pilots have had odor concerns, and in some cases are no longer being operated. Given the lack of information on controls for aerobic bioreactors, and the fact that very few are in operation or expected to start-up in the near future, EPA has concluded that it is not necessary for this supplemental proposal to address aerobic bioreactors. Portions of a landfill that are operated as aerobic bioreactors would continue to be subject to the NSPS/EG and the landfill NESHAP requirements. If a landfill that includes an aerobic bioreactor meets the design capacity and uncontrolled NMOC emission rate criteria in the NSPS/EG, a collection and control system must be installed in the landfill, including the aerobic bioreactor area, according to the schedule in the NSPS/EG. Landfills with pilot scale aerobic bioreactors have had success in routing emissions from aerobic bioreactor and other landfill areas together for control in flares.

3 EMISSIONS AND ENGINEERING COSTS ANALYSIS

3.1 Introduction

In this chapter, we present estimates of the projected emissions reductions and engineering compliance costs associated with the proposed NSPS and EG amendments for the 2025 to 2044 period. As mentioned in Section 1, we present these impacts over this 20-year analysis period since all of the control equipment that large MWCs are likely to apply to meet the proposed emission limits have an equipment life of 20 years, and 2025 is the first year in which impacts from this proposal if finalized will be incurred. The projected costs and emissions impacts are based on facility-level estimates of the costs of meeting the proposed emission limits and the expected emissions reduction of installing the necessary controls. The baseline emissions and emission reduction estimates are based on the best available information on emissions and activities for each source of emissions as described in the emission reductions memo for this proposal.

These estimates are provided for not only the proposed option in this RIA, but also less and more stringent alternative regulatory options in adherence to OMB Circular A-4. The less stringent option is the option in which all large MWCs meet the MACT floor emission limits. The most stringent option is the option in which all large MWCs meet beyond the MACT floor emission limits and also requirements determined in the 5th year review of emissions limits necessary as part of this proposal. More information on the less and more stringent alternative regulatory options can be found in the Emission Reduction Estimates for Existing Large MWCs Memorandum prepared for this proposal.

3.2 Choosing Controls Needed for Each Unit to Meet Potential Emissions Limits

A significant portion of the total cost for industry compliance comes from the cost of installing new or improving existing air pollution control devices (APCDs) for units not currently meeting the potential proposed limits. In order to determine the control costs, it was necessary to evaluate, for each large MWC, how much improvement for each pollutant would be needed to meet the potential proposed emissions limits. To do this, the average of available stack test and CEMS data from 2000 through 2015 was compared to the corresponding emissions limit. For CEMS pollutants, each datapoint included in the average reflects a unit's highest CEMS reading for a given year. Data gaps were filled first by using the measured data from similar units operated by the corporate entity. If these data were not available, then the means of available data for similar combustion and control types were used. Once every unit was assigned a concentration value, percentages were calculated to quantify the amount of improvement needed for each unit to meet each limit.

Control measures were then assigned for each pollutant grouping, depending on the level of control required and the control configurations already in place. In cases where one unit at a facility cannot meet a given limit but a similar unit at the facility can, it is assumed the facility will be able to adjust operational parameters to bring the non-complying unit into compliance. The assumptions for that analysis follows.

3.2.1 *Particulates (Cd, Pb, PM)*

As explained in the cost memorandum for this proposal, existing control options include fabric filter (FF) retrofit, FF improvement, a combination of retrofit and improvement, and complete FF replacement.8

ESP-equipped units that cannot meet the MACT Floor limits for at least one of the three pollutants will likely need to be retrofitted with FF. It is assumed they would need even further control (i.e., FF retrofit + improvement) to meet BTF/TR limits. This would entail a better filter bag beyond the retrofit alone.

Several units have already retrofit or are currently retrofitting to FF; in those cases, no FF retrofit costs are included for the unit. FF-equipped units that cannot meet the new limits for at least one of the three pollutants will need equipment improvements. It is assumed upgraded FF bag replacements would be sufficient and that ID fan replacement would not be necessary. For FF-equipped units needing more than 33 percent improvement to meet a BTF/TR limit, a conservative assumption that the FF will need to be replaced is used.

3.2.2 *Mercury, Dioxins and Furans*

Existing control options include activated carbon injection (ACI), increasing carbon injection (CI) rates, or a combination of the two.

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8 Eastern Research Group, for U.S. EPA. Compliance Cost Analyses for Proposed Large MWC Rule Amendments. September 18, 2023.

Units that do not currently have ACI installed and cannot meet the MACT Floor limit for one or both pollutants will need to be retrofitted with ACI. It is assumed they would need further control (ACI + increased CI rate) to meet BTF/TR limits. For units that can meet the MACT Floor limit but not the corresponding BTF/TR limit, ACI installation alone is assumed sufficient to meet the BTF/TR limit. For units that already have ACI installed but cannot meet the proposed limits, assumed an increased rate of carbon injection.

3.2.3 *Acid Gases (HCl and SO_2)*

Existing control options include increasing lime injection rates and circulating fluidized bed scrubbers (CFBS).

All units have spray dryer absorbers or dry sorbent injection towers, so it's assumed units that cannot meet the MACT Floor limit for one or both pollutants will increase their lime injection rate. These units could possibly require further control to meet the BTF/TR limits, so a conservative assumption that they would install circulating fluidized bed scrubber (CFBS) to comply with that option is used. The capital cost for this control device is considerably more expensive than for spray dryer absorbers or dry sorbent injection towers, as presented in the control memorandum for this proposal.

Units that can meet the MACT Floor limit but not the corresponding BTF/TR limit are assumed to require only increased lime injection to comply with the BTF/TR limit.

The most recently built MWC units are assumed to have state of the art spray dryer absorbers and need no further controls to meet either limit.

3.2.4 *Nitrous Oxides (NO_x)*

Existing control options include advanced selective non-catalytic reduction (ASNCR) and low-NO_x technology (Covanta LN™).

It is assumed that units located in the Ozone Transport Region and covered under the final Good Neighbor Plan rule, published in May 2023 and requiring NOx control to occur by May 1, 2026, will be able to meet the large MWC MACT Floor or BTF/TR limit for NOx and that associated impacts and burden estimates will already be accounted for in that rulemaking. To avoid double counting, EPA is not including costs for these units to come into compliance.

For both the MACT Floor and BTF/TR based limits, units unable to comply are assumed to require retrofit with either ASNCR or low NOx technology. Specifically, it is assumed Covanta units will be equipped with their LNTM technology as needed. Several of these units have already been equipped with LN TM, in which case no NOx control costs were included for compliance with either limit option. Non-Covanta units requiring additional control were assigned ASNCR.

3.2.5 *Carbon Monoxide (CO)*

No add-on controls are specified for CO. Most of the CO data, which comprise annual highest CEMS readings, are likely reported during operational transition periods and may be artificially inflated due to the 7% O_2 correction. The proposed removal of the 7% O_2 correction (and averaging using data reported at stack O_2) during warmup, startup/shutdown periods will likely abate the non-compliant readings to a large degree.

3.3 Engineering Cost Analysis

3.3.1 *Detailed Cost Impacts Tables*

This section presents detailed cost tables for each section of the proposed amendments. All tables contain per-year figures with the exception of total capital investment (which represents one-time or initial costs). Total annualized costs include capital costs annualized using the bank prime rate in accord with the guidance of the EPA Air Pollution Control Cost Manual (U.S. EPA, 2017a), operating and maintenance costs, and costs of additional monitoring, recordkeeping, and reporting (MRR) (when necessary). To estimate these annualized costs, the EPA uses a conventional and widely accepted approach, called equivalent uniform annual cost (EUAC) that applies a capital recovery factor (CRF) multiplier to capital investments and adds that to the annual incremental operating expenses to estimate annual costs. This cost estimation approach is described in the EPA Air Pollution Control Cost Manual (U.S. EPA, 2017a). These annualized costs are the costs to directly affected firms and facilities (or "private investment"), and thus are not true social costs. Detailed discussion of these costs, including all calculations and assumptions made in conducting estimates of total capital investment, annual O&M, and compliance testing/MRR costs, can be found in the "Compliance Cost Analyses for Proposed Large MWC Rule Amendments" memorandum and its Appendices A, B, and C , in the docket for the proposal. These costs incorporate impacts such as increased water usage and waste disposal, and other effects such as those to electricity generation at affected facilities. The bank prime rate was 7.5 percent at the time of the analysis. All cost figures are in 2022$.

Table 3-1 through Table 3-5 provide a summary of the total capital investment and annualized costs for control of the different types of pollutants affected by this proposal EG and NSPS. Table 3-6 provides a summary of the total capital investment and annualized costs for the whole of the proposal.

Table 3-1: Summary of Total Capital Investment and Annualized Costs per Year for Particulate Sources (2022$)[a]

	Less Stringent	Proposal	More Stringent
Total Capital Investment	$41,000,000	$41,000,000	$120,000,000
Annual O&M	$2,400,000	$2,400,000	$2,400,000
Annualized Capital	$4,800,000	$4,800,000	$12,000,000
Total Annualized Cost	$7,200,000	$7,200,000	$15,000,000

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted.

Table 3-2: Summary of Total Capital Investment and Annualized Costs per Year for Mercury and Dioxins/Furans (2022$)[a]

	Less Stringent	Proposal	More Stringent
Total Capital Investment	$50,000,000	$50,000,000	$98,000,000
Annual O&M	$37,000,000	$37,000,000	$19,000,000
Annualized Capital	$8,800,000	$8,800,000	$19,000,000
Total Annualized Cost	$45,000,000	$45,000,000	$140,000,000

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted.

Table 3-3: Summary of Total Capital Investment and Annualized Costs per Year for Acid Gases (2022$)[a]

	Less Stringent	Proposal	More Stringent
Total Capital Investment	$15,000,000	$15,000,000	$1,100,000,000
Annual O&M	$17,000,000	$17,000,000	$260,000,000
Annualized Capital	$2,200,000	$2,200,000	$270,000,000
Total Annualized Cost	$19,000,000	$19,000,000	$530,000,000

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted.

Table 3-4: Summary of Total Capital Investment and Annualized Costs per Year for Nitrous Oxides (2022$)[a]

	Less Stringent	Proposal	More Stringent
Total Capital Investment	$51,000,000	$260,000,000	$260,000,000
Annual O&M	$5,800,000	$34,000,000	$34,000,000
Annualized Capital	$5,000,000	$25,000,000	$25,000,000
Total Annualized Cost	$11,000,000	$59,000,000	$59,000,000

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted.

Table 3-5: Summary of Total Capital Investment and Annualized Costs per Year for Continuous Emissions Monitoring (2022$)[a]

	Mercury (Hg)	Hydrogen Chloride (HCl)	Particulates (PM)
Total Capital Investment	$33,000,000	$15,000,000	$5,400,000
Annual O&M	$11,000,000	$2,200,000	$390,000
Annualized Capital	$4,800,000	$2,200,000	$790,000
Total Annualized Cost	$16,000,000	$4,000,000	$1,200,000

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted.

Table 3-6: Summary of Total Capital Investment and Annualized Costs per Year (2022$)[a]

	Less Stringent	Proposal	More Stringent
Total Capital Investment	$210,000,000	$420,000,000	$1,600,000,000
Annual O&M	$76,000,000	$100,000,000	$330,000,000
Annualized Capital	$29,000,000	$49,000,000	$330,000,000
Total Annualized Cost	$100,000,000	$150,000,000	$770,000,000

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted.

Table 3-7 provides a breakdown of the composition of undiscounted compliance costs incurred in each year of analysis. An important assumption for this composition is that the capital costs are presumed to be incurred entirely in one year, 2025. Thus, for purposes of this analysis, all control equipment is presumed to be ready for operation by the end of that year, just about one year after the rule's effective date. Given that compliance is not required until 3 years after the effective date of the final rule, this assumption may potentially overstate the costs of this rule as estimated in this analysis. As this assumption similarly shifts the timing of benefits to be in line with the timing of the costs, benefits would be potentially overestimated, with the ratio of discounted benefits with this assumption to those from a delayed, 2027 operational status being similar to the ratio of discounted costs under the two alternative assumptions. The ratio of discounted costs to discounted benefits should therefore remain unchanged. Table 3-8 discounts the sum of those annual costs to 2023 using 3% and 7% discount rates and provides an equivalent annualized value (EAV), which represents a flow of constant annual values that would yield a sum equivalent to the PV. This EAV represents the value of a typical cost for each year of the analysis, consistent with the estimate of the PV, in contrast to year-specific estimates. Similar values are provided for the benefits in Section 1 of this RIA. The estimated present-value of compliance costs in 2023 is about $1.7 billion ($110 million EAV) using a 3 percent social discount rate and about $1.2 billion ($120 million EAV) using a 7 percent social discount rate from 2025-2044. Compliance costs are similarly summarized for the more stringent and less stringent alternatives in Table 6-1. Additional information and calculations to support those summary values appear in the LMWC Cost workbook in the docket for this proposal.

Table 3-7: Costs by Year for the Proposed Option (2022$)[a]

Year	Capital	Annual O&M	Total
2025	$360,000,000	$90,000,000	$450,000,000
2026	$0	$90,000,000	$90,000,000
2027	$0	$90,000,000	$90,000,000
2028	$0	$90,000,000	$90,000,000
2029	$0	$90,000,000	$90,000,000
2030	$0	$90,000,000	$90,000,000
2031	$0	$90,000,000	$90,000,000
2032	$0	$90,000,000	$90,000,000
2033	$0	$90,000,000	$90,000,000
2034	$0	$90,000,000	$90,000,000
2035	$54,000,000	$90,000,000	$140,000,000
2036	$0	$90,000,000	$90,000,000
2037	$0	$90,000,000	$90,000,000
2038	$0	$90,000,000	$90,000,000
2039	$0	$90,000,000	$90,000,000
2040	$36,000,000	$90,000,000	$130,000,000
2041	$0	$90,000,000	$90,000,000
2042	$0	$90,000,000	$90,000,000
2043	$0	$90,000,000	$90,000,000
2044	$0	$90,000,000	$90,000,000

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted.

Table 3-8: Present-Value, Equivalent Annualized Value, and Discounted Costs for Proposed Option, 2025-2044 (million 2022$)[a]

Year	Discount Rate (Discounted to 2023)	
	3%	7%
2025	$430	$400
2026	$83	$74
2027	$80	$69
2028	$78	$64
2029	$76	$60
2030	$73	$56
2031	$71	$53
2032	$69	$49
2033	$67	$46
2034	$65	$43
2035	$100	$64
2036	$62	$37
2037	$60	$35
2038	$58	$33
2039	$56	$31
2040	$76	$40
2041	$53	$27
2042	$52	$25
2043	$50	$23
2044	$49	$22
PV	**$1,700**	**$1,200**
EAV	**$110**	**$120**

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted.

4 HUMAN HEALTH BENEFITS OF EMISSIONS REDUCTIONS

4.1 Introduction

The emissions controls installed to comply with this action are expected to reduce emissions of HAPs including HCl, mercury, lead, cadmium, dioxins/furans. The EPA provides a qualitative discussion of the benefits of reducing HAP emissions later in this chapter. The emission controls are also expected to reduce emissions of $PM_{2.5}$, precursors NOx and SO_2 and summer season NOx. Summer NOx, in conjunction with volatile organic compounds (VOC) and in the presence of sunlight, form ground-level ozone (O_3). This chapter reports the estimated $PM_{2.5}$- and ozone-related benefits of reducing emissions in terms of the number and value of avoided ozone-attributable deaths and illnesses. The potential benefits from reduced ecosystem effects from the reduction in NOx and SOx deposition and O_3 concentrations are not quantified or monetized here. Time and data limitations for quantifying the effect of this action on aquatic and terrestrial ecosystems, biomass loss and foliar injury and the ensuing change in the provision of ecosystem services prevent an assessment of the benefits to ecosystems.

The PV of the low estimate of the benefits for the proposed rulemaking is $5.1 billion at a 3 percent discount rate to $3.1 billion at a 7 percent discount rate with an EAV of $340 million to $290 million, respectively. The PV of the high estimate of the benefits for the proposed rulemaking is $16 billion at a 3 percent discount rate to $9.8 billion at a 7 percent discount rate with an EAV of $1.1 billion and $920 million, respectively. All estimates are reported in 2022 dollars and are calculated over the 2025-2044 analytical timeframe described earlier in this RIA.

4.2 Human Health Effects from Exposure to Hazardous Air Pollutants (HAP)

In the subsequent sections, we describe the health effects associated with the main HAP of concern from the LMWC source category: HCl, mercury, lead, cadmium, dioxins/furans. As stated in our cost analysis, this proposal is projected to reduce HCl from LMWC by approximately 344 tons per year (tpy) and reduce mercury emissions by approximately 0.0285 tpy. We also estimate that the proposed rule would reduce other HAP emissions by approximately 0.225 tpy. More information on the size of these HAP emission reductions and how they are estimated can be found in the Emission Reduction Estimates for Existing Large MWCs Memorandum and its Appendix A for this proposal that is available in the docket for this action.

Quantifying and monetizing the economic value of reducing the risk of cancer and non-cancer effects is made difficult by the lack of a central estimate of estimate of cancer and non-cancer risk and estimates of the value of an avoided case of cancer (fatal and non-fatal) and morbidity effects. Due to methodology and data limitations, we did not attempt to monetize the health benefits of reductions in HAP in this analysis. Instead, we are providing a qualitative discussion of the health effects associated with HAP emitted from sources subject to control under the proposed action.

4.2.1 *Hydrogen Chloride*

Hydrogen chloride is a corrosive gas that 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 (ATSDRa). 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 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 (U.S. EPA, 1995).

4.2.2 *Lead*

Lead is found naturally in ore deposits. A major source of lead in the U.S. environment has historically been from combustion of leaded gasoline, which was phased out of use after 1973. Other sources of lead have included mining and smelting of ore; manufacture of and use of Pb-containing products (e.g., Pb-based paints, pigments, and glazes; electrical shielding; plumbing; storage batteries; solder; and welding fluxes); manufacture and application of Pb-containing pesticides; combustion of coal and oil; and waste incineration. Lead is associated with toxic effects in every organ system including adverse renal, cardiovascular, hematological, reproductive, and developmental effects. However, the major target for Pb toxicity is the nervous system, both in adults and children. Long-term exposure of adults to Pb at work has resulted in decreased performance in some tests that measure functions of the nervous system.

Lead exposure may also cause weakness in fingers, wrists, or ankles. Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people and may also cause anemia. Children are more sensitive to the health effects of Pb than adults. No safe blood Pb level in children has been determined. At lower levels of exposure, Pb can affect a child's mental and physical growth. Fetuses exposed to Pb in the womb may be born prematurely and have lower weights at birth. Exposure in the womb, in infancy, or in early childhood also may slow mental development and cause lower intelligence later in childhood. There is evidence that these effects may persist beyond childhood (ATSDR, 2020). EPA has determined that Pb is a probable human carcinogen (Group 2B) (U.S. EPA, 2004).

4.2.3 *Dioxins and Furans*

Dioxins and furans are a group of chemicals formed as unintentional byproducts of incomplete combustion. They are released to the environment during the combustion of fossil fuels and wood, and during the incineration of municipal and industrial wastes (ATSDR, 1998). Dioxins and furans are generally compared to 2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) as a reference (or index) chemical because it is relatively well-studied and the most toxic compound within the group.2 Out of all HAPs for which a health benchmark has been assigned, 2,3,7,8-TCDD is the most potent for both cancer and non-cancer hazard. 2,3,7,8-TCDD causes chloracne in humans, a severe acne-like condition. It is known to be a developmental toxicant in animals, causing skeletal deformities, kidney defects, and weakened immune responses in the offspring of animals exposed to 2,3,7,8-TCDD during pregnancy. Human studies have shown an association between 2,3,7,8-TCDD and soft-tissue sarcomas, lymphomas, and stomach carcinomas.[1] EPA has classified 2,3,7,8- TCDD as a probable human carcinogen (Group B2) (U.S.EPA, 1985).

4.2.4 *Cadmium*

The main sources of cadmium in air are the burning of fossil fuels and the incineration of municipal waste. Acute inhalation in humans causes adverse effects in the lung, such as pulmonary irritation. Chronic inhalation in humans can result in a build-up of Cd in the kidney, and if sufficiently high, may result in kidney disease. Animal studies indicate that cadmium may cause adverse developmental effects, including reduced body weight, skeletal malformation, and altered behavior and learning (ATSDR, 2012). Lung cancer has been found in some studies of workers exposed to Cd in the air and studies of rats that inhaled Cd. EPA has classified cadmium as a probable human carcinogen (Group B1) (U.S. EPA, 1987).

4.2.5 *Mercury*

Mercury exists in three forms: elemental mercury (Hg, oxidation state 0); inorganic mercury compounds (oxidation state +1, univalent; or +2, divalent); and organic mercury compounds. Elemental mercury can exist as a shiny silver liquid, but readily vaporizes into air. All forms of mercury are toxic, and each form exhibits different health effects. Acute (short-term) exposure to high levels of elemental mercury vapors results in central nervous system (CNS) effects such as tremors, mood changes, and slowed sensory and motor nerve function. Chronic (long-term) exposure to elemental mercury in humans also affects the CNS, with effects such as erethism (increased excitability), irritability, excessive shyness, and tremors. The kidney is also affected by mercury. There is consistent evidence that chronic ingestion or inhalation of inorganic mercury (across a range of concentrations/doses) leads to kidney damage via induction of an immune response. Methylmercury (CH_3Hg^+) is the most common organic mercury compound in the environment. Methylmercury is formed by microbial action in the top layers of sediment and soils, after oxidized or particle-bound mercury forms have precipitated from the air and deposited into waterbodies or land. Once formed, methylmercury is taken up by aquatic organisms and bioaccumulates up the aquatic food web. Larger predatory fish may have methylmercury concentrations many times, typically on the order of one million times, that of the concentrations in the freshwater body in which they live. Acute exposure of humans to very high levels of methyl mercury results in profound CNS effects such as blindness and spastic quadriparesis. Chronic exposure to methyl mercury, most commonly by consumption of fish, also affects the CNS with symptoms such as paresthesia (a sensation of pricking on the skin), blurred vision, malaise, speech difficulties, and constriction of the visual field. Ingestion of methyl mercury can lead to significant developmental effects. Infants born to women who ingested high levels of methyl mercury exhibited mental retardation, ataxia, constriction of the visual field, blindness, and cerebral palsy (ATSDR, 1999). EPA has concluded that mercuric chloride and methyl mercury are possibly carcinogenic to humans (U.S. EPA, 1995, U.S. EPA, 2001).

4.3 Approach to Estimating $PM_{2.5}$-related Human Health Benefits

This section summarizes the EPA's approach to estimating the incidence and economic value of the $PM_{2.5}$-related benefits estimated for this rule. The Regulatory Impact Analysis for the Proposed National Emission Standards for Hazardous Air Pollutants: Coal- and Oil-Fired Electric Utility Steam Generating Units Review of the Residual Risk and Technology Review (U.S. EPA, 2023a) and its corresponding Technical Support Document Estimating PM2.5 -and Ozone – Attributable Health Benefits (TSD) (U.S. EPA, 2023b) 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 RIA for the PM NAAQS (U.S. EPA, 2022). The $PM_{2.5}$ NAAQS RIA hypothesizes, but does 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.

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

4.3.1 *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) (U.S. EPA, 2019a) as summarized in the Technical Support Document (TSD) for the 2022 PM NAAQS Reconsideration Proposal RIA: *Estimating $PM_{2.5}$- and Ozone-Attributable Health Benefits* (U.S. EPA, 2023d). 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 4-2 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. 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 the TSD, which details the approach EPA followed for selecting and quantifying PM-attributable effects (U.S. EPA, 2023d).

In December of 2022, EPA published the Regulatory Impact Analysis (RIA) for the proposed Particulate Matter National Ambient Air Quality Standards (U.S.EPA, 2022). EPA quantified the PM-related benefits of this rule after publication of the proposed PM NAAQS RIA. The PM-related benefits reported in this RIA reflect methods consistent with the TSD (U.S. EPA, 2023d). We estimate PM-related benefits using methods consistent with the proposed PM NAAQS RIA. Specifically, we quantify PM-attributable deaths using concentration-response parameters from the Pope et al. (2019) and Wu et al. (2020) long-term exposure studies of the Medicare and National Health Interview Survey cohorts, respectively.

Table 4-1: Human Health Effects of $PM_{2.5}$ and whether they were Quantified and/or Monetized in this RIA

Category	Effect	Effect Quantified	Effect Monetized	More Information
Premature mortality from exposure to $PM_{2.5}$	Adult premature mortality from long-term exposure (age 65-99 or age 30-99)	✓	✓	PM ISA
	Infant mortality (age <1)	✓	✓	PM ISA
Nonfatal morbidity from exposure to $PM_{2.5}$	Heart attacks (age > 18)	✓	✓	PM ISA
	Hospital admissions—cardiovascular (ages 65-99)	✓	✓[1]	PM ISA
	Emergency department visits— cardiovascular (age 0-99)	✓	✓	PM ISA
	Hospital admissions—respiratory (ages 0-18 and 65-99)	✓	✓	PM ISA
	Emergency room visits—respiratory (all ages)	✓	✓	PM ISA
	Cardiac arrest (ages 0-99; excludes initial hospital and/or emergency department visits)	✓	✓[1]	PM ISA
	Stroke (ages 65-99)	✓	✓[1]	PM ISA
	Asthma onset (ages 0-17)	✓	✓	PM ISA
	Asthma symptoms/exacerbation (6-17)	✓	✓	PM ISA
	Lung cancer (ages 30-99)	✓	✓	PM ISA
	Allergic rhinitis (hay fever) symptoms (ages 3-17)	✓	✓	PM ISA
	Lost work days (age 18-65)	✓	✓	PM ISA
	Minor restricted-activity days (age 18-65)	✓	✓	PM ISA
	Hospital admissions—Alzheimer's disease (ages 65-99)	✓	✓	PM ISA
	Hospital admissions—Parkinson's disease (ages 65-99)	✓	✓	PM ISA
	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]
	Other nervous system effects (*e.g.*, autism, cognitive decline, dementia)	—	—	PM ISA[2]
	Metabolic effects (*e.g.*, diabetes)	—	—	PM ISA[2]
	Reproductive and developmental effects (*e.g.*, low birth weight, pre-term births, etc.)	—	—	PM ISA[2]
	Cancer, mutagenicity, and genotoxicity effects	—	—	PM ISA[2]

[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.

4.3.2 *Quantifying Cases of PM2.5-Attributable Premature Death*

This section summarizes our approach to estimating the incidence and economic value of the $PM_{2.5}$ benefits estimated for this rule. A full discussion of EPA's approach to selecting human health endpoints, epidemiologic studies and economic unit values can be found in the Technical Support Document (TSD) supporting the final Cross-State Update rule (U.S. EPA, 2021b). The user manual for the environmental Benefits Mapping and Analysis Program-Community Edition (BenMAP-CE) program[1] separately details EPA's approach for quantifying and monetizing PM-attributable effects in the BenMAP-CE program. In these documents the reader can find the rationale for selecting health endpoints to quantify; the demographic, health and economic data we apply within BenMAP-CE; modeling assumptions; and our techniques for quantifying uncertainty.

The PM ISA, which was reviewed by the Clean Air Scientific Advisory Committee of the EPA's Science Advisory Board (U.S. EPA-SAB-CASAC, 2019), 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 identified epidemiologic 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 from recent studies reduce uncertainties related to potential co-pollutant confounding and continues to provide strong support for a linear, no-threshold concentration-response relationship" (U.S. EPA, 2019a). Consistent with this evidence, the EPA historically has estimated health impacts above and below the prevailing NAAQS.[2]

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 (U.S. EPA, 2021b). As noted in the preamble to the 2020 PM NAAQS final rule, the "health effects can occur over the entire distributions of ambient $PM_{2.5}$ concentrations evaluated, and epidemiological studies do not identify a population-level threshold below which it can be concluded with confidence that PM-associated health effects do not occur."[3] 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 (U.S. EPA, 2021b). 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 Ozone-related Human Health Benefit

This section summarizes the EPA's approach to estimating the incidence and economic value of the ozone-related benefits estimated for this action. The Regulatory Impact Analysis (RIA) Final Revised Cross-State Air Pollution Rule (U.S. EPA, 2021) and its corresponding Technical Support Document Estimating PM2.5 -and Ozone – Attributable Health Benefits

(TSD) (U.S. EPA, 2021) 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 action will affect the distribution of ozone concentrations throughout the U.S.; this includes locations both meeting and exceeding the NAAQS for O_3. This RIA estimates avoided O_3-related health impacts that are distinct from those reported in the RIAs for the O_3 NAAQS (U.S. EPA, 2015). The O_3 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.

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

4.4.2 *Selecting Air Pollution Health Endpoints to Quantify*

As a first step in quantifying O_3-related human health impacts, the EPA consults the Integrated Science Assessment for Ozone (Ozone ISA) (U.S. EPA, 2020) as summarized in the TSD for the Final Revised Cross State Air Pollution Rule Update (U.S. EPA, 2021). 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.

In brief, the ISA for ozone found short-term (less than one month) exposures to ozone to be causally related to respiratory effects, a “likely to be causal” relationship with metabolic effects and a “suggestive of, but not sufficient to infer, a causal relationship” for central nervous system effects, cardiovascular effects, and total mortality. The ISA reported that long-term exposures (one month or longer) to ozone are “likely to be causal” for respiratory effects including respiratory mortality, and a “suggestive of, but not sufficient to infer, a causal relationship” for cardiovascular effects, reproductive effects, central nervous system effects, metabolic effects, and total mortality.

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 any welfare effects such as biomass loss and foliar injury. These effects are described in Chapter 7 of the Ozone NAAQS RIA (EPA, 2015).

Table 4-2: Human Health Effects of Ambient Ozone and whether they were Quantified and/or Monetized in this RIA

Category	Effect	Effect Quantified	Effect Monetized	More Information
Premature mortality from exposure to $PM_{2.5}$	Adult premature mortality from long-term exposure (age 65-99 or age 30-99)	✓	✓	PM ISA
	Infant mortality (age <1)	✓	✓	PM ISA
Nonfatal morbidity from exposure to $PM_{2.5}$	Heart attacks (age > 18)	✓	✓[1]	PM ISA
	Hospital admissions—cardiovascular (ages 65-99)	✓	✓	PM ISA
	Emergency department visits— cardiovascular (age 0-99)	✓	✓	PM ISA
	Hospital admissions—respiratory (ages 0-18 and 65-99)	✓	✓	PM ISA
	Emergency room visits—respiratory (all ages)	✓	✓	PM ISA
	Cardiac arrest (ages 0-99; excludes initial hospital and/or emergency department visits)	✓	✓[1]	PM ISA
	Stroke (ages 65-99)	✓	✓[1]	PM ISA
	Asthma onset (ages 0-17)	✓	✓	PM ISA
	Asthma symptoms/exacerbation (6-17)	✓	✓	PM ISA
	Lung cancer (ages 30-99)	✓	✓	PM ISA
	Allergic rhinitis (hay fever) symptoms (ages 3-17)	✓	✓	PM ISA
	Lost work days (age 18-65)	✓	✓	PM ISA
	Minor restricted-activity days (age 18-65)	✓	✓	PM ISA
	Hospital admissions—Alzheimer's disease (ages 65-99)	✓	✓	PM ISA
	Hospital admissions—Parkinson's disease (ages 65-99)	✓	✓	PM ISA
	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]
	Other nervous system effects (*e.g.*, autism, cognitive decline, dementia)	—	—	PM ISA[2]
	Metabolic effects (*e.g.*, diabetes)	—	—	PM ISA[2]
	Reproductive and developmental effects (*e.g.*, low birth weight, pre-term births, etc.)	—	—	PM ISA[2]
	Cancer, mutagenicity, and genotoxicity effects	—	—	PM ISA[2]

[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.

4.4.3 *Quantifying Cases of Ozone-Attributable Premature Mortality*

Mortality risk reductions account for the majority of monetized ozone-related benefits. For this reason, this subsection and the following provide a brief background of the scientific assessments that underly the quantification of these mortality risks and identifies the risk studies used to quantify them in this RIA for ozone. As noted above, the Estimating PM2.5- and Ozone-Attributable Health Benefits TSD describes fully the Agency's approach for quantifying the number and value of ozone air pollution-related impacts, including additional discussion of how the Agency selected the risk studies used to quantify them in this RIA. The TSD also includes additional discussion of the assessments that support quantification of these mortality risk than provide here.

In 2008, the National Academies of Science (NRC 2008) issued a series of recommendations to EPA regarding the procedure for quantifying and valuing ozone-related mortality due to short-term exposures. Chief among these was that "…short-term exposure to ambient ozone is likely to contribute to premature deaths" and the committee recommended that "ozone-related mortality be included in future estimates of the health benefits of reducing ozone exposures…" The NAS also recommended that "…the greatest emphasis be placed on the multicity and [National Mortality and Morbidity Air Pollution Studies (NMMAPS)] …studies without exclusion of the meta-analyses" (NRC 2008). Prior to the 2015 Ozone NAAQS RIA, the Agency estimated ozone-attributable premature deaths using an NMMAPS-based analysis of total mortality (Bell et al. 2004), two multi-city studies of cardiopulmonary and total mortality (Huang et al. 2004; Schwartz 2005) and effect estimates from three meta-analyses of non-accidental mortality (Bell et al. 2005; Ito et al. 2005; Levy et al. 2005). Beginning with the 2015 Ozone NAAQS RIA, the Agency began quantifying ozone-attributable premature deaths using two newer multi-city studies of non-accidental mortality (Smith et al. 2009; Zanobetti and Schwartz 2008) and one long-term cohort study of respiratory mortality (Jerrett et al. 2009). The 2020 Ozone ISA included changes to the causality relationship determinations between short-term exposures and total mortality, as well as including more recent epidemiologic analyses of long-term exposure effects on respiratory mortality (U.S. EPA, 2020). In this RIA, as described in the corresponding TSD, two estimates of ozone-attributable respiratory deaths from short-term exposures are estimated using the risk estimate parameters from Zanobetti et al. (2008) and Katsouyanni et al. (2009). Ozone-attributable respiratory deaths from long-term exposures are estimated using Turner et al. (2016). Due to time and resource limitations, we were unable to reflect the warm season defined by Zanobetti et al. (2008) as June-August. Instead, we apply this risk estimate to our standard warm season of May-September.

4.5 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 value of avoided pain and suffering from the health effect. The unit values applied in this analysis are provided in the TSD for the 2022 PM NAAQS Reconsideration Proposal RIA: Estimating PM2.5- and Ozone-Attributable Health Benefits (U.S. EPA, 2023d).

Avoided premature deaths account for 95 percent of monetized ozone-related benefits and 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 Scientific Advisory Board's (SAB) 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). 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 while the EPA continues its efforts to update its guidance on this issue (U.S. EPA, 2016). 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 $12.8 million ($2022).

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

Because short-term ozone-related premature mortality occurs within the analysis year, the estimated ozone-related benefits are identical for all discount rates. When valuing changes in ozone-attributable deaths using the Turner et al. (2016) study, we follow advice provided by the Health Effects Subcommittee of the SAB, which found that "…there is no evidence in the literature to support a different cessation lag between ozone and particulate matter. The HES therefore recommends using the same cessation lag structure and assumptions as for particulate matter when utilizing cohort mortality evidence for ozone" (U.S. EPA-SAB 2010).

These estimated health benefits do not account for the influence of future changes in the climate on ambient concentrations of pollutants (USGCRP 2016). For example, recent research suggests that future changes to climate may create conditions more conducive to forming ozone. The estimated health benefits also do not consider the potential for climate-induced changes in temperature to modify the relationship between ozone and the risk of premature mortality (Jhun et al. 2014; Ren et al. 2008a, 2008b).

4.5.1 *Benefit-per-Ton Estimates*

The EPA did not conduct air quality modeling for this proposed rule. Rather, we quantified the value of reducing PM and ozone concentrations using a “benefit-per-ton” approach, due to the relatively small number of facilities and the fact that these facilities are located in a discrete location. Specifically, EPA believes that the emissions reductions due to this rule are small and because we cannot be confident of the location of new facilities under the NSPS, EPA elected to use the benefit-per-ton approach. 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 benefits of this rulemaking. These BPT estimates provide the total monetized human health benefits (the sum of premature mortality and premature morbidity) of reducing one ton of the $PM_{2.5}$, NOx and SO_2 precursor for $PM_{2.5}$ and the NOx precursor for ozone from a specified source. Specifically, in this analysis, we multiplied the estimates from the “Pulp and Paper” sector by the corresponding emission reductions. We chose the Pulp and Paper sector as a surrogate for the LMWC sector due to the similarity of the spatial distribution of the emissions from these sectors. The method used to derive these estimates is described in the BPT Technical Support Document (BPT TSD) on Estimating the Benefit per Ton of Reducing Directly-Emitted $PM_{2.5}$, $PM_{2.5}$ Precursors and Ozone Precursors from 21 Sectors (U.S. EPA, 2023). As noted above, we were unable to quantify the value of changes in exposure to HAP and dioxin/furans.

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 the action, and they may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors for any specific location. Given sector specific air quality modeling and the small changes in emissions considered in this action, 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.

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 benefits (compared to full-scale modeling) under different scenarios and air quality concentrations. The EPA Science Advisory Board (SAB) convened a panel to review this report.[5] In particular, the SAB assessed 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 (RIAs).

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 (IEc, 2019. Evaluating Reduced-Form Tools for Estimating Air Quality Benefits. Final Report). 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, a sector used as an example for evaluating the application of the new methodology in the final report. The ratios for individual PM 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-form air quality modeling combined with BenMAP. This provides some initial understanding of the uncertainty which is associated with using the BPT approach instead of full-form air quality modeling.

4.6 Unquantified Welfare Benefits

The Clean Air Act definition of welfare effects includes, but is not limited to, effects on soils, water, wildlife, vegetation, visibility, weather, and climate, as well as effects on man-made materials, economic values, and personal comfort and well-being.

4.6.1 *PM, NOx and SOx Ecosystem Effects*

Detailed information regarding the ecological effects of nitrogen and sulfur deposition is available in the Integrated Science Assessment for Oxides of Nitrogen, Oxides of Sulfur, and

Particulate Matter— Ecological Criteria (ISA) (U.S. EPA, 2020b).

Particulate matter (PM) is composed of some or all of the following components: nitrate (NO_3^-), sulfate (SO_4^{2-}), ammonium (NH_4^+), metals, minerals (dust), and organic and elemental carbon. Nitrate, sulfate, and ammonium contribute to nitrogen (N) and sulfur (S) deposition, which causes substantial ecological effects. The ecological effects of deposition are grouped into three main categories: acidification, N enrichment/N driven eutrophication, and S enrichment. Ecological effects are further subdivided into terrestrial, wetland, freshwater, and estuarine/near-coastal ecosystems. These ecosystems and effects are linked by the connectivity of terrestrial and aquatic habitats through biogeochemical pathways of N and S.

4.6.2 *Ozone Vegetation Effects*

Exposure to ozone has been found to be associated with a wide array of vegetation and ecosystem effects in the published literature (U.S. EPA, 2020). Sensitivity to ozone is highly variable across species, with over 66 vegetation species identified as "ozone-sensitive," many of which occur in state and national parks and forests. These effects include those that cause damage to, or impairment of, the intended use of the plant or ecosystem. Such effects are considered adverse to public welfare and can include reduced growth and/or biomass production in sensitive trees, reduced yield and quality of crops, visible foliar injury, changed to species composition, and changes in ecosystems and associated ecosystem services.

4.6.3 *Climate Effects of $PM_{2.5}$*

In the climate section of Chapter 5 of the 2020 PM2.5 Primary NAAQS Policy

Assessment it states “Thus, as in the last review, the data remain insufficient to conduct quantitative analyses for PM effects on climate in the current review.” (U.S. EPA, 2020d) Pollutants that affect the energy balance of the earth are referred to as climate forcers. A pollutant that increases the amount of energy in the Earth’s climate system is said to exert “positive radiative forcing,” which leads to warming and climate change. In contrast, a pollutant that exerts negative radiative forcing reduces the amount of energy in the Earth’s system and leads to cooling.

Atmospheric particles influence climate in multiple ways: directly absorbing light, scattering light, changing the reflectivity (“albedo”) of snow and ice through deposition, and interacting with clouds. Depending on the particle’s composition, the timing of emissions, and where it is in the atmosphere determine if it contributes to cooling or warming. The short atmospheric lifetime of particles, lasting from days to weeks, and the mechanisms by which particles affect climate, distinguish it from long-lived greenhouse gases like CO_2. This means that actions taken to reduce $PM_{2.5}$ will have near term effects on climate change. The Intergovernmental Panel on Climate Change Sixth Assessment Report concludes that for forcers with short lifetimes, “the response in surface temperature occurs 5-26 strongly, as soon as a sustained change in emissions is implemented”. The potential to affect near-term climate change and the rate of climate change with policies to address these emissions is gaining attention nationally and internationally (e.g., Black Carbon Report to Congress, Arctic Council, Climate and Clean Air Coalition, and Convention on Long-Range Transboundary Air Pollution of the United Nations Economic Commission for Europe). Recent reports have concluded that short-lived compounds play a prominent role in keeping global warming below 1.5° C (IPCC, 2018), and are especially important in the rapidly warming Arctic (AMAP, 2021).

4.6.4 *Ozone Climate Effects*

Ozone is a well-known short-lived climate forcing GHG (IPCC, 2014). Stratospheric ozone (the upper ozone layer) is beneficial because it protects life on Earth from the sun's harmful ultraviolet (UV) radiation. In contrast, tropospheric ozone (ozone in the lower atmosphere) is a harmful air pollutant that adversely affects human health and the environment and contributes significantly to regional and global climate change. The IPCC AR5 estimated that the contribution to current warming levels of increased tropospheric ozone concentrations resulting from human methane, NO_X, and VOC emissions was 0.5 W/m^2, or about 30 percent as large a warming influence as elevated CO_2 concentrations. This quantifiable influence of ground level ozone on climate leads to increases in global surface temperature and changes in hydrological cycles.

4.6.5 *Total Health Benefits - $PM_{2.5}$ - and Ozone- Related Benefits Results*

Tables 4-3, 4-4, 4-5 and 4-6 list the estimated $PM_{2.5}$- and ozone- related benefits per ton applied in this national level analysis. These estimates are used to generate the total health benefits of the proposal, which represent the total monetized benefits of this proposal since there are no benefits from climate pollutant changes or other benefits or disbenefits as mentioned earlier in this section. The total health benefits are presented for the less and more stringent alternatives as well. These total health benefits are presented in Table 4-7. Benefits are estimated using two alternative concentration-response parameters from three epidemiologic studies when quantifying both $PM_{2.5}$ and ozone-related mortality (Di et al. 2017, Turner et al. 2016 and Katsouyanni et al. 2009) These results are discounted at 3 and 7 percent for a 2022 currency year. For all estimates, we summarize the monetized health benefits using discount rates of 3 percent and 7 percent for the 20-year analysis period of this proposed rule discounted back to 2023 rounded to 2 significant figures as presented in Table 4-7. The PV of the low estimate of the benefits for the proposed rulemaking is $5.1 billion at a 3 percent discount rate and $3.1 billion at a 7 percent discount rate with an EAV of $340 million and $290 million, respectively. The PV of the high estimate of the benefits for the proposed rulemaking is $16 billion at a 3 percent discount rate and $9.8 billion at a 7 percent discount rate with an EAV of $1.1 billion and $920 million, respectively. All estimates are reported in 2022 dollars. Undiscounted (that is, values not discounted to 2023) benefits are presented by year for the proposed, less stringent and more stringent alternative options in Tables 4-8, 4-9, and 4-10. For the full set of underlying calculations see the "LMWC Benefits workbook," an Excel spreadsheet that is available in the docket for the proposal.

Table 4-3: Pulp and Paper: Benefit per Ton Estimates of $PM_{2.5}$-Attributable Premature Mortality and Illness for the Proposal, 2025-2044 (2022$)

	Discount Rate					
Year	3 Percent			7 Percent		
2025	$158,702	and	$343,292	$142,945	and	$308,400
2030	$174,460	and	$363,552	$157,577	and	$327,535
2035	$199,222	and	$402,646	$178,962	and	$362,427
2040	$220,607	and	$438,964	$198,097	and	$395,067

Table 4-4: Pulp and Paper: Benefit per Ton Estimates of NOx Precursor to $PM_{2.5}$-Attributable Premature Mortality and Illness for the Proposal, 2025-2044 (2022$)

	Discount Rate					
Year	3 Percent			7 Percent		
2025	$12,268	and	$26,338	$11,008	and	$23,749
2030	$13,507	and	$27,914	$12,043	and	$25,100
2035	$15,195	and	$30,953	$13,732	and	$27,801
2040	$16,883	and	$33,541	$15,195	and	$30,277

Table 4-5: Pulp and Paper: Benefit per Ton Estimates of SO_2 Precursor to $PM_{2.5}$-Attributable Premature Mortality and Illness for the Proposal, 2025-2044 (2022$)

	Discount Rate					
Year	3 Percent			7 Percent		
2025	$42,996	and	$92,970	$38,719	and	$83,628
2030	$47,498	and	$98,823	$42,658	and	$88,918
2035	$54,139	and	$109,854	$48,624	and	$98,823
2040	$60,329	and	$120,434	$54,251	and	$108,165

Table 4-6: Pulp and Paper: Benefit per Ton Estimates of NOx Precursor to Ozone-Attributable Premature Mortality and Illness for the Proposal, 2025-2044 (2022$)

	Discount Rate					
Year	3 Percent			7 Percent		
2025	$10,749	and	$90,494	$9,646	and	$81,309
2030	$11,481	and	$100,399	$10,389	and	$90,044
2035	$12,268	and	$111,317	$11,087	and	$99,724
2040	$12,944	and	$120,434	$11,706	and	$108,503

Table 4-7: Large Municipal Waste Combustors: Monetized Benefits Estimates of $PM_{2.5}$ - and Ozone-Attributable Premature Mortality and Illness for Proposal Options (million 2022$)[a,b]

	Less Stringent Regulatory Option		Proposed Regulatory Option		More Stringent Regulatory Option	
	Discount Rate		Discount Rate		Discount Rate	
	3 Percent	7 Percent	3 Percent	7 Percent	3 Percent	7 Percent
PV	$2,500 and $6,300	$1,500 and $3,800	$5,100 and $16,000	$3,100 and $9,800	$6,700 and $20,000	$4,100 and $12,000
EAV	$170 and $420	$140 and $360	$340 and $1,100	$290 and $920	$450 and $1,300	$380 and $1,100

Non-Monetized Benefits

Emissions reductions of 340 tpy of HAPs including hydrogen chloride, cadmium, mercury and dioxin/furan.[c]

Benefits to provision of ecosystem services associated with reductions in N and S deposition and ozone concentrations.

[a]Discounted to 2023. Calculations of PV and EAV reflect benefits estimates for the 2025-2044 analysis timeframe described in Chapter 1 of this RIA.
[b]Rounded to 2 significant figures.
[c]Reductions in hydrogen chloride (HCl) emissions dominate the HAP reductions (340 tpy) occurring from this proposal. Emission reductions for individual HAP species are found in Section 4.2 of this RIA and the Emission Reduction Estimates for Existing Large MWCs Memo for this proposal.

Table 4-8: Undiscounted Monetized Benefits Estimates of $PM_{2.5}$-Attributable Premature Mortality and Illness for the Proposed Option (million 2022$), 2025-2044[a,b]

Year	3%	7%
2025	$300 and $970	$270 and $870
2026	$300 and $970	$270 and $870
2027	$300 and $970	$270 and $870
2028	$330 and $1,000	$290 and $940
2029	$330 and $1,000	$290 and $940
2030	$330 and $1,000	$290 and $940
2031	$330 and $1,000	$290 and $940
2032	$330 and $1,000	$290 and $940
2033	$370 and $1,200	$330 and $1,000
2034	$370 and $1,200	$330 and $1,000
2035	$370 and $1,200	$330 and $1,000
2036	$370 and $1,200	$330 and $1,000
2037	$370 and $1,200	$330 and $1,000
2038	$410 and $1,300	$370 and $1,100
2039	$410 and $1,300	$370 and $1,100
2040	$410 and $1,300	$370 and $1,100
2041	$410 and $1,300	$370 and $1,100
2042	$410 and $1,300	$370 and $1,100
2043	$410 and $1,300	$370 and $1,100
2044	$410 and $1,300	$370 and $1,100

[a] Rounded to 2 significant figures

[b] The monetized health benefits are quantified using two alternative concentration-response relationships from the Di et al. (2016) and Turner et al. (2017) studies and presented at real discount rates of 3 and 7 percent.

Table 4-9: Undiscounted Monetized Benefits Estimates of $PM_{2.5}$-Attributable Premature Mortality and Illness for the Less Stringent Alternative (million 2022$), 2025-2044[a,b]

Year	3%	7%
2025	$150 and $380	$130 and $340
2026	$150 and $380	$130 and $340
2027	$150 and $380	$130 and $340
2028	$160 and $400	$140 and $360
2029	$160 and $400	$140 and $360
2030	$160 and $400	$140 and $360
2031	$160 and $400	$140 and $360
2032	$160 and $400	$140 and $360
2033	$180 and $450	$160 and $400
2034	$180 and $450	$160 and $400
2035	$180 and $450	$160 and $400
2036	$180 and $450	$160 and $400
2037	$180 and $450	$160 and $400
2038	$200 and $490	$180 and $440
2039	$200 and $490	$180 and $440
2040	$200 and $490	$180 and $440
2041	$200 and $490	$180 and $440
2042	$200 and $490	$180 and $440
2043	$200 and $490	$180 and $440
2044	$200 and $490	$180 and $440

[a] Rounded to 2 significant figures
[b] The monetized health benefits are quantified using two alternative concentration-response relationships from the Di et al. (2016) and Turner et al. (2017) studies and presented at real discount rates of 3 and 7 percent.

Table 4-10: Undiscounted Monetized Benefits Estimates of $PM_{2.5}$-Attributable Premature Mortality and Illness for the More Stringent Alternative (million 2022$), 2025-2044[a,b]

Year	3%	7%
2025	$390 and $1,200	$350 and $1,000
2026	$390 and $1,200	$350 and $1,000
2027	$390 and $1,200	$350 and $1,000
2028	$430 and $1,300	$390 and $1,100
2029	$430 and $1,300	$390 and $1,100
2030	$430 and $1,300	$390 and $1,100
2031	$430 and $1,300	$390 and $1,100
2032	$430 and $1,300	$390 and $1,100
2033	$490 and $1,400	$440 and $1,300
2034	$490 and $1,400	$440 and $1,300
2035	$490 and $1,400	$440 and $1,300
2036	$490 and $1,400	$440 and $1,300
2037	$490 and $1,400	$440 and $1,300
2038	$540 and $1,500	$480 and $1,400
2039	$540 and $1,500	$480 and $1,400
2040	$540 and $1,500	$480 and $1,400
2041	$540 and $1,500	$480 and $1,400
2042	$540 and $1,500	$480 and $1,400
2043	$540 and $1,500	$480 and $1,400
2044	$540 and $1,500	$480 and $1,400

[a] Rounded to 2 significant figures
[b] The monetized health benefits are quantified using two alternative concentration-response relationships from the Di et al. (2016) and Turner et al. (2017) studies and presented at real discount rates of 3 and 7 percent.

4.7 Characterization of Uncertainty in Monetized 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 benefits estimate. When the uncertainties from each stage of the analysis are compounded, even small uncertainties can have large effects on the total quantified benefits. Therefore, the estimates of annual benefits should be viewed as representative of the magnitude of benefits expected, rather than the actual benefits that would occur every year.

5 ECONOMIC IMPACT ANALYSIS AND DISTRIBUTIONAL ASSESSMENTS

5.1 Introduction

The proposed amendments are projected to result in environmental control expenditures and work practice adjustments to comply with the rule. The national-level compliance cost analysis in Section 3 does not speak directly to potential economic and distributional impacts of the proposed rule, which may be important consequences of the action. This section is directed towards complementing the compliance cost analysis and includes an analysis of potential firm- and entity-level impacts of regulatory costs and a discussion of potential employment and small entity impacts.

5.2 Economic Impact Analysis

Although facility-specific economic impacts (production changes or closures, for example) cannot be estimated by this analysis, the EPA conducted a screening analysis of compliance costs compared to the revenue of firms or government bodies owning MWC facilities. The EPA often performs a partial equilibrium analysis to estimate impacts on producers and consumers of the products or services provided by the regulated firms. This type of economic analysis estimates impacts on a single affected industry or several affected industries, and all impacts of this rule on industries outside of those affected are assumed to be zero or inconsequential (U.S. EPA, 2016).

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 may consist of a calculation of annual (or annualized) costs as a percent of sales for affected parent companies. This type of analysis is often applied when a partial equilibrium or more complex economic impact analysis approach is deemed unnecessary given the expected size of the impacts. 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. We conducted a cost-to-sales analysis to estimate the economic impacts of this proposal, given that the EAV of the compliance costs range are $120 million using a 7 percent or $110 million using a 3 percent discount rate in 2022 dollars, which is small relative to the revenues of the MWC industry.

The EPA prefers as stated in its guidance for implementing the RFA as amended by SBREFA 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.9 This is consistent with guidance published by the U.S. Small Business Administration (SBA) 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.10 This is because revenues or sales data are commonly available for entities impacted by the EPA regulations and profits data may often

9 More information on sales and profit tests as used in analyses done by U.S. EPA can be found in the Final Guidance for EPA Rulewriters: Regulatory Flexibility Act as Amended by the Small Business Regulatory Enforcement Fairness Act, November 2006, pp. 32-33. Available at https://19january2017snapshot.epa.gov/sites/production/files/2015-06/documents/guidance-regflexact.pdf.

10 U.S. SBA, Office of Advocacy. August 2017. A Guide for Government Agencies, How to Comply with the Regulatory Flexibility Act, Implementing the President's Small Business Agenda and Executive Order 13272. Available at https://www.sba.gov/sites/default/files/advocacy/How-to-Comply-with-the-RFA-WEB.pdf.

be private or tend to misrepresent true economic profits earned by firms after undertaking legally available accounting and tax considerations.

While a "sales test" can provide some insight as to the economic impact of an action such as this one, it assumes that the impacts of a rule are solely incident on a directly affected firm (therefore, no impact to consumers of an affected product), or solely incident on consumers of output directly affected by this action (therefore, no impact to companies that are producers of affected product). Thus, an analysis such as this one is best viewed as providing insight on the polar examples of economic impacts: maximum impact to either directly affected companies or their consumers. A "sales test" analysis does not consider shifts in supply and demand curves to reflect intermediate economic outcomes such as output adjustments in response to increased costs.

5.3 Employment Impacts Analysis

This section presents a qualitative overview of the various ways that environmental regulation can affect employment. Employment impacts of environmental regulations are generally composed of a mix of potential declines and gains in different areas of the economy over time. Regulatory employment impacts can vary across occupations, regions, and industries; by labor and product demand and supply elasticities; and in response to other labor market conditions. Isolating such impacts is a challenge, as they are difficult to disentangle from employment impacts caused by a wide variety of ongoing, concurrent economic changes. The EPA continues to explore the relevant theoretical and empirical literature and to seek public comments in order to ensure that the way the EPA characterizes the employment effects of its regulations is reasonable and informative.[11]

Environmental regulation “typically affects the distribution of employment among industries rather than the general employment level” (Arrow, et al., 1996). Even if impacts are small after long-run market adjustments to full employment, many regulatory actions have transitional effects in the short run (Office of Management and Budget, 2015). These movements of workers in and out of jobs in response to environmental regulation are potentially important and of interest to policymakers. Transitional job losses have consequences for workers that operate in declining industries or occupations, have limited capacity to migrate, or reside in communities or regions with high unemployment rates.

As indicated by the potential impacts to MWC facilities discussed in Section 5.2, the proposed requirements are unlikely to cause large shifts in electricity production or MWC disposal costs. As a result, demand for labor employed in MWC activities and associated industries is unlikely to see large changes but might experience adjustments as there may be increases in compliance-related labor requirements such as labor associated with the manufacture, installation, and operation of pollution control devices as well as either consume the power generated by MWC facilities or communities using MWC services. For this proposal,

11 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).

however, we do not have the data and analysis available to quantify these potential labor impacts.

5.4 Small Business Impact Analysis

To determine the possible impacts of the proposed amendments on small businesses, parent companies or entities of MWC facilities are categorized as small or large using the Small Business Administration's (SBA's) general size standards definitions for affected NAICS codes, and a definition for small municipalities of 50,000 or less in population. Based on the SBA definitions and the definition for small municipalities just mentioned, this proposed rule does not affect any small businesses or entities. Hence, there is no significant impact on a substantial number of small entities (SISNOSE) for this proposed rule.

6 COMPARISON OF BENEFITS AND COSTS

In this chapter, we present a comparison of the benefits and costs of this proposed action and the more and less stringent alternative regulatory options. As explained previously in the sections document, all costs and benefits outlined in this RIA are estimated as the change from the baseline, which reflects the requirements already promulgated. 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 proposed action. Further, the monetized benefits associated with $PM_{2.5}$, SO_2, and NO_x include health benefits associated with reduced premature mortality and morbidity associated with exposure to $PM_{2.5}$, and do not include other health and environmental impacts associated with reduced PM emissions, such as ecosystem effects (such as reduced N and S deposition). EPA expects these benefits are positive, and as a result the net benefits presented in this section are likely understated.

6.1 Results

As part of fulfilling analytical guidance with respect to E.O. 12866, EPA presents estimates of the present value (PV) of the benefits and costs over the period 2025 to 2044. To calculate the present value of the social net benefits of the proposed action, annual benefits and costs are in 2022 dollars and are discounted to 2023 at 3 percent and 7 percent discount rates as directed by OMB's Circular A-4. The EPA also presents the equivalent annualized value (EAV), which represents a flow of constant annual values that would yield a sum equivalent to the PV. The EAV represents the value of a typical cost or benefit for each year of the analysis, consistent with the estimate of the PV, in contrast to year-specific estimates.

Table 6-1 presents a summary of the monetized benefits, compliance costs, and net benefits of the proposed EG and NSPS amendments, and the more and less stringent alternative regulatory options, in terms of present value (PV) and equivalent annualized value (EAV). Table 6-1 lists benefits using two alternative concentration-response from Di et al. (2016) and Turner et al. (2017).

Table 6-1: Summary of Monetized Benefits, Compliance Costs, Net Benefits, and Non-Monetized Benefits PV/EAV, 2025-2044 (million 2022$, discounted to 2023)[a,b]

	Proposal		Less Stringent Alternative		More Stringent Alternative	
3%	PV	EAV	PV	EAV	PV	EAV
Health Benefits	$5,100 and $16,000	$340 and $1,100	$2,500 and $6,300	$170 and $420	$6,700 and $20,000	$450 and $1,300
Compliance Costs	$1,700	$110	$1,100	$74	$6,900	$460
Net Benefits	$3,400 and $14,000	$230 and $970	$1,400 and $5,200	$95 and $350	-$120 and $13,000	-$8 and $850
7%						
Health Benefits	$3,100 and $9,800	$290 and $920	$1,500 and $3,800	$140 and $360	$4,100 and $12,000	$380 and $1,100
Compliance Costs	$1,200	$120	$780	$74	$4,900	$470
Net Benefits	$1,800 and $8,500	$170 and $800	$730 and $3,000	$69 and $280	-$890 and $6,800	-$84 and $640

[a] Rounded to two significant figures. Rows may not appear to add correctly due to rounding.

[b] Monetized benefits include health benefits associated with reductions in $PM_{2.5}$ emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The monetized health benefits are quantified using two alternative concentration-response relationships from the Di et al. (2016) and Turner et al. (2017) studies and presented at real discount rates of 3 and 7 percent. Benefits from HAP reductions remain unmonetized and are thus not reflected in the table. Rows may not appear to add correctly due to rounding.

[c] For details on HAP health effects associated with the rule, see Section **Error! Reference source not found.**.
[d] Adverse effects include terrestrial and aquatic acidification, terrestrial nitrogen enrichment and aquatic eutrophication.

Given these results, the EPA expects that implementation of the proposed amendments, based solely on an economic efficiency criterion, will provide society with a substantial net gain in welfare, notwithstanding the set of health and environmental benefits and other impacts we were unable to quantify such as monetization of benefits from HAP emission reductions. Further quantification of directly-emitted $PM_{2.5}$ and HAP benefits would increase the estimated net benefits of the proposed action. In addition to providing discounted net benefits in accordance with OMB Circular A-4, we also provide net benefits that are undiscounted. These values are discounted to 2023 later in Section 6 of this RIA. The undiscounted net benefits of the proposed amendments are presented in Table 6-2, Table 6-3, and 2025-2044a,b

Year	3%	7%
2025	-$120 and $110	-$130 and $76
2026	$81 and $310	$67 and $270
2027	$81 and $310	$67 and $270
2028	$96 and $340	$79 and $300
2029	$96 and $340	$79 and $300
2030	$96 and $340	$79 and $300
2031	$96 and $340	$79 and $300
2032	$96 and $340	$79 and $300
2033	$120 and $380	$99 and $340
2034	$120 and $380	$99 and $340
2035	$58 and $330	$40 and $280
2036	$120 and $380	$99 and $340
2037	$120 and $380	$99 and $340
2038	$140 and $420	$120 and $380
2039	$140 and $420	$120 and $380
2040	$65 and $350	$45 and $300
2041	$140 and $420	$120 and $380
2042	$140 and $420	$120 and $380
2043	$140 and $420	$120 and $380
2044	$140 and $420	$120 and $380

[a] Rounded to 2 significant figures
[b] The monetized health benefits are quantified using two alternative concentration-response relationships from the Di et al. (2016) and Turner et al. (2017) studies and presented at real discount rates of 3 and 7 percent.

Table 6-4 below.

Table 6-2: Undiscounted Net Benefits Estimates for the Proposed Option (million 2022$), 2025-2044[a,b]

Year	3%	7%
2025	-$150 and $510	-$180 and $420
2026	$210 and $880	$180 and $780
2027	$210 and $880	$180 and $780
2028	$240 and $960	$200 and $850
2029	$240 and $960	$200 and $850
2030	$240 and $960	$200 and $850
2031	$240 and $960	$200 and $850
2032	$240 and $960	$200 and $850
2033	$280 and $1,100	$240 and $950
2034	$280 and $1,100	$240 and $950
2035	$220 and $1,000	$190 and $900
2036	$280 and $1,100	$240 and $950
2037	$280 and $1,100	$240 and $950
2038	$320 and $1,200	$280 and $1,000
2039	$320 and $1,200	$280 and $1,000
2040	$280 and $1,100	$240 and $1,000
2041	$320 and $1,200	$280 and $1,000
2042	$320 and $1,200	$280 and $1,000
2043	$320 and $1,200	$280 and $1,000
2044	$320 and $1,200	$280 and $1,000

[a] Rounded to 2 significant figures
[b] The monetized health benefits are quantified using two alternative concentration-response relationships from the Di et al. (2016) and Turner et al. (2017) studies and presented at real discount rates of 3 and 7 percent.

Table 6-3: Undiscounted Net Benefits Estimates for the Less Stringent Alternative Option (million 2022$), 2025-2044[a,b]

Year	3%	7%
2025	-$120 and $110	-$130 and $76
2026	$81 and $310	$67 and $270
2027	$81 and $310	$67 and $270
2028	$96 and $340	$79 and $300
2029	$96 and $340	$79 and $300
2030	$96 and $340	$79 and $300
2031	$96 and $340	$79 and $300
2032	$96 and $340	$79 and $300
2033	$120 and $380	$99 and $340
2034	$120 and $380	$99 and $340
2035	$58 and $330	$40 and $280
2036	$120 and $380	$99 and $340
2037	$120 and $380	$99 and $340
2038	$140 and $420	$120 and $380
2039	$140 and $420	$120 and $380
2040	$65 and $350	$45 and $300
2041	$140 and $420	$120 and $380
2042	$140 and $420	$120 and $380
2043	$140 and $420	$120 and $380
2044	$140 and $420	$120 and $380

[a] Rounded to 2 significant figures
[b] The monetized health benefits are quantified using two alternative concentration-response relationships from the Di et al. (2016) and Turner et al. (2017) studies and presented at real discount rates of 3 and 7 percent.

Table 6-4: Undiscounted Net Benefits Estimates for the More Stringent Alternative Option (million 2022$), 2025-2044[a,b]

Year	3%	7%
2025	-$1,500 and -$730	-$1,600 and -$930
2026	$74 and $880	$34 and $680
2027	$74 and $880	$34 and $680
2028	$110 and $980	$74 and $780
2029	$110 and $980	$74 and $780
2030	$110 and $980	$74 and $780
2031	$110 and $980	$74 and $780
2032	$110 and $980	$74 and $780
2033	$170 and $1,100	$120 and $980
2034	$170 and $1,100	$120 and $980
2035	$120 and $1,000	$71 and $930
2036	$170 and $1,100	$120 and $980
2037	$170 and $1,100	$120 and $980
2038	$220 and $1,200	$160 and $1,100
2039	$220 and $1,200	$160 and $1,100
2040	-$1,000 and -$53	-$1,100 and -$150
2041	$220 and $1,200	$160 and $1,100
2042	$220 and $1,200	$160 and $1,100
2043	$220 and $1,200	$160 and $1,100
2044	$220 and $1,200	$160 and $1,100

[a] Rounded to 2 significant figures
[b] The monetized health benefits are quantified using two alternative concentration-response relationships from the Di et al. (2016) and Turner et al. (2017) studies and presented at real discount rates of 3 and 7 percent.

6.2 Uncertainties and Limitations

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

Projection methods and assumptions: The number of facilities in operation is assumed to be constant over the course of the analysis period. Unexpected facility closure or idling affects the number of facilities subject to the proposed amendments. We also assume 100 percent compliance with these proposed rules and existing rules, starting from when the source becomes affected. If sources do not comply with these rules, at all or as written, or choose to close rather than comply, the cost impacts and emission reductions, and other impacts, may be overestimated. Historically, 1.2% of facilties have closed each year. The rule will not prevent the future emissions of facilities that would close regardless of the rule. If facilities close during the period of analysis, the assumption that the number of facilities will be constant could result in an overestimate of the future costs and a larger overestimate of the future benefits of the rule. Additionally, new control technologies may become available in the future at lower cost, and we are unable to predict exactly how industry will comply with the proposed rules in the future.

- **Years of analysis**: The years of the cost analysis are 2025, to represent the first-year facilities are fully compliant with the proposed amendments, through 2044, to present 20 years of potential regulatory impacts, as discussed in Chapter 3. Extending the analysis beyond 2044 would introduce substantial and increasing uncertainties in the projected impacts of the proposed amendments.
- **Compliance Costs**: There is uncertainty associated with the costs required to install and operate the equipment and perform the work practices necessary to meet the proposed emissions limits. There is also uncertainty associated with the exact controls

a facility may install to comply with the requirements, and the interest rate they are able to obtain if financing capital purchases. There may be an opportunity cost associated with the installation of environmental controls (for purposes of mitigating the emission of pollutants) that is not reflected in the compliance costs included in Chapter 3. If environmental investment displaces investment in productive capital, the difference between the rate of return on the marginal investment (which is discretionary in nature) displaced by the mandatory environmental investment is a measure of the opportunity cost of the environmental requirement to the regulated entity. To the extent that any opportunity costs are not included in the control costs, the compliance costs presented above for this proposed action may be underestimated.

- **Emissions Reductions**: Baseline emissions and projected emissions reductions are based on emissions from monitors, assumptions about current emissions controls, and facility stack testing. To the extent that any of these data or assumptions are unrepresentative, the emissions reductions (and therefore benefits) associated with the proposed amendments could be over or underestimated.

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 the action, and they may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors for any specific location. Recently, 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 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: Numerous categories of health and welfare benefits are not quantified and monetized in this RIA. These unquantified benefits, including benefits from reductions in emissions of pollutants such as HAP and dioxin/furan which are to be reduced by this proposed action, are described in detail in Section 4 of this RIA.

PM health impacts: In this RIA, we quantify an array of adverse health impacts attributable to emissions of PM. The Integrated Science Assessment for Particulate Matter (U.S. EPA, 2019) identifies the human health effects associated with ambient particles, which include premature death and a variety of illnesses associated with acute and chronic exposures. As described in the TSD "Estimating $PM_{2.5}$ and Ozone-Attributable Health Benefits" (U.S. EPA, 2023b), EPA did not quantify endpoints classified in the ISA as being "less than causally" related to $PM_{2.5}$.

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United States Environmental Protection Agency	Office of Air Quality Planning and Standards Health and Environmental Impacts Division Research Triangle Park, NC	Publication No. EPA-452/R-24-007 January 2024