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

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0   EXECUTIVE SUMMARY

0.1   Introduction

The U.S. Environmental Protection Agency (EPA) is finalizing 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 Municipal Waste Combustors (LMWC) 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 and industries that this final action is likely to affect. The final standards, once promulgated, will be directly applicable to the affected sources. 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 and E.O. 13563, the guidelines of OMB Circular A-4 and EPA's *Guidelines for Preparing Economic Analyses*, this regulatory impact analysis (RIA) analyzes the benefits and estimated costs associated with the projected emissions reductions under the final requirements. The costs of the final rules are presented for the 2030 to 2049 time period.

0.1.1   *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, if appropriate, revise the standards and the requirements for solid waste incineration units, including large MWC units.

In setting forth the methodology that the EPA must use to establish the first-stage technology-based 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. These are Cadmium (Cd), Carbon Monoxide (CO), Dioxins/Furans (D/F), Hydrogen Chloride (HCl), Lead (Pb), Mercury (Hg), Nitrogen Oxides (NO_X), Particulate Matter (PM), and Sulfur Dioxide (SO_2). In addition, the standards "shall be based on methods and technologies for removal or destruction of pollutants" CAA section 129(a)(3). The EPA has substantial discretion to distinguish among classes, types, and sizes of incinerator units within a category while setting standards.

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, 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, modified, 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." These MACT floor provisions are designed to ensure that the higher-emitting sources in an industry make improvements to bring emissions in line with levels already achieved in practice by the lower-emitting sources. The resulting performance

standards give all sources the flexibility to decide the most cost-effective way to comply, and they 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" (BTF), 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 with an appropriate accounting for emissions variability. Where there is more than one method or technology to control emissions, the analysis may result in several potential 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. 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.

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, if appropriate, revise the standards. This revision may include a standard that is more restrictive with emission limits set below the level resulting from MACT floor calculations based on technological feasibility, availability of controls, and cost. This type of standard would be characterized as a BTF standard. In conducting periodic reviews under CAA section 129(a)(5), the EPA assesses 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."

0.1.2 *Regulatory Background*

In December 1995, EPA adopted EG (40 CFR part 60, subpart Cb) and an NSPS (40 CFR part 60, subpart Eb)[1] 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 EG and NSPS require compliance with emission limitations that reflect the performance of MACT. The 1995 NSPS apply to new large MWC units for which construction commenced after September 20, 1994. The 1995 EG apply to existing large MWC units for which construction commenced on or before September 20, 1994. The 1995 MACT floors were derived in part from state-issued air permits. The 1995 EG required that necessary emission control retrofits and other actions necessary to meet EG limits be completed by [2] December 2000. Retrofits of controls at existing large MWC units were completed on time 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 NO_X is regulated under the 1995 EG and NSPS, the emissions reductions for NO_X were relatively modest compared to the other CAA section 129 pollutants. In this final rule, we are noting some significant potential improvements in performance of existing control technologies as well as new applications of different technology that could impact the NO_X standards for existing and new large MWC units.

As the CAA requires review of section 129 standards every five years, with revision as necessary, the EPA promulgated a new final rule in 2006. This rulemaking amended standards for existing MWC units to reflect the actual performance levels being achieved by existing MWC units and amended performance standards for new MWC units to align the performance of potential future units with the best performing units already in operation. Following promulgation of the 2006 rulemaking that set the current EG and NSPS, environmental groups filed a petition for review in the D.C. Circuit challenging the rulemaking.[3] In relevant part, the

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[1] 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.

[2] 70 Fed. Reg. 75,348, 75,350

[3] EPA–HQ–OAR–2005–0117 (2006). U.S. EPA. *Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Large Municipal Waste Combustors* Final Rule. Available at https://www.govinfo.gov/content/pkg/FR-2006-05-10/pdf/06-4197.pdf. Accessed September 17, 2025.

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. The D.C. Circuit issued an order granting the EPA's request for a remand in 2008, which directed the EPA to review its 2006 rulemaking. Order, *Sierra Club v. EPA*, No. 06-1250 (D.C. Cir. filed Feb. 15, 2008).

This regulatory action is to fulfill the EPA's obligation on the D.C. Circuit's remand, and to complete the 5-year review pursuant to CAA section 129(a)(5). The consent decree extension that is a basis for this regulatory action calls for promulgation by May 29, 2026.

0.1.3 *Final Requirements*

These final amendments reflect the results from a reevaluation of the MACT floor levels, a 5-year review, and removal of startup, shutdown and malfunction exclusions and exceptions. These final 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 NSPS and EG. These final amendments would revise all of the nine emission limits in the EG, except for carbon monoxide (CO) limits for two subcategories of combustors, and all nine emission limits in the NSPS.

0.2 Market Failure

This RIA evaluates several economic considerations in this rulemaking which updates the LMWC emissions standards for the protection of human health and the environment. E.O. 12866 directs that, "Each agency shall identify the problem that it intends to address (including, where applicable, the failures of private markets or public institutions that warrant new agency action) as well as assess the significance of that problem." Economic efficiency can be achieved from private competition in free markets, but E.O. 12866 recognizes that some markets may not achieve economic efficiency when there exists some form of market failure. OMB's Circular A-4

(2003) notes that "the major types of market failure include: externality, market power, and inadequate or asymmetric information." An externality occurs "when one party's actions impose uncompensated benefits or costs on another party. Environmental problems are a classic case of externality."

As detailed later in this RIA, LMWC facilities provide important waste management services to communities. The human health impacts of emissions from the facilities are an example of an externality where private firms (e.g., the operators of waste combustion facilities) do not fully account for the human health impacts of their operations.[4] At the same time, consumers who are billed a per-wastebin price, or a fixed charge per month, do not fully account for the human health impacts of their waste disposal activities as the marginal price of disposing of another unit of waste is generally zero (up until the bin itself is full). In the presence of such an externality, federal intervention may be warranted. Circular A-4 states, "If the regulation is designed to correct a significant market failure, you should describe the failure both qualitatively and (where feasible) quantitatively. You should show that a government intervention is likely to do more good than harm."[5]

For this final rule, EPA has followed the directions of E.O. 12866 and Circular A-4 as well as the EPA's Guidelines for Preparing Economic Analyses[6] in publishing an impact analysis characterizing the potential costs and benefits of the final rule, soliciting public comment on the proposed rulemaking, and now providing an updated analysis in this RIA estimating the costs of the final rule relative to the baseline. Specifically, EPA's analysis considers the human health benefits from changes in emissions from the regulated facilities and the increased compliance

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[4] Private firms may account for some of the human health or other impacts of their emissions, but they are not necessarily incentivized to fully internalize these external costs. For example, some private firms may be required to address pollution under state or local regulations or as the result of litigation. Firms may also voluntarily control emissions in response to workplace safety concerns, community concerns, or other societal pressures. However, these considerations are not necessarily sufficient to achieve economic efficiency.

[5] In addition to the directive that Federal rulemakings establish a justification for intervention, E.O. 12866 and Circular A-4 also direct agencies to consider benefits and costs in the rulemaking process. Specifically, E.O. 12866 states, "In deciding whether and how to regulate, agencies should assess all costs and benefits of available regulatory alternatives, including the alternative of not regulating. Costs and benefits shall be understood to include both quantifiable measures (to the fullest extent that these can be usefully estimated) and qualitative measures of costs and benefits that are difficult to quantify, but nevertheless essential to consider. Further, in choosing among alternative regulatory approaches, agencies should select those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity), unless a statute requires another regulatory approach."

[6] U.S. EPA. 2024. Guidelines for Preparing Economic Analyses (3rd edition). Report number EPA-240-R-24-001. Washington, DC.

costs associated with new regulatory requirements. This RIA also describes the broader potential economic impacts of this rulemaking, employment effects, and various unquantified impacts.

0.3   Results for Final Action

0.3.1   *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. This baseline includes the use of control technologies necessary to meet the current EG and NSPS for large MWCs as well as capabilities of existing facilities that allow for current emissions levels to be below the limits currently in place. It also assumes that existing facilities would continue to operate as they currently operate, processing the same volume of municipal waste, having the same energy demands, generate the same amount of electricity, and producing the same levels of each regulated pollutant as is observed in the years preceding this new regulatory action. Finally, it includes the impact of the stay of the Good Neighbor Plan rule, a rule to reduce interstate transport of NO_X emissions from May 1 to September 30 for purposes of implementing the current ozone (O_3) National Ambient Air Quality Standard (NAAQS), where NOx is an O_3 precursor.[7] The proposed LMWC rule assumed that the Good Neighbor Plan would be finalized and promulgated. The Good Neighbor Plan would have imposed, among other requirements, NO_X emissions rate limits on solid waste combustors or incinerators beginning May 1, 2026. There were 23 states subject to the Good Neighbor Plan, of which nine have at least one large MWC unit subject to the large MWC EG and NSPS.[8] If a large MWC was subject to the Good Neighbor Plan rule and thereby already required to meet the emissions limit of this rulemaking, then that unit was expected to not require additional NO_X control to comply with the final NO_X amendments to the large MWC EG and NSPS. With respect to our analysis of this final LMWC rule, we no longer make that assumption.[9] As a result, while the inventory of facilities may not

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[7] U.S. EPA. Federal "Good Neighbor Plan" for the 2015 Ozone National Ambient Air Quality Standard. June 5, 2023. 88 FR 107. Available at https://www.govinfo.gov/content/pkg/FR-2023-06-05/pdf/2023-05744.pdf.

[8] These nine states with at least one large MWC unit subject to this final rule and that would have been subject to the stayed GNP promulgated in 2023 are: California, Oklahoma, Indiana, Michigan, Virginia, Maryland, Pennsylvania, New Jersey, and New York.

[9] For purposes of developing an appropriate baseline for economic analysis, the EPA need not definitively conclude that the GNP was unlawful or could never have gone into effect in some form. Rather, as circumstances

have changed, a greater number of facilities in the inventory may need to either install controls or incur positive compliance costs in order to comply with the NO_X emission limits of this rule.

In this RIA, we present analysis results for the final amendments to the large MWC EG and NSPS. Throughout this document, we focus the analysis on the final requirements that result in quantifiable compliance cost or emissions changes compared to the baseline as identified above. For each rule and most emissions sources, we assumed each facility achieved emissions control meeting the current (or 2006) EG and NSPS, and estimated emissions reductions and cost relative to this baseline. We calculate cost and emissions reductions relative to the baseline for the period 2030-2049. This time frame spans the period from when the impact of the final action takes effect through the lifetime of the typical capital equipment (20 years) expected to be installed as a result of the final EG and NSPS amendments if finalized. The impacts of this final action are almost entirely a result of the final EG amendments as shown later in this RIA, for the EPA does not anticipate any construction of new units or NSPS-triggering reconstruction or modifications of existing units within the next 3 years, and the EG requirements will not be fully implemented until late in 2029.[10] Hence, we set 2030 to 2049 as the period of analysis to reflect this projection of impacts. Each existing large MWC unit subject to the EG is expected to remain operational during this period both in the baseline and under the final rule. New units may be constructed and begin operation during the analysis period, and those new units would be subject to the NSPS limits set by this rule. As the EPA is unable to forecast or anticipate new construction in this industry given the data available, this analysis does not account for new construction or new units beginning operations over the analysis period. If new units were to open during the analysis period, the compliance costs estimates presented in this EIA would be under-estimated.

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regarding legal implementation and applicability create a uniquely high level of uncertainty concerning the GNP, it is reasonable not to include the GNP in the regulatory baseline for analyzing the economic effects of this regulatory action. This approach follows guidance from OMB Circular A-4 that the baseline "should be the best assessment of the way the world would look absent the proposed action. The choice of an appropriate baseline may require consideration of a wide range of potential factors". Therefore, the analysis in this RIA assumes the GNP is not in effect in the baseline.

[10] U.S. EPA. ICR Supporting Statement for Large MWC EG and NSPS. EPA ICR No. 7784.01, OMB Control No. 2060-NEW. November 2024.

0.3.2 *Overview of Costs and Benefits for the Final Options*

The final amendments to the large MWC EG and NSPS constitute a significant regulatory action. This action is significant according to Executive Order 12866 under section 3(f)(1), because it likely to have an annual effect on the economy of $100 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

Table 0-1 details the projected annual emissions reductions from the policy presented and analyzed in this RIA. All annual pollutant reductions are listed in tons per year (tpy) except for D/F (g/yr).

Table 0-1 Annual Emission Reductions[a,b]

Pollutant	Emission Reduction
Cadmium (Cd)	0.0024
Lead (Pb)	0.0409
Dioxins/Furans (D/F)	4.00
Hydrogen Chloride (HCl)	641
Nitrogen Oxides (Entire Year)	2,630
Nitrogen Oxides (Apr-Sep)[c]	1,310

[a] Values have been rounded to three significant figures.
[b] Values are presented in tons per year (TPY) for all pollutants except Hg (lb/yr) and D/F (g/yr).
[c] This analysis also assumes a six-month ozone season, rather than the five-month period assumed in the proposal RIA. We made this change due to due to improvements in data availability.

Table 0-2 presents compliance costs and benefits from the final amendments to the EG and NSPS. Compliance costs are calculated as the total cost of building and installing pollution control equipment and the operating and maintenance costs associated with running this equipment. The compliance cost estimate is used as an estimate of the social cost of this regulation. The private cost of purchasing and operating pollution control equipment is assumed to reflect the social opportunity cost of these technologies. Furthermore, the regulation is not anticipated to meaningfully affect behavior and prices – in particular disposal fees at large MWCs – and thus the quantity of trash produced and where it is disposed. To the extent there may be behavioral changes, the consequences of these potential changes on the social cost estimate are described in section 2.2.7 of this RIA.

The unmonetized effects include benefits from HAP emission reductions. As mentioned earlier, we calculate and present cost and emissions reductions relative to the baseline for the period 2030-2049, with costs discounted to 2025. All estimates are in 2024 dollars. Estimates of are in present value (PV) and equivalent annualized value (EAV) terms. An EAV is an equivalent estimate of impacts that is annualized over the time period of the analysis, the sum of which is equal to the PV.

Table 0-2 Compliance Costs and Benefits of the Final Rule PV/EAV, 2030 to 2049 (millions of 2024$, discounted to 2025)[a,b,c]

		3% Discount Rate	7% Discount Rate
Compliance Costs	PV	$330	$210
	EAV	$25	$28
Non-Monetized Benefits in this Table	Benefits from reducing HAP such as mercury, cadmium, lead, and dioxin/furans		
	Benefits to human health from reduction of HCl		
	Benefits to human health from reduction of NO_X, particularly those with summer season ozone benefits		
	Visibility benefits from NOx reductions		
	Benefits to vegetation and ecosystem services from NO_X reductions		

[a] Values have been rounded to two significant figures. Rows may not appear to sum correctly due to rounding.
[b] The equivalent annualized present value of costs is calculated over the 20-year period from 2030 to 2049. The choice of this analysis period is explained in Section 2 of this RIA.
[c] Non-monetized benefits include benefits from annual emission reductions in HAP including 0.0024 tons of cadmium, 0.0409 tons of lead and 4.00 grams of dioxin/furan. Details on how these emission reductions were estimated can be found in Section 2 of this RIA. In addition, benefits to provision of ecosystem services associated with reductions in nitrogen deposition and ozone concentrations are not monetized.

As shown in Table 0-2, at a three percent discount rate, this final rule is expected to generate compliance costs with a PV $330 million and an EAV of about $25 million. At a seven percent discount rate, this final rule is expected to generate compliance costs with a PV $210 million and an EAV of about $28 million. Potential benefits from dioxin/furan, cadmium, and lead emission reductions and reduced nitrogen (N) deposition are not monetized in this analysis.

0.3.3 *Comparison of Costs and Benefits for the Final Options Relative to the Proposed Rule*

Several factors influence the differences in costs and benefits between this final rule and the proposed option. First, the final rule imposes a MACT floor emissions limit on NO_X, whereas the proposed option imposed BTF limits for NO_X. All else equal, this leads to lower estimates of costs as well as emissions reductions. At the same time, the final rule analysis no longer assumes

that certain units would be regulated by the GNP, and this leads to a greater number of units incurring positive costs for NO_X abatement, driving cost and emission reduction estimates of the final rule upward relative to the 2023 proposal. This analysis also assumes a six-month ozone season, rather than the five-month window assumed in the proposal RIA. This change was made to more closely align with scientific literature on the subject and to more accurately reflect the period over which these impacts should be expected. Next, the final rule analysis includes updated calculations of MACT floor limits. These updates and recalculations are a result of improved data availability and lead to different emission limits than proposed and consequentially different expected emission reduction estimates. Finally, the analysis for the proposed option monetized health benefits, whereas the final rule analysis does not for reasons described in section 3.

0.4   Organization of the Report

The remainder of this report details the methodology and the results of the RIA. Section 1 presents a profile of the large MWC source category. Section 2 describes emissions, emissions control options, and engineering costs. Section 3 presents the benefits analysis, including a qualitative discussion of the benefits associated with HAP and NO_x emissions reductions. Section 4 presents analyses of economic impacts, impacts on small entities, and a narrow analysis of employment impacts. Section 5 presents costs. Section 6 contains the references for this RIA.

1   INDUSTRY PROFILE

1.1   Introduction

Regulation of emissions from large 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. Emissions from large MWCs include NO_X, SO_2, PM, and various HAPs such as lead (Pb), cadmium (Cd), mercury (Hg), and acid gases such as hydrogen chloride (HCl) among others. NO_X formation is strongly dependent on temperature and can substantially increase from combustion processes as temperature is at or above what is typical in large MWCs (approximately 2,000 degrees Fahrenheit). At or above such temperatures, nitrogen molecules disassociate into nitrogen atoms that then readily combine with oxygen atoms to form NO_X. The SO_2 and acid gas emissions result from sulfur being naturally present in organic materials like proteins, as well as from added compounds in products like rubber (vulcanization) and certain detergents, food scraps, and animal products. 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 waste flow volumes to MWCs. The section concludes by introducing the inventory of MWCs used to analyze the impacts of the final regulation.

1.2   Generators

Generators of MSW provide most of the potential demand for MWC services, which is derived from their demand for collection and disposal services. MSW generators generally do not directly purchase MWC services, instead contracting directly or indirectly with MSW collectors who purchase these services. 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 is 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 final rule are listed in Table 1-1.

Table 1-1: Industries Potentially Affected by the Final Rule

Category	NAICS Code	SIC Code
Administration of Air and Water Resource and Solid Waste Management Programs	924110	9511
Solid waste combustors and incinerators	562213	4953

Various underlying factors influence the trends in the quantity and composition 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.

1.3   Collection and Disposal

Governments - local, state, and federal - continue to play a large role in regulating and operating MSW management systems. Governmental influence, however, is limited by material, engineering, geographic, cost, and other technical and economic conditions. All MSW management systems also 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. Generally, these technical and market relationships condition the influence of local governments on MSW management.

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 result from the disposal of MSW.

1.4 Revenue Generation

The costs of building and operating large MWCs are financed through various blends of debt and equity and public versus private investment.[11] In the U.S., most facilities are built with financial backing from municipal bonds, which is a form of debt security that typically 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, MWCs rely primarily on tipping fees

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[11] U.S. EPA. "Energy Recovery from the Combustion of Municipal Solid Waste (MSW)". Available at https://www.epa.gov/smm/energy-recovery-combustion-municipal-solid-waste-msw. Accessed October 28, 2025.

(the price charged by the waste processor to process and dispose of waste) secondarily on electricity sales for revenues. As an example, the Palm Beach Country (FL) Solid Waste Authority, which 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.[12] Covanta, which owns many of the large MWCs affected by this final rule, indicates that revenues for their MWCs (or waste to energy (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.[13] These revenue sources are from the municipalities or geographic regions that these large MWCs serve, which are the official service areas for each authority that manage the large MWCs.

The costs of developing and operating waste disposal facilities are 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). Landfills and MWC facilities generate revenue, at least in part, from tipping fees charged to those disposing of MSW. For this analysis, we use observable landfill tipping fees as a reference point and consider them to be illustrative of the cost of the disposal services provided by MSW facilities in the same region. As of 2023, the nationwide average tipping fee for MSW landfills was $56.80/ton (2023 dollars). This represents a decrease of three percent compared to the nationwide average tipping fee from 2022. The range of average tipping fees is from a high of $83.44/ton in the Northeast to a low of $43.18/ton in the Southeast.[14] The use of taxes or fixed annual fees as a revenue source

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[12] 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.

[13] 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.

[14] Environmental Research and Education Foundation (2024). *Analysis of MSW Landfill Tipping Fees – 2023*. Available at https://erefdn.org/product/analysis-of-msw-landfill-tipping-fees-2023/. Accessed September 17, 2025.

rather than tipping fees has implications on waste disposal services for both landfills and MWC facilities. First, when disposal costs are included in taxes, most people are not aware of the actual costs involved, and without an effective mechanism for transmitting cost information, waste generators have no incentive to reduce their generation rates. A distinction must be drawn between tipping fees and the actual costs of waste disposal. 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 and waste combustion facilities supplementing tipping fee revenues with tax revenues is usually much higher than the fee charged. Regardless of the revenue generation model of the MWC facility in question, increases in costs from environmental regulation or other operation factors will generally be recovered from the end consumers, those producing the waste being processed by these facilities.

1.5   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 or an electrostatic precipitator (ESP), with baghouse fabric filter (FF) systems being the most common PM control at units found at MSW combustion facilities by far (144 out of 151, based on LMWC inventory data for 2024).

An electrostatic precipitator (ESP) is a particle control device that uses electrical forces to move the particles out of the flowing gas stream and onto collector plates. Once the particles are collected on the plates, they must be removed from the plates without reintroducing them into the gas stream. A fabric filter unit, on the other hand, consists of one or more isolated compartments containing rows of fabric bags. Particles suspended in gas pass along the surface of the bags then through the fabric, and the cleaned gas stream is vented to the atmosphere. The filter is intermittently removed from the process for cleaning.

As the gas stream travels through such 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. Ash residue from the furnace can be processed for removal of recyclable scrap metals. Figure 1-1 illustrates how this energy recovery process works.

Figure 1-1: Waste to Energy Plant Diagram
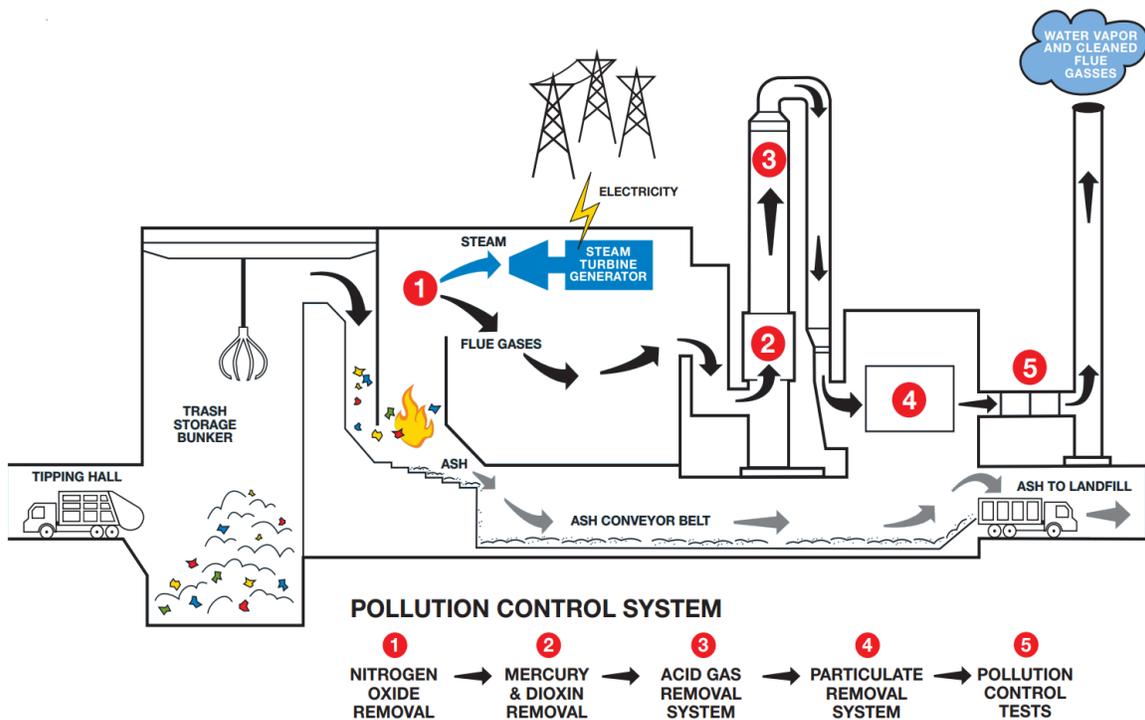
*From the EPA archive, supplied by Ecomaine.

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.

1.6 Existing Fleet Composition

LMWC facilities are known to exist in 20 states, as shown in Figure 1-2. They are generally concentrated in the northeastern portion of the contiguous United States as well as in the coastal states of California, Florida, Oregon, and Washington. This information comes from the inventory of facilities presented and analyzed in the Cost Memo Appendix and Emissions Memo Appendix that are docketed for this rule.

Figure 1-2: States with Existing LMWC Facilities (2024)
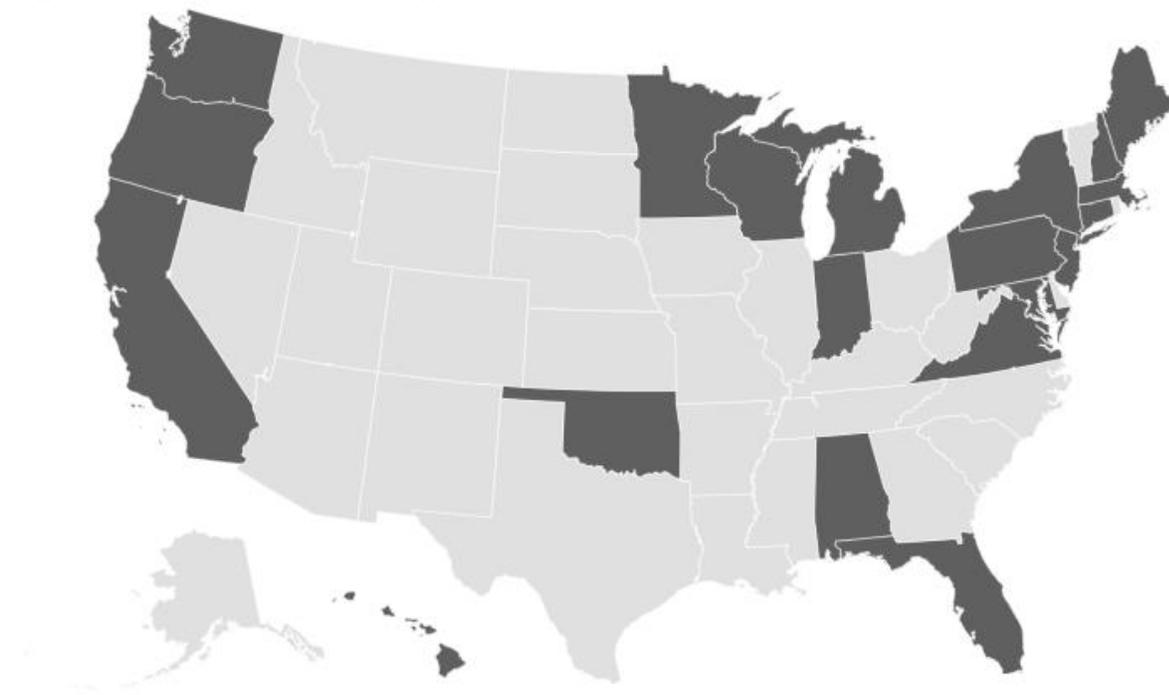
As reflected in Table 1-2, the industry is composed of 57 distinct facilities, each of which may operate one to six units, for a total of 151 active units. The mixture of control technologies in place at each facility and on each unit is not uniform, nor is the use of one technology indicative of the presence or use of another. 147 units use spray dryers (SD), ten units use electrostatic precipitators (ESP), 128 use carbon injection (CI), 144 use fabric filters (FF), 121 use selective noncatalytic reduction (SNCR also using Low NO_X (LNTM) technology), and three units use

advanced selective noncatalytic reduction (ASNCR). Some of the LMWCs use a combination of these control technologies. These control technologies are accounted for in the baseline of this RIA and serve as a basis for the estimated compliance costs as well as emissions reductions. For more information on each of these emission control technologies, please refer to Section 2.2 of this RIA.

Table 1-2: Existing LMWC Facilities and Control Technologies in Baseline

Existing Fleet						
Facilities				Units		
57				151		
Active Control Technologies						
SD	ESP	ACI	FF	SNCR	+LNTM	ASNCR
147	10	128	144	121	17	3

1.7 Baseline Employment

This section begins with a description of the total labor force in this final rule's baseline for industries affected by the final rule, focusing on the directly regulated industries and groups of affected workers. The waste treatment and disposal industry (NAICS 5622) is the industry that includes LMWCs with the largest number of people employed. The Bureau of Labor Statistics (BLS) Current Employment Statistics show that this industry employs 105,100 people nationally as of 2023 (up from 101,000 in 2021). The administration of air and water resource and solid waste management program industry (NAICS 9241) is also impacted by the final rule but falls under the umbrella of federal, state, and local government entities on which no equivalent employment data is available. We rely on two public sources to get a range of estimates of employment per output by sector: the Economic Census (EC), and the Annual Survey of Manufacturers (ASM), both provided by the U.S. Census Bureau. The EC is conducted every 5 years, most recently in 2017.[15] The ASM is an annual subset of the EC and is based on a sample of establishments. The latest set of data from the ASM is from 2019. Both sets of U.S. Census Bureau data provide detailed industry data, providing estimates at the 4-digit NAICS level. They provide separate estimates of the number of employees and the value of shipments at the 4-digit NAICS, which we convert to a ratio in this employment analysis. For the waste treatment and disposal industry (NAICS 5622), the only estimate available is the EC, which allows us to

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[15] Data on employment at establishments (i.e., facilities) and firms as collected by the Census Bureau for the next Economic Census (2022) will not be released until June 2025 according to the Census Bureau press release at https://www.census.gov/programs-surveys/economic-census/surveys/year/2022/news-updates/releases.html.

provide an estimate of 3.25 employees per $1 million of products sold by the industry for each data source in 2017$.

Generally, there are significant challenges when trying to evaluate the employment effects due to additional environmental regulation from employment effects due to a wide variety of other economic changes.

For the waste treatment and disposal industries, without more detailed information on the labor required for installing and operating pollution controls in this industry, we are not able to determine the potential effect of employment changes associated with this final rule.

2 EMISSIONS AND ENGINEERING COST ANALYSIS

2.1 Introduction

In this chapter, we present estimates of the projected emissions reductions and engineering compliance costs associated with the final NSPS and EG amendments for the 2030 to 2049 period. We present these impacts over this 20-year analysis period since all of the control equipment that large MWCs may apply to meet the final emission limits have an equipment life of up to 20 years, and 2030 is the first year in which impacts from this final rule will be incurred. This initial year of analysis aligns with the effective date of the rule, which allows three years for compliance after the approval of state implementation plans, which themselves are allowed one year for completion after the promulgation date in mid-2026. The projected costs and emissions impacts are based on facility-level estimates of the costs of meeting the final 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 memo *Emission Reduction Estimates for Existing Large MWCs Final Rule Amendments*. As the Agency does not have information as to facility-specific expected future changes operations and emissions behavior, the baseline annual emissions of each facility are assumed to remain the same in each year without this regulatory action.

These estimates are provided for the final standards in this RIA. More information on the final standards can be found in the *Emission Reduction Estimates for Existing Large MWCs Memorandum* prepared for this final rule.

2.2 Emission Rates and Control Measures

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 final limits. In order to determine the control costs, it was necessary to first evaluate, for each large MWC, how much reduction for each pollutant would be needed to meet

the final emissions limits.[16] To do this, an average of available stack test and CEMS data from 2000 through 2015 was used as a representation of typical baseline performance for the unit to compare to the corresponding finalized emissions limit. For CEMS pollutants (CO, NO_X, and SO_2), each datapoint included in this average reflects a unit's highest CEMS compliance average (calculated over a pollutant-specific averaging period as identified for the corresponding emission rate standard, which can range from four to 24 hours, as applicable) for a given year as required in the current NSPS and EGs. Typically, these values are less than the current applicable emission limit (i.e., as required by the 2006 rule) and are assumed to be representative of currently achievable performance levels of the unit. For instances where the average falls above the current applicable emissions limit (i.e., the unit may be complying with the alternative percent reduction standard instead of the numeric emission limit), the applicable emission limit was assumed as the achievable performance level.

Stack test data (i.e., data from pollutants whose emissions are not required to be measured by CEMS) were averaged as these values represent the measured concentration and, unlike CEMS, are not an annual peak value. The arithmetic average of annual stack tests were assumed as the achieved performance level for the unit. However, the final limits incorporate new data submitted for years 1990 to 1995 for unit ranking and upper prediction limit (UPL) determinations, in addition to the 2000 to 2009 compliance dataset used at proposal. Considering the unique situation of the MACT reevaluation, the limited ability to gather multiple years of tests for the top performers from several decades ago, and the highly variable waste stream as a fuel source, the EPA has also revised the NSPS methodology to account for additional intra-source variability in top performers instead of reliance upon a singular test from the 1990s. For each stack test pollutant, the EPA performed a UPL analysis using the annual test averages from the 1990 to 1995 dataset and adjusted averages from the 2000 to 2009 dataset. For EG limits, average annual run data corresponding to the top 12 percent of units were used, and for NSPS limits, run data for the single top performer were used. For NSPS limits, the distribution and variance of 2000 to 2009 test averages for the top performer were also assessed and incorporated

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[16] This section describes how representative baseline emission rates for determining whether a unit needs to install controls to comply with the finalized emission rate were calculated. Section 2.2.8 describes how typical annual average baseline emission rate for each unit was calculated for determining a baseline annual total emissions level. The annual total emission level is subsequently used to estimate the total emission reductions achieved by the assumed incremental controls for the purpose of estimating the total benefits of this final rule.

into the UPL calculation. Data gaps were filled first by using the measured emission rate data from similar units operated by the corporate entity. If these data were not available, then the average of available data for large MWCs with similar combustion and control types were used. Once every unit was assigned an achievable emissions level depending on if annual stack test data is available from each unit's corporate entity, or not, percentages were calculated to quantify the amount of improvement needed for each unit to meet each finalized emissions limit. For CEMS pollutants (CO, NOx, and SO_2), the EPA reevaluated MACT floor limits by averaging annual peak CEMS data corresponding to the top performers for each pollutant and applicable subcategory. For NOx and CO, the EPA calculated separate NSPS limits for only two subcategories, mass burn waterwall (or MB as reflected by MB/WW combustor technology) and refuse-derived fuel stoker (RDF). In cases where results were greater (less stringent) than the current large MWC EG limit, the EPA retained the existing regulation limit as the MACT floor limit. More information on the basis for the determination of emission rate data for each large MWC affected by this final rule, please refer to section III of the preamble for the final rule.

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 without cost. If there are factors that would lead the noncompliant unit to continue to exceed emissions limits once all costless adjustments were made, this assumption would understate the cost of compliance for the unit in question. The assumptions for this analysis are shown in the subsections that follow and the final standards are compared to the current standards in Table 2-1 and Table 2-2.

Table 2-1 Comparison of Existing Source Limits for 2006 Large MWC Rule and the Final Emission Limits for Existing Sources

Pollutant	Units (@ 7 percent O$_2$)	2006 EG (Current) Limits	Final Subcategory EG Limits				
			MB/WW[f]	MB/RC[f]	RDF/S[f]	RDF/SS[f]	RDF/FBC[f]
Cd	μg/dscm	35			10		
Pb	μg/dscm	400			68		
PM	mg/dscm	25			20		
Hg	μg/dscm	50			50		
PCDD/PCDF	ng/dscm	30/35[a]			14		
HCl	ppmvd	29			10		
SO$_2$	ppmvd	29			22		
NO$_x$	ppmvd	180–250[b]	205[d]	150	160	160	180[d]
CO	ppmvd	50–250[c]	100[d]	110	110	250[d]	110

[a] 30 ng/dscm for fabric filter equipped MWC units and 35 ng/dscm for electrostatic precipitator-equipped MWC units.
[b] Range in limits based on combustor type. MB/WW (205); RDF (250); MB/RC (210); RDF/FBC (180).
[c] Range in limits based on combustor type. MB/WW (100); MB/RC (250); RDF/S (200); RDF/SS (250); RDF/FBC (200); modular starved air or modular excess air (50).
[d] Reevaluated MACT floor limit was less stringent than current limit, so current limit was retained.
[f] Mass burn waterwall (MB/WW); Mass burn rotary combustor (MB/RC); Refuse-derived fuel stoker (RDF/S); Spreader stoker fixed floor/100 percent coal capable and RDF semi-suspension/wet RDF process conversion (RDF/SS); RDF/fluidized bed combustion (RDF/FBC).

Table 2-2 Comparison of New Source Limits for 2006 Large MWC Rule and the Final Emission Limits for New Sources

Pollutant	Units (@ 7 percent O$_2$)	2006 NSPS (Current) Limits	Final Subcategory NSPS Limits	
			MB	RDF
Cd	μg/dscm	10		2.3
Pb	μg/dscm	140		23
PM	mg/dscm	20		5.1
Hg	μg/dscm	50		32
PCDD/PCDF	ng/dscm	13		11
HCl	ppmvd	25		7.2
SO$_2$	ppmvd	30		14
NO$_x$[a]	ppmvd	150		50
CO	ppmvd	50-150[b]	76	100

[a] NO$_x$ limit based on 50 ppm (24 hour) permitted limit for units currently equipped with SCR control devices.
[b] Range in limits based on combustor type. MB/WW (100); RDF/S (150); Modular starved air or modular excess air (50).

2.2.1   *Particulates (Cd, Pb, PM)*

As explained in the cost memorandum for this final rule, existing control options for particulates (a surrogate for non-mercury metals) include fabric filter (FF) retrofit, FF improvement, a combination of retrofit and improvement, and complete FF replacement. Units equipped with electrostatic precipitators (ESPs) that cannot meet the MACT floor limits for at least one of the three pollutants will likely need to be retrofitted with FF. However, MACT floor limits are not the only alternative that the agency has reviewed for this rulemaking. These additional limits, that emerge from technology review analyses, may prove more stringent and demand control beyond the (MACT) floor.

2.2.2   *Mercury, Dioxins and Furans*

Existing control options for mercury and dioxins and furans include activated carbon injection (ACI), increasing carbon injection (CI) rates for existing ACI controls, or a combination of the two. 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.. For units that already have ACI installed but cannot meet the final MACT floor limits, assumed an increased rate of CI.

2.2.3   *Acid Gases (HCl and SO$_2$)*

Existing control options for acid gases (hydrochloric acid and sulfur dioxide) include increasing lime injection rates and retrofitting with 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. For these acid gases, the EPA is finalizing recalculated alternative percent reduction standards based on additional 1990-1995 removal efficiency data for the best performing units used in the re-evaluated MACT standards for Hg, HCl and SO$_2$. It is assumed that the facilities would comply with the less stringent of the alternative percent removal standards or MACT floor limits. . The most recently built MWC units, such as Palm Beach Ref 2 and Hillsborough 4, are assumed to have state of the art spray dryer absorbers and need no further controls nor additional

lime injection to meet either the MACT Floor limit or the removal efficiency necessary for compliance with the alternative percent reduction standards

2.2.4 *Nitrogen Oxides (NOₓ)*

Existing control options for oxides of nitrogen include selective non-catalytic reduction (SNCR), advanced selective non-catalytic reduction (ASNCR) and low-NO$_X$ technology (Covanta LN^{TM}, or LNTM).[17] In the analysis of the proposal of this rule, some units in the current inventory (used to determine the baseline for the final rule) were assumed to be required to meet the final NO$_X$ emissions limit as a consequence of state implementation plans and/or being located in the Ozone Transport Region and being covered by the final Good Neighbor Plan rule, published in May 2023. On June 27, 2024, the United States Supreme Court granted emergency applications seeking a stay of the Good Neighbor Plan pending judicial review. On October 29, 2024, the US EPA issued a final rule to administratively stay the effectiveness of the Good Neighbor Plan's requirements for all sources covered by that rule as promulgated where an administrative stay was not already in place. As a result, it is no longer uniformly assumed that these units that require NO$_X$ control would be able to meet the large MWC MACT Floor limit for NO$_X$ without the installation of new controls or increased use of control technologies with variable materials cost. Their associated impacts and burden estimates for compliance with this rulemaking are accounted for here. Relative to the proposal, this results in larger number of facilities that may incur compliance costs as some facilities that may have previously been assumed to incur zero costs may now have positive estimated compliance costs.

2.2.5 *Carbon Monoxide (CO)*

No add-on controls are specified for carbon monoxide. 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 percent O$_2$ correction.[18] The final removal of the 7

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[17] The Covanta LN™ process involves modifications to the combustion air system of a municipal waste combustor (MWC), combined with modifications to the combustion monitoring and controls systems, and it may be combined with SNCR or ASNCR systems to achieve even greater reduction and removal of NO$_X$.

[18] Combustion source standards are often expressed in terms of a common or standard O$_2$ or CO$_2$ diluent concentration for establishing a consistent basis for comparison and measurement. In the case of large MWCs, this is set to 7% O$_2$ as the reference diluent concentration. During periods where the stack gas oxygen content

percent 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.

For the MACT floor limits, units unable to comply in the baseline are assumed to require retrofit with either ASNCR or low- NO$_X$ 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 LNTM, in which case no NO$_X$ control costs were included for compliance with either limit option. Non-Covanta units requiring additional control were assigned ASNCR as it is believed that SNCR systems would not be able to reduce emissions effectively enough to meet the final standards or that SNCR systems would not be able to do so at a lower incremental cost than ASNCR would.

2.2.6 *Control Alternatives or Options*

For this final RIA, we include analysis for the MACT floor control option for all regulated pollutants except SO2 for which we are maintaining an alternative percent reduction standard. Consistent with EPA's *Guidelines for Preparing Economic Analysis*, we assume that facilities with baseline emission rates above the finalized limits choose the least-cost compliance strategy for attaining the limits based on information available to the Agency. For existing units, the EPA is finalizing a NO$_X$ emissions limit of 150 to 205 parts per million by dry volume (ppmvd) (24-hour) concentration level, with the levels depending on combustor type. For all new units, the EPA is finalizing a NO$_X$ NSPS limit of 50 ppmvd (24-hour), based on the permitted NO$_X$ limit for the only facility currently using SCR technology with an air-to-air heat exchanger providing flue gas reheat prior to entering the SCR reactor. While the standards for NO$_X$, or other pollutants, do not prescribe a particular control technology to be installed for compliance, as we discuss in the preamble to the final rule (89 FR 4252), SCR for new sources and ASNCR and Covanta's LN^{TM} technologies have been used to achieve NO$_X$ performance standards, implying that these control methods are more effective or lower in cost than alternative methods. For SO$_2$, no additional controls are needed to meet alternative percent reduction standards, but additional

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approaches the 20.9% O$_2$ atmospheric O$_2$ content, however such as warmup, startup or shutdown of the combustor, correcting to this diluent concentration creates a situation where the stack pollutant measurement must be multiplied by a factor approaching infinity, thus is an artificial inflation of the actual measurement.

use of hydrated lime with the existing SO_2 (also acid gas) control technique would be the basis for emissions of that pollutant to fall below a potentially lower MACT floor standard.

Table 2-3 summarizes the technological improvements anticipated at different facilities for full compliance with the final rule, disaggregated by regulatory component. In order to meet PM standards, two units are expected to require FF retrofitting. For control of Mercury and D/F, no facilities are expected to need ACI retrofitting. In order to meet NO_X standards, 17 units are assumed to need to adopt additional controls to attain the standard. Of these 17 units, six units (at two facilities) already have SNCR installed. As these six units would need to achieve reductions of 24 percent to 33 percent, it is believed that they could achieve this through modified usage of SNCR. If this were possible at a lower cost than through installation of ASNCR, the compliance cost estimates of this rulemaking would be overstated.

Table 2-3: Technological Improvements for Existing Fleet Compliance with Final Rule

Existing Fleet						
Facilities				Units		
57				151		
Active Control Technologies						
SD	ESP	ACI	FF	SNCR	+LNTM	ASNCR
147	10	128	144	121	17	3
Anticipated Technological Improvement Needs						
Particulate Matter Control (MACT Floor)						
SD	ESP	ACI	FF[a]	SNCR	+LNTM	ASNCR
0	0	0	2	0	0	0
Mercury and Dioxin/Furan Control (MACT Floor)						
SD	ESP	ACI[b]	FF	SNCR	+LNTM	ASNCR
0	0	0	0	0	0	0
Acid Gas Control (MACT Floor)[c]						
SD	ESP	ACI	FF	SNCR	+LNTM	ASNCR
0	0	0	0	0	0	0
Nitrogen Oxide Control (MACT Floor)						
SD	ESP	ACI	FF	SNCR	+LNTM	ASNCR
0	0	0	0	0	0	17

[a] FF indicates that retrofit installations are necessary.
[b] ACI indicates that retrofitting of activated carbon injection units would be needed for compliance.
[c] Acid gas controls are expected to be achieved by increased lime injection rates.

2.3 Engineering Cost Analysis

This section presents detailed cost tables for the control of each pollutant by the final amendments, and in total. All tables contain per-year values with the exception of total capital investment (which represents one-time or initial costs). Total annualized private costs include capital costs annualized using the prevailing 7.5 percent bank prime rate in accord with the guidance of the EPA Air Pollution Control Cost Manual (U.S. EPA, 2017a) as of December 2024, operating and maintenance (O&M) costs, and costs of additional monitoring, recordkeeping, and reporting (MRR). We have used the bank prime rate as of December 2024. To estimate these annualized private 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 private costs are the costs to directly affected firms and facilities (or "private investment") and thus are not annualized social costs, although they are related. Detailed discussion of the components of private 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 Final Large MWC Rule Amendments" memorandum and its Appendices A, B, and C, in the docket for the final rule. These costs incorporate impacts such as increased water usage and waste disposal, and other effects such as those to electricity generation at affected facilities. All cost estimates are in 2024 dollars.

Table 2-4 provides a summary of the total capital investment and annualized costs for control of the different types of pollutants affected by these final EG and NSPS rules. It also provides a summary of the total capital investment and private annualized costs for the whole of the final rule. For acid gases and particulate sources, the equipment life is assumed to be 15 years, rather than 20 years as for the other control technologies. Thus, the capital costs would occur twice in the 20 year analysis period. The Total Capital Investment in Table 2-4: Summary of Total Capital Investment and Private Annualized Costs (2024$)ª is the undiscounted sum of the capital costs for these controls assumed to occur twice in the analysis period. Capital costs are amortized over the equipment life of the controls to calculate the private annualized capital cost.

Table 2-4: Summary of Total Capital Investment and Private Annualized Costs (2024$)[a]

	Particulate	Hg and D/F	Acid Gases	NOₓ	Total
Total Capital Investment	$19,000,000	$0	$0	$71,000,000	$90,000,000
Annual O&M	$120,000	$0	$11,000,000	$8,100,000	$19,000,000
Annualized Capital [b]	$1,000,000	$0	$0	$6,500,000	$7,500,000
Total Annualized Cost	$1,100,000	$0	$11,000,000	$14,000,000	$26,000,000

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted.
[b] Annualized capital costs are amortized over 15 years using a 7.5 percent bank prime rate as the private rate of borrowing.

2.4 Social Cost Analysis

This regulatory analysis uses engineering costs of compliance (i.e., compliance costs) as an estimate of social cost, with the exception that the social cost estimate accounts for when capital costs are incurred rather than use the estimate of the private annualized payment to capital. Specifically, the present value of the social cost over the time horizon of the analysis is the sum of the total investment cost plus annual operation and maintenance costs across all affected facilities discounted using a social discount rate (annualized social costs are calculated by annualizing the present value of the social cost at the corresponding social discount rate). The prices of pollution control and monitoring equipment and the inputs used to operate them are assumed to reflect the social opportunity cost of the resources used to produce and install them, and therefore the social opportunity cost of using them to reduce pollution from large MWCs rather than their best alternative use. These opportunity costs include the value of forgone electricity sales due to outages to install pollution control equipment. From the perspective of a large MWC, the lost value of electricity production is simply the lost revenue from electricity sales. From the perspective of society, that lost value of electricity not produced by large MWCs is either the resources needed to produce that electricity by other generators, or the opportunity cost of forgoing the consumption of that electricity.[19] Total revenue lost at all facilities during down time to replace or retrofit fabric filters, primarily through lost electricity sales revenue, is estimated to be $7.6 million. To the extent the compliance expenditures - discounted at a social

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[19] To the extent the wholesale price of electricity received by large MWCs equals the social opportunity cost of electricity production and the forgone value of electricity consumed, the lost revenue equals this social opportunity cost.

discount rate - do not reflect the social opportunity cost of these resources, actual social costs may be higher or lower depending on the direction of the difference between the social opportunity cost and the private opportunity cost of those resources.

The social cost estimate based on compliance costs (discounted at the social discount rate) further assumes that there are no changes in behavior of large MWCs and their consumers other than the installation and operation of pollution control equipment. If the cost of compliance expenditures were passed on through tipping fees, and consumers then reduced their use of the services of large MWCs, then the estimate of social cost estimated would differ from actual social costs.[20] Generally, the actual social costs would be overestimated because these additional opportunities for behavioral change are not accounted for. However, because alternative means of disposal, such as landfilling waste, may have their own associated externalities that are not reflected in the cost of these services, actual social costs may be higher.

Table 2-5 provides a breakdown of the composition of undiscounted compliance costs incurred in each year of analysis, and Table 2-6 presents the PV equivalents of the annual sums of these costs as well as EAVs. An important assumption for this analysis is that the capital costs are presumed to be incurred entirely in one year, 2030 (or also in 2045 in the case of those technologies that have a 15-year lifetime as discussed above). Most of the control technologies and techniques that will be applied are improvements to existing control technologies or additional use of reagent at control technologies. Among these types of control technologies and techniques are improvements to FF and additional use of activated carbon in ACI as mentioned earlier in this RIA section. Control equipment such as ASNCR, while a route for compliance with the final NO_X standard, has a longer timeframe for implementation compared to an FF improvement or additional ACI use.[21] Thus, for purposes of this analysis, all control equipment and operation of such equipment is presumed to be ready for operation for compliance with this final rule at the start of 2030. To the extent that controls may not need to be fully operational until after the start of 2030, then the present value of costs may be overestimated.

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[20] In this case, where the delivery of solid waste services is often determined through contracts, this type of scenario is reasonable to assume here given that entities owning affected large MWCs will find it difficult to adjust their level of service given an increase in their costs and difficulty in quickly passing through some portion of that increase in cost to their consumers.

[21] Eastern Research Group, for U.S. EPA. Compliance Cost Analyses for Final Large MWC Rule Amendments. October 2025.

The analysis timeframe is different from that applied in the proposal RIA, in which the analytic timeframe was 2025-2044. We revised the analytic timeframe to account for the finding that the quantified impacts of the final rule will be due to the EG requirements, and implementation of these requirements will not be complete until 2030. The estimated present-value of compliance costs in 2025 is about $330 million ($25 million EAV) using a three percent social discount rate and about $210 million ($28 million EAV) using a seven percent social discount rate from 2030-2049. Additional information and calculations to support those summary values appear in the LMWC Cost workbook in the docket for this final rule.

Table 2-5: Costs by Year for the Final Options (millions of 2024$)[a]

Year	Capital	Annual O&M	Total
2030	$80	$19	$99
2031	$0	$19	$19
2032	$0	$19	$19
2033	$0	$19	$19
2034	$0	$19	$19
2035	$0	$19	$19
2036	$0	$19	$19
2037	$0	$19	$19
2038	$0	$19	$19
2039	$0	$19	$19
2040	$0	$19	$19
2041	$0	$19	$19
2042	$0	$19	$19
2043	$0	$19	$19
2044	$0	$19	$19
2045	$10	$19	$29
2046	$0	$19	$19
2047	$0	$19	$19
2048	$0	$19	$19
2049	$0	$19	$19

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

Table 2-6: Present-Value, Equivalent Annualized Value, and Discounted Costs for Final Options, 2030-2049 (million 2024$)[a]

Year	3%	7%
2030	$86	$71
2031	$16	$13
2032	$16	$12
2033	$15	$11
2034	$15	$10
2035	$14	$10
2036	$14	$9
2037	$13	$9
2038	$13	$8
2039	$13	$7
2040	$12	$7
2041	$12	$7
2042	$12	$6
2043	$11	$6
2044	$11	$5
2045	$16	$7
2046	$10	$5
2047	$10	$4
2048	$10	$4
2049	$9	$4
PV	$330	$210
EAV	$25	$28

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

2.5   Emission Reductions

In order to quantify the impact of the regulatory options considered in this impact analysis, we began by calculating baseline emissions for each of the nine pollutants affected by the final rule (PM$_{2.5}$, Hg, D/F, HCl, SO$_2$, NO$_X$, CO, Cd, and Pb). These baseline emissions represent the estimated annual emissions of existing units prior to control measures taken to comply with the potential new limits. For each unit, the average of available stack test data from 2000 to 2015 was used as the baseline emissions concentration for stack test pollutants. If such data were not available, the means of available data for large MWC units with similar

combustion and control types were used. For SO_2 and NO_X, CEMS data were used for calculating baseline emissions. As the CEMS data represent peak annual readings, the values were retained for units with average CEMS values below the existing (2006) limit, and the existing emissions limit (i.e., 2006 rule) was substituted for those units whose average exceeded that limit under the assumption that units are currently performing at or below the existing standard.

Table 2-7 presents the baseline emissions as well as emission reductions for pollutants reduced by these final rules. As the baseline emission levels for CEMS pollutants represent the highest 24-hour reading for a given year rather than the average emission rate over that year and as those peaks may exceed the average rates, the estimated reductions of those pollutants attributable to this rule may be overestimated. Annual averages are unavailable to correct for this bias. For a point of comparison, the National Emissions Inventory values for this sector in 2008 are roughly 30% below the baseline values in this analysis. The emissions reductions estimates in this table, as well as those used for estimating cost effectiveness, assume that no reductions would be observed for units already in compliance with the final regulatory options. However, certain pollutants are abated through application of the same control technologies (e.g. Cd, Pb, and PM are controlled together, as are Hg and D/F). Therefore, the estimated reductions of any of these pollutants are likely to result in reductions of their paired pollutants. Due to technical limitations of the emissions estimation procedures used in this rulemaking, the EPA is unable to quantify these changes.

Table 2-7: Emissions Reductions from Final Rule Amendments[a,b]

Pollutant	Baseline Emissions	Emissions Reductions
Cadmium (Cd)	0.198	0.0024
Lead (Pb)	2.72	0.0409
Dioxins/Furans (D/F)	435	4.0
Hydrogen Chloride (HCl)	2,430	641
Nitrogen Oxides (Entire Year)	52,000	2,630
Nitrogen Oxides (Apr-Sep)	21,700	1,310

[a] Total emission reductions are presented in TPY, except for Hg (lb/yr) and D/F (g/yr).
[b] All values are rounded to three significant figures when more than three are available.

3 BENEFITS

3.1 Introduction

The emissions controls installed to comply with this action are expected to reduce emissions of HAPs including HCl, lead, cadmium, and 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 concentrations of ozone and $PM_{2.5}$ as a consequence of NO_X reductions. Summer season NO_X emissions, in conjunction with emissions of volatile organic compounds (VOC), form ground-level ozone (O_3) in the presence of sunlight in what is known as the photochemical effect. The EPA provides a qualitative discussion of the benefits of reducing PM and ozone later in this chapter.

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

In this section, we describe the health effects associated with the main HAP of concern emitted from the LMWC source category: HCl, lead, cadmium, and dioxins/furans. As stated in our cost analysis, this final rule is projected to reduce HCl from LMWC by approximately 641 tons per year (tpy). We also estimate that the final rules would reduce all other HAP emissions by approximately 0.0433 tpy, as detailed and decomposed in Table ES-1. More information on the size of these HAP emission reductions and how they are estimated can be found in Section 2 of this RIA.

Quantifying the risk of cancer and non-cancer effects due to HAP is made difficult by the lack of expected value estimates of cancer and non-cancer risk due to HAP. 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 final action.

3.2.1 *Hydrogen Chloride*

Hydrogen chloride (HCl) is a corrosive gas that can cause irritation of the mucous membranes of the nose, throat, and respiratory tract. Hydrogen chloride used in the production of chlorides, fertilizers, and dyes, in electroplating, and in the photographic, textile, and rubber

industries. HCl in MWC flue gas is the result of combustion of solid wastes containing chlorine, such as polyvinyl chloride-containing plastics found in consumer products and packaging. Brief exposure to 35 ppm causes throat irritation, and levels of 50 to 100 ppm are barely tolerable for 1 hour (ATSDR, 2014). 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. Exposure to high concentrations can also lead to immediate onset of rapid breathing, blue coloring of the skin, accumulation of fluid in the lungs, narrowing of the bronchioles. Exposure to HCl can lead to reactive airways dysfunction syndrome (RADS), a chemically or irritant-induced type of asthma. Children may be more vulnerable to corrosive agents than adults because of the relatively smaller diameter of their airways. Children may also be more vulnerable to gas exposure because of increased minute ventilation per kg and failure to evacuate an area promptly when exposed. HCl has not been classified for carcinogenic effects (U.S. EPA, 1995b).

3.2.2 *Lead*

Lead (Pb) 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 (ATSDR, 2020). Lead in MSW (and MWC emissions) is most likely due to lead contained in lead-acid batteries that have entered the waste stream (U.S. EPA, 2018). Lead causes adverse effects on the nervous system in children (cognitive function decrements and the group of externalizing behaviors comprising attention, impulsivity and hyperactivity), the hematological system (altered heme synthesis and decreased red blood cell survival and function), and the cardiovascular system (hypertension and coronary heart disease), and on reproduction and development (postnatal development and male reproductive function). Lead is also likely to cause adverse effects on the nervous system in adults, adverse effects on immune system function, increased risk of symptoms of depression and anxiety and withdrawn behavior, and cancer in humans (U.S. EPA, 2024). Children are more sensitive to the health effects of Pb than adults. No safe blood Pb level in children has been determined. Exposure to lead is known to present serious health risks to the

brain and nervous system of children. In utero and early childhood exposure to lead is associated with increased risk to the baby's brain and/or nervous system, manifesting as delayed metal or physical growth, lowered intelligence quotient (IQ), and increased risk of learning, attention, or behavioral problems in life (U.S. EPA, 2024). Lead exposure can also result in serious health effects to the developing fetus and infant such as preterm birth (U.S. EPA, 2024). In adults, lead is associated with increased risk of coronary heart disease and related premature death, renal, reproductive, immunological, and neurological effects (U.S. EPA, 2024). Occupational exposure to lead is associated with significant health effects in adults as well, particularly renal and gastrointestinal. EPA has determined that Pb is a probable human carcinogen (Group 2B) (U.S. EPA, 2004).

3.2.3 *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. 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. Exposure to high concentrations may induce long-term alterations in glucose metabolism and changes in hormone levels. It is a developmental and reproductive toxicant and disrupts thyroid hormone levels of newborn infants born to mothers who were exposed to 2,3,7,8-TCDD (U.S. EPA, 2012b). In certain animal species, 2,3,7,8-TCDD is especially harmful and can cause death after a single exposure. Human studies have shown an association between 2,3,7,8-TCDD and soft-tissue sarcomas, lymphomas, and stomach carcinomas (ATSDR, 1998). EPA has classified 2,3,7,8-TCDD as a probable human carcinogen (Group B2) (U.S. EPA, 1985).

3.2.4 *Cadmium*

The main sources of cadmium (Cd) 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 (U.S. EPA, 1989a). 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).

3.3   Criteria Pollutant Impacts

Historically, the EPA estimated the monetized benefits of avoided $PM_{2.5}$- and ozone-related impacts, which accounted for most, if not all, of the monetized benefits of many air regulations–even when the regulation was not regulating $PM_{2.5}$ or ozone–within Regulatory Impact Analyses (RIAs).[22] Throughout these analyses, the EPA acknowledged significant uncertainties related to monetized $PM_{2.5}$ and ozone impacts. The EPA has and is considering various techniques for characterizing the uncertainty in such estimates, such as estimating the fraction of avoided health effects occurring at various concentration ranges, sensitivity analyses, and alternate concentration-response assumptions. Because of the significant impacts of environmental regulations on the U.S. economy, it is essential that the Agency have confidence in the estimated benefits of an action prior to utilizing these estimates in a regulatory context.

In previous Regulatory Impact Analyses (RIAs), the Agency's approach to estimating the impacts to human health of the changes in concentrations of ozone and $PM_{2.5}$ relied substantially on information from the Integrated Science Assessments for ozone and particulate matter (e.g., (U.S. EPA, 2020a), (U.S. EPA, 2019). These documents synthesize the toxicological, clinical, and epidemiological evidence to determine whether PM and ozone are 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 ISAs reflect the Agency most up-to-date evaluation of the strength and limitations of the available scientific evidence, and clearly identify

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[22] See OMB's 2017 Report to Congress on Benefits and Costs of Federal Regulations and Agency Compliance with the Unfunded Mandates Reform Act for fuller discussion on uncertainties, available at https://trumpwhitehouse.archives.gov/wp-content/uploads/2019/12/2019-CATS-5885-REV_DOC-2017Cost_BenefitReport11_18_2019.docx.pdf

the health and welfare endpoints for which the evidence is strongest. The Agency continues to focus on these endpoints in considering how regulatory actions may impact public health and welfare. Historically, the Agency has estimated the incidence of air pollution effects for those health endpoints that the ISA classified as either causal or likely-to-be-causal and these endpoints are shown in Table 3-1. The table omits welfare effects such as acidification and nutrient enrichment.

Table 3-1: Health Effects of Ambient Ozone and PM$_{2.5}$

Category	Effect	Causal/Likely-to-be-causal	More Information
Premature mortality from exposure to PM$_{2.5}$	Adult premature mortality based on cohort study estimates and expert elicitation estimates (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)	✓	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)	✓	PM ISA
	Stroke (ages 65-99)	✓	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	✓	PM ISA
	Other respiratory effects	✓	PM ISA
	Other nervous system effects	✓	PM ISA
	Cancer	✓	PM ISA
	Reproductive and developmental effects	—	PM ISA
	Metabolic effects	—	PM ISA
Mortality from exposure to ozone	Premature respiratory mortality based on short-term study estimates (0-99)	✓	Ozone ISA
	Premature respiratory mortality based on long-term study estimates (age 30–99)	✓	Ozone ISA
Nonfatal morbidity from exposure to ozone	Hospital admissions—respiratory (ages 0-99)	✓	Ozone ISA
	Emergency department visits—respiratory (ages 0-99)	✓	Ozone ISA
	Asthma onset (0-17)	✓	Ozone ISA
	Asthma symptoms/exacerbation (asthmatics age 2-17)	✓	Ozone ISA
	Allergic rhinitis (hay fever) symptoms (ages 3-17)	✓	Ozone ISA
	Minor restricted-activity days (age 18–65)	✓	Ozone ISA
	School absence days (age 5–17)	✓	Ozone ISA
	Metabolic effects (e.g., diabetes)	✓	Ozone ISA

For regulatory analyses, the Agency estimated changes in health effects in response to modeled air quality changes for each health endpoint identified as causal or likely-to-be-causal in Table 3-1. The environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE) software program was used to quantify counts of premature deaths and illnesses attributable to photochemical modeled changes in annual mean $PM_{2.5}$ and summer season average ozone. This approach to estimating health impacts involved two major steps: (1) developing spatial fields of air quality across the U.S. for the baseline and regulatory scenarios using nationwide photochemical source apportionment modeling and related analyses; and (2) using these spatial fields in BenMAP-CE to quantify selected endpoints under each scenario and each year as compared to the baseline in that year while accounting for the changes in population size, income growth, and baseline incidence and prevalence rates.

Figure 3-1 summarizes the key data inputs and modeling steps for estimating the health impacts of a regulatory impact analysis using $PM_{2.5}$ inputs as an example.

Figure 3-1: Data Inputs and Outputs for the BenMAP-CE Model Using PM2.5 as an Example
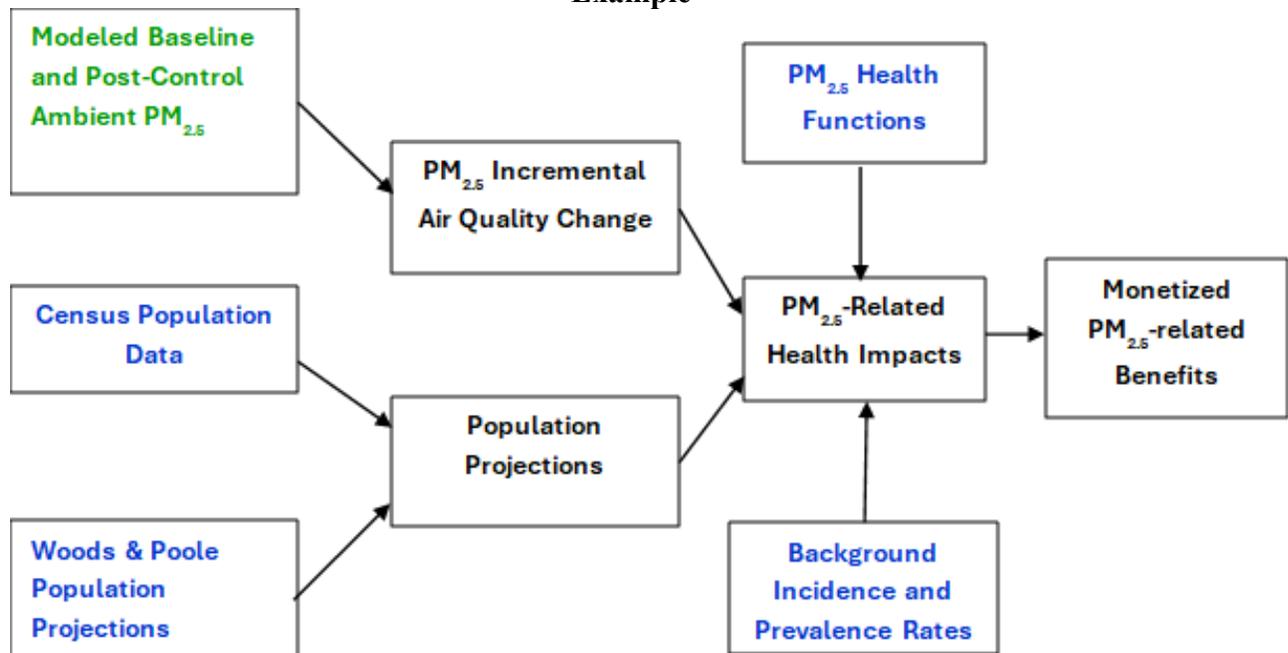
As the diagram above illustrates, the approach for estimating $PM_{2.5}$ and O_3 benefits included health effect risk estimates from epidemiologic studies, population data, population growth estimates, economic data for monetizing benefits, and assumptions regarding the future state of the world (i.e., on-the-books regulations). Each of these inputs has unique uncertainties associated with it. When the uncertainties from each stage of the analysis are compounded, even small uncertainties can have large effects on the total quantified benefits. Where possible, the EPA in the past has attempted to quantitatively assess uncertainty in each input parameter. In some cases, quantitative analysis has not been possible due to lack of data, so the Agency instead characterized the sensitivity of the results to alternative plausible input parameters. And, for some inputs into the benefits analysis, such as the air quality data, we lacked the data to perform either a quantitative uncertainty analysis or sensitivity analysis.

Throughout prior regulatory impact analyses, the EPA acknowledged these significant uncertainties around input parameters and employed various techniques for characterizing the resulting uncertainty in estimates of regulatory impacts. For example, the Agency has estimated the fraction of avoided health effects occurring at various concentration ranges, conducted sensitivity analyses, and employed alternate concentration-response assumptions to show how much estimates could vary depending on which assumptions and inputs were used.

Chapter 6 of the EPA Health Benefits TSD, Estimating $PM_{2.5}$ - and Ozone-Attributable Health Benefits: 2024 Update, details our approach to characterizing uncertainty associated with the estimation of $PM_{2.5}$ and O_3 benefits in both quantitative and qualitative terms (U.S. EPA, 2024). Some of the key types of uncertainty highlighted in this chapter include:

- Statistical uncertainty around the risk estimate

- Uncertainty around low concentration exposures and the potential for thresholds

- Uncertainty in exposure estimates

- Co-pollutant confounding

- Confounding by other individual risk factors

- Effect modification

- Application of risk estimates to other locations and populations

- Uncertainties regarding at-risk populations

- Baseline incidence rate uncertainties

- Economic valuation estimate uncertainties (e.g. income elasticity of willingness to pay, statistical estimates of VSL, Alzheimer's and Parkinson's onset lifetime costs)

- Unquantified uncertainties (e.g. causality determination, estimating and assigning exposures in epidemiology studies, risk attributable to long-term and short-term exposures, shape of the concentration-response relationship)

Despite substantial investments by the EPA in approaches to characterize uncertainties, the regulatory impact analyses have still tended to focus on point estimates for $PM_{2.5}$ and ozone-related benefits. Frequently, the Agency has utilized more than one epidemiologic study to estimate mortality impacts because these estimates drive overall benefits for a given regulatory action due to the large monetary value assigned to such impacts. Risk estimates using the top epidemiologic studies sometimes differ by a factor of two or more. Presenting multiple estimates drawn directly from the primary literature is one way to convey the prevailing uncertainty. While this leads to an estimated range of benefits, it is not a range that reflects the true uncertainties in the underlying parameters supporting each study, either for mortality or for other effects. Because of the significant impacts of environmental regulations on the U.S. economy, it is essential that the Agency have confidence in the estimated benefits of an action, and their underlying uncertainties, prior to utilizing these estimates in a regulatory context.

A 2024 Scientific Advisory Board reviewed EPA's methods for estimating the health effects of $PM_{2.5}$ and clearly and repeatedly recommended that EPA improve its approach to characterizing and presenting the uncertainty in estimating the health effects of $PM_{2.5}$.[23] A Tier 1 SAB recommendation was that the EPA present a single probabilistic mortality estimate based on pooled risk estimates with associated uncertainty ranges rather than present multiple estimates of mortality outcomes from the epidemiologic studies. EPA was encouraged to explore meta-

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[23] U.S. EPA. (2024). *Review of BenMAP and Benefits Methods.* (EPA/SAB/24/003). Washington DC: U.S. Environmental Protection Agency. Available at: https://sab.epa.gov/ords/sab/r/sab_apex/sab/advisoryactivitydetail?p18_id=2617&clear=18&session=15054897040198#report

analysis methods or other forms of information synthesis, and support research and development of modified methods as needed.

The OMB "2017 Report to Congress on the Benefits and Costs of Federal Regulations" listed six key assumptions underpinning PM$_{2.5}$ health effect estimation which introduce substantial uncertainties in the health effect estimates[24]:

1. That inhalation of fine particles is causally associated with premature death at concentrations near those experienced by most Americans on a daily basis;

2. That the concentration-response function for fine particles and premature mortality is approximately linear, even for concentrations below the levels established by the NAAQS;

3. That all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality;

4. That the forecasts for future emissions and associated air quality modeling accurately predict both the baseline (state of the world absent a rule) and the air quality impacts of the rule being analyzed;

5. That BPT approaches, when used to estimate benefits, are based on regional or national-level analysis that may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors; and

6. That the estimated value of mortality risk reductions is an accurate reflection of what people would be willing to pay for incremental reductions in mortality risk from air pollution exposure, and that these values are constant across the life-cycle.

To the extent that any of these assumptions is incorrect, the benefit estimates will change, though the magnitude of bias is not known with certainty. The EPA is interested in improving understanding in each of these six areas. EPA understands that additional research is needed, and will begin to develop approaches that reduce these uncertainties. The EPA will seek peer

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[24] See the OMB's "2017 Report to Congress on Benefits and Costs of Federal Regulations and Agency Compliance with the Unfunded Mandates Reform Act" for a fuller discussion on uncertainties. Available at https://trumpwhitehouse.archives.gov/wp-content/uploads/2019/12/2019-CATS-5885-REV_DOC-2017Cost_BenefitReport11_18_2019.docx.pdf

review for new methods developed from this work consistent with the OMB's Peer Review Guidance.[25]

In particular, the EPA is interested in reevaluating the validity of the approach for estimating the benefits of air quality improvements relative to the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ and ozone. These standards, which have been set at a level which the Administrator judges to be requisite to protect public health or welfare with an adequate margin of safety, are widely understood to represent the divide between clean air and air with an unacceptable level of pollution. Even in instances where an assumption is found to be justified based on scientific evidence, the EPA is interested in reevaluating its approach to characterizing and communicating underlying uncertainty to the public.

In the past, the EPA has explored a variety of approaches to shed light on how the estimated benefits of an action relate to the level of the NAAQS. For example, in estimating PM benefits, the Agency has employed techniques such as cutpoint analyses and Lowest Measured Level analyses, noting that we are most confident in the magnitude of the risks we project at $PM_{2.5}$ concentrations that coincide with the bulk of the observed $PM_{2.5}$ concentrations in the epidemiological studies that are used to estimate the benefits (Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units, Section 4.4.4, p. 4-26). However, such approaches address only a few of the sources of uncertainty that influence PM-related air quality benefits.

The limitations of reduced-form approaches, such as the BPT approach are even more pronounced than photochemical modeling/BenMAP-CE approaches due to: 1) the compounding effects of emissions reductions typically occurring across many geographic areas simultaneously, with varying proximity to population centers; 2) differing atmospheric transformation pathways for nitrous oxides (NO_X), volatile organic compounds (VOCs), and secondary $PM_{2.5}$; and 3) region-specific photochemical and meteorological conditions. Using a national BPT estimate implicitly assumes uniform marginal health benefits for each ton of reduced emissions, an

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[25] OMB (2005). *Memorandum M-05-03, Memorandum for the Heads of Executive Departments and Agencies: Issuance of OMB's Final Information Quality Bulletin for Peer Review*. Available at:https://www.federalregister.gov/documents/2005/01/14/05-769/final-information-quality-bulletin-for-peer-review.

assumption not supported given heterogeneity in exposure patterns and atmospheric chemistry. As more areas achieve or maintain attainment with the NAAQS, the uncertainties associated with low-concentration health effects grow, and marginal benefits become more difficult to characterize with precision.

Therefore, it may be appropriate for the EPA to separate exposures and impacts above the level of the standard from those occurring at lower ambient concentrations.

3.4   PM$_{2.5}$-Related Health Effects

PM$_{2.5}$ describes an array of pollutants from human and natural sources with diameters that are generally 2.5 micrometers and smaller. This includes directly emitted PM$_{2.5}$ as well as PM$_{2.5}$ formed through atmospheric chemical reactions of precursor pollutants including NO$_X$ and SO$_2$.

Following a comprehensive review of toxicological, clinical, and epidemiological evidence, the Integrated Science Assessment for Particulate Matter (PM ISA) (U.S. EPA, 2020a) and the Supplement to the Integrated Science Assessment for Particulate Matter (PM ISA Supplement) (U.S. EPA, 2022b) found PM$_{2.5}$ to be related to an array of adverse human health effects. For each effect, the PM ISA and PM ISA Supplement report relationships 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. This assessment is based on the body of scientific evidence which can include observational human studies, experimental human exposure studies, animal model studies, and mechanistic studies.

The PM ISA and PM ISA Supplement found acute and chronic exposures to PM$_{2.5}$ to be causally related to cardiovascular effects and total mortality (i.e., premature death), and respiratory effects as likely-to-be-causally related. Chronic exposures to PM$_{2.5}$ were also determined to be likely-to-be-causally related to nervous system effects and cancer, with the latter determination based primarily on evidence from studies of lung cancer incidence as well as decades of research on the mutagenicity and carcinogenicity of PM. Evidence was suggestive of a causal relationship for reproductive and developmental effects, pregnancy and birth outcomes, and metabolic effects.

When adequate data and resources are available, the EPA has generally quantified health effects which the PM ISA and PM ISA Supplement classified as causally related or likely-to-be-causally related to $PM_{2.5}$ exposure. Health effects classified as suggestive-of-causality or weaker have not historically been quantified. Historically quantified health effects include premature mortality, heart attacks, cardiovascular hospital admissions, cardiovascular emergency department visits, respiratory hospital admissions, respiratory emergency room visits, cardiac arrest, stroke, asthma onset, asthma symptoms/exacerbation, lung cancer, allergic rhinitis (hay fever) symptoms, lost workdays, and minor restricted-activity days. The EPA did not quantify or monetize the benefits or disbenefits associated with changes in the incidence of the listed health effects for this rule.

3.5   NO$_X$ -Related Health Effects

The Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (NO$_X$ ISA) reviewed evidence from epidemiologic and laboratory studies on the health effects of exposure to NO$_X$, concluding that there is a likely causal relationship between respiratory health effects and short-term exposure to nitrogen dioxide (NO_2) (U.S. EPA, 2016). Epidemiologic and experimental studies encompassed several endpoints including emergency department visits and hospitalizations, respiratory symptoms, airway hyperresponsiveness, airway inflammation, and lung function. The NO$_X$ ISA also concluded that the relationship between short-term NO_2 exposure and premature mortality was "suggestive but not sufficient to infer a causal relationship," because it is difficult to attribute the mortality risk effects to NO_2 alone. Although the NO$_X$ ISA stated that studies consistently reported a relationship between NO_2 exposure and mortality, the effect was generally smaller than that for other pollutants such as PM. NO$_X$ emissions are also a precursor to ozone and fine particulate matter ($PM_{2.5}$) and may affect human health through these additional pathways.

3.6   Ozone-Related Health Effects

Following a comprehensive review of toxicological, clinical, and epidemiological evidence, the Integrated Science Assessment for Ozone and Related Photochemical Oxidants (Ozone ISA) (U.S. EPA, 2020) found both short-term (i.e., less than one month) and long-term (i.e., one month or longer) ozone exposure to be related to an array of adverse human health effects. For each effect, the Ozone ISA reports relationships 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. This assessment is based on the body of scientific evidence which can include observational human studies, experimental human exposure studies, animal model studies, and mechanistic studies.

The Ozone ISA found short-term exposure to ozone to be causally related to respiratory effects, including respiratory mortality, and likely to be causally related to metabolic effects. For short-term exposure, evidence was suggestive of a causal relationship for cardiovascular and nervous system effects as well as total mortality. The Ozone ISA reported that long-term exposure to ozone is likely-to-be-causally related to respiratory effects, including respiratory mortality. Evidence on metabolic, cardiovascular, reproductive, and nervous system effects as well as total mortality was suggestive of a causal relationship with long-term ozone exposure.

When adequate data and resources are available, the EPA has generally quantified health effects which the Ozone ISA classified as causally related or likely-to-be-causally related to short- or long-term ozone exposure. Health effects classified as suggestive-of-causality or weaker have not historically been quantified. Historically quantified health effects include premature respiratory mortality, hospital admissions and emergency department visits, asthma onset and related symptoms (chest tightness, cough, shortness of breath, and wheeze), allergic rhinitis symptoms, as well as restricted activity days and school absences. The EPA did not quantify or monetize the benefits or disbenefits associated with changes in the incidence of the listed health effects for this rule.

3.7 Welfare Effects

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.[26]

Data, time, and resource limitations prevented EPA from quantifying the estimated health impacts associated with direct exposure to NO_2 and SO_2, independent of the role NO_2 and SO_2 play as precursors to $PM_{2.5}$ and ozone, ecosystem effects, and visibility impairment due to the absence of air quality modeling data for these pollutants in this analysis. Criteria pollutants from

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[26] 42 U.S. Code § 7602

U.S. electricity generating units (EGUs) such as LMWC facilities can also be transported downwind into foreign countries, in particular Canada and Mexico. Therefore, reduced criteria pollutants from U.S. EGUs can lead to public health and welfare benefits in foreign countries. EPA is currently unable to quantify these effects.

The EPA is also unable to quantify the incremental potential benefits of allowing facilities to utilize CEMS rather than only allowing the use of annual stack testing for PM, Hg, and HCl, but the requirement has been considered qualitatively. The continuous monitoring of these pollutants is not required by this rule, but if facilities were to choose to use CEMS for compliance, it would likely provide several additional benefits to the public which are not quantified in this rule, including greater certainty, accuracy, transparency, and granularity in emissions information than exists today.

3.7.1 *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, 2020a). 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.

3.7.2 *Visibility Effects*

Reducing secondary formation of $PM_{2.5}$ would improve levels of visibility in the U.S. because suspended particles and gases degrade visibility by scattering and absorbing light (U.S. EPA, 2019). Fine particles with significant light-extinction efficiencies include sulfates, nitrates, organic carbon, elemental carbon, and soil. Visibility has direct significance to people's enjoyment of daily activities and their overall sense of wellbeing. Good visibility increases the quality of life where individuals live and work, and where they engage in recreational activities. Particulate sulfate is the dominant source of regional haze in the eastern U.S. and particulate

nitrate is an important contributor to light extinction in California (U.S. EPA, 2019). Previous analyses such as U.S. EPA (2012) show that visibility benefits can be a significant welfare benefit category.

3.7.3 *Ozone: Animal Welfare Effects*

While effects can be context- and species-specific, a large body of scientific evidence links ozone exposure to health effects in animals. When exploring environmental pathways through which environmental effects of ozone may impact animals, the Ozone ISA found a likely-to-be-causal relationship between ambient ozone concentrations and alterations of herbivore growth and reproduction (U.S. EPA, 2020b, Girón-Calva et al. 2016, Habeck and Lindroth, 2013, Hong et al., 2016, Ueno et al., 2016). In addition, many animal toxicological studies served as evidence for determining the causality of relationships between human exposure to ozone and human health effects, including respiratory and metabolic effects. The Ozone ISA states, "A large body of experimental animal toxicological studies demonstrates (short- and long-term) ozone-induced changes in measures of lung function, inflammation, increased airway responsiveness, and impaired lung host defense" (U.S. EPA, 2020b). Additionally, animal studies report relationships between short-term ozone exposure and metabolic effects in various stocks and strains of animals across multiple laboratories (U.S. EPA, 2020b, Gordon et al., 2017, Miller et al., 2015, Ying et al., 2016,).

3.7.4 *PM: Animal Welfare Effects*

While effects can be context- and species-specific, a large body of scientific evidence links $PM_{2.5}$ exposure to health effects in animals. The PM ISA and PM ISA Supplement evaluated relationships exposures to $PM_{2.5}$ and an array of health markers described in animal toxicological studies. Animal toxicological studies have found evidence that $PM_{2.5}$ induces changes in measurements including but not limited to breathing patterns (Diaz et al., 2013), airway irritation (Nikolov et al., 2008), impaired heart function (Kurhanewicz et al., 2014), changes in blood pressure (Wagner et a., 2014), oxidative stress (Ghelfi et al., 2010, Davel et al., 2012), reproductive outcomes (Pires et al., 2011, Veras et al. 2012, de Melo et al., 2015), and other outcomes (U.S. EPA, 2019; U.S. EPA, 2022a).

However, neither the PM ISA nor the PM ISA Supplement provide a causality determination of the causality of PM$_{2.5}$ affecting animal health endpoints (U.S. EPA, 2019; U.S. EPA, 2022a).

4   ECONOMIC IMPACT ANALYSIS AND DISTRIBUTIONAL ASSESSMENTS

4.1   Introduction

The final 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 final 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.

4.2   Economic Impact Analysis

Although the full spectrum of 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 large MWC facilities.

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 final rule, given that the EAV of the compliance costs are $28 million using a seven percent or $25 million using a three percent discount rate, in 2024 dollars, which is small relative to the revenues of the MWC industry.

The EPA sometimes employs a "sales test", in which or annualized regulatory costs are calculated as a percentage of firm revenues, as the impact methodology in economic impact analyses. The sales test is useful in industries where compliance costs are born entirely by the regulated industry, with no regulatory cost pass-through to consumers). Alternatively, the sales test is useful when regulatory costs are solely incident on consumers of output directly affected by this action (therefore, no impact to firms that are producers of affected product). Thus, an analysis such as this one is best viewed as providing potential upper bounds on impacts on firms or consumers. An important limitation of "sales test" is that it does not consider shifts in supply and demand curves to reflect intermediate economic outcomes such as output adjustments in response to increased costs.

The sales test is generally preferred to the "profits test", in which annualized compliance costs are calculated as a share of profits. This is because revenue or sales data are often available for entities impacted by EPA regulations. Meanwhile, profits data, if available, are often based on accounting profits, which are not the true economic profits earned by firms due to accounting and tax considerations. True economic profit estimates would involve considerations of opportunity costs of the regulated entities, including the possible other uses or investments of funds used for capital and operations of controls. Therefore, accounting profits either match or exceed economic profits and may be an overstatement of the profitability of the sector.

The EPA's review of the regulated sector found that the inventory of 151 facilities was owned by 21 distinct ultimate parent entities, with each ultimate parent owning between one and 56 units. For each of these ultimate parent entities, the EPA compared the compliance costs of the rule to their estimated annual revenue, which is the "sales test". The average compliance cost ranged from 0.0 to 2.1 percent of annual entity revenue, with an average compliance cost of 0.4 percent of revenue.[27] Of the 21 ultimate parent companies that own and/or operate municipal waste combustors regulated under this rule, six facilities are assumed to be able to meet the final rule standards with no incremental compliance costs, most would incur annual compliance costs below one percent of their annual revenues, and two facilities would incur annual costs greater than one percent of their annual revenues. These costs are, thus, both small relative to the

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[27] The compliance cost estimates for this rulemaking account for the estimated costs of downtime for facilities installing controls, which include the lost revenue from generation of electricity as well as the reduced ability to process MSW.

receipts of the affected industry and lower than the costs of the 2024 proposed rule. Detailed results of this analysis can be found in the "2025 LMWC Final Rule Economic Analysis" workbook prepared by the EPA for this final rule and included in the final rule docket.

4.3   Employment Impacts Analysis

This section discusses employment impacts related to the rule. 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. A discussion of these potential labor demand channels and a review of relevant empirical literature is presented in Gray, Shadbegian, and Wolverton (2023).

Over the long run, environmental regulation is expected to cause a shift of employment among employers rather than affect the general employment level (Arrow et al., 1996; Hafstead and Williams, 2020). The expectation is that there will be a movement of labor towards jobs that are associated with greater environmental protection, and away from those that are not. Even if impacts are small after long-run market adjustments to full employment, many regulatory actions move workers in and out of jobs and industries, which are potentially important distributional impacts of environmental regulations in the shorter run (Walker, 2013; U.S. OMB, 2015). Transitional job losses have consequences for workers that operate in declining industries or occupations, have limited capacity to migrate, or live in communities or regions with high unemployment rates.

As indicated by the potential impacts to MWC facilities discussed in Section 4.2, the final 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. For this final rule, however, we do not have the data and analysis available to quantify these potential labor impacts.

4.4   Consumer Impact Analysis

Regulations that raise production costs or indirectly tax the production process raise prices and generate welfare implications for end consumers. In the MSW combustion sector, the regulated facilities and entities produce two consumable products: electricity and waste disposal. With respect to the electricity production of these facilities, we treat them as price-taking, meaning that they do not have the ability to influence the sale price of the electricity they generate to any significant extent and must take the market price of electricity as given. As a large portion of these facilities, if not all, primarily or fully sell their electricity to a grid rather than directly to end consumers, this assumption is appropriate. Therefore, we assume that the entities in question would pass the additional compliance costs on to their waste disposal consumers.

To attempt to quantify the impact to the waste disposal consumers served by these entities, the EPA estimated the impact of the final rule amendments on the final bills under the assumption that the facilities would pass the costs on to their consumers in a one-to-one fashion, dividing the cost across the households and population they serve. For the markets in question, we estimated the number of households served by each facility using an estimate of waste production per capita[28], divided the compliance cost for the facility across the households they each serve, using state-level data on individuals per household[29], and compared it to the average household waste disposal bill in the state in question[30]. For areas with waste disposal as a component of annual taxes, a change in the household bill estimate serves as a proxy for the change in annual taxes or an offset of other services funded by tax revenue. Finally, as households represent only a fraction of the customers served by MSW combustion facilities, assuming that the cost would fully be passed onto those households potentially overstates the impact and cost increases that could be expected for these households.

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[28] Waste production per household is assumed to be nationally homogeneous, with volume data from the EPA's "National Overview: Facts and Figures on Materials, Wastes and Recycling" (https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials).
[29] State-level household size date sourced from the U.S. Census's 2025 "World Population Review" (https://worldpopulationreview.com/state-rankings/average-household-size-by-state).
[30] State-level household waste disposal data sourced from DOXO's "2025 Household Bill Pay Report" (https://www.doxo.com/wp-content/uploads/2025/04/doxoINSIGHTS_2025_U.S._Household_Bill_Pay_Report.pdf).

For the affected entities and facilities, we estimate that the compliance costs would increase household bills by an average of 0.27 percent, with the facility-level price increase ranging from zero percent to 3.1 percent. Ownership of multiple facilities could distort these price differences across the facilities owned and/or operated by the same parent entity, and the one-to-one assumption of pass-through could overestimate or underestimate price changes if the entities in question found it optimal to only pass on a fraction of costs or if they found it optimal to include a markup factor.

4.5   Small Business Impact Analysis

To determine the possible impacts of the final 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, this final 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 final rule.

5   COSTS

5.1   Introduction

In this section, we present a comparison of the benefits and costs of this final action. As explained previously, all costs and benefits outlined in this RIA are estimated as the change from the baseline, which reflects current emission requirements. The compliance costs reflect the incremental application of existing control technologies or techniques at all 151 affected LMWCs for all pollutants under this final rule. As described in section 3 on benefits, EPA did not provide a monetized estimate of the benefits from emission reductions but did provide in the benefits section an extensive qualitative discussion of the benefits from the emission reductions expected to occur as a result of this final rule.

5.2   Results

As part of fulfilling analytical guidance with respect to E.O. 12866, EPA presents estimates of the present value (PV) costs over the period 2030 to 2049. To calculate the present value, annual costs are in 2024 dollars and are discounted to 2025 at three percent and seven percent discount rates as directed by OMB's Circular A-4. The EPA also presents the equivalent annualized value (EAV), which 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, and when discounted, this flow of constant annual values would yield a sum equivalent to the PV.

Table 5-1 details the projected annual emissions reductions presented and analyzed in this RIA. All annual pollutant reductions are listed in tons per year (tpy) except for Hg (stated in lb/yr) and D/F (g/yr). The final regulatory option is expected to reduce emissions of NO_X by 2,630 tpy, and HAP by approximately 641 tpy (mostly HCl).

Table 5-1: Annual Emission Reductions under the Final Rule[a,b]

Pollutant	Baseline Emissions	Emissions Reductions
Cadmium (Cd)	0.198	0.0024
Lead (Pb)	2.72	0.0409
Dioxins/Furans (D/F)	435	4.0
Hydrogen Chloride (HCl)	2,430	641
Nitrogen Oxides (Entire Year)	52,000	2,630
Nitrogen Oxides (Apr-Sep)	21,700	1,310

[a] Values have been rounded to three significant figures.
[b] Values are presented in tons per year (TPY) for all pollutants except Hg (lb/yr) and D/F (g/yr).

Table 5-2 presents a summary of the compliance costs of the final EG and NSPS amendments in terms of present value (PV) and equivalent annualized value (EAV).

Table 5-2: Summary of Compliance Costs and Benefits PV/EAV, 2030-2049 (million 2024$, discounted to 2025)[a,b,c,d]

		3% Discount Rate	7% Discount Rate
Compliance Costs	PV	$330	$210
	EAV	$25	$28
Non-Monetized Benefits in this Table	Benefits from reducing HAP such as mercury, cadmium, lead, and dioxin/furans		
	Benefits to human health from reduction of HCl, including corrosive impacts to throats		
	Benefits to human health from reduction of NO_X, particularly those with summer season ozone benefits		
	Visibility benefits from NO_X reductions		
	Benefits to vegetation and ecosystem services from NO_X reductions		

[a] Values have been rounded to two significant figures. Rows may not appear to sum correctly due to rounding.
[b] The equivalent annualized present value of costs is calculated over the 20-year period from 2030 to 2049. The choice of this analysis period is explained in Section 2 of this RIA.
[c] Non-monetized benefits include benefits from annual emission reductions in HAP including 0.0024 tons of cadmium, 0.0409 tons of lead and 4.00 grams of dioxin/furan. Details on how these emission reductions were estimated can be found in Section 2 of this RIA. In addition, benefits to provision of ecosystem services associated with reductions in nitrogen deposition and ozone concentrations are not monetized.

5.3 Section 14192 Regulatory Accounting

The PV and EAV presented in Table 5-2 are based on a 20-year analytic timeframe (2030 to 2049) using a 2025 present value year and beginning-of-period discounting. For E.O. 14192 regulatory accounting purposes, EPA has prepared an alternative analysis that estimates costs in perpetuity. This requires EPA to extrapolate costs beyond the 20-year analytic timeframe. For this rule, EPA projects that the annual operating costs repeat indefinitely and uniformly. Based on equipment life estimates, the capital costs for NO_X are assumed to repeat every 20 years (2030, 2050, 2070, and 2090) while those for particulates are assumed to repeat every 15 years (2030, 2045, 2060, 2075, and 2090). When using an infinite time horizon, the estimated present value of the costs of this rule is $250 million and the annualized value of the costs of this rule is $18 million using a seven percent discount rate (2024$, discounted to 2025). This analysis is provided in the file named "EO 14192 Workbook - LMWC.xlsx."

5.4 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 final amendments. We summarize the key elements of our discussions of uncertainty here:

Projection methods and assumptions: The 57 facilities that operate the 151 large MWCs impacted by this final rule are assumed to be the affected source population over the course of the analysis period. Unexpected facility closure or idling during the analysis period, whether due to the final rule or other factors, will affect the number of facilities subject to the final amendments as well as the impact estimates. 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 final rules in the future.

Years of analysis: The years of the cost analysis are 2030, to represent the first-year facilities are fully compliant with the final rule, through 2049, to present 20 years of potential regulatory impacts, as discussed in Section 3. Extending the analysis beyond 2049 would introduce substantial and increasing uncertainties in the projected impacts of the final rule.

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 final 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. The cost analysis for this final rule draws upon inventory data for LMWCs that has considerable detail on emission controls, so the data the EPA has on emission controls as a basis for analysis of options is considerable and accurate. We use a single interest rate (the bank prime rate as of September 2022), which reflects decisions by the Federal Reserve and is readily obtainable at the Federal Reserve's web site, to estimate annualized capital costs, and it is possible that affected firms and sources may finance compliance costs using different interest rates. This interest rate is a private one given that it reflects interest rates for financing as faced by large financial institutions and businesses. It is not a social discount rate in that the rate does not reflect impacts that are measured as those experience by society as a whole but is rather reflecting a rate specific to affected entities. The Agency does not have information on specific interest rates that may be relevant for the financing of capital investments, such as those for compliance efforts, by large MWCs, and no information on such interest rates was offered by

commenters on the proposed rule. Use of a single interest rate provides consistency in cost estimation but may lead to uncertainty in the actual estimate of cost for specific affected facilities.

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 associated with the final amendments could be over or underestimated. Similarly, as data are not easily accessible from this source category, the emissions data collected in the 2000-2009, and occasionally, more recent years if available, were used to estimate baseline emissions from which emissions reductions are calculated. There may be changes in the composition of municipal solid waste since the early 2000s that are not fully characterized by these data. More detailed information on the estimated emission reductions of this final rule can be found in "*Emission Reduction Estimates for Existing Large MWCs Final Rule Amendments,*" a memo that is available in the docket to this rulemaking.

Non-monetized benefits: Numerous categories of health and welfare benefits are not quantified and monetized in this RIA. These unquantified benefits, along with potential impacts of exposure to emissions of pollutants such as HAP that are to be reduced by this final action, are described in detail in Section 3 of this RIA.

PM health impacts: In this RIA, we qualitatively describe 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.

6   REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR) 1998. Toxicological Profile for Chlorinated Dibenzop-Dioxins. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR, 1999). Toxicological Profile for Mercury. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. https://www.atsdr.cdc.gov/toxprofiles/tp46.pdf

Agency for Toxic Substances and Disease Registry (ATSDR). 2012. Toxicological profile for Cadmium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Agency for Toxic Substances and Disease Registry (ATSDR). 2020. Toxicological profile for Lead. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Arrow, K. J.; M. L. Cropper; G. C. Eads; R. W. Hahn; L. B. Lave; R. G. Noll; Paul R. Portney; M. Russell; R. Schmalensee; V. K. Smith and R. N. Stavins (1996). "Benefit-Cost Analysis in Environmental, Health, and Safety Regulation: A Statement of Principles." American Enterprise Institute, the Annapolis Center, and Resources for the Future; AEI Press

BenMAP-CE Manual and Appendices, (2022). https://www.epa.gov/benmap/benmap-ce-manual-and-appendices

Chartwell Information Publishers, Inc (1998). Chartwell's Directory and Atlas of Solid Waste Disposal Facilities, 1997-98.

Gray, W.B., Shadbegian, R. and Wolverton, A. (2023). Environmental Regulation and Labor Demand: What Does the Evidence Tell Us? Annual Review of Resource Economics, 15, pp.177-197. https://doi.org/10.1146/annurev-resource-101422-115834

Hafstead, M.A. and Williams III, R.C. (2020). Jobs and environmental regulation. Environmental and Energy Policy and the Economy, 1(1), pp.192-240. https://doi.org/10.1086/706799

U.S. Environmental Protection Agency), (1985). U.S. EPA. Health Assessment Document for Polychlorinated Dibenzo-P-Dioxins, Washington, D.C., EPA/600/8-84/014F (NTIS PB86122546.

U.S. Environmental Protection Agency, (1987). Integrated Risk Information System (IRIS) on Cadmium. National Center for Environmental Assessment, Office of Research and Development, Washington, DC.

U.S. Environmental Protection Agency, (1989a). Integrated Risk Information System (IRIS) on

Cadmium. National Center for Environmental Assessment, Office of Research and Development, Washington, DC.

U.S. Environmental Protection Agency (1989b). In three parts: Final Report of the Municipal Solid Waste Task Force, EPA/530-SW-89-019. Background Document, EPA/530-SW-88-054a. Appendices A-B-C, EPA/530-SW-88-054b.

U.S. Environmental Protection Agency, (1995). Integrated Risk Information System File of Hydrogen Chloride. Research and Development, National Center for Environmental Assessment, Washington, DC

U.S. Environmental Protection Agency, (2004). IRIS Summary on Lead and compounds (inorganic). National Center for Environmental Assessment, Office of Research and Development, Washington, DC.

U.S. EPA. (2012b). Integrated Risk Information System (IRIS) on 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD). National Center for Environmental Assessment, Office of Research and Development, Washington, DC.

U.S. EPA. (2016) Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (Final report, 2016) Research Triangle Park, NC. U.S. EPA. EPA/600/R-15/068 Available at: https://ordspub.epa.gov/ords/eims/eimscomm.getfile?p_download_id=526855

U.S. EPA, (2017a). EPA Air Pollution Control Cost Manual. Available at https://www.epa.gov/economics-and-cost-analysis-of-air-pollution-regulations/cost-reports-and-guidance-air-pollution#cost%20manual.

U.S. EPA, (2018). Facts and Figures about Materials, Waste and Recycling - Other Nonferrous Metals: Material-Specific Data. Available at https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/other-nonferrous-metals-material-specific#:~:text=Other%20nonferrous%20metals%20such%20as,municipal%20solid%20waste%20(MSW).

U.S. EPA. (2019). Integrated Science Assessment for Particulate Matter. EPA/600/R-08/139F.

U.S. EPA (2020a). Integrated Science Assessment for Ozone and Related Photochemical Oxidants. U.S. Environmental Protection Agency. Washington, DC. Office of Research and Development. EPA/600/R-20/012. Available at: https://www.epa.gov/isa/integrated-science-assessment-isa-ozone-and-related-photochemical-oxidants.

U.S. EPA (2020b). Policy Assessment for the Review of the National Ambient Air Quality Standards for Particulate Matter. Office of Air Quality Planning and Standards, Health and Environmental Impacts Division. Research Triangle Park, NC. U.S. EPA. EPA452/R-20-002. January 2020. Available at:https://www.epa.gov/system/files/documents/2021-10/final-policy-assessment-for-thereview-of-the-pm-naaqs-01-2020.pdf.

U.S. EPA (2022a). Regulatory Impact Analysis for the Final Reconsideration of the National

Ambient Air Quality Standards for Particulate Matter. Office of Air Quality Planning and Standards, Health and Environmental Impacts Division, Research Triangle Park, NC. Docket number: EPA-HQ-OAR-2019-0587. Available at: https://www.epa.gov/system/files/documents/2023-01/naaqs-pm_ria_final_2022-12.pdf.

U.S. EPA (2022b). Policy Assessment for the Reconsideration of the National Ambient Air Quality Standards for Particulate Matter. Office of Air Quality Planning and Standards, Health and Environmental Impacts Division, Research Triangle Park, NC. EPA-452/R-22-004. Available at: https://www.epa.gov/system/files/documents/2022-5/Final%20Policy%20Assessment%20for%20the%20Reconsideration%20of%20the%20PM%20NAAQS_May2022_0.pdf.

U.S. EPA (2024). Integrated Science Assessment (ISA) for Lead (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-23/375.

U.S. Environmental Protection Agency, (2024b). Guidelines for Preparing Economic Analyses (3rd edition). Washington, DC, EPA-240-R-24-001.

Walker, W.R. (2013). The transitional costs of sectoral reallocation: Evidence from the clean air act and the workforce. The Quarterly journal of economics, 128(4), pp.1787-1835. https://doi.org/10.1093/qje/qjt022