# Regulatory Impact Analysis for the Final New Source Performance Standards for the Synthetic Organic Chemical Manufacturing Industry and National Emission Standards for Hazardous Air Pollutants for the Synthetic Organic Chemical Manufacturing Industry and Group I & II Polymers and Resins Industry

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# 1 EXECUTIVE SUMMARY

## 1.1 Introduction

The U.S Environmental Protection Agency (EPA) is finalizing amendments to the National Emissions Standards for Hazardous Air Pollutants (NESHAP) for subparts (40 CFR part 63, subparts F, G, H, and I) that apply to the synthetic organic chemical manufacturing industry (SOCMI) and to equipment leaks from certain non-SOCMI processes[1] located at chemical plants. These four NESHAP are more commonly referred to together as the Hazardous Organic NESHAP (HON). The HON contains maximum achievable control technology (MACT) standards for hazardous air pollutants (HAP) from heat exchange systems, process vents, storage vessels, transfer racks, wastewater, and equipment leaks at chemical plants that are major sources of HAP-producing SOCMI chemicals (*e.g.*, bulk commodity chemicals) and for equipment leaks for certain non-SOCMI chemical processes. The EPA is also revising NESHAP requirements for storage tanks, loading operations, and equipment leaks to reflect cost-effective developments in practices, processes, or controls of HAP.

The EPA is also finalizing amendments to the NESHAP for subparts (40 CFR part 63, subparts U and W) that apply to the polymers and resins (P&R) Group I and II industries. P&R Group I refers to major source facilities that produce certain elastomers and regulates HAP emissions from nine different source categories. P&R Group I contains MACT standards for HAP from storage tanks, process vents, equipment leaks, wastewater systems, and heat exchange systems. P&R Group II applies to existing and new epoxy resins and non-nylon polyamides production operations that are located at major sources. Similarly, P&R Group II contains MACT standards for HAP from storage tanks, process vents, equipment leaks, and wastewater systems.

The EPA is also finalizing New Source Performance Standards (NSPS) to reflect best system of emissions reduction for four SOCMI NSPS subparts (40 CFR part 60, subparts III, NNN, RRR, and VV) for emissions of volatile organic compounds (VOC) from SOCMI air oxidation unit processes, SOCMI distillation operations, SOCMI reactor processes, and

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[1] NESHAP Subpart I provides the applicability criteria for the non-SOCMI processes subject to the negotiated regulation for equipment leaks and requires owners and operators to comply with subpart H.

equipment leaks located at SOCMI sources. The rule also includes revisions related to emissions during periods of startup, shutdown, and malfunction (SSM); additional requirements for electronic reporting of performance test results, performance evaluation reports, and compliance reports; revisions to monitoring and operating requirements for control devices; and other minor technical improvements.

### *1.1.1 NESHAP for subparts F, G, H, I, U, & W*

The statutory authority for the NESHAP amendments is provided by sections 112 and 301 of the Clean Air Act (CAA), as amended (42 U.S.C. 7401 *et seq.*). Section 112 of the CAA establishes a two-stage regulatory process to develop standards for emissions of HAP from stationary sources. Generally, the first stage involves establishing technology-based standards and the second stage involves evaluating those standards that are based on maximum achievable control technology (MACT) to determine whether additional standards are needed to address any remaining risk associated with HAP emissions. In the second stage of the regulatory process, the CAA requires the EPA to undertake two different analyses, which we refer to as the technology review and the residual risk review. Under the technology review, we must review the technology-based standards and revise them "as necessary (taking into account developments in practices, processes, and control technologies)" no less frequently than every 8 years, pursuant to CAA section 112(d)(6). Under the residual risk review, we must evaluate the risk to public health remaining after application of the technology-based standards and revise the standards, if necessary, to provide an ample margin of safety to protect public health or to prevent, taking into consideration costs, energy, safety, and other relevant factors, an adverse environmental effect. The residual risk review is required within 8 years after promulgation of the MACT standards, pursuant to CAA section 112(f).

In the first stage of the CAA section 112 standard setting process, the EPA promulgates technology-based standards under CAA section 112(d) for categories of sources identified as emitting one or more of the HAP listed in CAA section 112(b). Sources of HAP emissions are either major sources or area sources, and CAA section 112 establishes different requirements for major source standards and area source standards. "Major sources" are those that emit or have the potential to emit 10 tons per year (tpy) or more of a single HAP or 25 tpy or more of any combination of HAP. All other sources are "area sources." For major sources, CAA section

112(d)(2) provides that the technology-based NESHAP must reflect the maximum degree of emission reductions of HAP achievable (after considering cost, energy requirements, and non-air quality health and environmental impacts). These standards are commonly referred to as MACT standards. CAA section 112(d)(3) also establishes a minimum control level for MACT standards, known as the MACT "floor." In certain instances, as provided in CAA section 112(h), the EPA may set work practice standards in lieu of numerical emission standards. The EPA must also consider control options that are more stringent than the floor. Standards more stringent than the floor are commonly referred to as beyond-the-floor standards. For area sources, CAA section 112(d)(5) allows the EPA to set standards based on generally available control technologies or management practices (GACT standards) in lieu of MACT standards. For categories of major sources and any area source categories subject to MACT standards, the second stage in standard-setting focuses on identifying and addressing any remaining (*i.e.,* "residual") risk pursuant to CAA section 112(f) and concurrently conducting a technology review pursuant to CAA section 112(d)(6). MACT standards were finalized for the HON source category in 1994. The residual risk and technology review (RTR) was finalized in 2006.

The MACT standards for P&R Group I (40 CFR part 63, subpart U) were initially promulgated in 1996. Most recently, the agency conducted its RTR of the Group I NESHAP in 2008, for four source categories, and in 2011, for the remaining source categories. The MACT standards for P&R Group II (40 CFR part 63, subpart W) were initially promulgated in 1995, with the agency most recently conducting its RTR of the Group II NESHAP in 2008.

The source categories that are the subject of this rulemaking include the HON source category (the facilities, sources and processes of which we often refer to as "HON facilities," "HON sources," and "HON processes") and several Polymers and Resins Production source categories covered in P&R Group I and II (see section II.B of the preamble for detailed information about the source categories). The North American Industry Classification System (NAICS) code for SOCMI facilities begins with 325, for P&R I is 325212, and for P&R II is 325211. The list of NAICS codes is not intended to be exhaustive, but rather provides a guide for readers regarding the entities that this final action is likely to affect.

As defined in the Initial List of Categories of Sources Under Section 112(c)(1) of the CAA Amendments of 1990 (see 57 FR 31576, July 16, 1992) and Documentation for

Developing the Initial Source Category List, Final Report (see EPA-450/3-91-030, July 1992), the SOCMI source category is any facility engaged in "manufacturing processes that produce one or more of the chemicals [listed] that either (1) use an organic HAP as a reactant or (2) produce an organic HAP as a product, co-product, by-product, or isolated intermediate." Related chemicals for the HON and P&R Group I and II source categories are listed in the Industry Profile section of this report.

This action constitutes another CAA section 112(d)(6) technology review for the HON, P&R I, and P&R II. This action also constitutes an updated CAA section 112(f) risk review based on new information for the HON and for affected sources producing neoprene subject to P&R I. We note that although there is no statutory CAA obligation under CAA section 112(f) for the EPA to conduct a second residual risk review of the HON or standards for affected sources producing neoprene subject to P&R I, the EPA retains discretion to revisit its residual risk reviews where the Agency deems that is warranted; for additional information on statutory authority please see section II.A of the preamble.

### *1.1.2 NSPS subparts III, NNN, RRR, & VVb*

The EPA's authority for the NSPS is CAA section 111, which governs the establishment of standards of performance for stationary sources. CAA section 111(b)(1)(A) requires the EPA Administrator to list categories of stationary sources that in the Administrator's judgment cause or contribute significantly to air pollution that may reasonably be anticipated to endanger public health or welfare. The EPA must then issue performance standards for new (and modified or reconstructed) sources in each source category pursuant to CAA section 111(b)(1)(B). These standards are referred to as new source performance standards, or NSPS. The EPA has the authority under CAA section 111(b) to define the scope of the source categories, determine the pollutants for which standards should be developed, set the emission level of the standards, and distinguish among classes, type, and sizes within categories in establishing the standards.

Section 111(b)(1)(B) of the CAA requires the EPA to "at least every 8 years review and, if appropriate, revise" new source performance standards. Section 111(a)(1) of the CAA provides that performance standards are to "reflect the degree of emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction and any non-air quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated." We refer to this level of control as the best system of emission reduction or "BSER." The term "standard of performance" in CAA 111(a)(1) makes clear that the EPA is to determine both the BSER for the regulated sources in the source category and the degree of emission limitation achievable through application of the BSER. The EPA must then, under CAA section 111(b)(1)(B), promulgate standards of performance for new sources that reflect that level of stringency. These subparts were originally promulgated pursuant to CAA section 111(b) on June 29, 1990 (subparts III and NNN); August 31, 1993 (subpart RRR); and November 16, 2007 (subpart VV).

The emission sources covered by these NSPS subparts are comparable (and in many instances are the same) as HON sources subject to the standards for process vents (NSPS III, NNN, and RRR) and equipment leaks (NSPS VV), though regulated pollutants and definitions of what constitutes an affected source/affected facility are different between the NESHAP and NSPS. The emissions limits for these NSPS regulate VOC that are in many instances also HAP.

## 1.2 Market Failure

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

While recognizing that the optimal social level of pollution may not be zero, HAP and VOC emissions impose costs on society, such as negative health and welfare impacts (that are discussed in the benefits chapter of this RIA), that are not reflected in the market price of the goods produced through the polluting process. For this regulatory action, the goods produced are chemical products (e.g., butadiene, ethylene oxide). If processes of producing chemicals, such as butadiene or ethylene oxide, yield pollution emitted into the atmosphere, the social costs imposed by the pollution will not be borne by the polluting firms but rather by society as a whole. In addition, in the case of this regulation, it's not just the pollution from the process that poses a negative externality, but the fugitive emissions of the goods themselves (e.g., ethylene oxide itself is harmful to society, not just the pollution from the process of making ethylene oxide). Thus, the producers are imposing a negative externality, or a social cost from these emissions, on society. The equilibrium market price of chemical products such as butadiene or ethylene oxide may fail to incorporate the full opportunity cost to society of consuming the chemical product. Consequently, absent a regulation or some other action to limit such emissions, producers will not internalize the negative externality of pollution due to emissions and social costs will be higher as a result. This regulation will serve to address this market failure by causing affected producers to begin internalizing the existing negative externality associated with HAP and other emissions also affected by this rule such as VOC.

## 1.3 Results for the Final Action

We present benefits and costs for each final rule and their more and less stringent alternatives. We group the impacts of the IIIa, NNNa, and RRRa NSPS together for presentational clarity and consistency with the presentation of impacts for these three NSPS in the preamble and the remainder of the materials for this final action. All benefits and costs outlined in this RIA are estimated as the change from the baseline, which reflects the current business practice for the affected sources. There is no monetized estimate of the benefits for the HAP emission reductions expected to occur as a result of this final action. We do present monetized estimates for other impacts of this action, such as benefits from both short- and long-term reduced exposure to ozone caused by VOC emissions reductions, benefits from decreases in $CH_4$ emissions, and disbenefits from increases in $CO_2$ and $N_2O$ emissions.

### *1.3.1 Baseline for the Regulation*

The impacts of regulatory actions are evaluated relative to a baseline that represents, to the extent possible, the world without the regulatory action. Throughout this document, the EPA focuses the analysis on the final regulatory requirements that result in quantifiable compliance cost or emissions changes compared to the baseline as identified above. For each rule and most emissions sources, the EPA assumed each facility achieved emissions control meeting current standards and estimated emissions reductions and cost relative to this baseline. The baseline for the analysis includes “excess emissions” from SOCMI sources, which are emissions from the source category that should be controlled to current standards but in practice are not.

We calculate cost and emissions reductions relative to the baseline (inclusive of excess emissions) for the period 2024-2038. This time frame spans the time period from when the NSPSs take effect (under the presumption that these rules are finalized in 2024 as per the consent decree under which this rulemaking is being prepared) through the lifetime of the typical capital equipment (15 years) expected to be installed as a result of the NESHAP and NSPS amendments.

The summaries of impact results below are for the final options. In accordance with the OMB Circular A-4 (US OMB, 2003),[2] we also present impact results for a more stringent and less stringent set of options as defined by that circular, which is the guidance for regulatory analysis to be followed by Federal agencies preparing an RIA such as this one. These alternatives are defined in Chapter 6, where results are presented for these options along with those for the final policy option.

### *1.3.2 Overview of Costs and Benefits for the Final Options*

The amendments to this chemical sector package constitute a significant regulatory action. This action is significant, under Executive Order 14094, because it likely to have an annual effect on the economy of $200 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or state, local, or tribal governments or communities. The EPA monetized the projected benefits of reducing VOC emissions in terms of the value of avoided ozone and $NO_x$-attributable deaths and illnesses, both short- (ST) and long-term (LT). The EPA also monetized the benefits and disbenefits from changes in emissions of greenhouse gases (GHG) such as carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), and methane ($CH_4$). In addition, we include a discussion of the unmonetized benefits that will result from this final rulemaking.

Table 1-1 through Table 1-5 present the projected ozone health benefits, climate benefits from $CH_4$ reductions, climate disbenefits from $CO_2$ and $N_2O$, compliance costs, net benefits, and unmonetized HAP emission reductions from the amendments to each regulatory action included in this rulemaking. The projected climate disbenefits are caused by combusting emissions in flares, thermal oxidizers, and increased electricity usage for the emission controls included in the cost analysis. Projected climate benefits are caused by reduction of $CH_4$ emissions from control

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[2] U.S. Office of Management and Budget. Circular A-4, “Regulatory Analysis.” September 17, 2003. Available at https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A4/a-4.pdf. Draft revisions to Circular A-4 became final in November 2023 but will not become effective until after this rule is promulgated. Hence, the 2003 Circular A-4 will be a basis for the analyses in this RIA.

of flares. Certain control options analyzed in this RIA lead to chemical product recovery, which has been monetized as product recovery credits that are incorporated into the annual cost calculations. Net compliance costs are calculated as total compliance costs minus product recovery credits. For a discussion of product recovery, see Chapter 3. Monetized net benefits are projected to be negative under each discount rate used in the analysis. The benefits from HAP reductions (annually) and VOC reductions outside of the ozone season (May-September) have not been monetized for this action. If we were able to monetize these beneficial impacts, it would increase the net benefits of this analysis. In addition, the emissions control of HAP reductions is tied to bringing the cancer risks down to an acceptable level, so while we are unable to monetize what that HAP reduction is, that the reduction quantity is tied to a health-based threshold.

As mentioned earlier, we calculate cost and emissions reductions relative to the baseline for the period 2024-2038, with costs discounted to 2023.

**Table 1-1 Monetized Benefits, Compliance Costs, Emission Reductions and Net Benefits for Amendments to the HON (dollars in million 2021$[3])[a]**

| | **3 Percent Discount Rate** | | **7 Percent Discount Rate** | |
|---|---|---|---|---|
| | **PV** | **EAV** | **PV** | **EAV** |
| Monetized Health Benefits[b] | 70 and 630 | 5.9 and 53 | 48 and 420 | 5.2 and 46 |
| Climate Disbenefits[c] | 140 | 11 | 140 | 11 |
| Net Compliance Costs[d] | 1,550 | 130 | 1,200 | 130 |
| *Compliance Costs* | 1,560 | 130 | 1,200 | 130 |
| *Value of Product Recovery* | 12 | 1 | 9 | 1 |
| **Net Benefits** | **(1,600) and (1,100)** | **(140) and (88)** | **(1,300) and (920)** | **(140) and (95)** |
| Nonmonetized Benefits | 1,107 tons of HAP emission reductions. Health effects from reduced exposure to ethylene oxide, chloroprene, benzene, 1,3-butadiene, vinyl chloride, ethylene dichloride, chlorine, maleicanhydride, and acrolein | | | |

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted. A number in parentheses denotes a negative value.

[b] Monetized health benefits include ozone related health benefits associated with reductions in VOC emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The two benefits estimates are separated by the word "and" to signify that they are two separate estimates. The estimates do not represent lower- and upper-bound estimates. Benefits from HAP reductions (annually) and VOC reductions (outside of the ozone season) remain unmonetized and are thus not reflected in the table. The unmonetized effects also include disbenefits resulting from the secondary impact of an increase in CO emissions.

[c] Monetized climate benefits and disbenefits are based on increases in $CO_2$ and $N_2O$ emissions and decreases in $CH_4$ emissions and are calculated using three different estimates of the social cost of each greenhouse gas (SC-GHG)

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[3] When necessary, dollar figures in this RIA have been converted to 2021$ using the annual GDP Implicit Price Deflator values in the U.S. Bureau of Economic Analysis' (BEA) NIPA Table 1.1.9 found at <https://fred.stlouisfed.org/release/tables?rid=53&eid=41158>.

(under 1.5 percent, 2.0 percent, and 2.5 percent near-term Ramsey discount rates). For the presentational purposes of this table, we show the net climate disbenefits associated with the SC-GHG at a 2 percent near-term Ramsey discount rate.

[d] Net compliance costs are the engineering control costs minus the value of recovered product.

**Table 1-2 Monetized Benefits, Compliance Costs, and Net Benefits for Amendments to P&R I (dollars in million 2021$)[a]**

| | 3 Percent Discount Rate | | 7 Percent Discount Rate | |
|---|---|---|---|---|
| | **PV** | **EAV** | **PV** | **EAV** |
| Health Benefits[b] | (0.2) and (1.7) | (0.02) and (0.1) | (0.2) and (1.5) | (0.02) and (0.2) |
| Climate Disbenefits[c] | 22 | 2 | 22 | 2 |
| Net Compliance Costs[d] | 140 | 12 | 110 | 12 |
| *Compliance Costs* | 140 | 12 | 110 | 12 |
| *Value of Product Recovery* | 1 | 0.2 | 1 | 0.1 |
| **Net Benefits** | **(160) and (160)** | **(14) and (14)** | **(130) and (130)** | **(14) and (14)** |
| Nonmonetized Benefits | 264 tons per year (tpy) of HAP reductions, including an approximate 14 tpy reduction in chloroprene emissions | | | |

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted. A number in parentheses denotes a negative value.

[b] Monetized health benefits include ozone related health benefits associated with reductions in VOC emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The two benefits estimates are separated by the word "and" to signify that they are two separate estimates. The estimates do not represent lower- and upper-bound estimates. Benefits from HAP reductions and VOC reductions outside of the ozone season remain unmonetized and are thus not reflected in the table. The unmonetized effects also include disbenefits resulting from the secondary impact of an increase in CO emissions.

[c] Monetized climate benefits and disbenefits are based on increases in $CO_2$ and $N_2O$ emissions and decreases in $CH_4$ emissions and are calculated using three different estimates of the social cost of each greenhouse gas (SC-GHG) (under 1.5 percent, 2.0 percent, and 2.5 percent near-term Ramsey discount rates). For the presentational purposes of this table, we show the net climate disbenefits associated with the SC-GHG at a 2 percent near-term Ramsey discount rate.

[d] Net compliance costs are the engineering control costs minus the value of recovered product. A negative net compliance costs occurs when the value of the recovered product exceeds the compliance costs.

**Table 1-3 Monetized Benefits, Compliance Costs, and Net Benefits for Amendments to P&R II (dollars in million 2021$)[a]**

| | 3 Percent Discount Rate | | 7 Percent Discount Rate | |
|---|---|---|---|---|
| | **PV** | **EAV** | **PV** | **EAV** |
| Monetized Health Benefits[b] | 0 | 0 | 0 | 0 |
| Climate Disbenefits | 0 | 0 | 0 | 0 |
| Net Compliance Costs[c] | 15 | 1.3 | 11 | 1.3 |
| *Compliance Costs* | *15* | *1.3* | *11* | *1.3* |
| *Value of Product Recovery* | *0* | *0* | *0* | *0.0* |
| **Net Benefits** | **(15)** | **(1.3)** | **(11)** | **(1.3)** |
| Nonmonetized Benefits | 1 ton/year of HAP emission reduction. Reduced health exposure to epichlorohydrin | | | |

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

[b] There are no monetized health benefits for this final rule. There are also no climate benefits or disbenefits for the final amendments to P&R II. The unmonetized effects also include disbenefits resulting from the secondary impact of an increase in CO emissions.

[c] Net compliance costs are the engineering control costs minus the value of recovered product. A negative net compliance costs occurs when the value of the recovered product exceeds the compliance costs. For the final amendments to P&R II, there is no product recovery.

**Table 1-4 Monetized Benefits, Compliance Costs, and Net Benefits for NSPS subpart VVb (dollars in million 2021$)[a]**

| | 3 Percent Discount Rate | | 7 Percent Discount Rate | |
|---|---|---|---|---|
| | **PV** | **EAV** | **PV** | **EAV** |
| Monetized Health Benefits[b] | 1.3 and 12 | 0.1 and 1.0 | 0.9 and 7.9 | 0.1 and 0.9 |
| Net Compliance Costs[c] | 11 | 0.9 | 8.0 | 0.9 |
| *Compliance Costs* | *15* | *1.2* | *11* | *1.2* |
| *Value of Product Recovery* | *3.7* | *0.3* | *2.8* | *0.3* |
| **Net Benefits** | **(9.7) and 1** | **(0.8) and 0.1** | **(7.1) and (0.1)** | **(0.8) and (0.0)** |

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

[b] Monetized benefits include ozone related health benefits associated with reductions in VOC emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The two benefits estimates are separated by the word "and" to signify that they are two separate estimates. The estimates do not represent lower- and upper-bound estimates. Benefits from HAP reductions and VOC reductions outside of the ozone season remain unmonetized and are thus not reflected in the table. There are no climate benefits or disbenefits associated with this NSPS.

[c] Net compliance costs are the engineering control costs minus the value of recovered product. A negative net compliance costs occurs when the value of the recovered product exceeds the compliance costs.

**Table 1-5 Monetized Benefits, Compliance Costs, and Net Benefits for Amendments to Subparts IIIa, NNNa, and RRRa (dollars in million 2021$)[a]**

| | 3 Percent Discount Rate | | 7 Percent Discount Rate | |
|---|---|---|---|---|
| | **PV** | **EAV** | **PV** | **EAV** |
| Monetized Health Benefits[b] | 6 and 54 | 0.5 and 4.6 | 5.3 and 47 | 0.6 and 5.2 |
| Climate Disbenefits[c] | 4 | 0.3 | 4 | 0.3 |
| Net Compliance Costs[d] | 58 | 4.9 | 47 | 5.2 |
| *Compliance Costs* | 58 | 4.9 | 47 | 5.2 |
| *Value of Product Recovery* | *0* | *0* | *0* | *0* |
| **Net Benefits** | **(56) and (8)** | **(4.7) and (0.6)** | **(46) and (4)** | **(4.9) and (0.3)** |

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted. A number in parentheses denotes a negative value.

[b] Monetized health benefits include ozone related health benefits associated with reductions in VOC emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The two benefits estimates are separated by the word "and" to signify that they are two separate estimates. The estimates do not represent lower- and upper-bound estimates. Benefits from HAP reductions and VOC reductions outside of the ozone season remain unmonetized and are thus not reflected in the table. The unmonetized effects also include disbenefits resulting from the secondary impact of an increase in CO emissions.

[c] Monetized climate benefits and disbenefits are based on increases in $CO_2$ and $N_2O$ emissions and decreases in $CH_4$ emissions and are calculated using three different estimates of the social cost of each greenhouse gas (SC-GHG) (under 1.5 percent, 2.0 percent, and 2.5 percent near-term Ramsey discount rates). For the presentational purposes of this table, we show the net disbenefits associated with the SC-GHG at a 2 percent near-term Ramsey discount rate.

[d] Net compliance costs are the engineering control costs minus the value of recovered product.

#### *1.3.2.1 Overview of Costs and Benefits for All Rules (Cumulative Impacts)*

Table 1-6 presents the cumulative projected monetized health benefits, climate disbenefits (inclusive of climate benefits as with the HON summary impacts table above), and compliance costs (net of product recovery). This final action will reduce HAP and VOC emissions from HON, P&R I, and P&R II emission sources as well as the NSPS SOCMI air oxidation unit processes, distillation operations, reactor processes, and equipment leaks sources. Considering reported emissions inventories for ethylene oxide and chloroprene, we estimate that the final amendments to the NESHAP will reduce overall HAP emissions from the SOCMI source category by approximately 1,107 tpy, reduce overall HAP emissions from the P&R I source categories by approximately 264 tpy, and reduce overall HAP emissions from the P&R II source categories by approximately 1 tpy. We note that these emissions reductions do not consider the potential excess emissions reductions from flares that could result from the final monitoring requirements; we estimate flare excess emissions reductions of 4,858 tpy for HAP and 19,889 tpy for VOC. Based on our analysis of the finalized actions described in sections III.B.2, III.D.2, and III.E of this preamble for the NSPS, we estimate that the final amendments to the NSPS would reduce VOC emissions from the SOCMI source category by approximately 1,622 tpy. Emission reductions and secondary impacts (e.g., emission increases associated with supplemental fuel or additional electricity) by rule are listed below. The only change in air impacts since proposal stems from our reevaluation related to the TRE removal for HON and P&R I (based on comments received as discussed in sections IV.B.3.a.i and IV.B.3.b.i of the preamble).

There are also emission increases per year in criteria pollutants of 17.4 tons of particulate matter, 349 tons of nitrogen oxides (NOx), and 1.37 tons of sulfur dioxide ($SO_2$) due to additional energy usage from the controls applied in the cost analysis. Finally, there are emission increases per year of 741,102 tons of carbon dioxide ($CO_2$) and 6.86 tons of nitrous oxide ($N_2O$), and emission decreases per year of 22,951 tons of methane ($CH_4$). Table 3-26 contains the changes in emissions other than for HAP and VOC. Thus, there are projected climate benefits caused by $CH_4$ emission reductions, and projected climate disbenefits caused by $CO_2$ and $N_2O$ emissions increases. Table 3-27 contains the GHG emission estimates that were monetized for this rule. While benefits from HAP reductions and VOC reductions outside of the ozone season have not been monetized for this action, the EPA expects these benefits are positive. As mentioned earlier, we calculate cost and emissions reductions relative to the baseline for the period 2024-2038, discounted to 2023.

**Table 1-6 Total Monetized Benefits, Compliance Costs, Emission Reductions, and Net Benefits for the Final Rule (dollars in million 2021$)[a]**

| | 3 Percent Discount Rate | | 7 Percent Discount Rate | |
|---|---|---|---|---|
| | **PV** | **EAV** | **PV** | **EAV** |
| Monetized Health Benefits[b] | 77 and 690 | 6.5 and 58 | 53 and 475 | 5.9 and 52 |
| Climate Disbenefits[c] | 160 | 13 | 160 | 13 |
| Net Compliance Costs[d] | 1,770 | 150 | 1,370 | 150 |
| *Compliance Costs* | 1,790 | 150 | 1,380 | 150 |
| *Value of Product Recovery* | 16 | 1.3 | 12 | 1.3 |
| **Net Benefits** | **(1,900) and (1,200)** | **(160) and (110)** | **(1,500) and (1,100)** | **(160) and (110)** |
| Nonmonetized Benefits | 6,053 tons/year of HAP<br>Health effects of reduced exposure to ethylene oxide, chloroprene, benzene, 1,3-butadiene, vinyl chloride, ethylene dichloride, chlorine, maleic anhydride and acrolein | | | |

[a] Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted. A number in parentheses denotes a negative value.

[b] Monetized health benefits include ozone related health benefits associated with reductions in VOC emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The two benefits estimates are separated by the word “and” to signify that they are two separate estimates. The estimates do not represent lower- and upper-bound estimates. Benefits from HAP reductions and VOC reductions outside of the ozone season remain unmonetized and are thus not reflected in the table. The unmonetized effects also include disbenefits resulting from the secondary impact of an increase in CO emissions.

[c] Monetized climate benefits and disbenefits are based on increases in $CO_2$ and $N_2O$ emissions and decreases in $CH_4$ emissions and are calculated using three different estimates of the social cost of each greenhouse gas (SC-GHG) (under 1.5 percent, 2.0 percent, and 2.5 percent near-term Ramsey discount rates). For the presentational purposes of this table, we show the net disbenefits associated with the SC-GHG at a 2 percent near-term Ramsey discount rate.

[d] Net compliance costs are the engineering control costs minus the value of recovered product. A negative net compliance costs occurs when the value of the recovered product exceeds the compliance costs.

## 1.4 Organization of the Report

The remainder of this report details the methodology and the results of the RIA. Chapter 2 presents a profile of the SOCMI and P&R Group I and II industries, which also cover the industries with sources affected by the NSPS amendments included in this rulemaking. Chapter 3 describes emissions, emissions control options, and engineering costs. Chapter 4 presents the benefits analysis, including the monetized health benefits from VOC and other emission reductions, a qualitative discussion of the unmonetized benefits associated with HAP emissions reductions, and the monetized benefits associated with climate emissions decreases ($CH_4$) and disbenefits associated with climate ($CO_2$ and $N_2O$) emissions increases. Chapter 5 presents analyses of economic impacts, impacts on small businesses, and a narrow analysis of employment impacts. The economic impacts include estimates of price and output changes in response to the costs of different final rules in this rulemaking. The small business impact analysis includes estimates of annual cost to sales calculations for affected small businesses and concludes that no rule in this rulemaking will have a significant impact on a substantial number of small entities (or SISNOSE). Chapter 6 presents a comparison of the benefits and costs. Chapter 7 contains the references for this RIA.

# 2 INDUSTRY PROFILE

## 2.1 Introduction

This chapter will provide a profile of SOCMI and P&R Group I and II industries affected under this combined rulemaking. While there is overlap between these rules, affected facilities and area sources are distinct enough that this chapter will provide separate sub-chapters for SOCMI and P&R Group I and II below. The EPA constructed facility lists for these rules are based on data from the January 2021 version of the 2017 National Emissions Inventory (NEI). However, instances where facility-specific data was not available in the 2017 NEI, more recent data was collected from the 2018 inventory or recent state submittals to the Emissions Inventory System (EIS).[4] The construction of the facility list is described in the preamble for the final action.

## 2.2 SOCMI Industry Profile

The SOCMI source category includes chemical manufacturing processes producing commodity chemicals, see sections I.B and II.B of the preamble for detailed information about these source categories. An EPA regulatory impact analysis from 1994 identified approximately 30 key chemicals that represent a large portion of output from the industry.[5] This profile revisits these chemicals and their feedstocks, listed in Table 2-1, to provide an updated industry profile.

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[4] Revenue and employment information was collected through manual search of D&B Hoover's database in 2022.

[5] U.S. EPA. Regulatory Impact Analysis for the National Emissions Standards for Hazardous Air Pollutants for Source Categories: Organic Hazardous Air Pollutants from the Synthetic Organic Chemical Manufacturing Industry and Other Process Subject to the Negotiated Regulation for Equipment Leaks. EPA-453/R-94-019. March 1994.

**Table 2-1 Select SOCMI Chemicals by Feedstock***

| | |
|---|---|
| **Benzene** | **Methane** |
| Styrene-Butadiene Rubber | Formaldehyde |
| Cyclohexylamine | Chloroform |
| Hydroquinone | Methyl Tertiary Butyl Ether |
| Styrene | Methyl Chloride |
| Acetone | **Ethylene** |
| Bisphenol-A | Butadiene |
| Propylene Glycol | Polybutadiene |
| **Toluene** | Ethylene Dichloride |
| Benzoic Acid | Ethylene Oxide |
| **Xylene** | Ethylene Glycol |
| Terephthalic Acid | Triethylene Glycol |
| Phthalic Anhydride | **Propylene** |
| **Naphthalene** | Acrylonitrile |
| Ether | **Butylene** |

*This list of chemicals is from the HON Regulatory Impact Analysis (EPA, 1994)

Synthetic organic chemicals (SOCs) are derived from chemical reactions using feedstocks containing carbon, such as fossil fuels like oil and natural gas. Supply relies on the market prices of these feedstocks, but advancements in technology and energy efficiency have resulted in large production economies of scale. The main source of demand for SOCs is from plastics manufacturers. In addition, there is demand from a multitude of other industries that produce, but not limited to, rubber, paints, adhesives, food, and pesticides (Barnicki, 2017).

Existing overall market and industry research for SOCs is scarce. The SOC market in the United States was valued at $168 billion in 2022 (IBISWorld). SOCMI is a subsector of the much larger organic chemicals market, which includes natural organic chemicals. Seven of the eight major feedstocks (excluding naphthalene) belong to a subset of SOCs called petrochemicals, named for their derivation from crude oil and natural gas, in addition to other possible sources like coal or vegetable oils. Petrochemicals can be used to make a variety of products, including rubber, fuel, cleaning agents, and plastics (ScienceDirect, 2022).

The global petrochemicals market size value was $556.1 billion in 2021. An industry report from Grand View Research prepared in 2021 forecasts the petrochemical market to grow at a compound annual growth rate (CAGR) of 6.2 percent from 2022 to 2030. The growth in demand is expected to result from an increase in demand for downstream products from various end-use industries such as construction, pharmaceuticals, and automotive. Because crude oil is the basic raw material in production, crude oil price volatility significantly affects production and the final costs of petrochemical products (Grand View Research, 2021).

Ethylene had the largest revenue share for the petrochemical industry, over 40.0 percent in 2021. The large revenue share from the ethylene market is due to the wide variety of everyday products that use this chemical. Ethylene is developed into four different compounds that produce many products, including:

- Polyethylene (Plastics) – used to make food packaging, bottles, bags, and other plastics-based goods.
- Ethylene Oxide / Ethylene Glycol – used in polyester for textiles, as well as antifreeze for airplane engines and wings.
- Ethylene Dichloride – used in a vinyl product used in PVC pipes, siding, medical devices, and clothing.
- Styrene – synthetic rubber found in tires and foam insulation.

Ongoing industrialization and growing automotive and packaging sectors in emerging economies such as India, Brazil, Vietnam, and Thailand are forecasted to drive up demand for ethylene products. Butadiene was the second-largest product segment in 2021. Methanol is predicted to have the fastest revenue growth, a CAGR of 7.8 percent, over the forecast period. Methanol is a chemical building block for hundreds of everyday products, including plastics, paints, car parts and construction materials. Methanol also is a clean energy resource used to fuel cars, trucks, buses, ships, fuel cells, boilers and cook stoves. There is increasing demand for methanol from industries such as construction, paints and adhesives, pharmaceuticals, plastics, and automotive (OEC, 2022a).

The Asia Pacific region has a volume share of over 50.0 percent of the petrochemicals industry. Increasing natural gas exploration activities in the United States and Canada will grow the petrochemicals market in North America over the coming years; additionally, this provides an opportunity for substituting some raw materials with natural gas in the production of several petrochemicals (Grand View Research, 2021).

In 2018, total global trade of petrochemicals was valued at $123 billion. From 2017 to 2018, exports of petrochemicals worldwide grew by 42.5 percent, from $86.5 billion. The top exporters in 2018 were Saudi Arabia ($17.0 billion), the United States ($12.8 billion), Germany ($9.8 billion), Belgium ($7.5 billion), and Thailand ($7.0 billion). Of United States exports, 26.4 percent went to Mexico, 21.2% to Canada, and 9.0 percent to China.

The top importers of petrochemicals were China ($19.4 billion), Germany ($7.2 billion), the United States ($6.4 billion), Italy ($4.7 billion), and Turkey ($4.2 billion). The United States imported 42 percent of its petrochemicals from Canada, 19.9 percent from Mexico, 6.2 percent from Germany, and the remainder largely from Asia (OEC, 2022a). Hence, the U.S. was a net exporter in 2018 with exports at nearly twice the size of imports in monetary terms.

As more natural gas is tapped in the United States and prices decrease (as of 2021), the United States has become increasingly cost competitive in this market worldwide. U.S. production of ethylene, produced primarily in natural gas processing plants, has grown rapidly since 2013. Production has nearly doubled from 0.95 million barrels per day (b/d) in the first quarter of 2013 to 1.85 million b/d in the first quarter of 2021 (EIA, 2021).

More U.S. firms are keeping production in the United States instead of outsourcing to foreign countries or using imported oil. For example, firms like Dow Chemical, Exxon Mobile, Chevron Phillips Chemical, and Royal Dutch Shell have all invested in new ethylene plants and projects in the United States over the last several years, causing a significant increase in ethylene production (Pearce, 2014). As of 2021, the United States held approximately 40 percent of the world’s ethane petrochemical production capacity (Novicio, 2021). In 2022, the world gas supply chain was disrupted by the war in Ukraine. However, because of limited domestic LNG shipping capacity, U.S. gas prices are likely to remain below global market prices, continuing to give the U.S. petrochemical manufactures a slight competitive advantage.

Table 2-2 summarizes the top ten globally produced SOCs by total market value, with U.S. trade statistics and their common use cases. U.S. exports and imports include their global rank (in parentheses) if they fall within the top five global importers and exporters of that commodity.

## Table 2-2 Top 10 Globally Produced SOCs by Total Market Value (2021$)

| Chemical | Total Production (year) | Total Global Trade | U.S. Exports (global rank) | U.S. Imports (global rank) | Uses |
|---|---|---|---|---|---|
| Xylene | $178.45B (2021) | $2.18B | $49.9M | $26.1M | Production of drugs and plastics; solvents; intermediate for dyes and organic synthesis, especially isophthalic acid; insecticides; aviation fuel; manufacturing of polyester and alkyl resins; fibers, films, and resins; herbicide; production of polyester polyurethanes used in paints and sealants |
| Propylene | $96.47B (2021) | $5.59B | $559M (3) | $142M | Plastics and carpet fibers; chemical intermediate for the manufacture of acetone, isopropylbenzene, isopropanol, isopropyl halides, propylene oxide, acrylonitrile, and cumene; production of gasoline or used as a fuel in oil refineries |
| Ethylene | $81.34B (2020) | $4.95B | $401M (5) | $191K | Oxyethylene welding; chemical manufacturing; fruit ripening; general anesthetic; common ingredient in household products, such as plastics, certain foods, and some detergents; manufacturing ethylene oxide; polyethylene for plastics, alcohol, mustard gas, and other organics |
| Benzene | $68.3B (2021) | $4.75B | $38.7M | $632M (2) | Solvent for chemical synthesis, constituent in motor fuels, detergents, explosives, pharmaceuticals, dyestuffs |
| Terephthalic Acid | $49.2B (2020) | $4.12B | $23.3M | $414M (2) | Feedstock for the production of polyesters, such as PET; wool processing; production of plastic films and sheets; added to certain poultry feeds and antibiotics to increase effectiveness |
| Styrene | $34.23B (2022) | $7.22B | $1.65B (1) | $387M (5) | Polystyrene production (low cost, low friction |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | plastic used in packaging, textiles, and construction) |
| Toluene | $21.15B (2021) | $1.62B | $40.2M | $133M (4) | Solvent in aviation and automotive fuels; chemical production; production of paints, paint thinners, fingernail polish, lacquers, adhesives, and rubber; printing and leather tanning processes; production of benzene, TNT, nylon, plastics, and polyurethanes |
| Bisphenol-A | $16.23B (2020) | $1.46B | $2.88M | $37.2M | Production of polycarbonate plastics and epoxy resins |
| Acrylonitrile | $12.9B (2020) | $2.03B | $584M (1) | $9.26M | Manufacture of acrylic and modacrylic fibers, production of plastics |
| Styrene-Butadiene Rubber | $10.24B (2020) | $4.49B | $259M | $472M (2) | Rubber products such as gloves, tires, and adhesives |

### *2.2.1 Oil and Gas Sectors and SOCMI*

Olefins[6] (ethylene, propylene, butadiene and butenes) are derived from both natural gas and petroleum. The aromatics (benzene, toluene, and xylenes) are derived from petroleum and, minorly, coal. Whether natural gas fractions or petroleum are used for olefins varies throughout the world depending on the availability of natural gas and demand for gasoline. Both light and heavy naphthas[7] are petroleum fractions that can be used to make olefins. But they can also be used to make gasoline (Wittcoff, 2012).

In the United States, approximately 95 percent of all organic chemicals by weight are derivatives of petroleum and natural gas. There has historically been ample natural gas supply in the United States, resulting in cheaper processing of ethane and propane, as opposed to more expensive petroleum cracking processes[8] for liquids, and naphtha.

In addition, the United States has had an ample supply of propylene, because it is produced in steam cracking for other products and because catalytic cracking is a required

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[6] Olefins are a class of chemicals made up of hydrogen and carbon with one or more pairs of carbon atoms linked by a double bond. They are used as building block materials for products such as plastics, detergents, and adhesives.

[7] Naphthas are any of various volatile, highly flammable liquid hydrocarbon mixtures used chiefly as solvents and diluents and as raw materials for conversion to gasoline.

[8] Cracking is the process by which heavy hydrocarbon molecules are broken up into lighter molecules by means of heat and usually pressure and sometimes catalysts. Cracking is the most important process for the commercial production of gasoline and diesel fuel.

process in the gasoline industry. The propylene industry is based on this reaction that occurs in the catalytic cracking process, yielding billions of pounds of product generated (Wittcoff, 2012).

Because of low-cost and high-domestic availability in the United States, there is an incentive for U.S. manufacturers to use natural gas as a feedstock, replacing heavier liquid gases such as naphtha. Changes in incentives for raw material use also affects byproduct production prices, because byproducts, such as butadiene resulting from ethylene cracking, could be affected by new technologies or production processes. Most prices for raw materials will respond in the same direction as the changes in price for natural gas. Material costs respond in the opposite direction of natural gas prices, while costs for byproducts respond in tandem with natural gas prices (DeRosa, 2015).

The chemical industry is considered an upstream industry, because it purchases raw materials such as petroleum, natural gas, coal, and metallic or nonmetallic minerals and does not usually sell these products to final consumers. About one-fifth of materials are sold to other firms in the chemical industry for additional processing, and then the remainder is sold to other industries to assist in product manufacturing or services (Wittcoff, 2012).

It is often the case that oil refineries become integrated with nearby petrochemicals plants. This integration allows both plants to exchange supply chain streams. The petrochemical facility receives streams of raw materials from the oil refinery, and the refinery receives back streams from the petrochemical plant that can be used again for petroleum products (*e.g.*, gasoline blending). The petrochemical plants produce high-value products like ethylene, propylene, styrene, butadiene, and benzene. Furthermore, these base petrochemicals can be transformed further into other products like plastics, polyvinyl chloride (PVC), polystyrene, polyethylene, polypropylene, elastomers, and aromatics-based products.

### *2.2.2 SOCMI Supply Chain Disruptions*

Supply chain disruptions can happen either upstream or downstream,[9] but it is worth noting that within the chemical industry upstream suppliers tend to be of greater concern to continuity of operations (Kotzé, 2017).

In addition to geopolitical risk factors, natural hazard disruptions affect many facets of the petrochemical supply chain, resulting in longer recovery periods before production continues (Stamber, 2011). As an example, Hurricane Ike in 2008[10] damaged readily available electric and water infrastructure, raw materials, logistics, and production sites that negatively affected efforts to begin operations post-disaster. These disruptions can have impacts in upstream and downstream markets, affecting recovery.

Increases in the use of different feedstocks, such as natural gas, can also provide insights into production and market cost effects that can occur in chemical supply chains. In the United States, prices for natural gas use affect price patterns for byproducts of petrochemicals, such as benzene, butadiene, and propylene. The cost of benzene, a byproduct of naphtha, stays relatively constant during changes in natural gas price. The cost of butadiene, in contrast, increases as natural gas prices decrease.

On a global scale, COVID-19, and the Russia-Ukraine war both affected oil and chemical market prices. Continuing trends remain to affect the industry through changing societal concerns for environmental issues, preferences for sustainable products, accelerated energy transition, capacity demand and growth, and the continuous adoption of digitization. These trends disrupted pertinent supply chains. The first quarter of 2020 saw an unanticipated downturn for the oil, gas, and chemical industries as oversupply issues were exacerbated, and global oil price collapses narrowed domestic feedstock cost advantages that petrochemical companies in the United States benefitted from (Deloitte Insights, 2022).

While the COVID-19 crisis has abated worldwide since 2020, the Russia-Ukraine war has also been a key factor in oil price changes in 2022. Consumer demand reduced as oil prices

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[9] The upstream market stage in the petrochemical industry refers to the exploration and production of natural gas and crude oil. The downstream market focuses on taking natural gas and crude oil in finished products for consumers.

[10] https://cen.acs.org/articles/86/web/2008/09/Texas-Weathers-Ike.html

increased, thus eroding profitability in the chemical industry. China has surpassed the United States as the world's largest chemical market; it now accounts for more than 45 percent of worldwide chemical sales. Some European chemical companies are also feeling this pressure, as they expect a drop in 2022 profit (Stokes, 2022).

### *2.2.3 Ethylene*

Ethylene is a valuable chemical product in both the U.S. and the world. It is the third most valuable synthetic organic chemical product as of 2020 with $81.34 billion in revenue worldwide. U.S. exports of ethylene were $401 million as of 2020. U.S. demand for ethylene currently exceeds that of other top petrochemicals and is forecast to grow by 45 percent between 2020 and 2028 and by 51 percent between 2019 and 2035. Ethylene demand is driven by the demand for its derivatives among which the demand for polyethylene is the highest, followed (U.S. DOE, 2022 by ethylene dichloride (EDC) and ethylene oxide. U.S. market revenue from ethylene is projected to rise by approximately $47 billion from 2022 to 2028.

Ethylene by-products are valuable due to their many important uses in common products. One of those by-products is ethylene oxide. Ethylene oxide is used in the synthesis of ethylene glycol, as a sterilizing agent for medical supplies and foods, as a fumigant, and as an insecticide.[11]

Ethylene is a hydrocarbon gas that is produced by some fruits and vegetables through natural processes. Ethylene is a by-product during the decomposition of organic material. It is a common ingredient in various household products, including plastic, certain foods, and some detergents. In 2020, ethylene was the world's 596th most traded product, with a total trade of $4.95 billion. Between 2019 and 2020 the exports of ethylene decreased by 27.8 percent, from $6.85 billion to $4.95 billion, in part due to the Covid-19 pandemic. Trade in ethylene represents 0.03 percent of total world trade (OEC, 2022b).

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[11] Observatory of Economic Complexity (2022). "Oxirane (ethylene oxide)." https://oec.world/en/profile/hs/oxirane-ethylene-oxide

Ethylene is used to produce fabricated plastics, antifreeze, and fibers. It is also used in the process to produce ethylene oxide and to produce polyethylene for plastics, alcohol, mustard gas, and other organics (National Center for Biotechnology Information, 2022a). Ethylene is a product of steam cracking of petroleum hydrocarbons. Multiple feedstocks produce ethylene, including ethane, propane, butanes, naphthas, and gas oils. Naphthas are the primary raw material used in Western Europe and Japan, accounting for more than three-fourths of ethylene produced. Ethane is the primary feedstock in the United States, followed by propane, naphthas, gas oils, and butane. Small amounts of ethylene are recovered from other feedstocks, such as retrograde-field condensates and refinery waste gases. Dehydration of ethanol is the third commercial process for producing ethylene (National Center for Biotechnology Information, 2022a).

In 2020, the top exporters of ethylene were the Netherlands ($682 million), South Korea ($608 million), the United Kingdom ($587 million), and the United States ($401 million). Of U.S.'s ethylene exports, 38.5 percent were exported to Taiwan, 34.2 percent to China, 9.78 percent to Indonesia, 9.03 percent to Belgium. In the United States from 2019 to 2020, the export value was $401 million, an increase of 82.6 percent from a 2018 to 2019 value of $219 million (Fernández, Ethylene Prices Globally 2022, 2022).

In 2020, the top importers of ethylene were China ($1.35 billion), Belgium ($921 million), Indonesia ($552 million), Germany ($432 million), and Sweden ($360 million). In the United States from 2019 to 2020, the import value was $190,000, an increase of 135.4 percent from a 2018 to 2019 value of $81,000 (Fernández, Ethylene Prices Globally 2022, 2022).

The average price of ethylene worldwide was approximately $697 per metric ton in 2020. By July 2021, the average price for the year had risen to $1,014 per metric ton (see Figure 2-1), 45 percent higher than the previous year. "The global production capacity of ethylene is expected to grow from approximately 200 million tons in 2020 to some 300 million tons by 2025" (Fernández, Ethylene Prices Globally 2022, 2022).

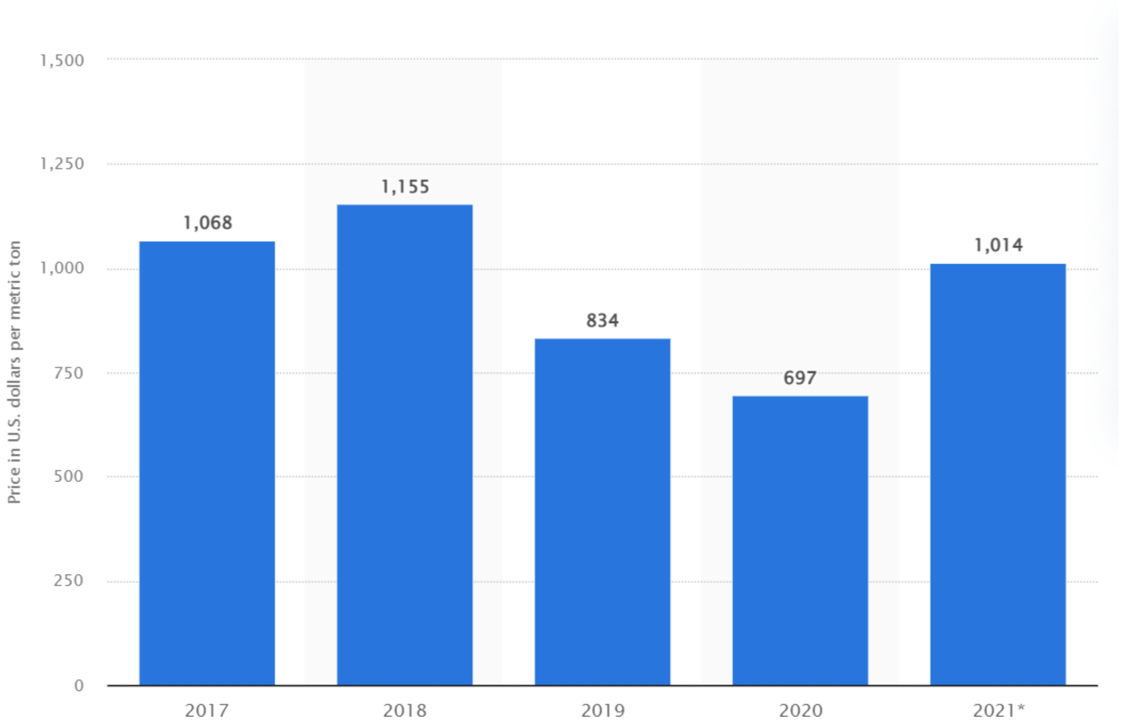

**Figure 2-1 Global Price of Ethylene (USD$/metric ton)**

The global ethylene market is expected to grow from $81.34 billion in 2020 to $161.61 billion by 2028 at a CAGR of 8.3 percent during the forecast period of 2021 to 2028. The increased use of coal as a feedstock for producing ethylene and the rising demand for ethylene products in the construction industry are some of the factors fueling the ethylene market (Global Newswire, 2022).

Key companies in the global ethylene market are Saudi Basic Industries Corp., Exxon Mobil Corporation, Dow DuPont Inc., Royal Dutch Shell plc, China Petroleum & Chemical Corporation, Chevron Phillips Chemical Company LLC, LyondellBasell Industries N.V., The National Petrochemical Company, BASF SE, and Lonza Group, among others (Polaris Market Research, 2021).

U.S. demand for ethane (the primary feedstock for ethylene) has been growing steadily because of capacity expansions of ethylene crackers in the petrochemical industry, which use ethane as a feedstock. Ethylene is a basic chemical used to produce plastics and resins. It is estimated that the U.S. petrochemical industry expanded its capacity to produce ethylene from almost 27 million metric tons per year (mt/y) in the first quarter of 2013 (when the first capacity additions to ethylene crackers in over a decade came online) to almost 40 million mt/y in 2020.

This growth in ethylene capacity caused domestic demand for ethane as a feedstock to grow from 960,000 b/d in the first quarter of 2013 to 1.83 million b/d in the fourth quarter of 2020 (U.S. EIA, 2021).

### *2.2.3.1 Butadiene*

Butadiene (1,3-Butadiene) is a synthetic, colorless gas that is basically insoluble in water but soluble in ethanol, ether, acetone, and benzene (National Center for Biotechnology Information, 2022b). Butadiene emits acrid fumes and is flammable when it is heated. When butadiene is oxidized, it can form explosive peroxides. Butadiene rubber is a primary material used in the production of car tires, gaskets, hoses, synthetic brushes, and synthetic carpets (National Center for Biotechnology Information, 2022b).

Butadiene is used as a monomer in the manufacturing process of many different types of polymers and copolymers. It is also used as a chemical intermediate in the production of industrial chemicals. Butadiene is manufactured primarily as a co-product of ethylene production from steam cracking in the United States, Western Europe, and Japan (National Center for Biotechnology Information, 2022b).

The global 1,3-Butadiene market is expected to reach $33.01 billion by 2020. Growing demand for tires of all types "on account of an upturn in the automotive industry (particularly in China, India, and Brazil) is expected to remain a key driving factor for the global market" (Grand View Research, 2015).

As shown in Figure 2-2, the price of Butadiene has decreased since 2017. At the start of the first quarter of 2022, prices remained low initially. "During January (2022), the prices dropped significantly by 10 percent as compared to last quarter of 2021. The initial decline in the prices was attributed to the abundant supplies and weak trading activities. Demand from downstream Styrene Butadiene Rubber (SBR) and Acrylonitrile Butadiene Styrene (ABS) plastic has remained bearish in the region. As the upstream Crude and Natural gas prices rallied upwards by the mid quarter, the Butadiene sentiments shifted marginally towards the upward side in U.S. Korea, a major exporter of Butadiene, exported the product to the U.S. at sky high values due to soaring freight charges. The price of Butadiene was last assessed at $1,445/[metric ton] during March of 2022 in the U.S. Moreover, robust demand from downstream derivatives [styrene-butadiene rubber] (SBR) and [Polybutadiene rubber] (PBR) kept the Butadiene prices on the higher side (Fernández, 2021).

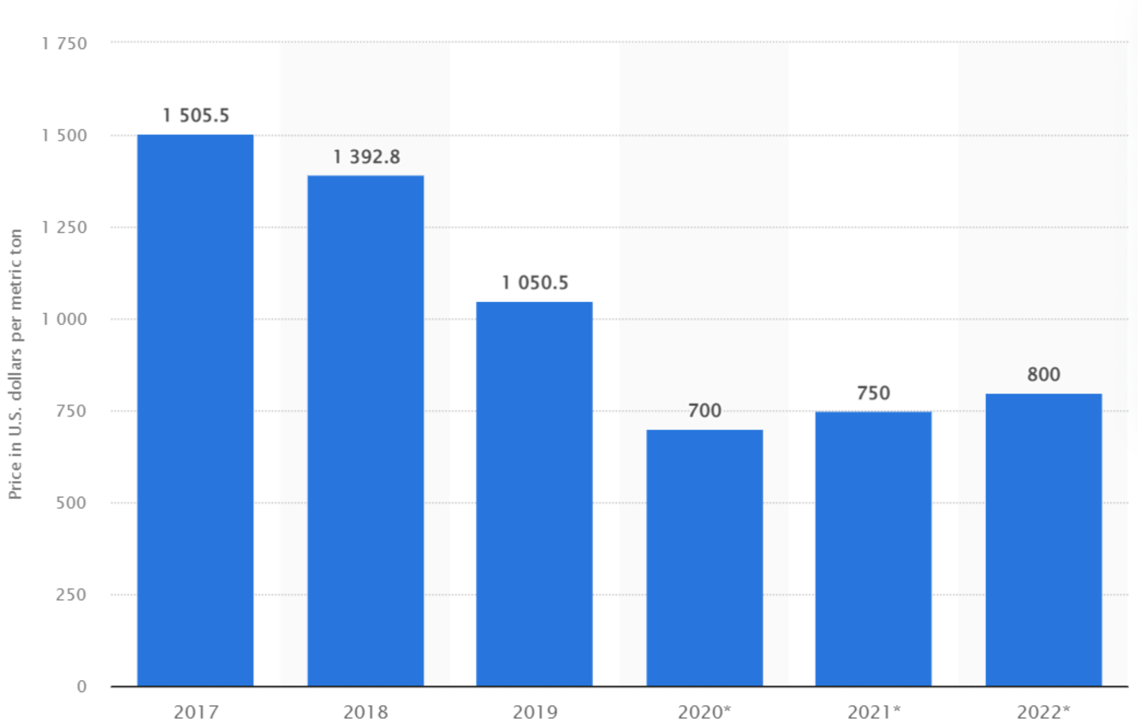

**Figure 2-2 Global Price of Butadiene from 2017 to 2019 with Estimated Figures for 2020 to 2022**

### *2.2.3.2 Ethylene Oxide*

Ethylene oxide is a colorless, flammable, toxic gaseous cyclic ether with a sweet ether-like smell (National Center for Biotechnology Information, 2022c). **"**Ethylene oxide is used especially in the synthesis of ethylene glycol and as a sterilizing agent for medical supplies and foods, as a fumigant and as an insecticide" (OEC, 2022c).

Exposure to ethylene oxide can be highly irritating to the eyes, skin, and respiratory tract, and can cause nausea, vomiting, and central nervous system depression (National Center for Biotechnology Information, 2022c). The EPA's Integrated Risk Information System (IRIS) characterized ethylene oxide as "carcinogenic to humans" by the inhalation route of exposure based on the total weight of evidence (U.S. EPA, 2016), in accordance with EPA's *Guidelines for Carcinogen Risk Assessment* (USEPA, 2005). EPA concluded that there was strong, but less than conclusive on its own, epidemiological evidence of lymphohematopoietic cancers and breast cancer in ethylene oxide-exposed workers (U.S. EPA, 2016).

Nearly all production of ethylene oxide in the United States uses the direct vapor phase oxidation process. “This process oxidizes ethylene with air or oxygen in the presence of a silver catalyst to produce ethylene oxide” (OEC, 2022c).

In 2020, the top exporters of ethylene oxide were Germany ($161 million), the Netherlands ($123 million), Belgium ($40 million), France ($28.9 million), and Russia ($15.8 million) (OEC, 2022c). In the United States from 2019 to 2020, the export value was $8.82 million, a decrease of 14.7 percent from a 2018 to 2019 value of $10.3 million.

In 2020, the top importers of ethylene oxide were Belgium ($88.9 million), Italy ($80.4 million), Germany ($73.6 million), France ($40.5 million), and the United Kingdom ($19.2 million). In the United States from 2019 to 2020, the import value was $68,900, an increase of 975 percent from a 2018 to 2019 value of $6,410.

Prices of nonyl phenol ethoxylates (upstream product of ethylene oxide) in the United States grew over 2021 and the first quarter of 2022 “in response to the higher Ethylene Oxide feedstock prices and outstretching demand” (ChemAnalyst, 2022).

Supply shocks can have a significant impact on the relatively concentrated market. For example, “the curtailed operations in ExxonMobil’s Baytown refinery following an explosion in late December 2021 have continued to create a supply deficiency of upstream olefins and consequently caused its prices to gain significant numbers. The high upstream pricing, which got transferred to its downstream Ethylene Oxide, weighed on the input cost of Nonylphenol Ethoxylates. Prompting the manufacturers for a price increase, thus, the Nonylphenol Ethoxylates US discussions reached $1,923/MT FOB Gulf Coast in the quarter ending March 2022” (U.S. EPA, 2016)[12].

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[12] "MT FOB" stands for "metric ton free on board." This refers to the price of one metric ton of a chemical product, which includes the cost of the product and the cost of loading it onto a vessel for transportation. "FOB" means that the cost of transportation from the point of origin to the port of shipment is included in the price, but the cost of shipping the product to its final destination is not included.

## 2.3 P&R Groups I and II

This sub-chapter focuses on the industries of the Polymers and Resin Group I and II NESHAP. The economic and financial information in this chapter characterizes the conditions in these industries which are likely to determine the nature of economic impacts associated with the implementation of the NESHAP.

Section 2.4 provides an overview of the Group I synthetic rubber industries. Section 2.4.1 details the production processes, properties, and unique market characteristics for each elastomer. Section 2.5 provides an overview of the industries covered by Polymers and Resin Group II. Sections 2.5.1 describes epoxy resins and non-nylon polyamides production and their markets.

Figure 2-3 provides a geographic overview of where Group I and Group II facilities affected by this rule are located across the U.S. Group I facilities are clustered in the South with most based in Louisiana and Texas and others spread across the Midwest. There are fewer Group II facilities affected under this rule; four facilities are distributed in the South, while one is in Oregon.

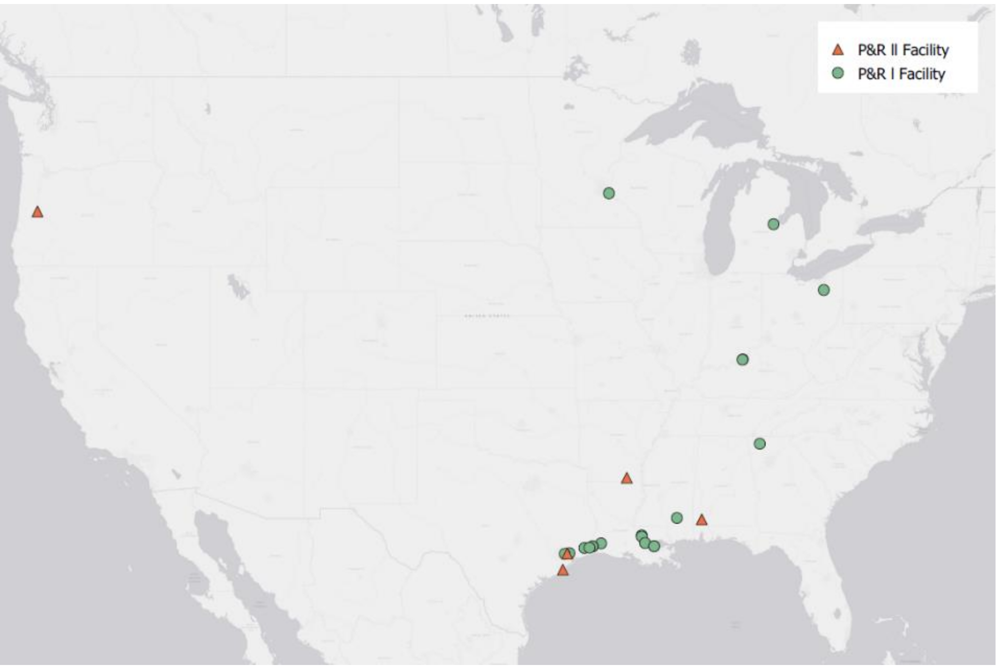

**Figure 2-3 P&R Group I and II Facilities Map**

## 2.4 Group I Industry Profile

This section reviews the organization, processes, and products of the affected synthetic rubber industries. The affected firms are further identified by size and economic impacts in a later section. Each facility considered in the production of Group I elastomers is categorized by a North American Industry Classification System (NAICS) code. This code is a "standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy" and used for defining industries. Across the identified facilities in Group I, there are four unique NAICS industries with varying representation in the associated NESHAP and the U.S. economy.[13] Table 2-3 provides 2017 data for these industries in the U.S. economy, not only considering facilities directly impacted by this rulemaking.[14] Data on industries is sourced from the quinquennial Economic Census which last occurred in 2017.

**Table 2-3 Polymers and Resin Group I Industries**

| NAICS | Name of Industry | Number of Facilities Impacted (% of Total Facilities Impacted) | Total Industry Revenue in 2017 (in Billions) | Total Industry Employment in 2017 |
|---|---|---|---|---|
| 325110 | Petrochemical Manufacturing | 1 (5.6%) | $52.97 | 9,369 |
| 325211 | Plastics Material and Resin Manufacturing | 3 (16.7%) | $89.52 | 75,998 |
| 325212 | Synthetic Rubber Manufacturing | 13 (72.2%) | $8.39 | 9,661 |
| 325998 | All Other Miscellaneous Chemical Product and Preparation Manufacturing | 1 (5.6%) | $21.85 | 36,900 |

### 2.4.1 *Industry Organization of Group I Industries*

This section provides information on the structure of the covered synthetic rubber industries and the characteristics of the market organization of the affected Group I industries. This is an attempt to characterize the impacts regulation can have in more detailed terms.

Table 2-4 shows how the firms in each product category can be characterized by market concentration: the market share percentage for the 50 largest firms of the affected industries by NAICS code. The standard economic framework is that the higher the market concentration, the

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[13] U.S. Census Bureau (2022). *North American Industry Classification System*. Retrieved from https://www.census.gov/naics/.

[14] Data available at https://www2.census.gov/programs-surveys/susb/tables/2017/us_6digitnaics_rcptsize_2017.xlsx. Accessed 11/7/2022. We note the publication of data from the 2022 Economic Census will not occur until late 2023 or early 2024.

more that changes in input price caused by regulation will lead to rises in output price. An example of this is presented in a 2018 report by Abdela and Steinbaum, which concludes that there is a market concentration problem in U.S. production, generally (Abdela, 2018). This assumption has been criticized by Newmark, who argues that "[P]rice-concentration studies are severely flawed. In industries in which sellers compete on quality and amenities, a positive price-concentration relation could result, not from coordinated effects, but from competitive superiority" (Newmark, 2004).

The table provides additional evidence to examine these issues. In addition to the percent values claimed by the largest companies in the product categories, it includes the Herfindahl-Hirschman Index (HHI) for industries based on value added. This index provides a signal of how concentrated market power is across a particular industry.

The U.S. Department of Justice (DOJ) and the Federal Trade Commission (FTC) use the HHI to identify markets where there are potential anti-trust concerns. They consider markets with an HHI below 1,000 to be unconcentrated; markets with HHI between 1,000 and 1,800 are considered moderately concentrated, and markets with HHI above 1,800 to be "highly concentrated" (U.S. EPA, 2013). For a given market, the HHI is calculated by squaring the market share of each firm competing in the market, then summing the squared shares, as shown in the following equation:

$HHI = \sum_i s_i^2$, where $s_i$ is the market share of the $i^{th}$ firm.

**Table 2-4 Concentration Findings of Affected Group I Industries**

| NAICS | Name of Industry | HHI Value* | Finding |
|---|---|---|---|
| 325110 | Petrochemical Manufacturing | 2,868.4 | Concentrated |
| 325211 | Plastics Material and Resin Manufacturing | 409.9 | Unconcentrated |
| 325212 | Synthetic Rubber Manufacturing | 652.6 | Unconcentrated |
| 325998 | All Other Miscellaneous Chemical Product and Preparation Manufacturing | 164.8 | Unconcentrated |

Notes: *HHI is based on the 50 largest companies for each NAICS code. HHI for years after 2012 are not available since comprehensive concentration data from the 2017 Economic Census is not yet available. This value is found using "value added" which is a measure of manufacturing activity. Value added is derived by subtracting the cost of purchased inputs from the value of shipments.
Source: US Census. Economic Census (August 2015).
https://www.census.gov/data/tables/2012/econ/census/manufacturing-reports.html

By the DOJ definition above, the only product category for which markets could be considered concentrated by the HHI was petrochemical manufacturing in 2012. Market concentration can develop due to various barriers to entry, pushing out potential entrants into a market. Barriers such as supply chain connection, capital requirements, and access to human capital can push certain industries to concentrate. Factors like these may be relevant in the case of the concentration of petrochemical manufacturing. However, there is evidence of a competitive market for the other synthetic rubber industries impacted by this regulation.

Competition for the synthetic rubber industries can arise due to a number of factors. The products of these industries can in some cases be substituted for one another. Other natural rubbers and imported products can also act as substitutes for these products. The presence of these alternatives can create excess capacity and can lead to falling prices for these industries.

### *2.4.2 Prices for Group I Industries*

From 2012 to 2021, product prices for the wider chemical manufacturing sector (NAICS 325) have increased overall, but the trend has been marked with some volatility over the years. Prices began falling in 2015, stayed steady and then increased considerably in 2017 and 2018, and increased sharply in 2021 by almost 12 percent year-over-year. Table 2-5 shows this erratic pattern in detail.

**Table 2-5 Chemical Manufacturing (NAICS 325) Product Price Index, 2012-2021 (2012 = 100)**

| NAICS 325 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2012-2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chemical Manufacturing** | 100.0 | 101.4 | 103.4 | 101.7 | 102.6 | 106.6 | 111.5 | 112.2 | 111.0 | 124.0 | |
| Change from Previous Year | | 1.4 | 2.0 | -1.7 | 0.9 | 4.0 | 4.8 | 0.7 | -1.2 | 13.0 | 24.0 |
| % Change from Previous Year | | 1.4% | 2.0% | -1.6% | 0.9% | 3.9% | 4.5% | 0.7% | -1.1% | 11.7% | 24.0% |

Source: U.S. Department of Labor, Bureau of Labor Statistics. Industries at a Glance: Chemical Manufacturing - NAICS 325. https://www.bls.gov/iag/tgs/iag325.htm

Table 2-6 shows a closer look at prices for synthetic rubber and related products from 2012 to 2021. Note that changes in product prices do not directly relate to the changes in synthetic rubber prices. Over this period, synthetic rubber prices fell considerably with a clear surge around 2017. This increase was a result of various supply-side conditions including growing costs in inputs to Styrene Butadiene Rubber (SBR), technical issues related to several manufacturing locations equipment failures affecting around 40 percent of U.S. styrene production, shortage of butadiene as well as its feedstock materials due to production issues, and other production issues. Tires and pneumatic tire prices remained relatively steady with only modest year to year changes, whereas rubber and plastics hose prices increased overall with some volatility in years 2013, 2015, and 2021.

Additionally, while not shown in the RIA, prices for natural rubber did not directly match the price changes in synthetic rubber as might be assumed from their substitutability. This is due to natural rubber following the supply-side constraint of agricultural inputs, whereas synthetic rubbers face the constraint of the availability and price of hydrocarbons. Moreover, the demand for rubbers is application dependent and may be based on the physical properties such as heat resistance and tear strength necessary for a particular use. This means substitutability of synthetic rubbers cannot be widely determined without knowing the needs of certain rubber applications (Wagner, 2020).

**Table 2-6 Producer Price Index of Synthetic Rubber, 2012-2021 (Index for 2012 is normalized to 100)**

| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2012-2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Synthetic Rubber** | 100.0 | 88.3 | 85.7 | 75.3 | 73.8 | 80.2 | 82.3 | 78.9 | 73.3 | 85.8 | |
| YoY Change | | -11.7 | -2.6 | -10.4 | -1.5 | 6.4 | 2.1 | -3.4 | -5.6 | 12.5 | -14.2 |
| % YoY Change | | -11.7% | -2.9% | -12.1% | -2.0% | 8.7% | 2.6% | -4.1% | -7.1% | 17.1% | -14.2% |
| **Tires, Tubes, Tread, and Repair Materials** | 100.0 | 98.2 | 95.8 | 93.8 | 92.4 | 93.4 | 94.6 | 95.6 | 95.9 | 100.1 | |
| YoY Change | | -1.8 | -2.4 | -2.0 | -1.4 | 1.0 | 1.2 | 1.0 | 0.3 | 4.2 | 0.1 |
| % YoY Change | | -1.8% | -2.4% | -2.1% | -1.5% | 1.0% | 1.3% | 1.1% | 0.3% | 4.4% | 0.1% |
| **Pneumatic Tires (on-road, off-road, and other)** | 100.0 | 98.2 | 95.7 | 93.6 | 92.1 | 93.1 | 94.3 | 95.3 | 95.6 | 99.7 | |
| YoY Change | | -1.8 | -2.5 | -2.1 | -1.5 | 1.0 | 1.2 | 1.1 | 0.3 | 4.1 | -0.3 |
| % YoY Change | | -1.8% | -2.5% | -2.2% | -1.6% | 1.1% | 1.3% | 1.1% | 0.3% | 4.3% | -0.3% |
| **Rubber and Plastics Hose** | 100 | 104.1 | 105.2 | 104.0 | 105.3 | 106.0 | 109.2 | 112.7 | 114.0 | 122.1 | |
| YoY Change | | 4.1 | 1.1 | -1.2 | 1.3 | 0.7 | 3.2 | 3.5 | 1.3 | 8.1 | 22.1 |
| % YoY Change | | 4.1% | 1.0% | -1.1% | 1.2% | 0.6% | 3.1% | 3.2% | 1.1% | 7.1% | 22.1% |
| **Rubber and Plastics Hose (for on- and off-road vehicles)** | 100 | 106.7 | 106.5 | 102.1 | 105.2 | 105.3 | 109.3 | 111.8 | 112.7 | 114.6 | |
| YoY Change | | 6.7 | -0.18 | -4.4 | 3.0 | 0.1 | 4.0 | 2.5 | 0.8 | 1.9 | 14.6 |
| % YoY Change | | 6.7% | -0.2% | -4.1% | 3.0% | 0.1% | 3.8% | 2.3% | 0.7% | 1.7% | 14.6% |

Note: “YoY” is an acronym for “Year over Year.”

Source: Federal Reserve Economic Data, Economic Research Division, Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/WPU071102, https://fred.stlouisfed.org/series/WPU0712, https://fred.stlouisfed.org/series/WPU0712010, https://fred.stlouisfed.org/series/WPU07130411, https://fred.stlouisfed.org/series/WPU071304118

### ***2.4.3 General Production Description of Group I Industries***

Synthetic rubber production requires the synthesis of monomers (derived from petrochemicals), followed by their polymerization. This process results in an aqueous suspension of rubber particles, or the latex, which may then be processed into marketable, dry, raw rubber. Synthetic rubbers are usually compounded with various additives and then molded, extruded, or calendared into the desired solid form. A percentage of elastomer production is also supplied in the form of water dispersions, called latexes (primarily used in foam rubber). HAP emission sources in synthetic rubber facilities include equipment leaks, process vents, wastewater, and storage tanks. It is important to note that elastomer production sites subject to this standard may be collocated with other production facilities that are, or will be, subject to NESHAP standards other than the Group I NESHAP. For example, a refining facility, chlorine plant, SOCMI facility, or non-elastomer polymer facility could be located on the same site as Group I production units.

### ***2.4.4 Product Description of Group I Industries***

The affected Group I elastomers are classified as synthetic rubbers which have specific elasticity and yield properties. Synthetic rubbers are either used as stand-alone products, or are compounded with natural rubber, other thermoplastic materials, or additives, depending on the desired end-use characteristics. This section describes the properties of each elastomer individually and identifies its primary end uses. Portions of this section are adapted from the *Economic Impact Analysis for the Polymers and Resin Group I NESHAP* (U.S. EPA, 1995).

#### *2.4.4.1 Butyl Rubber (Including Halobutyl Rubber)*

Butyl rubbers are copolymers of isobutylene (also known as isobutene) and other monomers. Other typical monomers include isoprene and methylstyrene. Most butyl rubber is produced by precipitation polymerization, although other methods may be used. Halobutyl rubber is a type of butyl rubber elastomer produced using halogenated copolymers and is typically used as a sealant. Characteristics of butyl rubber include low permeability to gases and high resistance to tear and aging. Butyl rubber is used as an input to the production of tires, tubes, and tire products. It is also used into the production of inner tubes because of its low air permeability. Butyl rubber is used in the production of automotive and mechanical goods, adhesives, and caulks like halobutyl rubber (Thomas, 2022a).

Butyl rubber had a total trade of $592 million in 2020. Between 2019 and 2020, the exports of butyl rubber decreased by 0.71 percent, from $596 million to $592 million. Russia had the highest total exports of butyl rubber, valued at $193 million, while the U.S. was third at $65.5 million. For the same year, China was the largest importer at $197 million (OEC, 2022d).

Halobutyl rubber had a total trade of $1.59 billion in 2020. Between 2019 and 2020, the exports of halobutyl rubber decreased by 19.3 percent, from $1.97 billion to $1.59 billion. Singapore had the highest total exports of halobutyl rubber, valued at $266 million, while the U.S. was fourth at $239 million. For the same year, China was the largest importer at $291 million, whereas the U.S. was fifth highest at $108 million (OEC, 2022e).

#### *2.4.4.2 Epichlorohydrin Elastomers (EPI)*

The production of EPI uses epichlorohydrin, ethylene oxide, and allyl glycetal ether, which are combined in a polymerization process. Due to its low gas permeability and resistance to heat, fuel, and abrasion, EPI is primarily used in automotive applications including gaskets, hoses, and seals.[15] Market information on epichlorohydrin elastomers markets was limited.

#### *2.4.4.3 Ethylene-Propylene Rubber (EPDM)*

The ethylene-propylene category includes both ethylene-propylene copolymers (EPD) and ethylene-propylene terpolymers (EPDM). EPDM is produced from the polymerization of ethylene and propylene, which may occur in either a solution process or a suspension process. EPDM is characterized by lower cost relative to other elastomers, and resistance to cracking, low temperature flexibility, and weather. EPDM compounds have been developed for many different applications including automotive, industrial, construction, and HVAC. End uses include roofing membranes, impact modifiers, oil additives, automobile parts, gaskets and seals, and hoses and

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[15] BRP Manufacturing (2000). *Epichlorohydrin Rubber*. https://brpmfg.com/epichlorihydrin-rubber/epichlorohydrin-rubber/

belts. The wide range of uses of this elastomer is attributable to its multifunctional nature (Thomas, 2022b).

EPDM had a total trade value of $1.57 billion in 2020. Between 2019 and 2020, the exports of EPDM rubber decreased by 18.2 percent, from $1.92 billion to $1.57 billion. The U.S. had the highest total exports of EPDM rubber, valued at $444 million. For the same year, China was the largest importer at $282 million, whereas the U.S. was fourth highest, at $90.8 million (OEC, 2022f).

#### *2.4.4.4 Chlorosulfonated Polyethylene (Hypalon$^{TM}$)*

Chlorosulfonated polyethylene, also known by the discontinued trade name “Hypalon$^{TM}$” (Anixter, 2022), is formed from polyethylene through a chlorination and chlorosulfonation process. Chlorosulfonated polyethylene is characterized by excellent resistance to ozone, oxidation, UV rays, and weather. Uses of chlorosulfonated polyethylene include coatings for roofs and tarpaulins, hose construction, wire coverings, industrial rolls, and sporting goods (Industrial Rubber Goods, 2022). Market information on Chlorosulfonated polyethylene markets was limited.

#### *2.4.4.5 Nitrile Butadiene Latex (NBL)*

Nitrile butadiene latex (NBL) is a polymer consisting primarily of unsaturated nitriles and dienes, usually acrylonitrile and 1,3-butadiene, that is sold as a latex. NBL is polymerized by free radical emulsion through advanced techniques. It is used in several applications because of its low cost, ease of processing, and low flammability. NBL is also used in several applications like gloves because of its oil resistance (Senlos Chem, 2022).

NBL had a total trade value of $1.6 billion in 2020. Between 2019 and 2020, the exports of NBL rubber increased by 33.8 percent, from $1.19 billion to $1.6 billion. South Korea had the highest total exports of NBL, valued at $886 million. For the same year, Malaysia was the largest importer at $1.08 billion. The U.S. was not among the five largest exporters or importers of NBL (OEC, 2022g).

### *2.4.4.6 Nitrile Butadiene Rubber (NBR)*

Nitrile butadiene rubber (NBR) is a copolymer of acrylonitrile and butadiene. Its most significant characteristic is its resistance to mineral oils, vegetable oils, and hydraulic fluids. NBR is the preferred product for gasoline hoses, gaskets, and printing rolls. Many of the properties of nitrile rubber are directly related to the proportion of acrylonitrile in the rubber. NBR is used in many hose applications where oil, fuel, chemicals, and solutions are transported. In powder form, NBR is used in cements, adhesives, and brake linings, and in plastics modification. NBR is also used in belting and cable, in addition to its uses in O-rings and seals, adhesives and sealants, sponges, and footwear (Polymerdatabase, 2022a).

NBR had a total trade value of $890 million in 2020. Between 2019 and 2020, the exports of NBR decreased by 16.8 percent, from $1.07 billion to $890 million. South Korea had the highest total exports of NBR, valued at $197 million, while the U.S. was fourth at $101 million. For the same year, China was the largest importer at $187 million, whereas the U.S. was third highest at $81.3 million (OEC, 2022h).

### *2.4.4.7 Neoprene*

Polychloroprene, also known as Neoprene, is produced from chloroprene through an emulsion process. It is characterized by its high flexibility, resistance to oils, strength, and resistance to abrasion, making it suitable for many diverse uses. Neoprene is similar to NBR in end uses, given that the primary use is for hoses and belts, with the remaining uses allocated among mechanical, adhesive, and wire and cable end uses. In latex form, Neoprene is used to manufacture household and industrial gloves (Polymerdatabase , 2022b).

In 2021, the total neoprene market was valued at $2.23 billion, with the Asia-Pacific market holding 40 percent of the market share. Acumen Research and Consulting projects a compound annual growth rate of 2.6 percent from 2022 to 2030. Two identified key market drivers are an increased adoption of neoprene rubber in the automotive sector and continual growth in construction and electronics industries in emerging economies. Denka Performance Elastomer LLC is also a prominent manufacturer in this market, producing over 23 percent of neoprene globally, and currently owns and operates the only neoprene production facility in the United States (Acumen Research and Consulting, 2022).

#### *2.4.4.8 Styrene-Butadiene Latex (SBL)*

Styrene-butadiene latex (SBL) is a polymer consisting primarily of styrene and butadiene monomer units produced using an emulsion process and sold as a latex. Most commercial styrene-butadiene polymers are heavily crosslinked, so they have a high gel content. This provides a greater degree of toughness, strength, and elasticity compared to other materials, allowing for its usefulness as a latex. SBL is commonly used as a "coating in paper products, such as magazines, flyers and catalogs, to achieve high gloss, good printability, and resistance to oil and water." It's also a popular choice as an adhesive in construction applications (Mallard Creek Polymers, 2020).

SBL had a total trade value of $939 million in 2020. Between 2019 and 2020, the exports of SBL decreased by 13.4 percent, from $1.8 billion to $939 million. Germany had the highest total exports of SBL, valued at $255 million, while the U.S. was second at $122 million. For the same year, China was the largest importer at $165 million (OEC, 2022i).

#### *2.4.4.9 Styrene-Butadiene Rubber (SBR)*

Styrene-butadiene rubber (SBR) is produced in the largest volume of all the synthetic rubbers. Its chemical properties include favorable performance in extreme temperatures, resistance to cracking and abrasion, and stability over time. The dominance of SBR among synthetic rubber types is attributable to its availability and processability. The availability of styrene and butadiene in fossil hydrocarbons make these two inputs an abundant source of synthetic rubber, and styrene and butadiene can be combined into rubber compounds which are easily processed into tire molds. Types of SBR differ in the ratios of styrene to butadiene, their content of additives, or the type of polymerization process used during the manufacturing process. The substitutability of SBR with natural rubber is primarily determined by the fluctuating prices of each, and by the properties required in the end product (Polymerdatabase , 2022c).

SBR had a total trade value of $4.49 billion in 2020. Between 2019 and 2020, the exports of SBR rubber decreased by 19.8 percent, from $5.6 billion to $4.49 billion. South Korea had the highest total exports of SBR, valued at $713 million. For the same year, China was the largest importer at $627 million, whereas the U.S. was second highest at $472 million (OEC, 2022j).

#### *2.4.4.10 Polybutadiene Rubber (PBR)*

Polybutadiene rubber (PBR) is formed from butadiene which undergoes emulsion polymerization. After SBR, polybutadiene rubber is the synthetic rubber produced in the second highest volume. It is also a relatively low-cost elastomer. The major use of PBR is in tires for the side walls and treads. To augment properties such as traction, rolling and abrasion resistance, it is typically compounded with other elastomers such as natural rubber and SBR. Other applications are golf ball cores, inner tubes of hoses for sandblasting, and covers for pneumatic and water hoses. Polybutadiene is also used as a toughening agent in the production of certain plastics (Polymerdatabase, 2022d).

PBR had a total trade of $2.35 billion in 2020. Between 2019 and 2020, the exports of PBR decreased by 25.1 percent, from $3.14 billion to $2.35 billion. South Korea had the highest total exports of PBR, valued at $427 million, while the U.S. was third highest, at $241 million. For the same year, China was the largest importer at $320 million (OEC, 2022k).

## 2.5 Group II Industry Profile

This section reviews Group II industries, which are characterized by the following source categories: epoxy and resins production and non-nylon polyamides production. The affected firms are more explicitly identified by size and economic impacts in a later section. Like the Group I facilities, each facility is identified using a NAICS code. Among the identified facilities in Group II, there are three unique NAICS codes represented in the associated NESHAP and the U.S. economy. Table 2-7 provides 2017 data for these industries in the U.S. economy, not only considering facilities directly impacted by this rulemaking.

**Table 2-7 Polymers and Resin Group II Industries**

| NAICS | Name of Industry | Number of Facilities Impacted (% of Total Facilities Impacted) | Total Industry Revenue in 2017 (in Billions) | Total Industry Employment in 2017 |
|---|---|---|---|---|
| 324110 | Petroleum Refineries | 1 (20%) | $478.60 | 63,594 |
| 325110 | Petrochemical Manufacturing | 1 (20%) | $52.67 | 9,369 |
| 325211 | Plastics Material and Resin Manufacturing | 3 (60%) | $89.52 | 75,998 |

### 2.5.1 Industry Organization of Group II Industries

This section provides information on the structure of the covered epoxy and resins industries, and the characteristics of the market organization of the affected Group II industries. This is an attempt to characterize the impacts this final regulation can have in more detailed terms.

Table 2-8 discusses how the firms in each product category can be characterized by market concentration: the market share percentage for the 50 largest firms of the affected industries by NAICS code.

**Table 2-8 Concentration Findings of Affected Group II Industries**

| NAICS | Name of Industry | HHI Value* | Finding |
|---|---|---|---|
| 324110 | Petroleum Refineries | 786 | Unconcentrated |
| 325110 | Petrochemical Manufacturing | 2,868.4 | Concentrated |
| 325211 | Plastics Material and Resin Manufacturing | 409.9 | Unconcentrated |

Notes: *HHI is based on the 50 largest companies for each NAICS code. HHI for years after 2012 are not available since comprehensive concentration data from the 2017 Economic Census is not yet available. This value is found using "value added" which is a measure of manufacturing activity. Value added is derived by subtracting the cost of purchased inputs from the value of shipments.
Source: US Census. Economic Census (August 2015).
https://www.census.gov/data/tables/2012/econ/census/manufacturing-reports.html

As presented in Section 2.2.1 and based on the given U.S. Department of Justice definition, only the petrochemical manufacturing markets could be considered concentrated in 2012. Whereas the HHI for both petroleum refineries and plastics materials and resin manufacturing markets suggest more competitive, unconcentrated industry markets. Like synthetic rubbers, most affected facilities under this rule inhabit more competitive markets, which generally suppresses the profit margins for certain firms and increases the price elasticity of demand. A market with output having higher price elasticity of demand shows a larger change in quantity demanded relative to a particular change in price, all else equal.

### 2.5.2 Prices for Group II Industries

Like Group I industries, Group II industries are also a part of the chemical manufacturing sector (NAICS 325). More information on prices for this sector can be found in Section 2.2.2. In this section, Table 2-9 shows a closer look at prices for epoxy and resins, and related products, from 2012 to 2021. Note that changes in the product prices of adhesives, coatings, and paper do directionally relate to price changes in the broader “Plastics Material and Resins Manufacturing” (Plastics and Resins) category, but the magnitude of these changes are varied.

Over this period, each product category saw overall prices increase with certain years with volatility in 2015 and 2019. In 2021, each product category saw its highest single-year spike in prices with Plastics and Resins increasing by over a third of its 2020 value. This one-year increase was largely a result of demand-side and supply-side conditions exacerbated by the COVID-19 pandemic. On the demand-side, COVID-19-related lockdowns increased the demand for delivered goods and therefore greater plastic packaging, while the healthcare industry augmented plastic demands for personal protective equipment (PPE). Supply-side issues also constrained the availability of plastics and resins due to related labor shortages or production slowdowns, as well as more widespread international supply chain difficulties (Pederson, 2021).

## Table 2-9 Producer Price Index of Epoxy and Resins, 2012-2021 (2012 = 100)

| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2012-2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Plastics Material and Resins Manufacturing** | 100.0 | 103.5 | 107.8 | 97.3 | 92.7 | 97.6 | 102.3 | 98.0 | 94.6 | 126.1 | |
| YoY Change | | 3.5 | 4.3 | -10.5 | -4.6 | 4.9 | 4.7 | -4.3 | -3.5 | 31.6 | 26.1 |
| % YoY Change | | 3.5% | 4.2% | -9.7% | -4.7% | 5.3% | 4.8% | -4.2% | -3.6% | 33.4% | 26.1% |
| **Adhesive Manufacturing: Synthetic Resin and Rubber Adhesives** | 100.0 | 100.7 | 102.1 | 101.3 | 100.2 | 101.7 | 104.2 | 106.5 | 107.0 | 113.0 | |
| YoY Change | | 0.7 | 1.4 | -0.8 | -1.1 | 1.5 | 2.4 | 2.4 | 0.4 | 6.0 | 13.0 |
| % YoY Change | | 0.7% | 1.4% | -0.8% | -1.1% | 1.5% | 2.4% | 2.3% | 0.4% | 5.6% | 13.0% |
| **Paint and Coating Manufacturing** | 100.0 | 101.3 | 102.1 | 101.0 | 100.5 | 101.6 | 105.3 | 110.0 | 112.1 | 121.3 | |
| YoY Change | | 1.3 | 0.8 | -1.1 | -0.6 | 1.1 | 3.7 | 4.7 | 2.1 | 9.1 | 21.3 |
| % YoY Change | | 1.3% | 0.8% | -1.1% | -0.5% | 1.1% | 3.7% | 4.4% | 1.9% | 8.2% | 21.3% |
| **Paper Manufacturing** | 100.0 | 102.2 | 103.6 | 103.4 | 102.6 | 105.2 | 108.9 | 110.2 | 108.6 | 117.6 | |
| YoY Change | | 2.2 | 1.4 | -0.2 | -0.8 | 2.6 | 3.7 | 1.3 | -1.6 | 9.0 | 17.6 |
| % YoY Change | | 2.2% | 1.4% | -0.2% | -0.8% | 2.5% | 3.5% | 1.2% | -1.5% | 8.3% | 17.6% |

Note: “YoY” is an acronym for “Year over Year”.

Source: Federal Reserve Economic Data, Economic Research Division, Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/PCU325211325211, https://fred.stlouisfed.org/series/PCU3255203255204, https://fred.stlouisfed.org/series/PCU325510325510, https://fred.stlouisfed.org/series/PCU322322

### *2.5.3 Product Description and Markets of Group II Industries*

The epoxy resins production source category involves the manufacture of basic liquid epoxy resins used in the production of glues, adhesives, plastic parts, and surface coatings. This source category does not include specialty or modified epoxy resins. The non-nylon polyamides production source category involves the manufacture of epichlorohydrin crosslinked non-nylon polyamides used primarily by the paper industry as an additive to paper products. Natural polymers, such as those contained in paper products, have little cross-linking, which allows their fibers to change position or separate completely when in contact with water. The addition of epichlorohydrin cross-linked non-nylon polyamides to these polymers causes the formation of a stable polymeric web among the natural fibers. Because the polymeric web holds the fibers in place even in the presence of water, epichlorohydrin cross-linked non-nylon polyamides are also referred to as wet-strength resins. HAP emission sources in Group II facilities include equipment leaks, process vents, wastewater, and storage tanks.

The epoxy resin market had a size of $12.8 billion in 2022. Grand View Research projects a compound annual growth rate of 7.3 percent from 2022 to 2030, forecasting a 2030 revenue of $22.4 billion. A key market driver is an increased demand for paints and coatings due to increased construction spending in North America and Western Europe. In 2021, “paints and coating” accounted for more than 37 percent of revenue share of epoxy resin applications and Asia-Pacific accounted for more than 61 percent of revenue share by region of the market (Grand View Research, 2022).

The non-nylon polyamide resin market had a size of $3.27 billion in 2020. Between 2019 and 2020, the exports decreased by 10.5 percent, from $3.65 billion to $3.27 billion. Germany had the highest total exports, valued at $197 million, while the U.S. was second at $529 million. For the same year, China was the largest importer at $502 million, whereas the U.S. was fourth highest at $155 million (OEC, 2022l).

# 3 EMISSIONS AND ENGINEERING COST ANALYSIS

## 3.1 Introduction

In this chapter, we present estimates of the projected emissions reductions and engineering compliance costs associated with the proposed action. The primary cost and emissions impacts are calculated at the emission points in the various HON and polymers and resins processes. This chapter has compliance cost estimates for heat exchange systems, storage vessels, process vents, wastewater, equipment leaks, flares, and fenceline monitoring. In addition to emissions reductions, some control options result in product recovery, which can then be sold. Estimates of annualized cost include the value of the product recovery where applicable.

## 3.2 HON

In general, the HON applies to chemical manufacturing process units (CMPUs) that: (1) produce one of the listed SOCMI chemicals, and (2) either use as a reactant or produce a listed organic HAP in the process. A CMPU refers to the collection of equipment assembled and connected by pipes or ducts to process raw materials and to manufacture an intended product. A CMPU consists of more than one unit operation. A CMPU includes air oxidation reactors and their associated product separators and recovery devices; reactors and their associated product separators and recovery devices; distillation units and their associated distillate receivers and recovery devices; associated unit operations; associated recovery devices; and any feed, intermediate and product storage vessels, product transfer racks, and connected ducts and piping. A CMPU includes pumps, compressors, agitators, pressure relief devices, sampling connection systems, open-ended valves or lines, valves, connectors, instrumentation systems, and control devices or systems. A CMPU is identified by its primary product.

The emissions sources affected by the current HON include heat exchange systems and maintenance wastewater regulated under NESHAP subpart F; process vents, storage vessels, transfer racks, and wastewater streams regulated under NESHAP subpart G; equipment leaks associated with SOCMI processes regulated under NESHAP subpart H; and equipment leaks from certain non-SOCMI processes at chemical plants regulated under NESHAP subpart I.

As of July 1, 2023, there were 207 facilities that are major sources of HAP emissions in operation that are subject to the HON. The list of facilities located in the United States that are major sources of HAP and part of the SOCMI source category with processes subject to HON is available in the memorandum titled: "Lists of Facilities Subject to the HON, Group I and Group II Polymers and Resins NESHAPs, and NSPS subparts VV, VVb, III, NNN, and RRR" (ERG, 2023a).

## 3.3 P&R I (Subpart U)

The P&R I NESHAP generally follows and refers to the requirements of the HON, with an addition of requirements for batch process vents. Generally, the P&R I NESHAP applies to elastomer product process units (EPPUs) and associated equipment. Similar to a CMPU in the HON, an EPPU means a collection of equipment assembled and connected by hard-piping or duct work used to process raw materials and manufacture elastomer product. The EPPU includes unit operations, recovery operations, process vents, storage vessels, and equipment that are covered by equipment leak standards and produce one of the elastomer types listed as an elastomer product (*i.e.*, the list found in Section 1.0 above). An EPPU consists of more than one unit operation. An EPPU includes, as equipment, pumps, compressors, agitators, pressure relief devices, sampling connection systems, open-ended valves or lines, valves, connectors, surge control vessels, bottoms receivers, and instrumentation systems, and control devices or systems.

The emissions sources affected by the current P&R I NESHAP include heat exchange systems and maintenance wastewater regulated under NESHAP subpart F; storage vessels, transfer racks, and wastewater streams regulated under NESHAP subpart G; and equipment leaks regulated under NESHAP subpart H. Process vents are also regulated emission sources but, unlike the HON, these emissions sources are subdivided into front and back-end process vent process vents in P&R I. The front-end are unit operations prior to and including the stripping operations. These are further subdivided into continuous front-end process vents regulated under NESHAP subpart G and batch front-end process vents that are regulated according to the requirements within the P&R I NESHAP. Back-end unit operations include filtering, coagulation, blending, concentration, drying, separating, and other finishing operations, as well as latex and crumb storage. The requirements for back-end process vents are not subcategorized into batch or continuous and are also found within the P&R I NESHAP.

As of July 1, 2023, there were 19 facilities that are major sources of HAP emissions in operation that are subject to the P&R I NESHAP. The list of facilities located in the United States that are major sources of HAP is available in the memorandum titled: "Lists of Facilities Subject to the HON, Group I and Group II Polymers and Resins NESHAPs, and NSPS subparts VV, VVa, III, NNN, and RRR" (ERG, 2023a).

## 3.4 P&R II (Subpart W)

The P&R II NESHAP takes a different regulatory and format approach from the P&R I NESHAP but still refers to HON provisions for a portion of the standards. There are two basic subcategories of manufacturing sources in the P&R II NESHAP – basic liquid epoxy resins (BLR) and wet strength resins (WSR). A BLR means resins made by reacting epichlorohydrin and bisphenol A to from diglycidyl ether of bisphenol-A (DGEBPA). A WSR means polyamide/epichlorohydrin condensates which are used to increase the tensile strength of paper products.

The emission sources affected by the P&R II NESHAP are all HAP emission points within a facility related to the production of BLR or WSR. These emission points include process vents, storage tanks, wastewater systems, and equipment leaks. Equipment includes connectors, pumps, compressors, agitators, pressure relief devices, sampling connection systems, open-ended valves and lines, and instrumentation system in organic HAP service. Equipment leaks are regulated under the HON (*i.e.*, NESHAP subpart G).

Process vents, storage tanks, and wastewater systems combined are regulated according to a production-based emission rate (*e.g.*, pounds HAP per million pounds BLR or WSR produced) standard for existing sources in both BLR (130 pounds) and WSR (10 pounds). For new sources, BLR requires 98 percent reduction or an overall limit of 5,000 pounds of HAP per year. New WSR sources are limited to 7 pounds of HAP per million pounds WSR produced.

As of July 1, 2023, there were 5 facilities that are major sources of HAP emissions in operation that are subject to the P&R II NESHAP. The list of facilities located in the United States that are major sources of HAP is available in the memorandum titled: "Lists of Facilities Subject to the HON, Group I and Group II Polymers and Resins NESHAPs, and NSPS subparts VV, VVa, III, NNN, and RRR" (ERG, 2023a).

## 3.5 Emission Points and Controls

The EPA evaluated developments in practices, processes, and control technologies for heat exchange systems, storage vessels, process vents, wastewater, and equipment leaks for processes subject to the HON, P&R I, and P&R II. Moreover, for the NSPS subpart VVa, we evaluated BSER for equipment leaks; and for the NSPS subparts III, NNN, and RRR we evaluated BSER for process vents associated with air oxidation units, distillation operations, and reactor processes, respectively. We analyzed costs and impacts for each emission source (*e.g.*, process vents) by each rule. For the different NSPS, we determined cost-effectiveness, cost per ton of emissions reduced, on a VOC basis. For each NESHAP, we determined cost-effectiveness on a HAP basis from the VOC emissions. The estimation of total capital cost (synonymous with total capital investment) and total annual cost follows the methodology in the *EPA Air Pollution Control Cost Manual* (U.S. EPA, 2017). Estimates of total annual cost presented in this chapter include both operating and maintenance and annualized capital costs (from capital recovery) and are estimated for each year in the analytic timeframe for this action of 2024-2038. The capital costs are annualized at 5.5% over a time period of 15 years (2024-2038), a time period that reflects the life of control equipment and measures applied to reduce HAP emissions. All costs are in 2021 dollars.

### *3.5.1 Flares*

Flares that control emissions from processes subject to HON or the P&R I NESHAP are required to meet certain design and operating requirements as specified in 40 CFR 63.11. The available data at the time these NESHAP were promulgated suggested that flares meeting these design and operating requirements would achieve a minimum destruction efficiency of no less than 98 percent emissions control. Relatively recent evidence through Passive Fourier Transform Infrared spectroscopy (PFTIR) testing suggests that steam- and air-assisted flares can have a significant degradation in destruction efficiency when operated at high turndown or at other times when steam- and air-assist rates are too high (EPA, 2012). As many of the flares operated at HON and P&R I facilities are steam- or air-assisted, concerns of poor flare destruction efficiency are particularly significant. We note that a substantial portion of the costs, both capital and annual, for the final HON and P&R I amendments and for this entire final action, are from the control requirements for flares. Tables 3-1 and 3-2 present cost and emission reductions for flare control options included as part of the HON amendments under this final action. More information on these systems and control options can be found in the preamble for this rulemaking.

**Table 3-1 Nationwide Cost Impacts (2021$) for Flares in the SOCMI Source Category that Control Emissions from HON Processes including P&R I Flares Collocated with HON Processes[a,b]**

| Control Option | Total Capital Investment (MM$) | Total Annualized Cost (MM$/yr) |
|---|---|---|
| Flare Operational and Monitoring Requirements | 323.1 | 67.8 |
| Work Practice Standards for Flares Operating Above Their Smokeless Capacity | 3.34 | 0.79 |
| **Nationwide Total** | **326.4** | **68.6** |

(a) We were unable to quantify emissions reductions for this option but anticipate some excess emissions reductions.

(b) VOC and HAP emission reductions are anticipated excess emissions impacts based on ensuring flares achieve the MACT level of control.

**Table 3-2 Nationwide VOC and HAP Emissions Reductions and Cost-Effectiveness for Flares in the SOCMI Source Category that Control Emissions from HON Processes including P&R I Flares Collocated with HON Processes**

| Control Option | VOC Emission Reductions (ton/yr) | VOC Cost-Effectiveness ($/ton) | HAP Emissions Reductions (ton/yr) | HAP Cost-Effectiveness ($/ton) |
|---|---|---|---|---|
| Flare Operational and Monitoring Requirements(a) | 19,325 | 3,512 | 4,717 | 14,387 |
| Work Practice Standards for Flares Operating Above Their Smokeless Capacity) (b) | -- | -- | -- | -- |

(a) VOC and HAP emission reductions are anticipated excess emissions impacts based on ensuring flares achieve the MACT level of control.

(b) There are no emission reductions for the work practice standards which is why this row is empty.

The nationwide impacts for applying the new flare operating and monitoring requirements to flares that control emissions from P&R I processes and applying alternative work practice standards for visible emissions events above the smokeless capacity of each of these flares are summarized in Tables 3-3 and 3-4.

**Table 3-3  Nationwide Cost Impacts (2021$) for Flares that Control Emissions from P&R I Processes**

| Control Option | Total Capital Investment (MM$) | Total Annualized Cost (MM$/yr) |
|---|---|---|
| Flare Operational and Monitoring Requirements | 6.93 | 1.46 |
| Work Practice Standards for Flares Operating Above Their Smokeless Capacity | 0.08 | 0.02 |
| **Nationwide Total** | **7.1** | **1.48** |

**Table 3-4  Nationwide VOC and HAP Emissions Reductions and Cost-Effectiveness for Flares that Control Emissions from P&R I Processes**

| Control Option | VOC Emission Reductions (ton/yr) | VOC Cost-Effectiveness ($/ton) | HAP Emissions Reductions (ton/yr) | HAP Cost-Effectiveness ($/ton) |
|---|---|---|---|---|
| Flare Operational and Monitoring Requirements(a) | 564 | 2,594 | 141 | 10,378 |
| Work Practice Standards for Flares Operating Above Their Smokeless Capacity(b) | -- | -- | -- | -- |

(a) VOC and HAP emission reductions are anticipated excess emissions impacts based on ensuring flares achieve the MACT level of control.

(b) There are no emission reductions for the work practice standards which is why this row is empty.

With respect to nationwide impacts, we anticipate that there would be no additional cost impacts for additional monitoring equipment needed to operate these flares at existing HON operations, as well as no additional emissions reductions realized. Multi-point ground flares are primarily secondary flares. Facilities that currently use these controls will already have the necessary monitoring equipment in place.

### *3.5.2 Fenceline Monitoring*

Fenceline monitoring refers to the placement of monitors along the perimeter of a facility to measure pollutant concentrations. Coupled with requirements for root cause analysis and corrective action upon triggering an actionable level, this work practice standard is a development in practices considered under CAA section 112(d)(6) for the purposes of managing fugitive emissions. Below in Tables 3-5 and 3-6 are costs and emission reductions associated with several fenceline monitoring scenarios or options in the final HON and P&R I amendments. More information on fenceline monitoring and implementation options can be found in the preamble for this rulemaking.

**Table 3-5 Nationwide Cost Impacts of Fenceline Monitoring for HON**

| Monitoring scenario | Number of Facilities Impacted | Monitoring option description | Total capital investment ($) | Total annualized costs ($/yr) |
|---|---|---|---|---|
| 1 | 35 | Passives only (1 analyte)* | 4,016,000 | 2,141,000 |
| 2 | 46 | Passives only (2 analytes) | 2,295,000 | 1,282,000 |
| 3 | 9 | Cannisters only | 115,500 | 5,366,000 |
| 4 | 16 | Cannisters and passives (1 analyte) | 1,606,000 | 10,397,000 |
| 5 | 20 | Cannisters and passives (2 analytes) | 1,721,000 | 12,869,000 |

*An analyte is the chemical substance being measured. For these fenceline monitoring options, the analyte is a HAP monitored under HON and P&R I requirements.

**Table 3-6 Nationwide Cost Impacts of Fenceline Monitoring for P&R I**

| Monitoring scenario | Number of Facilities Impacted | Monitoring option description | Total capital investment ($) | Total annualized costs ($/yr) |
|---|---|---|---|---|
| 1 | 1 | Cannisters and passives (2 analytes) | 114,700 | 659,000 |
| 2 | 1 | Cannisters only | 12,800 | 596,000 |

### *3.5.3 Pressure Relief Devices*

Pressure relief devices (PRD) are designed to open when the system pressure exceeds a set pressure, allowing the release of vapors or liquids until the system pressure is reduced to its normal operating level. When the normal pressure is re-attained, the valve re-seats and a seal is again formed. Leaks can occur as a result of improper reseating, or if the process is operating too close to the set pressure of the PRD and the PRD does not maintain its seal. PRD emissions can be controlled by venting emissions to a closed-vent system or through the use of a rupture disk.

For PRD releases, we are revising the definition of “pressure relief device” for the HON and P&R I, the definition of “relief valve” for the HON and P&R I, and the definition for “pressure relief device” in P&R II. Under CAA section 112(h), we are finalizing a work practice standard for PRDs at 40 CFR 63.165(e) (for HON) and 40 CFR 63.502(a)(1) and (a)(2) (which references 40 CFR 63.165, for P&R I) that consists of using at least three prevention measures and performing root cause analysis and corrective action in the event that a PRD does release emissions directly to the atmosphere. Examples of prevention measures include flow indicators, level indicators, temperature indicators, pressure indicators, routine inspection and maintenance programs or operator training, inherently safer designs or safety instrumentation systems, deluge systems, and staged relief systems where the initial PRD discharges to a control system. Table 3-7 provides cost estimates for PRDs in the HON and P&R I and II.

**Table 3-7 Nationwide Cost Impacts of Control Options Considered for Pressure Relief Devices at HON and P&R I and II Facilities**

| Control option 1 | Total capital investment ($) | Total annualized costs ($/yr) |
|---|---|---|
| HON | 16,829,351 | 7,481,607 |
| P&R I | 504,350 | 128,475 |
| P&R II | 132,724 | 33,809 |

### *3.5.4 Storage Vessels*

Storage vessels are used to store liquid and gaseous feedstocks for use in a process, as well as to store liquid and gaseous products from a process. Most storage vessels are designed for operation at atmospheric or near atmospheric pressures; high pressure vessels are used to store compressed gases and liquefied gases. Atmospheric storage vessels are typically cylindrical with a vertical orientation, and they are constructed with either a fixed roof or a floating roof. Some, generally small, atmospheric storage vessels are oriented horizontally. High pressure vessels are either spherical or horizontal cylinders.

Below in Tables 3-8 through 3-10 is a presentation of different control options considered for storage vessels, and then costs and emissions reductions for the different regulatory options. More information on these systems and control options can be found in the preamble for this rulemaking.

**Table 3-8 Summary of Storage Vessel Control Options Evaluated for the HON**

| Storage Vessel Control Option | Control Option Description |
|---|---|
| SV1 | Revise the HON and P&R I NESHAP applicability threshold to require existing storage vessels between 38 $m^3$ (10,000 gal) and 151 $m^3$ (40,000 gal) with a vapor pressure ≥6.9 kPa to add control.<br>Control is assumed to be a retrofitted IFR |
| SV2 | SV1 plus require upgraded deck fittings and controls for guide poles for all IFR storage vessels |
| SV3 | Convert each EFR to an IFR through installation of a geodesic dome plus require upgraded deck fittings and controls for guide poles. |

**Table 3-9 Nationwide Emissions Reductions and Cost Impacts of Control Options Considered for Storage Vessels at HON Facilities**

| Control option | Total capital investment ($) | Total annualized costs ($/yr) | VOC emission reductions (tpy) | HAP emission reductions (tpy) | HAP cost effectiveness ($/ton) |
|---|---|---|---|---|---|
| 1 | 1,727,000 | 327,400 | 58.0 | 40.6 | 8,070 |
| 2 | 2,191,500 | 415,500 | 68.2 | 47.7 | 8,710 |
| 3 | 28,916,200 | 4,065,700 | 84.3 | 59.0 | 68,880 |

**Table 3-10 Nationwide Emissions Reductions and Cost Impacts of Control Options Considered for Storage Vessels at P&R I Facilities (not collocated with HON facilities)**

| Control option | Total capital investment ($) | Total annualized costs ($/yr) | VOC emission reductions (tpy) | HAP emission reductions (tpy) | HAP cost effectiveness ($/ton) |
|---|---|---|---|---|---|
| 1 | 109,000 | 20,700 | 3.7 | 2.6 | 7,960 |
| 2 | 131,000 | 24,800 | 4.1 | 2.9 | 8,550 |
| 3 | 912,200 | 128,300 | 2.7 | 1.9 | 67,500 |

### *3.5.5 Heat Exchange Systems*

Heat exchangers are devices or collections of devices used to transfer heat from process fluids to another process fluid (typically water) without intentional direct contact of the process fluid with the cooling fluid (*i.e.*, non-contact heat exchanger). There are two types of heat exchange systems: Closed-loop recirculation systems and once-through systems. Closed-loop recirculation systems use a cooling tower to cool the heated water leaving the heat exchanger and then return the newly cooled water to the heat exchanger for reuse. Once-through systems typically use surface freshwater (*e.g.*, from rivers) as the influent cooling fluid to the heat exchangers, and the heated water leaving the heat exchangers is then discharged from the facility.

Based on the HON heat exchange system technology review at proposal, we identified the following control option (a development in practice as defined in section 112(c)(6)) for heat exchange systems: quarterly monitoring with the Modified El Paso Method.[16] This method uses a

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[16] ERG, 2023. Clean Air Act Section 112(d)(6) Technology Review for Heat Exchange Systems Located in the SOCMI Source Category that are Associated with Processes Subject to HON and for Heat Exchange Systems that are Associated with Processes Subject to Group I Polymers and Resins NESHAP. March 2023. EPA Docket No. EPA-HQ-OAR-2022-0730.

leak action level defined as a total strippable hydrocarbon concentration (as methane) in the stripping gas of 6.2 parts per million by volume (ppmv). This method does not allow the delay of repair of leaks for more than 30 days where a total strippable hydrocarbon concentration (as methane) in the stripping gas of 62 ppmv or higher is found. This option would also require re-monitoring at the monitoring location where the leak was identified to ensure that any leaks found are fixed. More information on these systems and control options can be found in the preamble for this rulemaking.

**Table 3-11 VOC and HAP Cost Effectiveness for the Control Option Evaluated for Heat Exchange Systems at HON Facilities (2021$)**

| Control option | Total capital investment ($) | Total annualized costs ($/yr) | VOC emission reductions (tpy) | HAP emission reductions (tpy) | HAP cost effectiveness ($/ton) |
|---|---|---|---|---|---|
| 1 | 784,000 | 238,000 | 934 | 93 | 2,441 |

### *3.5.6 Process Vents*

A process vent is a gas stream that is discharged during the operation of a particular unit operation (*e.g.*, separation processes, purification processes, mixing processes, reaction processes). The gas stream(s) may be routed to other unit operations for additional processing (*e.g.*, a gas stream from a reactor that is routed to a distillation column for separation of products), sent to one or more recovery devices, sent to a process vent header collection system (*e.g.*, blowdown system) and air pollution control device (APCD) (*e.g.*, flare, thermal oxidizer, carbon adsorber), and/or vented to the atmosphere. Process vents may be generated from continuous and/or batch operations,[17] as well as from other intermittent types of operations (*e.g.*, maintenance operations). If process vents are required to be controlled prior to discharge to the atmosphere to meet an applicable emissions standard, then they are typically collected and routed to an APCD through a closed vent system.

During the public comment period for the proposed amendments, the EPA received additional information from commenters on costs necessary for control of process vents that emit greater than or equal to 1.0 lb/hr of total organic HAP.

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[17] P&R I and P&R II regulate process vents from both continuous and batch operations. The HON and NSPS subparts III, NNN, and RRR only regulate process vents if some, or all, of the gas stream originates as a continuous flow.

The proposed cost estimate underestimated flow rates needed to route Group 2 continuous process vents with greater than or equal to 1.0 lb/hr of total organic HAP to APCDs. The revised estimates reflect the limitations of the correlations associated with the EPA's control cost template which starts with a flow rate of 500 standard cubic feet per minute (scfm). With these corrections, we estimate the average total capital investment (TCI) to install a new recuperative thermal oxidizer (for both HON and P&R I) is about $167,000 (as opposed to the $66,000 proposed).

In light of the fact that commenters were generally concerned about the cost estimate, we performed additional analyses to evaluate the cost effectiveness to remove the TRE concept from HON and P&R I. Using a TCI of $1,000,000 as provided by the commenter, and the EPA's control cost template (for installing a new recuperative thermal oxidizer with 70 percent energy recovery), we estimated an annual cost of approximately $330,000 (for HON) and $318,000 (for P&R I).

Tables 3-12 through 3-14 include a summary of control options for process vents, and costs and emission reductions for each option and type of process vents considered under each of the rules in this final rulemaking. More information on these systems and control options can be found in the preamble for this rulemaking.

**Table 3-12 Summary of Continuous Process Vent Control Options Evaluated for the HON and P&R I NESHAP**

| Process Vent Control Option | Control Option Description |
|---|---|
| PV1 | • Remove TRE concept in its entirety from HON and P&R I NESHAP.<br>• Remove 50 ppmv and 0.005 scmm Group 1 process vent thresholds from HON and P&R I NESHAP.<br>• Redefine a HON and P&R I NESHAP Group 1 process vent (require control) as any process vent that emits ≥1.0 lb/hr of total organic HAP. |
| PV2 | • Same as PV1 but redefine a HON and P&R I NESHAP Group 1 process vent (require control) as any process vent that emits ≥0.10 lb/hr of total organic HAP. |
| PV3 | • Keep TRE concept in HON and P&R I NESHAP but change index value threshold from 1.0 to 5.0 Keep 50 ppmv and 0.005 scmm Group 1 process vent thresholds in HON and P&R I NESHAP. |

**Table 3-13 Nationwide Emissions Reductions and Cost Impacts of Control Options Considered for Continuous Process Vents at HON and P&R I Facilities**

| Control option 1 | Total capital investment ($) | Total annualized costs ($/yr) | VOC emission reductions (tpy) | HAP emission reductions (tpy) | HAP cost effectiveness ($/ton) |
|---|---|---|---|---|---|
| HON – PV1 | $16,171,549 | $5,295,079 | 538 | 538 | $9,835 |
| PV2 | $21,903,378 | $15,624,555 | 809 | 533 | $29,314 |
| PV3 | $17,664,900 | $25,954,031 | 441 | 441 | $58,853 |
| P&R I – PV1 | $3,002,400 | $966,000 | 60.4 | 60.4 | $15,992 |
| PV2 | $3,559,327 | $2,208,379 | 80.1 | 72.4 | $30,502 |
| PV3 | $3,217,562 | $1,555,812 | 54.8 | 54.8 | $28,391 |

**Table 3-14 Nationwide Emissions Reductions and Cost Impacts of Control Options Considered for Batch Front-end Process Vents at P&R I Facilities**

| Control option | Total capital investment ($) | Total annualized costs ($/yr) | VOC emission reductions (tpy) | HAP emission reductions (tpy) | HAP cost effectiveness ($/ton) |
|---|---|---|---|---|---|
| 1 | 811,000 | 650,700 | 105 | 105 | 6,200 |

#### *3.5.6.1 Process Vents – Subpart IIIa, NNNa, and RRRa NSPS*

The EPA has used a TRE index value of 1.0 as a basis for distinguishing process vents in the SOCMI NSPS (40 CFR 60 subparts III, NNN, and RRR) rulemakings. In general, for these rules, process vents with a TRE index value equal to or less than 1.0 are required to be controlled (given that process vents with low TRE index values tend to have both higher emission stream flow rates and higher emission rates than process vents with higher TREs). Increased flow from a vent generally corresponds with increased size of the unit operation and increased production rate.

The TRE index is derived from the cost effectiveness associated with VOC control by thermal oxidation, and is a function of vent stream flowrate, vent stream net heating value, hourly emissions, and a set of coefficients. The coefficients are based on both the net heating value of the vent stream and whether or not the vent stream is chlorinated.

We evaluated cost and VOC emissions reductions for the HON for the same process vent control options for the same unit operations (i.e., air oxidation unit processes, distillation operations, and reactor processes). Therefore, we used the average cost and emissions reductions that we determined for process vents subject to the HON to evaluate the costs, VOC emission reductions, and cost-effectiveness of the process vent control options for NSPS subparts III, NNN, and RRR. Table 3-15 summarizes these average HON cost and VOC emissions reductions.

**Table 3-15 Average Cost and Emission Reductions for Process Vents Subject to the HON Used for the Suite of Process Vent Requirements Evaluated for the NSPS subparts IIIa, NNNa, and RRRa**

| Description | Total Capital Investment ($) | Total Annual Cost ($/yr) | Total Annual Cost w/ Recovery Credits ($/yr) | VOC Emission Reductions (tpy) |
|---|---|---|---|---|
| Flare monitoring requirements[1] | 3,752,200 | 789,200 | 789,200 | 93 |
| Maintenance vent requirements[2] | - | 460 | 460 | - |
| Revising the standard from a TRE calculation to control of all vent streams[3] | 39,300 | 98,400 | 98,400 | 9.1 |
| Adsorber monitoring (carbon cannisters)[4] | 26,500 | 2,500 | 2,500 | 0.21 |

[1] For additional details, see the document titled *Control Option Impacts for Flares Located in the SOCMI Source Category that Control Emissions from Processes Subject to HON and for Flares that Control Emissions from Processes Subject to Group I and Group II Polymers and Resins NESHAPs*, which is available in the docket for this rulemaking.
[2] For additional details, see the document titled *Review of Regulatory Alternatives for Certain Vent Streams in the SOCMI Source Category that are Associated with Processes Subject to HON and Processes Subject to Group I and Group II Polymers and Resins NESHAPs*, which is available in the docket for this rulemaking.
[3] For additional details, see the document titled *Clean Air Act Section 112(d)(6) Technology Review for Continuous Process Vents Located in the SOCMI Source Category that are Associated with Processes Subject to HON, Continuous Front-end and Batch Front-end Process Vents Associated with Processes Subject to Group I Polymers and Resins NESHAP, and Process Vents Associated with Processes Subject to Group II Polymers and Resins NESHAP*, which is available in the docket for this rulemaking.
[4] For additional details, see the document titled *Analysis of Monitoring Costs and Dual Bed Costs for Non-Regenerative Carbon Adsorbers Used in the SOCMI Source Category that are Associated with Processes Subject to HON and for Non-Regenerative Carbon Adsorbers that are Associated with Processes Subject to Group I Polymers and Resins NESHAP*, which is available in the docket for this rulemaking.

We analyzed the application of these requirements for process vents, varying the application based on whether new or existing facilities are affected and if the site is new, modified or reconstructed. For scenario 1 (i.e., affected facility is at a new greenfield facility), we assumed only one non-HON greenfield facility will trigger NSPS subpart III, NNN, or RRR over the next five years. We also assumed this greenfield facility would not be subject to the EMACT standards, MON, and petroleum refineries NESHAP, and the facility will use one flare and one non-flare APCD to control all their SOCMI NSPS unit operations.

We used facility responses to the EPA's CAA section 114 request to help us determine the number of facilities that could potentially trigger scenarios 2, 3, and 4.

For scenario 2 (new affected facilities constructed at existing plant sites), we estimate six new affected facilities will be built and be subject to new requirements in a new NSPS subpart IIIa, NNNa, or RRRa over the next five years. Facilities responding to the EPA's CAA section 114 request had 500 unit operations subject to either NSPS subpart III, NNN, or RRR; and only one of these unit operations was new construction in the last five years and not subject to the HON. We determined that there are currently 284 SOCMI facilities subject to either NSPS subpart III, NNN, or RRR; and 196 of these are non-HON facilities. Based on our CAA section 114 data, HON facilities have on average 45 unit operations per facility. Assuming non-HON facilities are smaller, we estimate that non-HON facilities subject to either NSPS subpart III, NNN, or RRR have 15 unit operations per facility. Assuming the same distribution of new construction for non-HON facilities, we estimate that six new affected facilities (one new unit operation per non-HON facility subject to either NSPS subpart III, NNN, or RRR), would have been constructed in the last five years ($\frac{1}{500} * 15 * 196$). This analysis assumes that the same number of unit operations that were constructed in the last five years would be constructed in the next five years.

For Scenarios 3 and 4 (existing facility is modified or reconstructed), we estimate 12 existing affected facilities will trigger new requirements in a new NSPS subpart IIIa, NNNa, or RRRa over the next five years due to modification or reconstruction. Facilities responding to the EPA's CAA section 114 request had 500 unit operations subject to either III, NNN, or RRR; however, only two of these unit operations were modified or reconstructed in the last 5 years and not subject to the HON. Using similar procedures as described above for scenario 2, we estimate that 12 modified or reconstructed affected facilities (1 modified or reconstructed unit operation per non-HON facility subject to the NSPS), would have been modified or reconstructed in the last five years ($\frac{2}{500} * 15 * 196$). This analysis assumes that the same number of unit operations that were modified or reconstructed in the last five years would be modified or reconstructed in the next five years.

Table 3-16 provides nationwide capital and annual costs to comply with the process vent control options.

**Table 3-16 Nationwide Emissions Reductions and Cost Impacts of Control Options Considered for Non-HON Vent Streams Triggering NSPS Subparts IIIa, NNNa, and/or RRRa**

| Scenario | Total Capital Investment ($) | Total Annual Cost ($/yr) | Total Annual Cost w/ Recovery Credits ($/yr) | VOC Emission Reductions (tpy) | Cost-effectiveness w/ Recovery Credits ($/ton VOC) |
|---|---|---|---|---|---|
| Scenario 1 (*i.e.*, one affected facility at a new greenfield facility) | 1,665,300 | 461,000 | 461,000 | 93 | 4,960 |
| Scenario 2 (*i.e.*, new affected facility at six existing facilities) | 7,609,500 | 1,780,000 | 1,780,000 | 392 | 4,540 |
| Scenarios 3 and 4 (*i.e.*, 12 existing affected facilities modified or triggers the reconstruction requirements) | 15,192,500 | 3,558,000 | 3,558,000 | 783 | 4,540 |
| **Total** | **24,467,300** | **5,799,800** | **5,799,800** | **1,269** | **4,570** |

### *3.5.7 Wastewater*

HAP are emitted into the air from wastewater collection, storage, and treatment systems that are uncovered or open to the atmosphere through volatilization of organic compounds at the liquid surface. Emissions occur by diffusive or convective means, or both. Diffusion occurs when organic concentrations at the water surface are much higher than ambient concentrations. The organics volatilize, or diffuse into the air, to reach equilibrium between aqueous and vapor phases. Convection occurs when air flows over the water surface, sweeping organic vapors from the water surface into the air. The rate of volatilization is related directly to the speed of the air flow over the water surface.

The HON defines wastewater to mean water that: (1) contains either: (i) an annual average concentration of compounds of at least 5 part per million by weight (ppmw) and has an annual average flow rate of 0.02 liter per minute (lpm) or greater or (ii) an annual average concentration of compounds of at least 10,000 ppmw at any flow rate, and that (2) is discarded from a CMPU that meets all of the criteria specified in 40 CFR 63.100 (b)(1) through (b)(3). Wastewater is process wastewater or maintenance wastewater.

P&R II defines wastewater as aqueous liquid waste streams exiting equipment at an affected source. No further stratification into groups for applicability is specified.

Below in Tables 3-17 and 3-18 are costs and emission reductions for control options considered for wastewater under the final HON amendments, and P&R I. More information on these systems and control options can be found in the preamble for this final rulemaking.

**Table 3-17 Nationwide Emissions Reductions and Cost Impacts of Control Options Considered for Wastewater Streams at HON Facilities**

| Control option | Total capital investment ($) | Total annualized costs ($/yr) | VOC emission reductions (tpy) | HAP emission reductions (tpy) | HAP cost effectiveness ($/ton) |
|---|---|---|---|---|---|
| 1 | 504,766,000 | 210,739,500 | 2,755 | 2,755 | 76,500 |

**Table 3-18 Nationwide Emissions Reductions and Cost Impacts of Control Options Considered for Wastewater Streams at P&R I Facilities**

| Control option | Total capital investment ($) | Total annualized costs ($/yr) | VOC emission reductions (tpy) | HAP emission reductions (tpy) | HAP cost effectiveness ($/ton) |
|---|---|---|---|---|---|
| 1 | 46,847,800 | 22,548,200 | 220 | 220 | 102,500 |

### *3.5.8 Equipment Leaks*

Emissions of VOC and HAP from equipment leaks occur in the form of gases or liquids that escape to the atmosphere through many types of connection points (*e.g.*, threaded fittings) or through the moving parts of certain types of process equipment during normal operation. Equipment regulated by the HON, P&R I, and P&R II includes agitators, compressors, connectors, instrumentation systems, OEL, PRDs, pumps, sampling collection systems, and valves[18] that contain or contact material that is five percent by weight or more of organic HAP, operate 300 hours per year or more, and are not in vacuum service.

Based on the costs and emission reductions for the options, we determined that none of them are cost effective. Therefore, we are not revising the HON, P&R I, and P&R II to reflect the requirements of these options pursuant to CAA section 112(d)(6). However, tighter requirements on equipment leaks will be included under Subpart VVb NSPS. Table 3-19 provides costs and emission reductions for these tighter requirements by type of affected

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[18] We believe P&R II contains a typographical error in that valves are currently excluded from the definition of equipment leaks at 40 CFR 63.522; see section III.D.10 of the preamble for this rulemaking for our rationale for this conclusion.

facilities as well as the total costs and emission reductions. More information on these systems and control options can be found in the preamble for this final rulemaking.

**Table 3-19 Nationwide Emissions Reductions and Cost Impacts of Control Options Considered for Affected Facilities Triggering NSPS Subpart VVb**

| Scenario | Total Capital Investment ($) | Total Annual Cost ($/yr) | Total Annual Cost w/ Recovery Credits ($/yr) | VOC Emission Reductions (tpy) | Cost-effectiveness w/ Recovery Credits ($/ton VOC) |
|---|---|---|---|---|---|
| Scenario 1 (*i.e.*, two affected facilities at a new greenfield facility) | 416,600 | 77,500 | 60,900 | 18 | 3,380 |
| Scenario 2 (*i.e.*, 34 new affected facilities) | 7,081,700 | 1,317,900 | 1,035,800 | 313 | 3,310 |
| Scenarios 3 and (*i.e.*, one modified existing affected facility) | 208,300 | 38,800 | 30,500 | 9 | 3,390 |
| **Total** | **7,706,600** | **1,434,200** | **1,127,200** | **340** | **3,320** |

## 3.6 Engineering Cost Analysis Summary Results

Table 3-20 below presents a summary of the costs for the HON amendments by emission point and in total. Capital and total annual costs are shown, and total annual costs are shown with and without product recovery. Engineering cost estimates in this chapter include projections of revenue from product recovery. This is because some control options analyzed in this RIA lead to the recovery of chemical products (e.g., leak detection and repair (LDAR) for equipment leak emissions). Recovered chemical product affected by this rulemaking is monetized as recovery credits by multiplying VOC emissions reductions by a VOC credit of $900/ton (2021 dollars). A recovery credit of $900 per ton VOC was applied to the VOC emission reductions in the analyses to calculate the savings in chemicals not being emitted (i.e., lost). The $900 per ton recovery credit has historically been used by EPA to represent the variety of chemicals that are used as reactants and produced at synthetic organic chemical manufacturing (SOCMI) facilities (EPA, 2007).

The effect of product recovery on the total annual costs is quite small, as is shown in the table. The total capital cost of the final HON amendments is about $455 million, and the total annual cost is about $168 million (with product recovery) and $169 million (without product recovery) in 2021 dollars. The estimation of total capital cost (synonymous with total capital investment) and total annual cost follows the methodology in the *EPA Air Pollution Control Cost Manual* (U.S. EPA, 2017). Estimates of total annual cost includes both operating and maintenance and annualized capital costs (from capital recovery) and are estimated for each year in the analytic timeframe for this action of 2024-2038. The inclusion of product recovery reduces the total annual cost by only 0.5 percent (about $980,000, as shown in the table), but its inclusion leads to annual cost savings from controls for heat exchange systems.

In the table below the ethylene oxide (EtO) Risk line item refers to costs considered for EtO specific changes to HON facilities for equipment leaks, wastewater, process vents, flare maintenance/equip openings, storage vessels, and heat exchange systems. While the three separate storage vessel line items refer to various measures the rule is addressing for that emission point. For example, the pressure vessel line is the cost estimate for monitoring, repair, recordkeeping, and reporting for annual Method 21 monitoring of a pressure vessel. For me details on the different rule provision please see the preamble for this final rulemaking.

**Table 3-20 Detailed Costs for the HON Source Category by Emission Point for the Final Rule (2021$)**

| Emission Point | Total Capital Cost ($) | Total Annual Cost ($/yr) Without Recovery Credits | Total Annual Cost ($/yr) With Recovery Credits | Annual Recovery Credits ($/yr) |
|---|---|---|---|---|
| Flares | 326,443,400 | 68,658,000 | 68,658,000 | 0 |
| Fenceline Monitoring | 9,754,300 | 32,055,300 | 32,055,300 | 0 |
| Pressure Relief Devices | 16,829,400 | 7,481,600 | 7,481,600 | 0 |
| Storage Vessels | 2,191,500 | 415,500 | 415,500 | 0 |
| Storage Vessels - Degassing | 0 | 751,500 | 751,500 | 0 |
| Storage Vessels – Pressure Vessels | 77,700 | 72,900 | 72,900 | 0 |
| Storage Vessels – 240hr Maintenance | 2,637,400 | 456,500 | 456,500 | 0 |
| Maintenance | 0 | 94,200 | 94,200 | 0 |
| Heat Exchange Systems | 783,800 | 237,700 | -603,000 | 840,800 |
| Process Vents | 16,171,500 | 5,294,600 | 5,294,600 | 0 |
| EtO Risk | 76,695,000 | 51,453,100 | 51,315,400 | 137,651 |
| Dioxins/Furans | 3,920,000 | 2,275,000 | 2,275,000 | 0 |
| Carbon Cannisters | 53,000 | 5,000 | 5,000 | 0 |
| **Total** | **455,557,700** | **169,250,100** | **168,273,200** | **983,900** |

Note: The estimation of total capital cost (synonymous with total capital investment) and total annual cost follows the methodology in the *EPA Air Pollution Control Cost Manual* (U.S. EPA, 2017). Estimates of total annual cost includes both operating and maintenance and annualized capital costs (from capital recovery) and are estimated for each year in the analytic timeframe for this action of 2024-2038. The assumed interest rate for the annualized cost is 5.5 percent.

Tables 3-21 and 3-22 below present a summary of the costs for the final P&R I (Table 3-21) and P&R II (Table 3-22) amendments by emission point and in total. Capital and total annual costs are shown, and total annual costs are shown with and without product recovery. The effect of product recovery on the total annual costs is quite small, as is shown in Table 3-21 for P&R I. The total capital cost of the final P&R I amendments is about $28 million, and the total annual cost is about $15 million (with product recovery) and $15 million (without product recovery) in 2021 dollars. The estimation of total capital cost (synonymous with total capital investment) and total annual cost follows the methodology in the EPA Air Pollution Control Cost Manual (EPA, 2017). Estimates of total annual cost includes both operating and maintenance and annualized capital costs (from capital recovery). The inclusion of product recovery reduces the total annual cost by only 0.2 percent (about $29,000, as shown in the table), but its inclusion leads to annual cost savings from controls for heat exchange systems. For the P&R II final amendments, Table 3-22 shows that the total capital cost is about $3 million, with about $2 million in total annual costs and no product recovery.

For the various NSPS rules, as shown in Table 3-23, the total capital cost for the subpart VVb is about $8 million, with a total annual cost of just over $1 million with product recovery included. With product recovery included, the total annual cost is about $300,000 lower. For the other three NSPS (subpart IIIa, NNNa, RRRa) considered together, the total capital cost is about $28 million, with a total annual cost of about $6 million as shown in Table 3-23. There is no product recovery associated with the controls to meet the requirements for these three NSPS.

Finally, the cumulative total capital cost for the entire final action, as shown in Table 3-23, is about $522 million, with a total annual cost for the entire action of $193 million with product recovery. Given that the product recovery is just over $1.3 million, the total annual cost without product recovery is $194 million. The cumulative product recovery is only about 0.6 percent of the total annual costs.

Because the controls considered lead to product recovery, it is possible for the cost of a control option to be negative once the value of product recovery is considered (the potential annualized costs may be outweighed by the revenue from product recovery). This observation may typically support an assumption that owners of facilities would continue to perform the emissions abatement activity regardless of whether a requirement is in place, because it is in their private self-interest. However, there may be an opportunity cost associated with the installation of environmental controls or implementation of compliance activities (for purposes of mitigating the emission of pollutants) that is not reflected in the control costs. If environmental investment displaces investment in productive capital, the difference between the rate of return on the marginal investment displaced by the mandatory environmental investment is a measure of the opportunity cost of the environmental requirement to the regulated entity. To the extent that any opportunity costs are not added to the control costs, the compliance costs presented above may be underestimated. In addition, the hurdle rate is defined as the minimum rate of return on an investment that a firm would deem acceptable under typical business practices. Thus, if the hurdle rate is higher on average for firms in this industry than the interest rate used in estimating the compliance costs (in this final action, 5.5 percent at the time of this analysis), then these investments in environmental controls may not necessarily be undertaken on average.

From a social perspective, however, the increased financial returns from product recovery accrue to entities somewhere along the chemical product supply chain and should be accounted for in a national-level analysis. An economic argument can be made that, in the long run, no single entity bears the entire burden of compliance costs or fully appropriates the financial gain of the additional revenues associated with chemical product recovery. The change in economic surplus resulting from product recovery may be likely to be spread across different market participants. The simplest and most transparent option for allocating these revenues would be to assign the compliance costs and revenues to a model plant and not make assumptions regarding the allocation of costs and revenues across economic agents. In the RIA, we treat these revenues as an offset to projected compliance costs, while the revenues may also be considered as a benefit of the regulatory action. However, regardless of whether the revenue from capture of natural gas is considered a compliance cost offset or a benefit, the net benefits are equivalent.

### Table 3-21 Detailed Costs for the P&R I Source Category by Emission Point for the Final Rule (2021$)

| Emission Point | Total Capital Cost ($) | Total Annual Cost ($/yr) Without Recovery Credits | Total Annual Cost ($/yr) With Recovery Credits | Annual Recovery Credits ($/yr) |
|---|---|---|---|---|
| Flares | 6,996,100 | 1,481,000 | 1,481,000 | 0 |
| Fenceline Monitoring | 127,600 | 1,255,000 | 1,255,000 | 0 |
| Pressure Relief Devices | 504,400 | 128,500 | 128,500 | 0 |
| Storage Vessels | 130,900 | 24,800 | 24,800 | 0 |
| Storage Vessels – Degassing | 0 | 12,300 | 12,300 | 0 |
| Storage Vessels – Pressure Vessels | 2,200 | 2,100 | 2,100 | 0 |
| Storage Vessels – 240hr Maintenance | 39,500 | 6,800 | 6,800 | 0 |
| Maintenance | 0 | 8,700 | 8,700 | 0 |
| Heat Exchange Systems | 48,300 | 9,900 | (19,300) | 29,300 |
| Process Vents | 3,813,400 | 1,616,700 | 1,616,700 | 0 |
| CP Risk | 15,948,900 | 10,354,500 | 10,354,500 | 0 |
| Dioxins/Furans | 560,000 | 325,000 | 325,000 | 0 |
| Carbon Cannisters | 27,000 | 2,000 | 2,000 | 0 |
| **Total** | **28,198,300** | **15,227,100** | **15,198,000** | **29,200** |

### Table 3-22 Detailed Costs for the P&R II Source Category by Emission Point for the Final Rule (2021$)

| Emission Point | Total Capital Cost ($) | Total Annual Cost ($/yr) Without Recovery Credits | Total Annual Cost ($/yr) With Recovery Credits | Annual Recovery Credits ($/yr) |
|---|---|---|---|---|
| Pressure Relief Devices | 132,700 | 33,800 | 33,800 | 0 |
| Storage Vessels - Degassing | 0 | 6,200 | 6,200 | 0 |
| Maintenance | 0 | 2,300 | 2,300 | 0 |
| Dioxins/Furans | 2,800,000 | 1,625,000 | 1,625,000 | 0 |
| **Total** | **2,932,500** | **1,667,200** | **1,667,200** | **0** |

### Table 3-23 Summary of the Total Costs by Final Rule ($2021)

| Rule | Total Capital Cost ($) | Total Annual Cost ($/yr) Without Recovery Credits | Total Annual Cost ($/yr) With Recovery Credits | Annual Recovery Credits ($/yr) |
|---|---|---|---|---|
| HON | 455,557,700 | 169,250,100 | 168,273,200 | 983,900 |
| P&R I | 28,198,300 | 15,227,100 | 15,198,000 | 29,200 |
| P&R II | 2,932,500 | 1,667,200 | 1,667,200 | 0 |
| NSPS VVb | 7,706,600 | 1,434,200 | 1,127,200 | 307,000 |
| NSPS IIIa, NNNa, & RRRa | 27,844,000 | 6,269,000 | 6,269,000 | 0 |
| **Total** | **522,239,100** | **193,847,600** | **192,534,600** | **1,320,100** |

We also show the costs in another way – the current day estimate of the costs of these rules over an analysis time period, and an equivalent annualized value (EAV) of those costs over the same analysis time period. To facilitate the presentation of these costs, Table 3-24 presents the present value (PV) and EAV of costs over the analysis time period of 2024-2038 for the cumulative impacts in this rulemaking, discounted to 2023. The present value is a current day estimate of the costs over the analysis time period for this final rulemaking, and the EAV is the average annual value of these costs whose sum is the PV. These costs include the value of product recovery, which is a very small percentage of the costs for the HON (less than 1 percent of the total annual costs) and cumulatively (also less than 1 percent of the total annual costs). Showing the costs in this way is consistent with OMB Circular A-4.

**Table 3-24 Discounted Costs, for the Final Amendments to the HON, P&R I, and P&R II NESHAP, and Subparts VVb, IIIa, NNNa, and RRRa NSPS, 2024-2038 (million 2021$, discounted to 2023)**

| **Year** | **3 percent** | **7 percent** |
|---|---|---|
| | Total Annual Cost with Revenue from Product Recovery | Total Annual Cost with Revenue from Product Recovery |
| 2024 | 169 | 163 |
| 2025 | 164 | 152 |
| 2026 | 159 | 142 |
| 2027 | 125 | 107 |
| 2028 | 121 | 100 |
| 2029 | 118 | 94 |
| 2030 | 114 | 88 |
| 2031 | 111 | 82 |
| 2032 | 108 | 76 |
| 2033 | 105 | 71 |
| 2034 | 102 | 67 |
| 2035 | 99 | 62 |
| 2036 | 96 | 58 |
| 2037 | 93 | 54 |
| 2038 | 90 | 51 |
| **PV** | **1,770** | **1,370** |
| **EAV** | **148** | **150** |

Note: Discounted to 2023. Totals may not sum due to independent rounding. Numbers rounded to two significant digits unless otherwise noted. The EAV is an annualized cost for it is an estimate calculated from annual costs across the 15-year analytical timeframe.

Table 3-25 contains a summary of the HAP and VOC emission reductions per year for each final rule within this regulatory action, and cumulative (total) estimates. These emission reductions are calculated based on a baseline that include the excess emissions from flares as explained in Chapter 1 of this RIA.

We note that these emissions reductions do not consider the potential excess emissions reductions from flares that could result from the final monitoring requirements; we estimate flare excess emissions reductions of 4,858 tpy HAP and 19,889 tpy VOC.

**Table 3-25 Summary of the HAP and VOC Emission Reductions per Year by Rule**

| Rule | HAP Emission Reductions (tons per year) | VOC Emission Reductions (tons per year) |
|---|---|---|
| HON | 1,107 | 1,919 |
| P&R I | 264 | 278 |
| P&R II | 1 | 1 |
| NSPS VVb | N/A* | 340 |
| NSPS IIIa, NNNa, & RRRa | N/A | 1,281 |
| Flare excess reductions | 4,858 | 19,889 |
| **Total** | **6,230** | **23,708** |

*N/A – not available. No HAP reductions are estimated for the final NSPS included in this rulemaking.

## 3.7 Secondary Air Emission Impacts

Table 3-26 contains a summary of other pollutants emissions changes (increases and decreases), both for criteria pollutants and GHGs, cumulatively for this final action. Calculations for the emissions changes in this table can be found in the technical memo titled *Secondary Impacts for Flares, Thermal Oxidizers, and Wastewater Controls for the SOCMI Source Category and Source Categories Subject to the Group I Polymers and Resins NESHAP* located in the docket for this rule. As a result of these changes to the flare combustion efficiency requirements, there will be a change in the GHG emissions that are primarily due to improved combustion efficiency of steam-assisted flares in these source categories, decreased steam demand, and increased need for supplemental natural gas.

Additionally, the EPA anticipates that some facilities will need to install and operate thermal oxidizer controls to better control process vents and streams containing ethylene oxide and chloroprene. With the installation of thermal oxidizer controls, additional emissions of GHG and criteria air pollutants (CAP) will occur as a result of controlling HAP and VOC emissions (i.e., from the combustion of these pollutants plus from the combustion of any auxiliary natural gas needed in the thermal oxidizer controls).

The increase in $CO_2$ emissions is primarily (63 percent) driven by the requirements for flares outlined in the preamble of this rulemaking; the additional $CO_2$ emission increases are from thermal oxidizers.

### Table 3-26 Summary of Emission Changes (Increases or Reductions) Other Then HAP and VOC in Tons per Year, Cumulative and by Final Rule

| Pollutant | Total | HON | P&R I | IIIa/NNNa/RRRa |
|---|---|---|---|---|
| CO | 845 | 714 | 110 | 21.51 |
| $CO_2$ | 741,102 | 609,761 | 115,975 | 15,366 |
| $CH_4$ | -22,951 | -20,177 | -2,017 | -756 |
| $N_2O$ | 6.86 | 5.27 | 1.54 | 0.06 |
| $NO_x$ | 349 | 272 | 73 | 3.96 |
| PM | 17.4 | 12.7 | 4.75 | 0 |
| $SO_2$ | 1.37 | 0 | 1.37 | 0 |

**The $CO_2$ impacts in**

Table 3-26 are the emission changes incremental to the baseline that are expected to occur from combustion flares and thermal oxidizers as well as the additional natural gas added to those devices. However, even in the absence of combustion-related emissions controls, most of the carbon in the VOC and $CH_4$ emissions would have eventually oxidized forming $CO_2$ in the atmosphere. Therefore, the combustion of these carbonaceous substances would be expected to lead to approximately the same long-run $CO_2$ concentrations as would have occurred without any controls.[19] Therefore, most of the impact of these $CO_2$ contributions to atmospheric concentrations from the flaring of $CH_4$ and VOC emissions versus future oxidization is not additional to the impacts that otherwise would have occurred through the atmospheric oxidation process.

In the case of VOCs, the oxidization time in the atmosphere is relatively short, on the order of hours to months, so from a climate perspective the difference between emitting the carbon immediately as $CO_2$ during combustion or as a VOC is expected to be negligible. In the NSPS OOOOa rulemaking, the EPA solicited comment on the appropriateness of monetizing: (1) the impact of $CO_2$ emissions associated with combusting methane and VOC emissions from oil and natural gas sites; and (2) a new potential approach for approximating this value using the SC-$CO_2$. The illustrative analysis in the NSPS OOOOa RIA provided a method for evaluating

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[19] The social cost of methane (SC-CH4) used in chapter 4 to monetize the benefits of the CH4 emissions reductions does not include the impact of the carbon in CH4 emissions after it oxidizes to CO2.

the estimated emissions outcomes associated with destroying one metric ton of methane by combusting fossil-based emissions at oil and natural gas sites (flaring) and releasing the $CO_2$ emissions immediately versus releasing them in the future via the methane oxidation process. The analysis demonstrated that the potential disbenefits of flaring (i.e., an earlier contribution of $CO_2$ emissions to atmospheric concentrations) are minor compared to the benefits of flaring (i.e., avoiding the release of and associated climate impacts from $CH_4$ emissions).

Given the timing of VOCs oxidizing the in the atmosphere and forming $CO_2$ we have chosen to only monetize the $CO_2$ emissions from the additional natural gas used in the flares and thermal oxidizers. Table 3-27 provides a summary of the final GHG emission changes that are monetized in Chapter 4.

**Table 3-27 Summary of Monetized Greenhouse Gas Emission Changes in Tons Per Year**

| Pollutant | Total | HON | P&R I | IIIa/NNNa/RRRa |
|---|---|---|---|---|
| $CO_2$ | 296,595 | 258,655 | 28,615 | 9,325 |
| $CH_4$ | -22,956 | -20,181 | -2,018 | -757 |
| $N_2O$ | 2.07 | 1.78 | 0.23 | 4 |

# 4 BENEFITS OF EMISSION REDUCTIONS

## 4.1 Introduction

The emission controls installed to comply with this final action are expected to reduce emissions of hazardous air pollutants (HAP); volatile organic compounds (VOC) which, in conjunction with $NO_X$ and in the presence of sunlight, form ground-level ozone ($O_3$). This chapter reports the estimated ozone-related benefits of reducing VOC emissions in terms of the number and value of avoided ozone-attributable deaths and illnesses. The potential benefits from reduced ecosystem effects from the reduction in $O_3$ concentrations are not quantified or monetized here. Time and data limitations for quantifying the effects of this action on biomass loss and foliar injury and the ensuing loss of ecosystem services prevent an assessment of the benefits to ecosystems. The EPA provides a qualitative discussion of the benefits of reducing HAP emissions later in this chapter in Section 4.2. Finally, we include an analysis of the climate benefits and disbenefits for this final action. We include a presentation of benefits estimates for each of the final rules in this rulemaking, and also a cumulative estimate with total benefits for the entire rulemaking.

The lower estimate of the present value (PV) of the cumulative health benefits for the final rules range from $77 million at a 3 percent discount rate to $54 million at a 7 percent discount rate with an equivalent annual value (EAV) of $6.5 million to $5.9 million respectively. The higher estimate of the PV of the benefits for the final rules range from $690 million at a 3 percent discount rate to $480 million at a 7 percent discount rate with an EAV of $58 to $52 million respectively. All estimates are reported in 2021 dollars. Benefits are estimated using two alternative concentration-response parameters from three epidemiologic studies when quantifying ozone-related mortality (Di et al., 2017; Turner et al., 2016; and Katsouyanni et al., 2009)

The monetized climate benefits of reductions of pollutants such as $CH_4$ and disbenefits resulting from increasing emissions of $CO_2$ and $N_2O$ as presented in Chapter 3 are included in this chapter in Section 4.7. The monetized climate benefits and disbenefits are calculated using benefit-per-ton estimates of the social cost of greenhouse gases (SC-GHG) estimates as explained later in this RIA chapter and are estimated at negative $1.6 billion PV at a 2 percent discount rate ($120 million EAV).[20]

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

In the subsequent sections, we describe the health effects associated with the main HAP of concern from SOCMI (found within the HON), P&R I, and P&R II source categories: ethylene oxide (Section 4.1.1), chloroprene (Section 4.1.2), benzene (Section 4.1.3), 1,3-butadiene (Section 4.1.4), vinyl chloride (Section 4.1.5), ethylene dichloride (Section 4.1.6), chlorine (Section 4.1.7), maleic anhydride (Section 4.1.8) and acrolein (Section 4.1.9). This rule is projected to reduce ethylene oxide emissions from HON processes by approximately 54 tons per year (tpy) and reduce chloroprene emissions from Neoprene Production processes in P&R I by approximately 14 tpy. We also estimate that the final amendments to the NESHAP would reduce other HAP emissions (excluding ethylene oxide and chloroprene) from the HON and P&R I source categories by approximately 6,230 tpy. The Agency was unable to estimate HAP emission reductions for the final amendments to the NSPS in this rulemaking.

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

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[20] Monetized climate effects are presented under a 2 percent near-term Ramsey discount rate, consistent with EPA's updated estimates of the SC-GHG. The 2003 version of OMB's Circular A-4 had generally recommended 3 percent and 7 percent as default discount rates for costs and benefits, though as part of the Interagency Working Group on the Social Cost of Greenhouse Gases, OMB had also long recognized that climate effects should be discounted only at appropriate consumption-based discount rates. While this RIA was being drafted and reviewed, OMB finalized an update to Circular A-4, in which it recommended the general application of a 2.0 percent discount rate to costs and benefits (subject to regular updates), as well as the consideration of the shadow price of capital when costs or benefits are likely to accrue to capital (OMB 2023). Because the SC-GHG estimates reflect net climate change damages in terms of reduced consumption (or monetary consumption equivalents), the use of the social rate of return on capital (7 percent under OMB Circular A-4 (2003)) to discount damages estimated in terms of reduced consumption would inappropriately underestimate the impacts of climate change for the purposes of estimating the SC-GHG.

### *4.2.1 Ethylene oxide*

Ethylene oxide is used as a chemical intermediate in the manufacture of ethylene glycol (antifreeze), textiles, detergents, polyurethane foam, solvents, medicine, adhesives, and other products. Health effects from acute (short-term) exposure to ethylene oxide in humans consist mainly of central nervous system (CNS) depression and irritation of the eyes and mucous membranes. Chronic (long-term) exposure to ethylene oxide in humans can cause irritation of the eyes, skin, nose, throat, and lungs, and damage to the brain and nervous system. There is also some evidence linking ethylene oxide exposure to reproductive effects (ATSDR, 2022). The EPA's Integrated Risk Information System (IRIS) characterized ethylene oxide as "carcinogenic to humans" by the inhalation route of exposure based on the total weight of evidence (U.S. EPA, 2016), in accordance with EPA's *Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 2005). EPA concluded that there was strong, but less than conclusive on its own, epidemiological evidence of lymphohematopoietic cancers and breast cancer in ethylene oxide-exposed workers (U.S. EPA, 2016).

### *4.2.2 Chloroprene*

Chloroprene is used primarily in the manufacture of polychloroprene (*e.g.*, Neoprene), which is used to make diverse products requiring chemical, oil, and/or weather resistance (*e.g.*, adhesives, automotive and industrial parts (*e.g.*, belts and hoses), caulks, flame-resistant cushioning). Health effects from acute (short-term) inhalation exposure to high concentrations of chloroprene include headache, irritability, dizziness, insomnia, fatigue, respiratory irritation, cardiac palpitations, chest pains, nausea, dermatitis, and corneal necrosis. Health effects of chronic (long-term) exposure may include fatigue, chest pains, irritability, dermatitis, and hair loss. Other effects reported include changes to the nervous system, changes to the cardiovascular system, and depression of the immune system. There is evidence of an association between occupational exposure to chloroprene and liver cancer. There is also suggestive evidence of an association between occupational exposure to chloroprene and lung cancer (U.S. EPA, 2010). Studies in animals have observed tumors in multiple organs/organ systems (including reproductive, hepatic, respiratory, gastrointestinal, dermal, and ocular). The EPA's Integrated Risk Information System (IRIS) database lists chloroprene as "likely to be carcinogenic to humans" by all routes of exposure (U.S. EPA, 2010), in accordance with EPA's *Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 2005.

### *4.2.3 Benzene*

Benzene is used as a constituent in motor fuels and is found in gasoline service station and motor vehicle exhaust emissions into air. Acute effects of benzene inhalation exposure in humans include neurological symptoms such as drowsiness, dizziness, headaches, and unconsciousness. Exposure to benzene vapor can cause eye, skin, and upper respiratory tract irritation. Chronic exposure to benzene is associated with blood disorders, such as preleukemia and aplastic anemia (ATSDR, 2007a). The EPA's Integrated Risk Information System (IRIS) database lists benzene as a known human carcinogen by all routes of exposure. IRIS found a causal relationship between benzene exposure and acute lymphocytic leukemia and a suggestive relationship between benzene exposure and chronic non-lymphocytic leukemia and chronic lymphocytic leukemia (U.S. EPA, 2000). The International Agency for Research on Cancer (IARC) has also determined that benzene is a human carcinogen (IARC, 2018).

### *4.2.4 1,3-Butadiene*

1,3-Butadiene is used in the production of styrene-butadiene rubber, plastics, and thermoplastic resins. A variety of reproductive and developmental effects have been observed in mice exposed to 1,3-butadiene by inhalation (ATSDR, 2012). There are no human data on reproductive or developmental effects (ATSDR, 2012). Epidemiological studies of workers in rubber plants have shown an association between 1,3-butadiene exposure and increased incidence of leukemia (U.S. EPA, 2002). Animal studies have reported tumors at various sites from 1,3-butadiene exposure. EPA has classified 1,3-butadiene as carcinogenic to humans by the inhalation route of exposure. (U.S. EPA, 2002).

### *4.2.5 Ethylene dichloride (1,2-dichloroethane)*

Ethylene dichloride is primarily used in the production of vinyl chloride as well as other chemicals. Inhalation of concentrated ethylene dichloride vapor can induce effects on the human nervous system, liver, and kidneys, as well as respiratory distress and cardiac arrhythmia. No information is available on the chronic effects of ethylene dichloride in humans. In animal studies, chronic (long-term) inhalation exposure to ethylene dichloride has been observed to cause effects on the liver and kidneys. Decreased fertility and increased embryo mortality have been observed in inhalation studies of rats (ATSDR, 1992). Epidemiological studies are not conclusive regarding the carcinogenic effects of ethylene dichloride, due to concomitant exposure to other chemicals. Following treatment by gavage (experimentally placing the chemical in the stomach), several tumor types have been induced in rats and mice. An increased incidence of lung papilloma has been reported in mice after topical application. EPA has classified ethylene dichloride as a Group B2, probable human carcinogen (U.S. EPA, 1999).

### *4.2.6 Vinyl chloride*

Most of the vinyl chloride produced is used to make polyvinyl chloride (PVC) plastic and vinyl products. Acute (short-term) exposure to high levels of vinyl chloride in air has resulted in CNS effects, such as dizziness, drowsiness, and headaches in humans. Chronic (long-term) exposure to vinyl chloride through inhalation and oral exposure in humans has resulted in CNS effects and liver damage. Animal studies have reported effects on the liver, kidney, and CNS from chronic exposure to vinyl chloride (ATSDR, 2006). Vinyl chloride exposure via inhalation has been shown to increase the risk of a rare form of liver cancer, angiosarcoma of the liver, in humans. EPA has concluded that vinyl chloride is carcinogenic to humans by the inhalation and oral routes of exposure, and highly likely to be carcinogenic by the dermal route of exposure (U.S. EPA, 2000).

### *4.2.7 Chlorine*

Chlorine ($Cl_2$) is a gas that is a potent irritant to the eyes and respiratory tract. Exposure to low levels of chlorine can result in nose, throat, and eye irritation. At higher levels, breathing chlorine gas may result in changes in breathing rate and coughing, and damage to the lungs. Studies in volunteers exposed to controlled concentrations of chlorine indicate that exposures to 1–3 ppm produce mild irritation of the nose that can be tolerated for about 1 hour; 5 ppm may produce eye irritation; headache and throat irritation may occur at concentrations of 5–15 ppm; 30 ppm produces immediate chest pain, nausea and vomiting, dyspnea, and cough; and 40–60 ppm produces toxic pneumonitis and pulmonary edema. Concentrations in typical human exposure environments are much lower than these levels unless an accident involving chlorine takes place nearby (*e.g.,* a leak from a chlorine tank or a leak from a facility that produces or uses chlorine). Chronic (long-term) exposure to chlorine gas in workers has resulted in respiratory effects, including eye and throat irritation and airflow obstruction (ATSDR, 2010). EPA has not assessed chlorine for carcinogenicity under the IRIS program (U.S. EPA, 1994).

### *4.2.8 Maleic anhydride*

Maleic anhydride is used in the formulation of resins. Exposure to maleic anhydride may occur from accidental releases to the environment or in workplaces where it is produced or used. Acute (short-term) inhalation exposure of humans to maleic anhydride has been observed to cause irritation of the respiratory tract and eye irritation. Chronic (long-term) exposure to maleic anhydride has been observed to cause chronic bronchitis, asthma-like attacks, and upper respiratory tract and eye irritation in workers. In some people, allergies have developed so that lower concentrations can no longer be tolerated. Kidney effects were observed in rats chronically exposed to maleic anhydride via gavage (CalEPA, 2001). EPA has not assessed maleic anhydride for carcinogenicity under the IRIS program (U.S. EPA, 1988).

### *4.2.9 Acrolein*

Acrolein is primarily used as an intermediate in the synthesis of acrylic acid and as a biocide. It is toxic to humans following inhalation, oral or dermal exposures. Acute (short-term) inhalation exposure may result in upper respiratory tract irritation and congestion. The major effects from chronic (long-term) inhalation exposure to acrolein in humans and animals consist of general respiratory congestion and eye, nose, and throat irritation (ATSDR, 2007b). The EPA IRIS program noted, in 2003, that the potential carcinogenicity of acrolein cannot be determined because the existing data are inadequate for an assessment of human carcinogenic potential for either the oral or inhalation route of exposure (U.S. EPA, 2003).

### *4.2.10 Other Hazardous Air Pollutants (HAP)*

In addition to the compounds described above, other toxic compounds might be affected by this action. Information regarding the health effects of those compounds can be found in *Health Effects Notebook for Hazardous Air Pollutants* (at https://www.epa.gov/haps/health-effects-notebook-hazardous-air-pollutants) and in the EPA Integrated Risk Information System (IRIS) database (at https://iris.epa.gov/AtoZ/?list_type=alpha).

## 4.3 Ozone-related Human Health Benefits

This section summarizes the EPA's approach to estimating the incidence and economic value of the ozone-related benefits estimated for this action. The Regulatory Impact Analysis (RIA) Final Revised Cross-State Air Pollution Rule (U.S. EPA, 2021) and its corresponding Technical Support Document Estimating $PM_{2.5}$- and Ozone-Attributable Health Benefits (TSD) (U.S. EPA, 2021) provide a full discussion of the EPA's approach for quantifying the incidence and value of estimated air pollution-related health impacts. In these documents, the reader can find the rationale for selecting the health endpoints quantified; the demographic, health and economic data applied in the environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE); modeling assumptions; and the EPA's techniques for quantifying uncertainty.

Implementing this action will affect the distribution of ozone concentrations throughout the U.S.; this includes locations both meeting and exceeding the NAAQS for $O_3$. This RIA estimates avoided $O_3$-related health impacts that are distinct from those reported in the RIAs for the $O_3$ NAAQS (U.S. EPA, 2015). The $O_3$ NAAQS RIAs hypothesize, but do not predict, the benefits and costs of strategies that states may choose to enact when implementing a revised NAAQS; these costs and benefits are illustrative and cannot be added to the costs and benefits of policies that prescribe specific emission control measures.

### *4.3.1 Estimating Ozone Related Health Impacts*

We estimate the quantity and economic value of air pollution-related effects by estimating counts of air pollution-attributable cases of adverse health outcomes, assigning dollar values to these counts, and assuming that each outcome is independent of one another. We construct these estimates by adapting primary research—specifically, air pollution epidemiology studies and economic value studies—from similar contexts. This approach is sometimes referred to as "benefits transfer." Below we describe the procedure we follow for: (1) selecting air pollution health endpoints to quantify; (2) calculating counts of air pollution effects using a health impact function; and (3) specifying the health impact function with concentration-response parameters drawn from the epidemiological literature.

### *4.3.2 Selecting Air Pollution Health Endpoints to Quantify*

As a first step in quantifying $O_3$-related human health impacts, the EPA consults the *Integrated Science Assessment for Ozone* (Ozone ISA) (U.S. EPA, 2020) as summarized in the TSD for the Final Revised Cross State Air Pollution Rule Update (U.S. EPA, 2021). This document synthesizes the toxicological, clinical, and epidemiological evidence to determine whether each pollutant is causally related to an array of adverse human health outcomes associated with either acute (*i.e.*, hours or days-long) or chronic (*i.e.*, years-long) exposure. For each outcome, the ISA reports this relationship to be causal, likely to be causal, suggestive of a causal relationship, inadequate to infer a causal relationship, or not likely to be a causal relationship.

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

The EPA estimates the incidence of air pollution effects for those health endpoints listed above where the ISA classified the impact as either causal or likely-to-be-causal. Table 4-1 reports the effects we quantified and those we did not quantify in this RIA. The list of benefit categories not quantified shown in that table is not exhaustive. And, among the effects we quantified, we might not have been able to completely quantify either all human health impacts or economic values. The table below omits any welfare effects such as biomass loss and foliar injury. These effects are described in Chapter 7 of the Ozone NAAQS RIA (2015).

**Table 4-1 Human Health Effects of Ambient Ozone and Whether they were Quantified and/or Monetized in this RIA**

| Category | Effect | Effect Quantified | Effect Monetized | More Information |
|---|---|---|---|---|
| Mortality from exposure to ozone | Premature respiratory mortality from short-term exposure (0-99) | ✓ | ✓ | Ozone ISA[1] |
| | Premature respiratory mortality from long-term exposure (age 30–99) | ✓ | ✓ | Ozone ISA |
| Nonfatal morbidity from exposure to ozone | Hospital admissions—respiratory (ages 65-99) | ✓ | ✓ | Ozone ISA |
| | Emergency department visits—respiratory (ages 0-99) | ✓ | ✓ | Ozone ISA |
| | Asthma onset (0-17) | ✓ | ✓ | Ozone ISA |
| | Asthma symptoms/exacerbation (asthmatics age 5-17) | ✓ | ✓ | 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 |
| | Decreased outdoor worker productivity (age 18–65) | — | — | Ozone ISA[2] |
| | Metabolic effects (*e.g.*, diabetes) | — | — | Ozone ISA[2] |
| | Other respiratory effects (*e.g.*, premature aging of lungs) | — | — | Ozone ISA[2] |
| | Cardiovascular and nervous system effects | — | — | Ozone ISA[2] |
| | Reproductive and developmental effects | — | — | Ozone ISA[2] |

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

### *4.3.3 Quantifying Cases of Ozone-Attributable Premature Mortality*

Mortality risk reductions account for the majority of monetized ozone-related benefits. For this reason, this subsection and the following provide a brief background of the scientific assessments that underly the quantification of these mortality risks and identifies the risk studies used to quantify them in this RIA for ozone. As noted above, the *Estimating $PM_{2.5}$- and Ozone-Attributable Health Benefits* TSD describes fully the Agency's approach for quantifying the number and value of ozone air pollution-related impacts, including additional discussion of how the Agency selected the risk studies used to quantify them in this RIA. The TSD also includes additional discussion of the assessments that support quantification of these mortality risk than provide here.

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

## 4.4 Economic Valuation

After quantifying the change in adverse health impacts, we estimate the economic value of these avoided impacts. Reductions in ambient concentrations of air pollution generally lower the risk of future adverse health effects for a large population. Therefore, the appropriate economic measure is willingness to pay (WTP) for changes in risk of a health effect. For some health effects, such as hospital admissions, WTP estimates are generally not available, so we use the cost of treating or mitigating the effect. These cost-of-illness (COI) estimates generally (although not necessarily in every case) understate the true value of reductions in risk of a health effect. They tend to reflect the direct expenditures related to treatment but not the value of avoided pain and suffering from the health effect. The unit values applied in this analysis are provided in Section 5.1 of the TSD for the MATS rule (U.S. EPA, 2023b).

Avoided premature deaths account for 95 percent of monetized ozone-related benefits. The economics literature concerning the appropriate method for valuing reductions in premature mortality risk is still developing. The value for the projected reduction in the risk of premature mortality is the subject of continuing discussion within the economics and public policy analysis community. Following the advice of the Scientific Advisory Board's (SAB) Environmental Economics Advisory Committee (SAB-EEAC), the EPA currently uses the value of statistical life (VSL) approach in calculating estimates of mortality benefits, because we believe this calculation provides the most reasonable single estimate of an individual's WTP for reductions in mortality risk (U.S. EPA–SAB, 2000). The VSL approach is a summary measure for the value of small changes in mortality risk experienced by a large number of people.

The EPA continues work to update its guidance on valuing mortality risk reductions and consulted several times with the SAB-EEAC on the issue. Until updated guidance is available, the EPA determined that a single, peer-reviewed estimate applied consistently best reflects the SAB-EEAC advice it has received. Therefore, the EPA applies the VSL that was vetted and endorsed by the SAB in the *Guidelines for Preparing Economic Analyses* while the EPA continues its efforts to update its guidance on this issue (U.S. EPA, 2016). This approach calculates a mean value across VSL estimates derived from 26 labor market and contingent valuation studies published between 1974 and 1991. The mean VSL across these studies is $10.7 million ($2016).[21]

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

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[21] In 1990$, this base VSL is $4.8 million. In 2016$, this base VSL is $10.7 million.

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

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

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

### *4.4.1 Benefit-per-Ton Estimates*

The EPA did not conduct air quality modeling for this final rulemaking. Rather, we quantified the value of changes in ozone, and NOx concentrations using a "benefit-per-ton" (BPT) approach, due to the relatively small number of facilities and the fact that these facilities are located in a discrete location. Specifically, the EPA believes that the emissions reductions due to this rule are small and because we cannot be confident of the location of new facilities under the NSPS included in this final action, we elected to use the benefit-per-ton approach. The EPA did not expect full air quality modeling to show a significant difference between the policy and baseline model runs. BPT estimates provide the total monetized human health benefits (the sum of premature mortality and premature morbidity) of reducing one ton of the VOC precursor for ozone from a specified source. Specifically, in this analysis, we multiplied the BPT estimates from the Synthetic Organic Chemicals sector by the corresponding emission reductions. The method used to derive these estimates is described in the BPT Technical Support Document (BPT TSD) on *Estimating the Benefit per Ton of Reducing Directly-Emitted $PM_{2.5}$, $PM_{2.5}$*

*Precursors and Ozone Precursors from 21 Sectors* (U.S. EPA, 2023b). As noted above, we were unable to quantify the value of changes in exposure to HAP, CO, and $NO_2$.

As noted below in the characterization of uncertainty, all BPT estimates have inherent limitations. Specifically, all national-average BPT estimates reflect the geographic distribution of the modeled emissions, which may not exactly match the emission reductions that would occur due to the action, and they may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors for any specific location. In an effort to address this limitation we have generated regional level BPTs for the synthetic organic chemicals sector. Given sector specific air quality modeling and the small changes in emissions considered in this action, the difference in the quantified health benefits that result from the BPT approach compared with if EPA had used a full-form air quality model should be minimal.

The EPA systematically compared the changes in benefits, and concentrations where available, from its BPT technique and other reduced-form techniques to the changes in benefits and concentrations derived from full-form photochemical model representation of a few different specific emissions scenarios. Reduced-form tools are less complex than the full air quality modeling, requiring less agency resources and time. That work, in which we also explore other reduced form models, is referred to as the “Reduced Form Tool Evaluation Project” (Project). It began in 2017, and the initial results were available at the end of 2018. The Agency’s goal was to create a methodology by which investigators could better understand the suitability of alternative reduced-form air quality modeling techniques for estimating the health impacts of criteria pollutant emissions changes in the EPA’s benefit-cost analysis, including the extent to which reduced-form models may over- or under-estimate benefits (compared to full-scale modeling) under different scenarios and air quality concentrations. The EPA Science Advisory Board (SAB) convened a panel to review this report.[22] In particular, the SAB assessed the techniques the Agency used to appraise these tools; the Agency’s approach for depicting the results of reduced-form tools; and steps the Agency might take for improving the reliability of reduced-form techniques for use in future Regulatory Impact Analyses (RIAs).

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[22] 85 FR 23823. April 29, 2020.

The scenario-specific emission inputs developed for this project are currently available online. The study design, methodology, and results of the project are described in the final report, *Evaluating Reduced-Form Tools for Estimating Air Quality Benefits. Final Report* (IEc, 2019). Results of this project found that total $PM_{2.5}$ BPT values were within approximately 10 percent of the health benefits calculated from full-form air quality modeling when analyzing the pulp and paper sector, a sector used as an example for evaluating the application of the new methodology in the final report. The ratios for individual PM species varied, and the report found that the ratio for the directly emitted $PM_{2.5}$ for the pulp and paper sector was 0.7 for the BPT approach compared to 1.0 for full-form air quality modeling combined with BenMAP. This provides some initial understanding of the uncertainty which is associated with using the BPT approach instead of full-form air quality modeling.

### *4.4.2 Ozone Vegetation Effects*

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

### *4.4.3 Ozone Climate Effects*

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

## 4.5 Ozone- and NOx- Related Benefits Results

Tables 4-2 list the estimated Ozone- and NOx--related benefits per ton applied in this national level analysis. Benefits are estimated using two alternative concentration-response parameters from three epidemiologic studies when quantifying ozone-related mortality (Di et al., 2017; Turner et al., 2016; and Katsouyanni et al., 2009). These results are discounted at 3 and 7 percent for a 2021 currency year. For all estimates, we summarize the monetized health benefits using discount rates of 3 percent and 7 percent for the 15-year analysis period of this rule, discounted back to 2023 and rounded to 2 significant figures, as presented in Table 4-4. The lower estimate of the Present Value (PV) of the cumulative health benefits for the final rules range from $77 million at a 3 percent discount rate to $54 million at a 7 percent discount rate with an equivalent annualized value (EAV) of $6.5 million to $5.9 million respectively. The higher estimate of the PV of the benefits for the final rules range from $690 million at a 3 percent discount rate to $480 million at a 7 percent discount rate with an EAV of $58 to $52 million respectively. All estimates are reported in 2021 dollars. Discounted benefits are presented by year for the final and less stringent alternative options in Table 4-4 and Table 4-5. For the full set of underlying calculations see the “Final HONSOCMI Benefits workbook,” available in the docket for the final action.

**Table 4-2 Synthetic Organic Chemicals: Benefit per Ton Estimates of Avoided Ozone-Attributable Premature Mortality and Illness for the Rule, 2024-2038 (2021$)**

| | Discount Rate | | | | | |
|---|---|---|---|---|---|---|
| **Year** | **3 Percent** | | | **7 Percent** | | |
| 2025 | 725 | and | 6,235 | 652 | and | 5,579 |
| 2030 | 773 | and | 6,859 | 698 | and | 6,150 |
| 2035 | 815 | and | 7,537 | 738 | and | 6,764 |
| 2040 | 851 | and | 8,109 | 773 | and | 7,272 |

Note: The standard reporting convention for EPA benefits is to round all results to two significant figures. Here, we report all significant figures so that readers may reproduce the results reported below.

### Table 4-3 Synthetic Organic Chemicals: Benefit per Ton Estimates of Avoided NOx-Attributable Premature Mortality and Illness for the Rule, 2024-2038 (2021$)

| | Discount Rate | | | | | |
|---|---|---|---|---|---|---|
| **Year** | **3 Percent** | | | **7 Percent** | | |
| 2025 | 17,572 | and | 37,685 | 15,878 | and | 33,874 |
| 2030 | 19,160 | and | 39,696 | 17,254 | and | 35,673 |
| 2035 | 21,489 | and | 43,507 | 19,372 | and | 39,061 |
| 2040 | 23,500 | and | 46,682 | 21,171 | and | 42,025 |

Note: The standard reporting convention for EPA benefits is to round all results to two significant figures. Here, we report all significant figures so that readers may reproduce the results reported below.

**Table 4-4 Total Benefits Estimates of Ozone- and NOx-Attributable Avoided Premature Mortality and Illness (million 2021$)[a,b,c,]**

| All Rules | | | | | | |
|---|---|---|---|---|---|---|
| | Less Stringent Regulatory Option | | Final Regulatory Option | | More Stringent Regulatory Option | |
| | Discount Rate | | Discount Rate | | Discount Rate | |
| | 3 Percent | 7 Percent | 3 Percent | 7 Percent | 3 Percent | 7 Percent |
| PV | 76 and 680 | 51 and 460 | 77 and 690 | 54 and 480 | 77 and 690 | 53 and 470 |
| EAV | 6.0 and 53 | 5.3 and 47 | 6.5 and 58 | 5.9 and 52 | 6.1 and 55 | 5.5 and 48 |
| Non-Monetized Benefits | | | | | | |
| Health benefits associated with emission reductions of 6,230 tpy of HAP including hexane, benzene, methanol, 1,3-butadiene, and vinyl acetate.<br>Health benefits associated with reduction of 54 tpy of ethylene oxide and 14 tpy of chloroprene.<br>Ecosystem benefits related to the reductions of ozone and nitrogen and sulfur deposition. | | | | | | |

[a] Discounted to 2023.

[b] Rounded to 2 significant figures. The small differences between the alternatives are masked by the rounding.

[c] Benefits are estimated for Ozone and NOx.

**Table 4-5 Undiscounted Total Benefits Estimates of Ozone- and NOx-Attributable Premature Mortality and Illness for the Final Option (million 2021$), 2024-2038[a,b,c]**

| | 3 Percent | | 7 Percent | |
|---|---|---|---|---|
| Year | | | | |
| 2024 | 8.5 | 73 | 7.6 | 65 |
| 2025 | 8.5 | 73 | 7.6 | 65 |
| 2026 | 8.5 | 73 | 7.6 | 65 |
| 2027 | 8.5 | 73 | 7.6 | 65 |
| 2028 | 9.0 | 80 | 8.1 | 72 |
| 2029 | 9.0 | 80 | 8.1 | 72 |
| 2030 | 9.0 | 80 | 8.1 | 72 |
| 2031 | 9.0 | 80 | 8.1 | 72 |
| 2032 | 9.0 | 80 | 8.1 | 72 |
| 2033 | 9.0 | 83 | 8.2 | 75 |
| 2034 | 9.0 | 83 | 8.2 | 75 |
| 2035 | 9.0 | 83 | 8.2 | 75 |
| 2036 | 9.0 | 83 | 8.2 | 75 |
| 2037 | 9.0 | 83 | 8.2 | 75 |
| 2038 | 10 | 95 | 9.0 | 85 |

[a] Rounded to 2 significant figures

[b] Benefits are estimated for Ozone and NOx

[c] This table presents benefits that are undiscounted for time value of money over the 15-year period. The 3 and 7 percent rates refer to the cessation lag of impacts for the value of long-term exposure related ozone deaths.

## 4.6 Characterization of Uncertainty in the Monetized Benefits

In any complex analysis using estimated parameters and inputs from a variety of models, there are likely to be many sources of uncertainty. This analysis is no exception. This analysis includes many data sources as inputs, including emission inventories, air quality data from models (with their associated parameters and inputs), population data, population estimates, health effect estimates from epidemiology studies, economic data for monetizing benefits, and assumptions regarding the future state of the world (*i.e.*, regulations, technology, and human behavior). Each of these inputs are uncertain and generate uncertainty in the benefits estimate. When the uncertainties from each stage of the analysis are compounded, even small uncertainties can have large effects on the total quantified benefits. There also remain unmonetized health benefits resulting from reductions in HAPs and VOCs, and unmonetized disbenefits resulting from a secondary increase in CO emissions. Additional uncertainties and limitations are outlined in Chapter 6.2. Therefore, the estimates of annual benefits should be viewed as representative of the magnitude of benefits expected, rather than the actual benefits that would occur every year.

## 4.7 Climate Impacts

The EPA estimates the climate impacts of GHG emissions changes expected from the final rule using estimates of the social cost of greenhouse gases (SC-GHG) that reflect recent advances in the scientific literature on climate change and its economic impacts and incorporate recommendations made by the National Academies of Science, Engineering, and Medicine (National Academies, 2017). The EPA published and used these estimates in the RIA for the December 2023 Final Oil and Gas NSPS/EG Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review." The EPA solicited public comment on the methodology and use of these estimates in the RIA for the agency's December 2022 Oil and Gas NSPS/EG Supplemental Proposal and has conducted an external peer review of these estimates, as described further below.

The SC-GHG is the monetary value of the net harm to society associated with a marginal increase in GHG emissions in a given year, or the benefit of avoiding that increase. In principle, SC-GHG includes the value of all climate change impacts (both negative and positive), including (but not limited to) changes in net agricultural productivity, human health effects, property damage from increased flood risk and natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. The SC-GHG, therefore, reflects the societal value of reducing emissions of the gas in question by one metric ton and is the theoretically appropriate value to use in conducting benefit-cost analyses of policies that affect GHG emissions. In practice, data and modeling limitations restrain the ability of SC-GHG estimates to include all physical, ecological, and economic impacts of climate change, implicitly assigning a value of zero to the omitted climate damages. The estimates are, therefore, a partial accounting of climate change impacts and likely underestimate the marginal impacts of abatement.

Since 2008, the EPA has used estimates of the social cost of various greenhouse gases (i.e., social cost of carbon (SC-$CO_2$), social cost of methane (SC-$CH_4$), and social cost of nitrous oxide (SC-$N_2O$), collectively referred to as the "social cost of greenhouse gases" (SC-GHG), in analyses of actions that affect GHG emissions. The values used by the EPA from 2009 to 2016, and since 2021 – including in the proposal for this rulemaking – have been consistent with those developed and recommended by the Interagency Working Group on the SC-GHG (IWG); and the values used from 2017 to 2020 were consistent with those required by E.O. 13783, which disbanded the IWG. During 2015-2017, the National Academies conducted a comprehensive review of the SC-$CO_2$ and issued a final report in 2017 recommending specific criteria for future updates to the SC-$CO_2$ estimates, a modeling framework to satisfy the specified criteria, and both near-term updates and longer-term research needs pertaining to various components of the estimation process (National Academies, 2017). The IWG was reconstituted in 2021 and E.O. 13990 directed it to develop a comprehensive update of its SC-GHG estimates, recommendations regarding areas of decision-making to which SC-GHG should be applied, and a standardized review and updating process to ensure that the recommended estimates continue to be based on the best available economics and science going forward.

The EPA is a member of the IWG and is participating in the IWG's work under E.O. 13990. As noted in previous EPA RIAs, while that process continues, the EPA is continuously reviewing developments in the scientific literature on the SC-GHG, including more robust methodologies for estimating damages from emissions, and looking for opportunities to further improve SC-GHG estimation.[23] As EPA noted in the proposal RIA for this rulemaking, in the December 2022 Oil and Gas NSPS/EG Supplemental Proposal RIA, the Agency included a sensitivity analysis of the climate benefits of the Supplemental Proposal using a new set of SC-GHG estimates that incorporates recent research addressing recommendations of the National Academies (National Academies, 2017) in addition to using the interim SC-GHG estimates presented in the Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990 (IWG, 2021) that the IWG recommended for use until updated estimates that address the National Academies' recommendations are available.

The EPA solicited public comment on the sensitivity analysis and the accompanying draft technical report, External Review Draft of Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances, which explains the methodology underlying

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[23] EPA strives to base its analyses on the best available science and economics, consistent with its responsibilities, for example, under the Information Quality Act.

the new set of estimates, in the December 2022 Supplemental Oil and Gas Proposal. The response to comments document can be found in the docket for that action.

To ensure that the methodological updates adopted in the technical report are consistent with economic theory and reflect the latest science, the EPA also initiated an external peer review panel to conduct a high-quality review of the technical report, completed in May 2023 (EPA, 2023c). The peer reviewers commended the agency on its development of the draft update, calling it a much-needed improvement in estimating the SC-GHG and a significant step towards addressing the National Academies' recommendations with defensible modeling choices based on current science. The peer reviewers provided numerous recommendations for refining the presentation and for future modeling improvements, especially with respect to climate change impacts and associated damages that are not currently included in the analysis. Additional discussion of omitted impacts and other updates have been incorporated in the technical report to address peer reviewer recommendations. Complete information about the external peer review, including the peer reviewer selection process, the final report with individual recommendations from peer reviewers, and the EPA's response to each recommendation is available on EPA's website (EPA, 2023c).

The remainder of this section provides an overview of the methodological updates incorporated into the SC-GHG estimates used in this final RIA. A more detailed explanation of each input and the modeling process is provided in the final technical report, EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances (EPA, 2023d). The Appendix to Chapter 4 shows the impacts of the final rule using the interim SC-GHG (IWG 2021) estimates presented in the proposal.

The steps necessary to estimate the SC-GHG with a climate change integrated assessment model (IAM) can generally be grouped into four modules: socioeconomics and emissions, climate, damages, and discounting. The emissions trajectories from the socioeconomic module are used to project future temperatures in the climate module. The damage module then translates the temperature and other climate endpoints (along with the projections of socioeconomic variables) into physical impacts and associated monetized economic damages, where the damages are calculated as the amount of money the individuals experiencing the climate change impacts would be willing to pay to avoid them. To calculate the marginal effect of emissions, i.e., the SC-GHG in year t, the entire model is run twice – first as a baseline and second with an additional pulse of emissions in year t. After recalculating the temperature effects and damages expected in all years beyond t resulting from the adjusted path of emissions, the losses are discounted to a present value in the discounting module. Many sources of uncertainty in the estimation process are incorporated using Monte Carlo techniques by taking draws from probability distributions that reflect the uncertainty in parameters.

The SC-GHG estimates used by the EPA and many other federal agencies since 2009 have relied on an ensemble of three widely used IAMs: Dynamic Integrated Climate and Economy (DICE) (Nordhaus W. , 2010) Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) (Anthoff & Tol, 2013); (Anthoff & Tol, 2013b) and Policy Analysis of the Greenhouse Gas Effect (PAGE) (Hope C. , 2013) In 2010, the IWG harmonized key inputs across the IAMs, but all other model features were left unchanged, relying on the model developers' best estimates and judgments. That is, the representation of climate dynamics and damage functions included in the default version of each IAM as used in the published literature was retained.

The SC-GHG estimates in this RIA no longer rely on the three IAMs (i.e., DICE, FUND, and PAGE) used in previous SC-GHG estimates. As explained in EPA (2023d), EPA uses a modular approach to estimate the SC-GHG, consistent with the National Academies' (National Academies, 2017) near-term recommendations. That is, the methodology underlying each component, or module, of the SC-GHG estimation process is developed by drawing on the latest research and expertise from the scientific disciplines relevant to that component. Under this approach, each step in the SC-GHG estimation improves consistency with the current state of scientific knowledge, enhances transparency, and allows for more explicit representation of uncertainty.

The socioeconomic and emissions module relies on a new set of probabilistic projections for population, income, and GHG emissions developed under the Resources for the Future (RFF) Social Cost of Carbon Initiative (Rennert K. P., 2021) (Rennert, et al., 2022a). These socioeconomic projections (hereafter collectively referred to as the RFF-SPs) are an internally consistent set of probabilistic projections of population, GDP, and GHG emissions ($CO_2$, $CH_4$, and $N_2O$) to 2300. Based on a review of available sources of long-run projections necessary for damage calculations, the RFF-SPs stand out as being most consistent with the National Academies' recommendations. Consistent with the National Academies' recommendation, the RFF-SPs were developed using a mix of statistical and expert elicitation techniques to capture uncertainty in a single probabilistic approach, taking into account the likelihood of future emissions mitigation policies and technological developments, and provide the level of disaggregation necessary for damage calculations. Unlike other sources of projections, they provide inputs for estimation out to 2300 without further extrapolation assumptions. Conditional on the modeling conducted for the SC-GHG estimates, this time horizon is far enough in the future to capture the majority of discounted climate damages. Including damages beyond 2300 would increase the estimates of the SC-GHG. As discussed in U.S. EPA (EPA, 2023c) the use of the RFF-SPs allows for capturing economic growth uncertainty within the discounting module.

The climate module relies on the Finite Amplitude Impulse Response (FaIR) model, (Smith, et al., 2018; IPCC, Climate Change 2021 - The Physical Science Basis, 2021; Millar, Nicholls, Friedlingstein, & Allen, 2017) a widely used Earth system model which captures the relationships between GHG emissions, atmospheric GHG concentrations, and global mean surface temperature. The FaIR model was originally developed by Richard Millar, Zeb Nicholls, and Myles Allen at Oxford University, as a modification of the approach used in IPCC AR5 to assess the GWP and GTP (Global Temperature Potential) of different gases. It is open source, widely used (e.g., (IPCC, 2018); (IPCC, 2021a) and was highlighted by the National Academies (National Academies, 2017) as a model that satisfies their recommendations for a near-term update of the climate module in SC-GHG estimation. Specifically, it translates GHG emissions into mean surface temperature response and represents the current understanding of the climate and GHG cycle systems and associated uncertainties within a probabilistic framework. The SC-GHG estimates used in this RIA rely on FaIR version 1.6.2 as used by the IPCC (IPCC, 2021). It provides, with high confidence, an accurate representation of the latest scientific consensus on the relationship between global emissions and global mean surface temperature and offers a code base that is fully transparent and available online. The uncertainty capabilities in FaIR 1.6.2 have been calibrated to the most recent assessment of the IPCC (which importantly narrowed the range of likely climate sensitivities relative to prior assessments). See U.S. EPA (EPA, 2023c) for more details.

The socioeconomic projections and outputs of the climate module are inputs into the damage module to estimate monetized future damages from climate change[24]. The National Academies' recommendations for the damage module, scientific literature on climate damages, updates to models that have been developed since 2010, as well as the public comments received on individual EPA rulemakings and the IWG's February 2021 TSD, have all helped to identify available sources of improved damage functions. The IWG (e.g., (IWG, 2010) (IWG, 2016a) (IWG, 2021)), the National Academies (2017), comprehensive studies (e.g., (Rose, et al., 2014)), and public comments have all recognized that the damages functions underlying the IWG SC-GHG estimates used since 2013 (taken from DICE 2010 (Nordhaus W. , 2010); FUND 3.8 (Anthoff & Tol, 2013b); (Anthoff & Tol, 2013); and PAGE 2009 (Hope C. , 2013)) do not include all the important physical, ecological, and economic impacts of climate change. The climate change literature and the science underlying the economic damage functions have evolved, and DICE 2010, FUND 3.8, and PAGE 2009 now lag behind the most recent research.

The challenges involved with updating damage functions have been widely recognized. Functional forms and calibrations are constrained by the available literature and need to extrapolate beyond warming levels or locations studied in that literature. Research and public resources focused on understanding how these physical changes translate into economic impacts have been significantly less than the resources focused on modeling and improving our understanding of climate system dynamics and the physical impacts from climate change (Auffhammer, 2018). Even so, there has been a large increase in research on climate impacts and damages in the time since DICE 2010, FUND 3.8, and PAGE 2009 were published. Along with this growth, there continues to be wide variation in methodologies and scope of studies, such that care is required when synthesizing the current understanding of impacts or damages. Based on a review of available studies and approaches to damage function estimation, the EPA uses three separate damage functions to form the damage module. They are: a subnational-scale, sectoral

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[24] In addition to temperature change, two of the three damage modules used in the SC-GHG estimation require global mean sea level (GMSL) projections as an input to estimate coastal damages. Those two damage modules use different models for generating estimates of GMSL. Both are based off reduced complexity models that can use the FaIR temperature outputs as inputs to the model and generate projections of GMSL accounting for the contributions of thermal expansion and glacial and ice sheet melting based on recent scientific research. Absent clear evidence on a preferred model, the SC-GHG estimates presented in this RIA retain both methods used by the damage module developers. See (EPA, 2023c) for more details.

damage function (based on the Data-driven Spatial Climate Impact Model (DSCIM) developed by the Climate Impact Lab (CIL, 2023) (Carleton, 2022) (Rode, et al., 2021), a country-scale, sectoral damage function (based on the Greenhouse Gas Impact Value Estimator (GIVE) model developed under RFF's Social Cost of Carbon Initiative (Rennert, et al., 2022) and a meta-analysis-based damage function (based on (Howard & Sterner, 2017)). The damage functions in DSCIM and GIVE represent substantial improvements relative to the damage functions underlying the SC-GHG estimates used by the EPA to date and reflect the forefront of scientific understanding about how temperature change and SLR lead to monetized net (market and nonmarket) damages for several categories of climate impacts. The models' spatially explicit and impact-specific modeling of relevant processes allow for improved understanding and transparency about mechanisms through which climate impacts are occurring and how each damage component contributes to the overall results, consistent with the National Academies' recommendations. DSCIM addresses common criticisms related to the damage functions underlying current SC-GHG estimates (e.g., (Pindyck, 2017)) by developing multi-sector, empirically grounded damage functions. The damage functions in the GIVE model offer a direct implementation of the National Academies' near-term recommendation to develop updated sectoral damage functions that are based on recently published work and reflective of the current state of knowledge about damages in each sector. Specifically, the National Academies noted that "[t]he literature on agriculture, mortality, coastal damages, and energy demand provide immediate opportunities to update the [models]" (National Academies, 2017), which are the four damage categories currently in GIVE. A limitation of both models is that the sectoral coverage is still limited, and even the categories that are represented are incomplete. Neither DSCIM nor GIVE yet accommodate estimation of several categories of temperature driven climate impacts (e.g., morbidity, conflict, migration, biodiversity loss) and only represent a limited subset of damages from changes in precipitation. For example, while precipitation is considered in the agriculture sectors in both DSCIM and GIVE, neither model takes into account impacts of flooding, changes in rainfall from tropical storms, and other precipitation related impacts. As another example, the coastal damage estimates in both models do not fully reflect the consequences of SLR-driven salt-water intrusion and erosion, or SLR damages to coastal tourism and recreation. Other missing elements are damages that result from other physical impacts (e.g., ocean acidification, non-temperature-related mortality such as diarrheal disease and malaria) and the many feedbacks and interactions across sectors and regions that can lead to additional damages[25]. See U.S. EPA (EPA, 2023c) for more discussion of omitted damage categories and other modeling limitations. DSCIM and GIVE do account for the most commonly cited benefits associated with $CO_2$ emissions and climate change – $CO_2$ crop fertilization and declines in cold related mortality. As such, while the GIVE- and DSCIM-based results provide state-of-the-science assessments of key climate change impacts, they remain partial estimates of future climate damages resulting from incremental changes in $CO_2$, $CH_4$, and $N_2O$[26].

Finally, given the still relatively narrow sectoral scope of the recently developed DSCIM and GIVE models, the damage module includes a third damage function that reflects a synthesis of the state of knowledge in other published climate damages literature. Studies that employ meta-analytic techniques[27] offer a tractable and straightforward way to combine the results of multiple studies into a single damage function that represents the body of evidence on climate damages that pre-date CIL and RFF's research initiatives. The first use of meta-analysis to combine multiple climate damage studies was done by (Tol, 2009) and included 14 studies. The studies in (Tol, 2009) served as the basis for the global damage function in DICE starting in version 2013R (Nordhaus W. , 2014). The damage function in the most recent published version of DICE, DICE 2016, is from an updated meta-analysis based on a rereview of existing damage studies and included 26 studies published over 1994-2013. Howard and Sterner provide a more recent published peer-reviewed meta-analysis of existing damage studies (published through 2016) and account for additional features of the underlying studies (Howard & Sterner, 2017). This study address differences in measurement across studies by adjusting estimates such that the data are relative to the same base period. They also eliminate double counting by removing duplicative estimates. Howard and Sterner's final sample is drawn from 20 studies that were published through 2015. (Howard & Sterner, 2017) present results under several specifications

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[25] The one exception is that the agricultural damage function in DSCIM and GIVE reflects the ways that trade can help mitigate damages arising from crop yield impacts.

[26] One advantage of the modular approach used by these models is that future research on new or alternative damage functions can be incorporated in a relatively straightforward way. DSCIM and GIVE developers have work underway on other impact categories that may be ready for consideration in future updates (e.g., morbidity and biodiversity loss).

[27] Meta-analysis is a statistical method of pooling data and/or results from a set of comparable studies of a problem. Pooling in this way provides a larger sample size for evaluation and allows for a stronger conclusion than can be provided by any single study. Meta-analysis yields a quantitative summary of the combined results and current state of the literature.

and shows that the estimates are somewhat sensitive to defensible alternative modeling choices. As discussed in detail in U.S. EPA (EPA, 2023c), the damage module underlying the SC-GHG estimates in this RIA includes the damage function specification (that excludes duplicate studies) from (Howard & Sterner, 2017) that leads to the lowest SC-GHG estimates, all else equal.

The discounting module discounts the stream of future net climate damages to its present value in the year when the additional unit of emissions was released. Given the long-time horizon over which the damages are expected to occur, the discount rate has a large influence on the present value of future damages. Consistent with the findings of (National Academies, 2017), the economic literature, OMB Circular A-4's guidance for regulatory analysis, and IWG recommendations to date (IWG, 2010) (IWG, 2013) (IWG, 2016a) (IWG, 2016b) (IWG, 2021), the EPA continues to conclude that the consumption rate of interest is the theoretically appropriate discount rate to discount the future benefits of reducing GHG emissions and that discount rate uncertainty should be accounted for in selecting future discount rates in this intergenerational context. OMB's Circular A-4 points out that "the analytically preferred method of handling temporal differences between benefits and costs is to adjust all the benefits and costs to reflect their value in equivalent units of consumption and to discount them at the rate consumers and savers would normally use in discounting future consumption benefits" (OMB, 2003). The damage module described above calculates future net damages in terms of reduced consumption (or monetary consumption equivalents), and so an application of this guidance is to use the consumption discount rate to calculate the SC-GHG. Thus, EPA concludes that the use of the social rate of return on capital (7 percent under current OMB Circular A-4 guidance), which does not reflect the consumption rate, to discount damages estimated in terms of reduced consumption would inappropriately underestimate the impacts of climate change for the purposes of estimating the SC-GHG[28].

For the SC-GHG estimates used in this RIA, EPA relies on a dynamic discounting approach that more fully captures the role of uncertainty in the discount rate in a manner consistent with the other modules. Based on a review of the literature and data on consumption discount rates, the public comments received on individual EPA rulemakings, and the February

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[28] See also the discussion of the inappropriateness of discounting consumption-equivalent measures of benefits and costs using a rate of return on capital in Circular A-4 (2023) (OMB, 2003).

2021 TSD (IWG, 2021), and the (National Academies, 2017)[29] recommendations for updating the discounting module, the SC-GHG estimates rely on discount rates that reflect more recent data on the consumption interest rate and uncertainty in future rates. Specifically, rather than using a constant discount rate, the evolution of the discount rate over time is defined following the latest empirical evidence on interest rate uncertainty and using a framework originally developed by (Ramsey, 1928) that connects economic growth and interest rates. The Ramsey approach explicitly reflects (1) preferences for utility in one period relative to utility in a later period and (2) the value of additional consumption as income changes. The dynamic discount rates used to develop the SC-GHG estimates applied in this RIA have been calibrated following the (Newell, Pizer, & Prest, 2022) approach, as applied in (Rennert, et al., 2022) (Rennert, et al., 2022a). This approach uses the discounting formula (Ramsey, 1928) in which the parameters are calibrated such that (1) the decline in the certainty-equivalent discount rate matches the latest empirical evidence on interest rate uncertainty estimated by (Bauer & Rudebusch, Interest rates under falling stars, 2020) (Bauer & Rudebusch, 2023) and (2) the average of the certainty-equivalent discount rate over the first decade matches a near-term consumption rate of interest. Uncertainty in the starting rate is addressed by using three near-term target rates (1.5, 2.0, and 2.5 percent) based on multiple lines of evidence on observed market interest rates.

The resulting dynamic discount rate provides a notable improvement over the constant discount rate framework used for SC-GHG estimation in previous EPA RIAs. Specifically, it provides internal consistency within the modeling and a more complete accounting of uncertainty consistent with economic theory (Arrow K. , et al., 2013) (Cropper, Freeman, Groom, & Pizer, 2014) and the (National Academies, 2017) recommendation to employ a more structural, Ramsey-like approach to discounting that explicitly recognizes the relationship between economic growth and discounting uncertainty. This approach is also consistent with the (National Academies, 2017) recommendation to use three sets of Ramsey parameters that reflect a range of near-term certainty-equivalent discount rates and are consistent with theory and empirical evidence on consumption rate uncertainty. Finally, the value of aversion to risk

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[29] Similarly, OMB's Circular A-4 (2023) points out that "The analytically preferred method of handling temporal differences between benefits and costs is to adjust all the benefits and costs to reflect their value in equivalent units of consumption before discounting them" (OMB, 2003).

associated with net damages from GHG emissions is explicitly incorporated into the modeling framework following the economic literature. See U.S. EPA (EPA, 2023c) for a more detailed discussion of the entire discounting module and methodology used to value risk aversion in the SC-GHG estimates.

The methodologies adopted in this SC-GHG estimation process allow for a more holistic treatment of uncertainty than past estimates used by the EPA. The updates incorporate a quantitative consideration of uncertainty into all modules and use a Monte Carlo approach that captures the compounding uncertainties across modules. The estimation process generates nine separate distributions of discounted marginal damages per metric ton – the product of using three damage modules and three near-term target discount rates – for each gas in each emissions year. These distributions have long right tails reflecting the extensive evidence in the scientific and economic literature that shows the potential for lower-probability but higher-impact outcomes from climate change, which would be particularly harmful to society. The uncertainty grows over the modeled time horizon. Therefore, under cases with a lower near-term target discount rate – that give relatively more weight to impacts in the future – the distribution of results is wider. To produce a range of estimates that reflects the uncertainty in the estimation exercise while also providing a manageable number of estimates for policy analysis, the EPA combines the multiple lines of evidence on damage modules by averaging the results across the three damage module specifications. The full results generated from the updated methodology for methane and other greenhouse gases (SC-$CO_2$, SC-$CH_4$, and SC-$N_2O$) for emissions years 2020 through 2080 are provided in U.S. EPA (EPA, 2023c).

Table 4-6 summarizes the resulting averaged certainty-equivalent SC-GHG estimates under each near-term discount rate that are used to estimate the climate impacts of the GHG emission changes expected from the final rule. These estimates are reported in 2021 dollars but are otherwise identical to those presented in U.S. EPA (EPA, 2023c). The SC-GHGs increases over time within the models — i.e., the societal harm from one metric ton emitted in 2030 is higher than the harm caused by one metric ton emitted in 2027 — because future emissions produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change, and because GDP is growing over time and many damage categories are modeled as proportional to GDP.

The methodological updates described above represent a major step forward in bringing SC-GHG estimation closer to the frontier of climate science and economics and address many of the (National Academies, 2017) near-term recommendations. Nevertheless, the resulting SC-GHG estimates presented in Table 4-6, still have several limitations, as would be expected for any modeling exercise that covers such a broad scope of scientific and economic issues across a complex global landscape. There are still many categories of climate impacts and associated damages that are only partially or not reflected yet in these estimates and sources of uncertainty that have not been fully characterized due to data and modeling limitations. For example, the modeling omits most of the consequences of changes in precipitation, damages from extreme weather events, the potential for nongradual damages from passing critical thresholds (e.g., tipping elements) in natural or socioeconomic systems, and non-climate mediated effects of GHG emissions. More specifically for methane, the SC-$CH_4$ estimates do not account for the direct health and welfare impacts associated with tropospheric ozone produced by methane. As discussed further in U.S. EPA (EPA, 2023c), recent studies have found the global ozone-related respiratory mortality benefits of $CH_4$ emissions reductions, which are not included in the SC-$CH_4$ values presented in Table 4-6, to be, in 2021 dollars, approximately $2,500 per metric ton of methane emissions in 2030. (McDuffie, et al., 2023). In addition, the SC-$CH_4$ estimates do not reflect that methane emissions lead to a reduction in atmospheric oxidants, like hydroxyl radicals, nor do they account for impacts associated with $CO_2$ produced from methane oxidizing in the atmosphere. Importantly, the updated SC-GHG methodology does not yet reflect interactions and feedback effects within, and across, Earth and human systems. For example, it does not explicitly reflect potential interactions among damage categories, such as those stemming from the interdependencies of energy, water, and land use. These, and other, interactions and feedbacks were highlighted by the National Academies as an important area of future research for longer-term enhancements in the SC-GHG estimation framework.

Table 4-6 summarizes the resulting averaged certainty-equivalent SC-GHG estimates under each near-term discount rate that are used to monetize the climate impacts of the GHG emission changes expected from the final rule. These estimates are reported in 2021 dollars but are otherwise identical to those presented in U.S. EPA () The SC-GHG increases over time within the models — i.e., the societal harm from one metric ton emitted in 2030 is higher than the harm caused by one metric ton emitted in 2025 — because future emissions produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change, and because GDP is growing over time and many damage categories are modeled as proportional to GDP.

**Table 4-6 Annual Rounded SC-$CO_2$, SC-$CH_4$, and SC-$N_2O$ Values, 2024-2038**

| Emission Year | SC-GHG and Near-term Ramsey Discount Rate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | SC-$CO_2$ *(2021 dollars per metric ton of $CO_2$)* | | | SC-$CH_4$ *(2021 dollars per metric ton of $CH_4$)* | | | SC-$N_2O$ *(2021 dollars per metric ton of $N_2O$)* | | |
| | Near-term Ramsey discount rate | | | Near-term Ramsey discount rate | | | Near-term Ramsey discount rate | | |
| | 2.5% | 2% | 1.5% | 2.5% | 2% | 1.5% | 2.5% | 2% | 1.5% |
| 2024 | 130 | 220 | 370 | 1,600 | 2,000 | 2,800 | 41,000 | 62,000 | 98,000 |
| 2025 | 140 | 220 | 390 | 1,700 | 2,100 | 2,900 | 42,000 | 63,000 | 100,000 |
| 2026 | 140 | 220 | 380 | 1,700 | 2,200 | 3,000 | 43,000 | 64,000 | 100,000 |
| 2027 | 140 | 230 | 390 | 1,800 | 2,300 | 3,000 | 44,000 | 66,000 | 100,000 |
| 2028 | 150 | 230 | 390 | 1,900 | 2,400 | 3,100 | 45,000 | 67,000 | 100,000 |
| 2029 | 150 | 240 | 400 | 1,900 | 2,400 | 3,200 | 46,000 | 68,000 | 110,000 |
| 2030 | 150 | 240 | 400 | 2,000 | 2,500 | 3,300 | 47,000 | 69,000 | 110,000 |
| 2031 | 150 | 240 | 410 | 2,100 | 2,600 | 3,400 | 48,000 | 71,000 | 110,000 |
| 2032 | 160 | 250 | 410 | 2,200 | 2,700 | 3,500 | 49,000 | 72,000 | 110,000 |
| 2033 | 160 | 250 | 420 | 2,300 | 2,800 | 3,600 | 50,000 | 73,000 | 110,000 |
| 2034 | 160 | 260 | 420 | 2,300 | 2,900 | 3,700 | 51,000 | 75,000 | 110,000 |
| 2035 | 170 | 260 | 430 | 2,400 | 3,000 | 3,800 | 52,000 | 76,000 | 120,000 |
| 2036 | 170 | 260 | 430 | 2,500 | 3,100 | 3,900 | 53,000 | 77,000 | 120,000 |
| 2037 | 170 | 270 | 440 | 2,600 | 3,200 | 4,100 | 54,000 | 79,000 | 120,000 |
| 2038 | 170 | 270 | 440 | 2,700 | 3,200 | 4,200 | 55,000 | 80,000 | 120,000 |

Source: U.S. EPA (2023f).
Note: These SC-GHG values are identical to those reported in the technical report U.S. EPA (2023d) adjusted for inflation to 2021 dollars using the annual GDP Implicit Price Deflator values in the U.S. Bureau of Economic Analysis' (BEA) NIPA Table 1.1.9 (U.S. BEA, 2021) . The values are stated in \$/metric ton GHG and vary depending on the year of GHG emissions. This table displays the values rounded to two significant figures. The annual unrounded values used in the calculations in this RIA are available in Appendix A.5 of U.S. EPA (2023f) and at: www.epa.gov/environmental-economics/scghg.

Table 4-7 shows the estimated monetary value of the estimated changes in $CO_2$, $CH_4$, and $N_2O$ emissions expected to occur over 2024 through 2038 for this rule. The EPA estimated the dollar value of the GHG-related effects for each analysis year between 2024 and 2038 by applying the SC-GHG estimates presented in Table 4-6 to the estimated changes in GHG emissions in the corresponding year as shown in Chapter 3. The EPA then calculated the present value (PV) and equivalent annualized value (EAV) of benefits from the perspective of 2023 by discounting each year-specific value to the year 2023 using the same discount rate used to calculate the SC-GHG.[30]

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**Table 4-7 Monetized Impacts of Estimated $CO_2$, $CH_4$, $N_2O$ Changes for the HON Amendments, P&R I and P&R II NESHAP and Subpart VVb, IIIa, NNNa, and RRRa NSPS Amendments, 2024-2038, (million 2021$)**

| | **$CO_2$ (Millions of 2021$)** | | | **$CH_4$ (Millions of 2021$)** | | | **$N_2O$ (Millions of 2021$)** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Near-term Ramsey Discount Rate | | | | | | | | |
| **Year** | **2.5%** | **2%** | **1.5%** | **2.5%** | **2%** | **1.5%** | **2.5%** | **2%** | **1.5%** |
| 2024 | (40) | (65) | (110) | 37 | 47 | 64 | (0.1) | (0.1) | (0.2) |
| 2025 | (40) | (66) | (114) | 38 | 49 | 66 | (0.1) | (0.1) | (0.2) |
| 2026 | (41) | (67) | (113) | 40 | 50 | 68 | (0.1) | (0.1) | (0.2) |
| 2027 | (42) | (68) | (115) | 41 | 52 | 70 | (0.1) | (0.1) | (0.2) |
| 2028 | (43) | (69) | (116) | 43 | 54 | 72 | (0.1) | (0.1) | (0.2) |
| 2029 | (44) | (70) | (118) | 45 | 56 | 74 | (0.1) | (0.1) | (0.2) |
| 2030 | (45) | (71) | (119) | 46 | 58 | 76 | (0.1) | (0.1) | (0.2) |
| 2031 | (46) | (73) | (121) | 48 | 60 | 78 | (0.1) | (0.1) | (0.2) |
| 2032 | (47) | (74) | (122) | 50 | 62 | 81 | (0.1) | (0.1) | (0.2) |
| 2033 | (47) | (75) | (123) | 52 | 64 | 83 | (0.1) | (0.2) | (0.2) |
| 2034 | (48) | (76) | (125) | 54 | 66 | 86 | (0.1) | (0.2) | (0.2) |
| 2035 | (49) | (77) | (127) | 56 | 68 | 88 | (0.1) | (0.2) | (0.2) |
| 2036 | (50) | (78) | (128) | 57 | 70 | 91 | (0.1) | (0.2) | (0.2) |
| 2037 | (51) | (79) | (129) | 59 | 72 | 93 | (0.1) | (0.2) | (0.2) |
| 2038 | (52) | (80) | (131) | 61 | 75 | 95 | (0.1) | (0.2) | (0.3) |
| **NPV** | **(560)** | **(926)** | **(1,607)** | **590** | **764** | **1,045** | **(1.2)** | **(1.9)** | **(3.0)** |
| **EAV** | **(45)** | **(72)** | **(120)** | **48** | **59** | **78** | **(0.1)** | **(0.1)** | **(0.2)** |

Note: Monetized climate impacts are based on changes (increases) in $CO_2$ and $N_2O$ emissions and decreases in $CH_4$ emissions and are calculated using three different estimates of the social cost of each greenhouse gas (SC-GHG) (2.5 percent, 2 percent, and 1.5 percent discount rates) from U.S. EPA (EPA, 2023c). A number in parenthesis represents a negative value.

Unlike many environmental problems where the causes and impacts are distributed more locally, GHG emissions are a global externality making climate change a true global challenge. GHG emissions contribute to damages around the world regardless of where they are emitted. Because of the distinctive global nature of climate change, in the RIA for this final rule the EPA centers attention on a global measure of climate impacts from GHG emissions. Consistent with all IWG recommended SC-GHG estimates to date, the SC-GHG values presented in Table 4-6 provide a global measure of monetized damages from $CO_2$, $CH_4$ and $N_2O$ and Table 4-7 present the monetized global climate impacts of the $CO_2$, $CH_4$ and $N_2O$ emission changes expected from the final rule. This approach is the same as that taken in EPA regulatory analyses from 2009 through 2016 and since 2021. It is also consistent with guidance in (OMB, 2003) that states when a regulation is likely to have international effects, "these effects should be reported"[31]. EPA also notes that EPA's cost estimates in RIAs, including the cost estimates contained in this RIA, regularly do not differentiate between the share of compliance costs expected to accrue to U.S. firms versus foreign interests, such as to foreign investors in regulated entities[32]. A global perspective on climate effects is therefore consistent with the approach EPA takes on costs. There are many reasons, as summarized in this section – and as articulated by OMB and in IWG assessments (IWG, 2010) (IWG, 2013) (IWG, 2016a) (IWG, 2016b) (IWG, 2021), the 2015 Response to Comments (IWG, 2015) and in detail in U.S. EPA (EPA, 2023c) and in Appendix A of the Response to Comments document for the December 2023 Final Oil and Gas NSPS/EG

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[31] While OMB Circular A-4 recommends that international effects we reported separately, the guidance also explains that "[d]ifferent regulations may call for different emphases in the analysis, depending on the nature and complexity of the regulatory issues" (OMB 2003). Circular A-4 (2023) states that "In certain contexts, it may be particularly appropriate to include effects experienced by noncitizens residing abroad in your primary analysis. Such contexts include, for example, when:

- assessing effects on noncitizens residing abroad provides a useful proxy for effects on U.S. citizens and residents that are difficult to otherwise estimate;
- assessing effects on noncitizens residing abroad provides a useful proxy for effects on U.S. national interests that are not otherwise fully captured by effects experienced by particular U.S. citizens and residents (e.g., national security interests, diplomatic interests, etc.);
- regulating an externality on the basis of its global effects supports a cooperative international approach to the regulation of the externality by potentially inducing other countries to follow suit or maintain existing efforts; or
- international or domestic legal obligations require or support a global calculation of regulatory effects" (OMB, 2003).

[32] For example, in the RIA for the 2018 Proposed Reconsideration of the Oil and Natural Gas Sector Emission Standards for New, Reconstructed, and Modified Sources, the EPA acknowledged that some portion of regulatory costs will likely "accru[e] to entities outside U.S. borders" through foreign ownership, employment, or consumption. In general, a significant share of U.S. corporate debt and equities are foreign-owned, including in the oil and gas industry.

Rulemaking – why the EPA focuses on the global value of climate change impacts when analyzing policies that affect GHG emissions.

International cooperation and reciprocity are essential to successfully addressing climate change, as the global nature of greenhouse gases means that a ton of GHGs emitted in any other country harms those in the U.S. just as much as a ton emitted within the territorial U.S. Assessing the benefits of U.S. GHG mitigation activities requires consideration of how those actions may affect mitigation activities by other countries, as those international mitigation actions will provide a benefit to U.S. citizens and residents by mitigating climate impacts that affect U.S. citizens and residents. This is a classic public goods problem because each country's reductions benefit everyone else, and no country can be excluded from enjoying the benefits of other countries' reductions. The only way to achieve an efficient allocation of resources for emissions reduction on a global basis — and so benefit the U.S. and its citizens and residents — is for all countries to base their policies on global estimates of damages. A wide range of scientific and economic experts have emphasized the issue of international cooperation and reciprocity as support for assessing global damages of GHG emission in domestic policy analysis. Using a global estimate of damages in U.S. analyses of regulatory actions allows the U.S. to continue to actively encourage other nations, including emerging major economies, to also assess global climate damages of their policies and to take steps to reduce emissions. For example, many countries and international institutions have already explicitly adapted the global SC-GHG estimates used by EPA in their domestic analyses (e.g., Canada, Israel) or developed their own estimates of global damages (e.g., Germany), and recently, there has been renewed interest by other countries to update their estimates since the draft release of the updated SC-GHG estimates presented in the December 2022 Oil and Gas NSPS/EG Supplemental Proposal RIA[33]. Several recent studies have empirically examined the evidence on international GHG mitigation reciprocity, through both policy diffusion and technology diffusion effects. See U.S. EPA (EPA, 2023c) for more discussion.

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[33] In April 2023, the government of Canada announced the publication of an interim update to their SC-GHG guidance, recommending SC-GHG estimates identical to the EPA's updated estimates presented in the December 2022 Supplemental Proposal RIA. The Canadian interim guidance will be used across all Canadian federal departments and agencies, with the values expected to be finalized by the end of the year. See more at https://www.canada.ca/en/environment-climate-change/services/climate-change/science-research-data/social-cost-ghg.html.

For all of these reasons, the EPA believes that a global metric is appropriate for assessing the climate impacts of GHG emissions in this final RIA. In addition, as emphasized in the (National Academies, 2017) recommendations, “[i]t is important to consider what constitutes a domestic impact in the case of a global pollutant that could have international implications that impact the United States.” The global nature of GHG pollution and its impacts means that U.S. interests are affected by climate change impacts through a multitude of pathways and these need to be considered when evaluating the benefits of GHG mitigation to U.S. citizens and residents. The increasing interconnectedness of global economy and populations means that impacts occuring outside of U.S. borders can have significant impacts on U.S. interests. Examples of affected interests include direct effects on U.S. citizens and assets located abroad, international trade, and tourism, and spillover pathways such as economic and political destabilization and global migration that can lead to adverse impacts on U.S. national security, public health, and humanitarian concerns. Those impacts point to the global nature of the climate change problem and are better captured within global measures of the social cost of greenhouse gases.

In the case of these global pollutants, for the reasons articulated in this section, the assessment of global net damages of GHG emissions allows EPA to fully disclose and contextualize the net climate impacts of GHG emission changes expected from this final rule. The EPA disagrees with public comments received on the December 2022 Oil and Gas NSPS/EG Supplemental Proposal that suggested that the EPA can or should use a metric focused on benefits resulting solely from changes in climate impacts occuring within U.S. borders. The global models used in the SC-GHG modeling described above do not lend themselves to be disaggregated in a way that could provide comprehensive information about the distribution of the rule's climate impacts to citizens and residents of particular countries, or population groups across the globe and within the U.S. Two of the models used to inform the damage module, the GIVE and DSCIM models, have spatial resolution that allows for some geographic disaggregation of future climate impacts across the world. This permits the calculation of a partial GIVE and DSCIM-based SC-GHG measuring the damages from four or five climate impact categories projected to physically occur within the U.S., respectively, subject to caveats. As discussed at length in U.S. EPA (EPA, 2023c), these damage modules are only a partial accounting and do not capture all of the pathways through which climate change affects public health and welfare. As discussed at length in U.S. EPA (EPA, 2023c), these damage modules are only a partial accounting and do not capture all of the pathways through which climate change affects public health and welfare. Thus, they only cover a subset of potential climate change impacts. Furthermore, the damage modules do not capture spillover or indirect effects whereby climate impacts in one country or region can affect the welfare of residents in other countries or regions—for example through the movement of refugees.

Additional modeling efforts can and have shed further light on some omitted damage categories. For example, the Framework for Evaluating Damages and Impacts (FrEDI) is an open-source modeling framework developed by the EPA[34] to facilitate the characterization of net annual climate change impacts in numerous impact categories within the contiguous U.S. and monetize the associated distribution of modeled damages (Sarofim, et al., 2021) (EPA, 2021). The additional impact categories included in FrEDI reflect the availability of U.S.-specific data and research on climate change effects. As discussed in U.S. EPA (EPA, 2023c) results from FrEDI show that annual damages resulting from climate change impacts within the contiguous U.S. (CONUS) (i.e., excluding Hawaii, Alaska, and U.S. territories) and for impact categories not represented in GIVE and DSCIM are expected to be substantial. As discussed in U.S. EPA (EPA, 2021), results from FrEDI show that annual damages resulting from climate change impacts within the contiguous U.S. (CONUS) (i.e., excluding Hawaii, Alaska, and U.S. territories) and for impact categories not represented in GIVE and DSCIM are expected to be substantial. For example, FrEDI estimates a partial SC-$CO_2$ of \$38/mt$CO_2$ for damages physically occurring within CONUS for 2030 emissions (under a 2 percent near-term Ramsey discount rate) (Hartin, et al., 2023), compared to a GIVE and DSCIM-based U.S.-specific SC-$CO_2$ of \$17/mt$CO_2$ and \$15/mt$CO_2$, respectively, for 2030 emissions (2021 USD). While the FrEDI results help to illustrate how monetized damages physically occurring within CONUS increase as more impacts are reflected in the modeling framework, they are still subject to many of the same limitations associated with the DSCIM and GIVE damage modules, including the

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[34] The FrEDI framework and Technical Documentation have been subject to a public review comment period and an independent external peer review, following guidance in the EPA Peer-Review Handbook for Influential Scientific Information (ISI). Information on the FrEDI peer-review is available at the EPA Science Inventory.

omission or partial modeling of important damage categories[35,36]. Finally, none of these modeling efforts – GIVE, DSCIM, and FrEDI – reflect non-climate mediated effects of GHG emissions experienced by U.S. populations (other than $CO_2$ fertilization effects on agriculture). As one example of new research on non-climate mediated effects of methane emissions, (McDuffie, et al., 2023) estimate the monetized increase in respiratory-related human mortality risk from the ozone produced from a marginal pulse of methane emissions. Using the socioeconomics from the RFF-SPs and the 2 percent near-term Ramsey discounting approach, this additional risk to U.S. populations is on the order of approximately \$330/mt$CH_4$ (2021 USD) for 2030 emissions.

Applying the U.S.-specific partial SC-GHG estimates derived from the multiple lines of evidence described above to the GHG emission changes expected under the final rule would also yield impacts. For example, the present value of the climate benefits of the final rule as measured by FrEDI from climate change impacts in CONUS are estimated to be \$35 million (under a 2 percent near-term Ramsey discount rate)[37]. However, the numerous explicitly omitted damage categories and other modeling limitations discussed above and throughout U.S. EPA ( (EPA, 2023c) make it likely that these estimates underestimate the impacts to U.S. citizens and residents of the GHG emission changes from the final rule; the limitations in developing a U.S.-specific estimate that accurately captures direct and spillover effects on U.S. citizens and residents further demonstrates that it is more appropriate to use a global measure of climate

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[35] Another method that has produced estimates of the effect of climate change on U.S.-specific outcomes uses a top-down approach to estimate aggregate damage functions. Published research using this approach include total-economy empirical studies that econometrically estimate the relationship between GDP and a climate variable, usually temperature. As discussed in U.S. EPA (EPA, 2023c) the modeling framework used in the existing published studies using this approach differ in important ways from the inputs underlying the SC-GHG estimates described above (e.g., discounting, risk aversion, and scenario uncertainty) and focus solely on SC-CO2. Hence, we do not consider this line of evidence in the analysis for this RIA. Updating the framework of total-economy empirical damage functions to be consistent with the methods described in this RIA and ibid. would require new analysis. Finally, because total-economy empirical studies estimate market impacts, they do not include any non-market impacts of climate change (e.g., heat related mortality) and therefore are also only a partial estimate. The EPA will continue to review developments in the literature and explore ways to better inform the public of the full range of GHG impacts.

[36] FrEDI estimates a partial SC-$CH_4$ ($N_2O$) of \$610/mtCH4 (\$11,000/mt$N_2O$) for damages physically occurring within CONUS for 2030 emissions (under a 2 percent near-term Ramsey discount rate) (Hartin, et al., 2023) compared to a GIVE and DSCIM-based U.S.-specific SC-$CH_4$ of \$290/mt$CH_4$ (\$5,200/mt$N_2O$) and \$78/mt$CH_4$ (\$4,000/mt$N_2O$), respectively, for 2030 emissions (USD 2021).

[37] DCIM and GIVE use global damage functions. Damage functions based on only U.S.-data and research, but not for other parts of the world, were not included in those models. FrEDI does make use of some of this U.S.-specific data and research and as a result has a broader coverage of climate impact categories.

impacts from GHG emissions. The EPA will continue to review developments in the literature, including more robust methodologies for estimating the magnitude of the various damages to U.S. populations from climate impacts and reciprocal international mitigation activities, and explore ways to better inform the public of the full range of GHG impacts.

## 4.8 Total Monetized Benefits

Table 4-8 through Table 4-10 present a summary of monetized benefits for the final amendments to rules included in this rulemaking, both individually and cumulatively. Net benefits in each table are calculated as the sum of monetized health benefits and climate benefits (including climate disbenefits). Non-monetized benefits are included qualitatively in each table. Benefits related to both short- and long-term exposure of ozone are estimated. Tables presenting benefits list both estimates, with short-term exposure benefits listed first. A complete presentation of benefits relative to costs appears in Chapter 6 of this RIA. We note, as we mentioned in Chapter 1, that there are minimal monetized benefits for the P&R II amendments, and hence there is no table of benefits for this final rule below. In addition, the benefits for the Subpart VVb and IIIa, NNNa, and RRRa NSPS are the same for the less and more stringent options, and thus those estimates are already presented earlier in this chapter. Hence, there is no table of benefits for each of these final rules below.

### Table 4-8 Summary of Monetized Benefits PV/EAV for the HON Amendments, 2024-2038 (million 2021$), Discounted to 2023

| | **Final Rule** | | **Less Stringent Alternative** | | **More Stringent Alternative** | |
|---|---|---|---|---|---|---|
| **3%** | **PV** | **EAV** | **PV** | **EAV** | **PV** | **EAV** |
| Monetized Health Benefits | 70 and 630 | 5.9 and 53 | 70 and 630 | 5.9 and 52 | 71 and 640 | 6 and 54 |
| Climate Disbenefits (2%) | 140 | 11 | 140 | 11 | 140 | 11 |
| **Total Benefits** | **(70) and 490** | **(5.1) and 42** | **(70) and 490** | **(5.1) and 41** | **(69) and 500** | **(5) and 43** |
| **7%** | **PV** | **EAV** | **PV** | **EAV** | **PV** | **EAV** |
| Monetized Health Benefits | 48 and 420 | 5.2 and 46 | 48 and 420 | 5.2 and 46 | 49 and 430 | 5.3 and 47 |
| Climate Disbenefits (2%) | 140 | 11 | 140 | 11 | 140 | 11 |
| **Total Benefits** | **(92) and 280** | **(5.8) and 35** | **(92) and 280** | **(5.8) and 35** | **(91) and 290** | **(5.7) and 36** |
| Nonmonetized Benefits | 1,107 tons of HAP emission reductions. Health effects from reduced exposure to ethylene oxide, chloroprene, benzene, 1,3-butadiene, vinyl chloride, ethylene dichloride, chlorine, maleicanhydride, and acrolein | | | | | |

Note: Monetized air-quality related health benefits include ozone related health benefits associated with reductions in VOC emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The two benefits estimates are separated by the word “and” to signify that they are two separate estimates. The estimates do not represent lower- and upper-bound estimates. Benefits from HAP reductions and VOC reductions outside of the ozone season remain unmonetized and are thus not reflected in the table. The unmonetized effects also include disbenefits resulting from a secondary increase in CO emissions. Monetized climate benefits and disbenefits are based on changes (increases) in $CO_2$ and $N_2O$ emissions and decreases in $CH_4$ emissions and are calculated using three different estimates of the social cost of each greenhouse gas (SC-GHG) (2.5 percent, 2 percent, and 1.5 percent discount rates). For the presentational purposes of this table, we show the benefits and disbenefits associated with the SC-GHG at a 2 percent discount rate. Parentheses around a number denotes a negative value. Negative climate disbenefits is a positive value. Rows may not appear to add correctly due to rounding.

**Table 4-9 Summary of Monetized Benefits PV/EAV for the P&R I Amendments, 2024-2038 (million 2021$), Discounted to 2023**

| | Final Rule | | Less Stringent Alternative | | More Stringent Alternative | |
|---|---|---|---|---|---|---|
| **3%** | **PV** | **EAV** | **PV** | **EAV** | **PV** | **EAV** |
| Monetized Health Benefits | (0.2) and (1.7) | (0.02) and (0.1) | (0.5) and (4) | -0.04 and -0.3 | (0.4) and (3) | (0.03) and (0.3) |
| Climate Disbenefits (2%) | 22 | 2 | 22 | 2 | 22 | 2 |
| **Total Benefits** | **(22) and (24)** | **(1.7) and (1.8)** | **(23) and (26)** | **(1.7) and (2)** | **(22) and (25)** | **(1.7) and (2)** |
| **7%** | **PV** | **EAV** | **PV** | **EAV** | **PV** | **EAV** |
| Monetized Health Benefits | (0.2) and (1.5) | (0.02) and (0.2) | (0.2) and (1.5) | (0.02) and (0.2) | (0.3) and (2.4) | (0.03) and (0.3) |
| Climate Disbenefits (2%) | 22 | 2 | 22 | 2 | 22 | 2 |
| **Total Benefits** | **(22) and (24)** | **(1.7) and (1.9)** | **(22) and (24)** | **(1.7) and (1.9)** | **(22) and (24)** | **(1.7) and (2)** |
| Nonmonetized Benefits | 264 tons per year (tpy) of HAP emission reductions, including an approximate 14 tpy reduction in chloroprene emissions | | | | | |

Note: Monetized benefits include ozone related health benefits associated with reductions in VOC emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The two benefits estimates are separated by the word “and” to signify that they are two separate estimates. The estimates do not represent lower- and upper-bound estimates. Benefits from HAP reductions and VOC reductions outside of the ozone season remain unmonetized and are thus not reflected in the table. The unmonetized effects also include disbenefits resulting from a secondary increase in CO emissions. Monetized climate benefits and disbenefits are based on changes (increases) in $CO_2$ and $N_2O$ emissions and decreases in $CH_4$ emissions and are calculated using three different estimates of the social cost of each greenhouse gas (SC-GHG) (2.5 percent, 2 percent, and 1.5 percent discount rates). For the presentational purposes of this table, we show the benefits and disbenefits associated with the SC-GHG at a 2 percent discount rate.

### Table 4-10 Summary of Monetized Benefits PV/EAV for the Cumulative Impact of the HON Amendments, P&R I and P&R II NESHAP and Subpart VVb, IIIa, NNNa, and RRRa NSPS Amendments, 2024-2038 (million 2021$), Discounted to 2023

| | **Final Rule** | | **Less Stringent Alternative** | | **More Stringent Alternative** | |
|---|---|---|---|---|---|---|
| **3%** | **PV** | **EAV** | **PV** | **EAV** | **PV** | **EAV** |
| Health Benefits | 71 and 640 | 6 and 53 | 71 and 640 | 5.9 and 53 | 72 and 650 | 6.1 and 53 |
| Climate Disbenefits | 160 | 13 | 160 | 13 | 160 | 13 |
| **Net Benefits** | **(89) and 480** | **(7) and 40** | **(89) and 480** | **(7.1) and 40** | **(88) and 490** | **(6.9) and 40** |
| **7%** | **PV** | **EAV** | **PV** | **EAV** | **PV** | **EAV** |
| Health Benefits | 48 and 430 | 5.3 and 47 | 48 and 430 | 5.3 and 47 | 49 and 440 | 5.3 and 47 |
| Climate Disbenefits | 160 | 13 | 160 | 13 | 160 | 13 |
| **Net Benefits** | **(110) and 270** | **(7.7) and 34** | **(110) and 270** | **(7.7) and 34** | **(110) and 280** | **(7.7) and 34** |
| Non-monetized Benefits: Health benefits associated with emission reductions of 6,230 tpy of HAP including hexane, benzene, methanol, 1,3-butadiene, and vinyl acetate. Health benefits associated with reduction of 54 tpy of ethylene oxide and 14 tpy of chloroprene. Ecosystem benefits related to the reductions of ozone and nitrogen and sulfur deposition. | | | | | | |

Note: Monetized benefits include ozone related health benefits associated with reductions in VOC emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The two benefits estimates are separated by the word “and” to signify that they are two separate estimates. The estimates do not represent lower- and upper-bound estimates. Benefits from HAP reductions and VOC reductions outside of the ozone season remain unmonetized and are thus not reflected in the table. The unmonetized effects also include disbenefits resulting from a secondary increase in CO emissions. Monetized climate benefits and disbenefits are based on changes (increases) in $CO_2$ and $N_2O$ emissions and decreases in $CH_4$ emissions and are calculated using three different estimates of the social cost of each greenhouse gas (SC-GHG) (2.5 percent, 2 percent, and 1.5 percent discount rates). For the presentational purposes of this table, we show the benefits and disbenefits associated with the SC-GHG at a 2 percent discount rate.

# CHAPTER 4 APPENDIX

Table 4A-1 through 4A-3 summarize the interim SC-$CO_2$, SC-$CH_4$, and SC-$N_2O$ estimates that were used in the RIA for the years 2024–2038. These estimates are reported in 2021 dollars but are otherwise identical to those presented in the IWG's 2021 TSD and 2016 TSD (IWG, 2021). The SC-GHG increases over time within the models (*i.e.*, the societal harm from one metric ton emitted in 2030 is higher than the harm caused by one metric ton emitted in 2025) because future emissions produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change, and because GDP is growing over time and many damage categories are modeled as proportional to GDP.

Table 4A-4 shows the estimated monetary value of the estimated changes in $CO_2$, $CH_4$, $N_2O$, and total GHG emissions expected to occur over 2024 through 2038 from the final rule using the IWG's interim SC-GHG estimates.

**Table 4A-1 Interim Social Cost of Carbon Values, 2024-2038 (2021$/Metric Ton $CO_2$)**

| **Emissions Year** | **Discount Rate and Statistic** | | | |
|---|---|---|---|---|
| | **5% Average** | **3% Average** | **2.5% Average** | **3% 95th Percentile** |
| 2024 | $17 | $58 | $85 | $170 |
| 2025 | $18 | $59 | $86 | $180 |
| 2026 | $18 | $60 | $88 | $180 |
| 2027 | $19 | $61 | $89 | $180 |
| 2028 | $19 | $62 | $90 | $190 |
| 2029 | $20 | $63 | $92 | $190 |
| 2030 | $20 | $64 | $93 | $190 |
| 2031 | $21 | $66 | $95 | $200 |
| 2032 | $21 | $67 | $96 | $200 |
| 2033 | $22 | $68 | $97 | $210 |
| 2034 | $23 | $69 | $99 | $210 |
| 2035 | $23 | $70 | $100 | $210 |
| 2036 | $24 | $71 | $100 | $220 |
| 2037 | $24 | $73 | $100 | $220 |
| 2038 | $25 | $74 | $110 | $230 |

Note: These SC-$CO_2$ values are identical to those reported in the IWG's 2021 TSD (IWG, 2021) and 2016 TSD (IWG, 2016a) adjusted to 2021 dollars using the annual GDP Implicit Price Deflator values in the U.S. Bureau of Economic Analysis' (BEA) NIPA Table 1.1.9 (U.S. BEA 2022). This table displays the values rounded to the nearest dollar; the annual unrounded values used in the calculations in this analysis are available on OMB's website: https://www.whitehouse.gov/omb/information-regulatory-affairs/regulatory-matters/#scghgs.

*Source: Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990 (IWG 2021)*

### Table 4A-2: Interim Social Cost of Methane Values, 2024-2038 (2021$ /Metric Ton $CH_4$)

| Emissions Year | Discount Rate and Statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2024 | $810 | $1,700 | $2,300 | $4,600 |
| 2025 | $840 | $1,800 | $2,300 | $4,700 |
| 2026 | $860 | $1,800 | $2,400 | $4,900 |
| 2027 | $890 | $1,900 | $2,400 | $5,000 |
| 2028 | $920 | $1,900 | $2,500 | $5,100 |
| 2029 | $950 | $2,000 | $2,600 | $5,300 |
| 2030 | $980 | $2,000 | $2,600 | $5,400 |
| 2031 | $1,000 | $2,100 | $2,700 | $5,600 |
| 2032 | $1,000 | $2,200 | $2,700 | $5,700 |
| 2033 | $1,100 | $2,200 | $2,800 | $5,900 |
| 2034 | $1,100 | $2,300 | $2,900 | $6,000 |
| 2035 | $1,200 | $2,300 | $2,900 | $6,200 |
| 2036 | $1,200 | $2,400 | $3,000 | $6,400 |
| 2037 | $1,200 | $2,400 | $3,100 | $6,500 |
| 2038 | $1,300 | $2,500 | $3,100 | $6,700 |

Note: These SC-$CH_4$ values are identical to those reported in the IWG's 2021 TSD (IWG, 2021) and 2016 TSD (IWG, 2016a) adjusted to 2021 dollars using the annual GDP Implicit Price Deflator values in the U.S. Bureau of Economic Analysis' (BEA) NIPA Table 1.1.9 (U.S. BEA 2022). This table displays the values rounded to two significant figures; the annual unrounded values used in the calculations in this analysis are available on OMB's website: https://www.whitehouse.gov/omb/information-regulatory-affairs/regulatory-matters/#scghgs.

*Source: Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990 (IWG 2021)*

### Table 4A-3: Interim Social Cost of Nitrous Oxide Values, 2024-2038 (2021$ /Metric Ton $N_2O$)

| Emissions Year | Discount Rate and Statistic | | | |
|---|---|---|---|---|
| | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2024 | $6,900 | $21,000 | $31,000 | $55,000 |
| 2025 | $7,100 | $21,000 | $31,000 | $57,000 |
| 2026 | $7,300 | $22,000 | $32,000 | $58,000 |
| 2027 | $7,500 | $22,000 | $32,000 | $59,000 |
| 2028 | $7,700 | $23,000 | $33,000 | $60,000 |
| 2029 | $7,900 | $23,000 | $33,000 | $62,000 |
| 2030 | $8,100 | $24,000 | $34,000 | $63,000 |
| 2031 | $8,400 | $24,000 | $35,000 | $64,000 |
| 2032 | $8,600 | $25,000 | $35,000 | $66,000 |
| 2033 | $8,900 | $25,000 | $36,000 | $67,000 |
| 2034 | $9,200 | $26,000 | $37,000 | $69,000 |
| 2035 | $9,400 | $26,000 | $37,000 | $70,000 |
| 2036 | $9,700 | $27,000 | $38,000 | $71,000 |
| 2037 | $9,900 | $27,000 | $39,000 | $73,000 |
| 2038 | $10,000 | $28,000 | $39,000 | $74,000 |

Note: These SC-$N_2O$ values are identical to those reported in the IWG's 2021 TSD (IWG, 2021) and 2016 TSD (IWG, 2016a) adjusted to 2021 dollars using the annual GDP Implicit Price Deflator values in the U.S. Bureau of Economic Analysis' (BEA) NIPA Table 1.1.9 (U.S. BEA 2022). This table displays the values rounded to two significant figures; the annual unrounded values used in the calculations in this analysis are available on OMB's website: https://www.whitehouse.gov/omb/information-regulatory-affairs/regulatory-matters/#scghgs.

*Source: Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990 (IWG 2021)*

## Table 4A-4 Monetized Benefits of Estimated $CO_2$, $CH_4$, $N_2O$ Changes of the HON Amendments, P&R I and P&R II NESHAP and Subpart VVb, IIIa, NNNa, and RRRa NSPS Amendments, 2024-2038, (million 2021$)

| | SC-$CO_2$ (Millions of 2021$) | | | | SC-$CH_4$ (Millions of 2021$) | | | | SC-$N_2O$ (Millions of 2021$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Discount rate and statistic | | | | Discount rate and statistic | | | | Discount rate and statistic | | | |
| **Year** | **5% Average** | **3% Average** | **2.5% Average** | **3% 95th Percentile** | **5% Average** | **3% Average** | **2.5% Average** | **3% 95th Percentile** | **5% Average** | **3% Average** | **2.5% Average** | **3% 95th Percentile** |
| 2024 | $(13) | $(43) | $(63) | $(128) | $19 | $40 | $52 | $106 | $(0.05) | $(0.14) | $(0.21) | $(0.38) |
| 2025 | $(13) | $(44) | $(64) | $(131) | $19 | $41 | $53 | $109 | $(0.05) | $(0.15) | $(0.21) | $(0.39) |
| 2026 | $(13) | $(44) | $(65) | $(133) | $20 | $42 | $55 | $112 | $(0.05) | $(0.15) | $(0.22) | $(0.40) |
| 2027 | $(14) | $(45) | $(66) | $(136) | $20 | $43 | $56 | $115 | $(0.05) | $(0.15) | $(0.22) | $(0.41) |
| 2028 | $(14) | $(46) | $(67) | $(139) | $21 | $44 | $57 | $118 | $(0.05) | $(0.16) | $(0.23) | $(0.41) |
| 2029 | $(15) | $(47) | $(68) | $(141) | $22 | $46 | $59 | $121 | $(0.05) | $(0.16) | $(0.23) | $(0.42) |
| 2030 | $(15) | $(48) | $(69) | $(144) | $22 | $47 | $60 | $124 | $(0.06) | $(0.16) | $(0.23) | $(0.43) |
| 2031 | $(15) | $(49) | $(70) | $(147) | $23 | $48 | $61 | $128 | $(0.06) | $(0.17) | $(0.24) | $(0.44) |
| 2032 | $(16) | $(49) | $(71) | $(150) | $24 | $49 | $63 | $131 | $(0.06) | $(0.17) | $(0.24) | $(0.45) |
| 2033 | $(16) | $(50) | $(72) | $(153) | $25 | $51 | $65 | $135 | $(0.06) | $(0.17) | $(0.25) | $(0.46) |
| 2034 | $(17) | $(51) | $(73) | $(156) | $26 | $52 | $66 | $139 | $(0.06) | $(0.18) | $(0.25) | $(0.47) |
| 2035 | $(17) | $(52) | $(74) | $(159) | $27 | $53 | $68 | $142 | $(0.06) | $(0.18) | $(0.26) | $(0.48) |
| 2036 | $(18) | $(53) | $(75) | $(162) | $27 | $55 | $69 | $146 | $(0.07) | $(0.18) | $(0.26) | $(0.49) |
| 2037 | $(18) | $(54) | $(76) | $(165) | $28 | $56 | $71 | $150 | $(0.07) | $(0.19) | $(0.26) | $(0.50) |
| 2038 | $(19) | $(55) | $(77) | $(168) | $29 | $57 | $72 | $153 | $(0.07) | $(0.19) | $(0.27) | $(0.51) |
| **NPV** | **($149)** | **($558)** | **($842)** | **($1,690)** | **$225** | **$552** | **$738** | **$1,469** | **($1)** | **($2)** | **($3)** | **($5)** |
| **EAV** | **$(15)** | **$(48)** | **$(70)** | **$(146)** | **$23** | **$48** | **$61** | **$127** | **($0.1)** | **($0.2)** | **($0.2)** | **($0.4)** |

# 5 ECONOMIC IMPACT ANALYSIS

## 5.1 Introduction

The final amendments to the NESHAP for the HON constitute a significant action according to Executive Order 14094. As discussed in the previous section, the emissions reductions estimated under the action are projected to produce substantial VOC health benefits. At the same time, these final HON amendments are projected to result in environmental control expenditures by the SOCMI to comply with the rule. The final amendments to the NESHAPs for P&R Group I and II, and their respective NSPS subparts (III, NNN, RRR, & VV) are not projected to be significant individually, but they are expected to result in VOC health benefits and increased environmental control expenditures.

Economic impact analyses focus on changes in market prices and output levels. If changes in market prices and output levels in the primary markets are significant enough, impacts on other markets may also be examined. Both the magnitude of costs needed to comply with a rule and the distribution of these costs among affected facilities can have a role in determining how the market will change in response to a rule. This chapter analyzes three sets of economic impact, small entity, and distributional analyses for each individual rule included in this final action. These analyses are directed toward complementing the benefit-cost analysis and include a partial equilibrium analysis of market impacts of three sets of NESHAP amendments from this rule package, analysis of impacts to potentially affected small entities, and employment impacts.

## 5.2 Economic Impact Analysis

This section summarizes the economic analysis of environmental control costs for the SOCMI. This analysis models the impact of two sets of control costs for three different final NESHAP amendments for the HON and P&R Group I and II, specifically. The analysis does not include economic impacts calculated for four final New Source Performance Standards (NSPS) – subparts III, NNN, RRR, and VV – that are part of the same rulemaking in which the three different NESHAP are also included.

This section outlines the data and sources used to calibrate and parameterize a simplified partial equilibrium model representing elastic domestic and foreign sources of supply and a single domestic consumer with elastic preferences. The model uses different cost shocks, including domestic compliance costs, foreign inflation, and combinations.

Economic analysis was conducted for seven synthetic organic chemicals in the SOCMI list. These chemicals were selected for their relative market size and the availability of data to conduct the economic analysis. The seven chemicals for which market analysis was conducted are butadiene, styrene, acrylonitrile, acetone, ethylene dichloride, ethylene glycol, and ethylene oxide.

## 5.3 Description of Approach, Model, and Framework

### *5.3.1 Data Limitations*

There were several limitations to data inputs for the economic modeling, including the availability of production data, the allocation of the control costs from facilities to individual chemical markets, and the ability to find specific market dynamics (elasticity) data. For production data, the primary source for most of the chemicals in this analysis included the American Fuel & Petrochemical Manufacturers (AFPM) Petrochemical Statistics dataset published in the first quarter of 2022.

For cost data, control costs were calculated by facility, but little detail was initially available on facility-level production, such as chemical or quantities produced. To allocate the control costs to specific chemicals, data was sourced from Securities and Exchange Commission (SEC) filings, company websites, and specific industry reports to identify chemicals produced at each facility to support the method for cost allocation from facilities to individual chemical markets for the partial equilibrium analysis.

For market supply and demand elasticities, no sources of previous SOCMI economic modeling were found, so elasticities were assigned to chemicals based on markets associated with end use products for the chemicals (such as different types of plastics or PVC piping).

These limitations are discussed more in detail in the following two subsections.

### *5.3.2 Benchmark Data*

There are approximately 400 synthetic organic chemicals, nearly all of which are contained within a single 6-digit North American Industry Classification System (NAICS) code

(325199). A detailed description of the approximately 25 largest SOCMI markets is contained in the SOCMI Industry Profile prepared for this final action.[38] The main limitation of collecting data for the industry profile was a lack of domestic production for each of the synthetic organic chemicals.

Trade data do, however, provide more granular information on products via harmonized system (HS) commodity codes. For the economic analysis, we selected seven of the largest SOCMI sectors, drawing domestic production quantities from the AFPM Petrochemical Statistics dataset, prices from Intratec commodities data (Intratec, 2023), and trade quantities from the United Nations "Comtrade" dataset (United Nations, 2022). Table 5-1 summarizes the physical quantities and prices for each of the seven chemicals included in the analysis. All physical quantities here are in tonnes (Metric Tons), which are 10 percent larger by mass than English tons.

**Table 5-1 Prices, Production, and Trade Quantities for the Seven Synthetic Organic Chemical Commodities Selected (in Metric Tons)**

| Chemical | U.S. Production (tonnes) | Exports (tonnes) | Imports (tonnes) | Price ($/tonne) |
|---|---|---|---|---|
| Butadiene | 1,218,232 | 46,261 | 391,496 | 1,220 |
| Styrene | 3,659,415 | 1,099,780 | 211,776 | 1,841 |
| Acrylonitrile | 848,390 | 529,330 | 9,003 | 1,040 |
| Acetone | 1,514,800 | 42,229 | 84,459 | 1,839 |
| Ethylene dichloride | 9,731,200 | 727,454 | 475 | 723 |
| Ethylene glycol | 1,578,142 | 1,269,166 | 236,920 | 1,220 |
| Ethylene oxide | 2,400,027 | 928 | 5 | 1,486 |

### *5.3.3 Control Data*

Control cost data is available for 225 facilities subject to HON or P&R I, not including the value of product recovery, which occurs in the HON and P&R I cost analyses due to detection and repair of equipment leaks. Inclusion of the value of product recovery would lead to double counting of impacts from a social welfare perspective. More information on how product recovery is estimated and monetized can be found in Section 3.3 of this RIA. The control cost data did not include the production processes, or a detailed accounting of chemicals produced at

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[38] RTI International. SOCMI Industry Profile. Prepared for the U.S. EPA. July 2022.

the affected facilities. To develop a method to allocate the control costs to specific chemicals, we reviewed annual SEC filings (for most companies, the 2021 10-k Report) and facility websites for all facilities to identify the chemicals produced at the facility. We found general information about the types of chemicals produced at 116 (51 percent) of those facilities and more detailed production data by chemical names for 79 (36 percent) of the total population of facilities.

For the 79 facilities with the best (*i.e.*, most complete) chemical production data, we used this information to identify which of the facilities were producing butadiene, styrene, acrylonitrile, and acetone. We allocated the control costs to these chemicals at the 79 facilities by equally distributing the control costs based on the total number of chemicals identified in production at that facility. The control costs for each chemical were then scaled up to the entire population based on the percentage of total control costs represented in the population of 79 facilities with specific chemical data.

For ethylene dichloride, ethylene glycol, and ethylene oxide, we reviewed publicly available reports to identify facilities that produced each specific chemical and then allocated a portion of the facility's HON costs to their production. The P&R costs apply only to polymers and resin products, so only HON costs were relevant for these three chemicals. For ethylene dichloride, a technical report on the conditions of use for ethylene dichloride listed the 15 facilities producing ethylene dichloride in the United States in 2018 (Material Research L3C, 2019). We allocated half of the HON control costs at each of these facilities to ethylene dichloride because most of these facilities are PVC production facilities, and ethylene dichloride is one of the two major chemical inputs, but there was not enough data to determine how much of the HON costs would be applied to the other chemicals produced.

The ethylene oxide facilities were identified from a Bloomberg Law article (Saiyid, 2019) that listed the top 16 sources of ethylene oxide emissions, 10 of which were production facilities and the other 6 were medical sterilization facilities. Facilities affected by this rule include ethylene oxide production facilities and not medical sterilization facilities. Sterilization facilities have also not been found to be co-located with any of the production facilities. The American Chemistry Society (2023) stated that at the end of 2018, the United States had 15 ethylene oxide facilities. The ethylene glycol facilities were identified from a toxicology profile from the Department of Health and Human Services (DHHS) (2010). The list of ethylene glycol facilities was from 2008, so it may not include all current production facilities. The DHHS report noted that nine ethylene oxide production facilities were included in the HON control cost data, six of which also produced ethylene oxide. These facilities did not generally provide detailed production data by chemical; for ethylene glycol and ethylene oxide, half of the HON costs for each facility were allocated to each chemical. Because only 10 of the 15 ethylene glycol production facilities were identified, the HON costs were multiplied by 1.5 to represent the entire population of facilities. Table 5-2 details the control costs for each chemical used in the model. Three of the seven chemicals are found to have total control costs of more than one percent of total domestic production value, though none reach two percent or higher.

**Table 5-2 Control Costs Attributed to Each Chemical Modeled (2021$)**

| Chemical | HON Control Cost (USD/yr) | P&R Control Costs (USD/yr) | Total Control Costs (USD/yr) | Domestic Production Value (USD/yr) | Total Control Cost % of Domestic Value |
|---|---|---|---|---|---|
| Acrylonitrile | 13,370,931 | 886,272 | 14,257,202 | 880,400,521 | 1.619% |
| Acetone | 4,816,333 | 1,965,581 | 6,781,915 | 2,779,501,547 | 0.244% |
| Butadiene | 4,921,906 | 3,895,051 | 8,816,958 | 1,483,128,462 | 0.594% |
| Ethylene dichloride | 8,684,650 | 0 | 8,684,650 | 7,022,564,654 | 0.124% |
| Ethylene glycol | 22,905,950 | 0 | 22,905,950 | 1,633,103,944 | 1.403% |
| Ethylene oxide | 6,441,600 | 0 | 36,441,600 | 3,559,565,671 | 1.024% |
| Styrene | 11,487,402 | 4,794,858 | 16,282,260 | 6,722,358,387 | 0.242% |
| **All 255 facilities** | **163,572,000** | **16,514,700** | **180,086,700** | | |

#### *5.3.3.1 Synthetic Organic Chemicals Manufacturing Industries (SOCMI) Model*

For the analysis, the EPA developed a simplified partial equilibrium model that can be calibrated to the benchmark data above. The model represents elastic domestic and foreign production and consumption (four elasticities) and a domestic consumer foreign-domestic substitution elasticity (one elasticity). Elasticity estimates are scarce for the specific chemicals. We identified several key elasticity values to populate our five elasticity parameters. For supply elasticities, we used a value of 0.54 from Chambers and Lichtenberg (1994) econometric estimation of long-run fertilizer supply for all chemicals except acetone. For acetone, we used a supply elasticity value of 0 because it is a byproduct of the production of phenol, a much higher value product.

For demand elasticities, we used values associated with a predominant end use industry for the product, if possible. For styrene, butadiene, ethylene glycol, ethylene dichloride, and ethylene oxide, we used a value of −0.38 from Trangadisaikul’s (2011) econometric estimation of global tire demand, a proxy market for rubber production.

Ethylene oxide is most commonly used for sterilizing medical equipment, and ethylene glycol and ethylene dichloride are more commonly used in plastic production, but demand elasticity data for those markets were not found in our research, so we used the secondary market of a rubber production input. For acrylonitrile and acetone, we used a value of −1.04 from Martinez’s (2012) estimation of demand elasticity for human-made fabrics in the textile industry because textile fiber production is a common use for those two chemicals. Last, we took a foreign-domestic consumer demand substitution elasticity estimate of −2.4 from Ahmad and Riker (2019) in order to account for substitution in consumer demand between domestic and foreign production of these chemicals. Our current estimates are summarized in Table 5-3.

**Table 5-3 Elasticity Parameter Values and Sources**

| Elasticity | Symbol | Value | Source |
|---|---|---|---|
| Supply [domestic ($y$), imports ($m$)] | $\sigma_y = \sigma_m$ | 0.54 | Chambers and Lichtenberg (1994) |
| Demand [domestic ($d$), foreign ($f$)] | $\sigma_{dD} = \sigma_{fD}$ | -0.38 | Trangadisaikul’s (2011) |
| | $\sigma_{dD} = \sigma_{fD}$ | -1.04 | Martinez (2012) |
| Consumer substitution | $\sigma_{df}$ | -2.4 | Ahmad and Riker (2019) |

The model is a modified version of that specified in Riker and Schreiber (Riker, 2019) in combination with the calibrated share form of the constant elasticity of substitution (CES) function detailed in Rutherford (2002). However, the original distinction between different import sources is removed since our model is only intended to cover domestic compliance cost shocks. Elastic domestic and foreign production is specified as:

$$Y = \bar{Y}\left(\frac{P_y}{\bar{P}_y}\right)^{\sigma_y} \tag{1}$$

$$M = \bar{M}\left(\frac{P_m}{\bar{P}_m}\right)^{\sigma_m} \tag{2}$$

where $Y$ is the value of domestic production, $M$ is the value of imports, $P$ is the corresponding price, and bars ( $\bar{}$ ) denote the benchmark value of a variable. Domestic and foreign demand are specified similarly to production as:

$$D = \bar{D}\left(\frac{P_c}{\bar{P}_c}\right)^{\sigma_{dD}} \tag{3}$$

$$X = \bar{X}\left(\frac{P_y}{\bar{P}_y}\right)^{\sigma_{fD}} \tag{4}$$

where $D$ is total domestic demand and $X$ is total export demand. We specified total domestic consumption as an aggregate of domestic- and foreign-produced goods using the calibrated share

$$dD = \theta \mathrm{D} \left( \frac{P_c}{\mathrm{p_y}} \right)^{\sigma_C} \tag{5}$$

$$fD = (1 - \theta) \mathrm{D} \left( \frac{P_c}{\mathrm{p_m}} \right)^{\sigma_C} \tag{6}$$

form of the CES function as:

where $dD$ is domestic consumer demand for domestic goods, and $fD$ is domestic consumer demand for foreign goods, and:

$$\theta = \frac{\mathrm{p_y}\, \overline{dD}}{\mathrm{p_y}\, \bar{D} + \ \mathrm{p_m}\, \overline{fD}} \tag{7}$$

$$p_c = \bar{p}_c \left( \theta \left( \frac{p_y}{\bar{p}_y} \right)^{(1-\sigma_C)} + (1 - \theta) \left( \frac{p_m}{\bar{p}_m} \right)^{(1-\sigma_C)} \right)^{\frac{1}{1-\sigma_C}} \tag{8}$$

The final conditions for the model require market clearance (*i.e.*, that supply equal demand in the domestic and foreign markets for the chemical). We specified this requirement as:

$$0 = \mathrm{Y} - \mathrm{X} - \mathrm{dD} \tag{9}$$

$$0 = M - fD \tag{10}$$

These nine equations (excluding the $\theta$ parameter definition in equation 9) form the basis of our model with the six quantity $(Y, M, D, X, dD, fD)$ and three price $(p_y, p_m, p_c)$ variables, which makes a square system of equations that we can implement in a constrained nonlinear system (CNS) mathematical program in the GAMS software language using a constrained optimization solver.

*5.3.3.2 SOCMI Model Simulations and Results*

For each of the seven chemicals in this analysis, we implemented five counterfactual shocks to the model to simulate new market outcomes. To implement counterfactual cases including increased production costs from regulatory compliance or inflation, we included cost shock parameters in equations (11) and (12) as follows:

$$Y = \ \bar{Y} \left( \frac{P_y}{(1 + c_y)\bar{P}_y} \right)^{\sigma_y} \tag{11}$$

$$M = \bar{M}\left(\frac{P_m}{(1+c_f)\bar{P}_m}\right)^{\sigma_m} \tag{12}$$

where the cost parameters, $c_y$ and $c_f$, are expressed in percentage terms and, when positive, reduce the effective prices received by suppliers.

Our analysis of the economic impact of costs includes three scenarios:

1) compliance costs due to the HON rule,
2) the compliance costs due to the two P&R rules,
3) the total compliance costs due to the three rules.

We also modeled two foreign market inflation scenarios to investigate the impact/interactions of an increased price of natural gas in foreign producing countries:

1) inflation caused by rises in foreign natural gas (NG) prices only—primarily energy inputs. This is referred to as foreign low inflation (INF_LO).

2) inflation caused by rises in foreign NG and natural gas liquid (NGL) prices associated with the product inputs. This is referred to as foreign inflation high (INF_HI).

*Note: We assumed foreign gas prices do not affect domestic production costs.*

For the inflation caused by NG and NGL price increases, we applied the average annual spot price increase in German NG prices from 2018 to 2021 ($8.57/mmBtu and $15.91 /mmBtu, respectively[39]) to the price increases due to NG and NGL price changes from the ACS study on the impact of NG and NGL prices on the U.S. chemical manufacturing industry (DeRosa, 2015). The chemicals with benzene as a feedstock—butadiene, styrene, and acetone—do not have any production cost increase associated with increased NG or NGL prices because benzene is a production by-product of other higher value products and does not have a cost change due to NG or NGL prices.

For each of the seven chemicals, we ran a business-as-usual (BAU) benchmark replication (*i.e.*, essentially a baseline model run) and the following five model runs:

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[39] https://ycharts.com/indicators/germany_natural_gas_border_price

- BAU: $c_y = 0\%$ and $c_f = 0\%$ (no compliance costs and no foreign inflation)
- HON: $c_{y1} =$ HON compliance costs only
- PR: $c_{y2} =$ P&R compliance costs only
- CC TOT : $c_{y1} + c_{y2} =$ HON and P&R total compliance.
- INF: $c_f =$ Foreign inflation costs only (no compliance costs)
- CC+INF: $c_{y1} + c_{y2} + c_f =$ HON and P&R compliance costs and foreign inflation costs

Model results for each of the seven chemicals included in the analysis are presented in Tables 5-4 through Table 5-10. The simulated market impacts from the 35 model runs using compliance costs as an input are consistent with our expectations in that compliance costs result in higher market prices and lower output and foreign inflation leads to domestic output percentage increases and dampens the impact of the regulation's compliance costs.

- Butadiene shows modest impacts of domestic production, decreasing about 0.20 percent. Because butadiene is a benzene by-product, there is no impact on foreign production costs due to NG or NGL price changes.
- Styrene and ethylene dichloride see the smallest impacts on domestic production, decreasing less than 0.05 percent.
- Acrylonitrile sees the largest output drop in response to compliance costs (0.57 percent) because of its smaller market size and relatively higher P&R compliance costs. Acrylonitrile also sees a high percentage drop in imports from higher foreign NG prices because of its high sensitivity to NGL prices.
- Acetone is the only product that does not see (at our significance level) a drop in production or an increase in price due to the compliance costs because of its very low relative compliance cost increase (only 0.17 percent of production costs).
- Ethylene glycol has a production decrease of about 0.5 percent with compliance costs. However, it sees a net increase in production of about 0.25 percent with the foreign NG prices increase.

- Ethylene oxide faces the highest compliance costs for chemical products affected by this final action due to the expected use of large add-on control technologies such as thermal oxidizers for compliance with the HON and P&R I requirements. It only sees a modest decrease in domestic production, however, because of its large domestic market and very low imports. There have been almost no ethylene oxide imports to the United States in the past 5 years.

**Table 5-4 Butadiene Results**

| | **BAU** | **HON** | **PR** | **CC_TOT** | **INF** | **CC+INF** |
|---|---|---|---|---|---|---|
| **Quantities** | | | | | | |
| Output | 1,218 | 1,217 | 1,217 | 1,216 | 1,218 | 1,216 |
| | | −0.11% | −0.09% | −0.20% | 0.00% | −0.20% |
| Exports | 46 | 46 | 46 | 46 | 46 | 46 |
| | | −0.05% | −0.04% | −0.08% | 0.00% | −0.08% |
| Imports | 391 | 392 | 392 | 392 | 391 | 392 |
| | | 0.12% | 0.09% | 0.21% | 0.00% | 0.21% |
| Demand | 1,563 | 1,563 | 1,563 | 1,562 | 1,563 | 1,562 |
| | | −0.06% | −0.04% | −0.10% | 0.00% | −0.10% |
| **Prices ($000/tonne)** | | | | | | |
| Domestic | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 |
| | | 0.16% | 0.08% | 0.25% | 0.00% | 0.25% |
| Consumption | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 | 1.22 |
| | | 0.16% | 0.08% | 0.25% | 0.00% | 0.25% |
| Import | 1.22 | 1.22 | 1.22 | 1.23 | 1.22 | 1.23 |
| | | 0.25% | 0.16% | 0.41% | 0.00% | 0.41% |

**Table 5-5 Styrene Simulation Results**

| | **BAU** | **HON** | **PR** | **CC_TOT** | **INF** | **CC+INF** |
|---|---|---|---|---|---|---|
| **Quantities** | | | | | | |
| Output | 3,659 | 3,658 | 3,659 | 3,657 | 3,659 | 3,657 |
| | | −0.04% | −0.02% | −0.06% | 0.00% | −0.06% |
| Exports | 1,100 | 1,099 | 1,100 | 1,099 | 1,100 | 1,099 |
| | | −0.04% | −0.01% | −0.05% | 0.00% | −0.05% |
| Imports | 212 | 212 | 212 | 212 | 212 | 212 |
| | | 0.08% | 0.03% | 0.11% | 0.00% | 0.11% |
| Demand | 2,771 | 2,770 | 2,771 | 2,770 | 2,771 | 2,770 |
| | | −0.04% | −0.02% | −0.05% | 0.00% | −0.05% |
| **Prices ($000/tonne)** | | | | | | |
| Domestic | 1.84 | 1.84 | 1.84 | 1.84 | 1.84 | 1.84 |
| | | 0.11% | 0.05% | 0.11% | 0.00% | 0.11% |
| Consumption | 1.84 | 1.84 | 1.84 | 1.84 | 1.84 | 1.84 |
| | | 0.11% | 0.05% | 0.11% | 0.00% | 0.11% |
| Import | 1.84 | 1.84 | 1.84 | 1.85 | 1.84 | 1.85 |
| | | 0.16% | 0.05% | 0.22% | 0.00% | 0.22% |

**Table 5-6 Acrylonitrile Simulation Results**

| | BAU | HON | PR | CC_TOT | INF | CC+INF |
|---|---|---|---|---|---|---|
| **Quantities** | | | | | | |
| Output | 848 | 844 | 848 | 844 | 850 | 845 |
| | | −0.54% | −0.04% | −0.57% | 0.18% | −0.39% |
| Exports | 529 | 527 | 529 | 526 | 528 | 525 |
| | | −0.52% | −0.03% | −0.55% | −0.34% | −0.90% |
| Imports | 9 | 9 | 9 | 9 | 6 | 6 |
| | | 0.52% | 0.03% | 0.57% | −38.34% | −38.00% |
| Demand | 328 | 326 | 328 | 326 | 328 | 326 |
| | | −0.53% | −0.04% | −0.57% | 0.07% | −0.50% |
| **Prices ($000/tonne)** | | | | | | |
| Domestic | 1.04 | 1.05 | 1.04 | 1.05 | 1.04 | 1.05 |
| | | 0.48% | 0.00% | 0.58% | 0.29% | 0.87% |
| Consumption | 1.04 | 1.05 | 1.04 | 1.05 | 1.04 | 1.05 |
| | | 0.48% | 0.00% | 0.58% | −0.10% | 0.48% |
| Import | 1.04 | 1.05 | 1.04 | 1.05 | 0.85 | 0.86 |
| | | 0.96% | 0.10% | 1.06% | −18.37% | −17.50% |

**Table 5-7 Acetone Simulation Results**

| | BAU | HON | PR | CC_TOT | CC+INF_LO | CC+INF_HI |
|---|---|---|---|---|---|---|
| **Quantities** | | | | | | |
| Output | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 |
| | | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Exports | 42 | 42 | 42 | 42 | 42 | 42 |
| | | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Imports | 84 | 84 | 84 | 84 | 84 | 84 |
| | | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Demand | 1,557 | 1,557 | 1,557 | 1,557 | 1,557 | 1,557 |
| | | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| **Prices ($000/tonne)** | | | | | | |
| Domestic | 1.84 | 1.84 | 1.84 | 1.84 | 1.84 | 1.84 |
| | | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Consumption | 1.84 | 1.84 | 1.84 | 1.84 | 1.84 | 1.84 |
| | | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Import | 1.84 | 1.84 | 1.84 | 1.84 | 1.84 | 1.84 |
| | | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

## Table 5-8 Ethylene Dichloride Simulation Results

| | BAU | HON | PR | CC_TOT | INF | CC+INF |
|---|---|---|---|---|---|---|
| **Quantities** | | | | | | |
| Output | 9,731 | 9,729 | 9,731 | 9,729 | 9,731 | 9,729 |
| | | −0.03% | 0.00% | −0.03% | 0.00% | −0.03% |
| Exports | 727 | 727 | 727 | 727 | 727 | 727 |
| | | −0.03% | 0.00% | −0.03% | 0.00% | −0.03% |
| Imports | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 0.21% | 0.00% | 0.21% | −8.00% | −8.00% |
| Demand | 9,004 | 9,002 | 9,004 | 9,002 | 9,004 | 9,002 |
| | | −0.03% | 0.00% | −0.03% | 0.00% | −0.03% |
| **Prices ($000/tonne)** | | | | | | |
| Domestic | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 |
| | | 0.14% | 0.00% | 0.14% | 0.00% | 0.14% |
| Consumption | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 |
| | | 0.14% | 0.00% | 0.14% | 0.00% | 0.14% |
| Import | 0.72 | 0.72 | 0.72 | 0.72 | 0.70 | 0.70 |
| | | 0.14% | 0.00% | 0.14% | −3.46% | −3.32% |

## Table 5-9 Ethylene Glycol Simulation Results

| | BAU | HON | PR | CC_TOT | INF | CC+INF |
|---|---|---|---|---|---|---|
| **Quantities** | | | | | | |
| Output | 1,578 | 1,571 | 1,578 | 1,571 | 1,589 | 1,582 |
| | | −0.43% | 0.00% | −0.43% | 0.67% | 0.26% |
| Exports | 1,269 | 1,266 | 1,269 | 1,266 | 1,263 | 1,260 |
| | | −0.23% | 0.00% | −0.23% | −0.47% | −0.71% |
| Imports | 237 | 239 | 237 | 239 | 222 | 223 |
| | | 0.79% | 0.00% | 0.79% | −6.44% | −5.73% |
| Demand | 546 | 544 | 546 | 544 | 548 | 546 |
| | | −0.37% | 0.00% | −0.37% | 0.31% | -0.05% |
| **Prices ($000/tonne)** | | | | | | |
| Domestic | 1.04 | 1.04 | 1.04 | 1.04 | 1.05 | 1.06 |
| | | 0.58% | 0.00% | 0.58% | 1.25% | 1.93% |
| Consumption | 1.04 | 1.05 | 1.04 | 1.05 | 1.03 | 1.04 |
| | | 0.96% | 0.00% | 0.96% | -0.77% | 0.10% |
| Import | 1.04 | 1.05 | 1.04 | 1.05 | 1.00 | 1.01 |
| | | 1.45% | 0.00% | 1.45% | −3.66% | −2.31% |

Table 5-10 Ethylene Oxide Simulation Results

| | BAU | HON | PR | CC_TOT | INF | CC+INF |
|---|---|---|---|---|---|---|
| **Quantities** | | | | | | |
| Output | 2,400 | 2,395 | 2,400 | 2,395 | 2,400 | 2,395 |
| | | −0.23% | 0.00% | −0.23% | 0.00% | −0.23% |
| Exports | 1 | 1 | 1 | 1 | 1 | 1 |
| | | −0.22% | 0.00% | −0.22% | 0.00% | −0.22% |
| Imports | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Demand | 2,399 | 2,394 | 2,399 | 2,394 | 2,399 | 2,394 |
| | | −0.23% | 0.00% | −0.23% | 0.00% | −0.23% |
| **Prices ($000/tonne)** | | | | | | |
| Domestic | 1.49 | 1.50 | 1.49 | 1.50 | 1.49 | 1.50 |
| | | 0.61% | 0.00% | 0.61% | 0.00% | 0.61% |
| Consumption | 1.49 | 1.50 | 1.49 | 1.50 | 1.49 | 1.50 |
| | | 0.61% | 0.00% | 0.61% | 0.00% | 0.61% |
| Import | 1.49 | 1.50 | 1.49 | 1.50 | 1.46 | 1.47 |
| | | 0.94% | 0.00% | 0.94% | −1.75% | −0.87% |

## 5.4 Small Business Impacts Analysis

For the final rule, the EPA performed a small entity screening analysis for impacts on all affected facilities by comparing compliance costs to historic revenues at the ultimate parent company level. This is known as the cost-to-revenue or cost-to-sales test, or the “sales test.” The sales test is an impact methodology the EPA employs in analyzing entity impacts as opposed to a “profits test,” in which annualized compliance costs are calculated as a share of profits. The sales test is frequently used because revenues or sales data are commonly available for entities impacted by the EPA regulations, and profits data normally made available are often not the true profit earned by firms because of accounting and tax considerations. Also, the use of a sales test for estimating small business impacts for a rulemaking is consistent with guidance offered by the EPA on compliance with the Regulatory Flexibility Act (RFA)[40] and is consistent with guidance published by the U.S. Small Business Administration’s (SBA) Office of Advocacy that suggests that cost as a percentage of total revenues is a metric for evaluating cost increases on small entities in relation to increases on large entities (SBA, 2017).

For purposes of assessing the impacts of this action on small entities, a small entity is defined as: (1) a small business as defined by the Small Business Administration’s (SBA)

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[40] The RFA compliance guidance to the EPA rule writers can be found at <https://www.epa.gov/sites/production/files/2015-06/documents/guidance-regflexact.pdf >

regulations at 13 CFR 121.201; (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise that is independently owned and operated and is not dominant in its field. Businesses in the Gasoline Distribution source category predominately have NAICS codes 325199 (All Other Basic Organic Chemical Manufacturing). For the SBA small business size standard definition for each NAICS classification, see below in Table 5-11.

**Table 5-11 SBA Size Standards by NAICS Code**

| NAICS Codes | NAICS U.S. Industry Title | Size Standards (million$ of annual sales/revenues) | Size Standards (Number of employees) |
|---|---|---|---|
| 325110 | Petrochemical Manufacturing | | 1,300 |
| 325120 | Industrial Gas Manufacturing | | 1,200 |
| 325130 | Synthetic Dye and Pigment Manufacturing | | 1,050 |
| 325180 | Other Basic Inorganic Chemical Manufacturing | | 1,000 |
| 325194 | Cyclic Crude, Intermediate, and Gum and Wood Chemical Manufacturing | | 1,250 |
| 325199 | All Other Basic Organic Chemical Manufacturing | | 1,250 |
| 325211 | Plastics Material and Resin Manufacturing | | 1,250 |
| 325212 | Synthetic Rubber Manufacturing | | 1,000 |
| 325220 | Artificial and Synthetic Fibers and Filaments Manufacturing | | 1,050 |
| 325311 | Nitrogenous Fertilizer Manufacturing | | 1,050 |
| 325320 | Pesticide and Other Agricultural Chemical Manufacturing | | 1,150 |
| 325412 | Pharmaceutical Preparation Manufacturing | | 1,300 |
| 325620 | Toilet Preparation Manufacturing | | 1,250 |
| 325920 | Explosives Manufacturing | | 750 |
| 325998 | All Other Miscellaneous Chemical Product and Preparation Manufacturing | | 650 |

The EPA constructed a facility list for the HON and P&R Group I and II source categories. For information on how this list was constructed, see Section 2. The initial facility lists consisted of 207 HON facilities, 19 P&R I facilities (and ten of the P&R I facilities are collocated with HON processes), and five P&R II facilities (and three of the P&R II facilities are collocated with HON processes). However, revised counts of active and unique facilities reduced the size of these lists. The EPA identified the ultimate parent company along with revenue and employment information for facilities using D&B Hoover's database. In total, the EPA identified 98 ultimate parent companies as owners of the 214 facilities, of which ten of these ultimate parent companies were identified as small entities (counts of parent companies do not sum over rules due to some companies owning facilities subject to multiple rules). These companies, including the small entities, operate in the SOCMI industry, which is marginally competitive as a whole as mentioned in Chapter 2 of this RIA. Summary statistics for these ultimate parent companies are in Table 5-12 below.

**Table 5-12 Summary Statistics of Potentially Affected Entities**

| Rule | Size | No. of Ultimate Parent Companies | Number of Facilities | Mean Revenue (million 2021$) | Median Revenue (million 2021$) |
|---|---|---|---|---|---|
| HON | Small | 8 | 9 | 299 | 97.3 |
| | Not Small | 88 | 194 | 22,500 | 4,900 |
| P&R I | Small | 1 | 2 | 290 | 290 |
| | Not Small | 11 | 16 | 40,900 | 8,940 |
| P&R II | Small | 0 | 0 | - | - |
| | Not Small | 4 | 5 | 78,900 | 22,900 |
| **Rules Combined** | Small | 9 | 10 | 273 | 62.2 |
| | Not Small | 89 | 204 | 22,500 | 4,970 |

Note: Some facilities are affected by more than one rule and therefore, to avoid double counting, “Rules Combined” will not equal the sum of facilities noted in individual rules.

## 5.5 Screening Analysis

Using the facility list discussed in the above section, the EPA conducted cost-to-sales analysis for the final action to screen small entities for potentially significant impacts. We present results specifically for each of the HON, P&R I and P&R II rules, and a total estimate for all of these three final rules. We are unable to provide an estimate of small entity impacts for the NSPS in this final action due to an inability to link impacts to specific known facilities and ultimate parent owners. While a sales test can provide some insight as to the economic impact of an action such as this one, it assumes that the impacts of a rule are solely incident on a directly affected firm (therefore, no impact to consumers of the affected product), or solely incident on consumers of output directly affected by this action (therefore, no impact to companies that are producers of the affected product). Thus, an analysis such as this one is best viewed as providing insight on the polar opposites of economic impacts: maximum impact to either directly affected companies with no impact on their consumers, or vice versa. A sales test analysis does not consider shifts in supply and demand curves to reflect intermediate economic outcomes. For a partial equilibrium analysis of the economic impacts of this action that attempts to parse impacts on consumers relative to producers, see section 5.2.

The results of this analysis for the final options are presented below. Table 5-13 shows the distribution of average costs for ultimate parent companies by final rule. Tables-5-14 and 5-15 below show the distribution of cost-to-sales ratios (CSRs) by rule and the percentage of CSRs clearing 1 percent and 3 percent for each rule. We present the results both with costs including product recovery and without product recovery. The results are virtually identical regardless of whether or not product recovery is included.

### Table 5-13 Distribution of Estimated Compliance Costs by Rule and Size for Final Action ($2021)[a]

| Rule | Size | No. of Firms | Average Cost with Product Recovery | Average Cost without Product Recovery |
|---|---|---|---|---|
| HON | Small | 8 | 309,000 | 313,000 |
| | Not Small | 88 | 852,000 | 857,000 |
| P&R I | Small | 1 | 43,900 | 43,900 |
| | Not Small | 11 | 944,000 | 946,000 |
| P&R II | Small | 0 | - | - |
| | Not Small | 4 | 333,000 | 333,000 |
| **Rules Combined** | Small | 9 | 291,000 | 295,000 |
| | Not Small | 89 | 893,000 | 897,000 |

[a] There are some firms, including one small firm, that are impacted by more than one final rule. This explains why the totals of combined impacted firms are less than the straight summation across the final rules.

### Table 5-14 Compliance Cost-to-Sales Ratio Distributions for Small Entities, Final Action

| Rule | | | With Product Recovery Included | | Without Product Recovery Included | |
|---|---|---|---|---|---|---|
| | | | Mean CSR | Maximum CSR | Mean CSR | Maximum CSR |
| HON | No. of Small Entities | 8 | 0.516% | 1.26% | 0.554% | 1.40% |
| P&R I | | 1 | 0.030% | 0.030% | 0.030% | 0.030% |
| P&R II | | 0 | - | - | - | - |
| All | No. of Small Entities | 9 | 0.469% | 1.26% | 0.504% | 1.40% |

[a] There is one small firm that is impacted by more than one final rule. This explains why the totals of combined impacted firms are less than the straight summation across the final rules.

**Table 5-15 Number and Extent of Impacts for Small Entities – Final Action[a]**

| Rule | | With Product Recovery Included | | Without Product Recovery Included | |
|---|---|---|---|---|---|
| | | No. of Small Entities | % of Small Entities | No. of Small Entities | % of Small Entities |
| HON | No. of Small Entities | 8 | 100% | 8 | 100% |
| | Greater than 1% | 2 | 25% | 2 | 25% |
| | Greater than 3% | 0 | 0.0% | 0 | 0.0% |
| P&R I | No. of Small Entities | 1 | 100% | 1 | 100% |
| | Greater than 1% | 0 | 0.0% | 0 | 0.0% |
| | Greater than 3% | 0 | 0.0% | 0 | 0.0% |
| P&R II | No. of Small Entities | 0 | - | 0 | - |
| | Greater than 1% | - | - | - | - |
| | Greater than 3% | - | - | - | - |
| All | No. of Small Entities | 9 | 100% | 9 | 100% |
| | Greater than 1% | 2 | 22% | 2 | 22% |
| | Greater than 3% | 0 | 0.0% | 0 | 0.0% |

[a] There is one small firm, that is impacted by more than one final rule. This explains why the totals of combined impacted firms are less than the straight summation across the final rules.

Given the relatively low average CSR for small entities (both with and without product recovery), as well as there being only two small entities with a CSR of at least one percent and no small entities with a CSR of at least three percent for the final HON amendments, we conclude that it is unlikely that the changes to the HON would have a significant impact on a substantial number of small entities (SISNOSE), and therefore we certify that there is no SISNOSE for this final rule. Given that there are no small entities with a CSR of at least one percent for either the P&R I or P&R II NESHAP, we conclude that we can certify no SISNOSE for either of these final rules.

## 5.6 Employment Impact Analysis

This section presents a qualitative overview of the various ways that environmental regulation can affect employment. Employment impacts of environmental regulations are generally composed of a mix of potential declines and gains in different areas of the economy over time. Regulatory employment impacts can vary across occupations, regions, and industries; by labor and product demand and supply elasticities; and in response to other labor market conditions. Isolating such impacts is a challenge, as they are difficult to disentangle from employment impacts caused by a wide variety of ongoing, concurrent economic changes. The EPA continues to explore the relevant theoretical and empirical literature and to seek public comments in order to ensure that the way the EPA characterizes the employment effects of its regulations is reasonable and informative.[41]

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 including macroeconomic phenomena such as the Covid 19 pandemic or general inflation.

In the long run, environmental regulation "typically affects the distribution of employment among industries rather than 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 (Walker 2013). The consequences of transitional job losses may be particularly important for workers who might not readily find alternative work. This might include workers with skills that do not transfer easily to other workplaces, or who operate in declining industries or occupations, have limited capacity to migrate, or reside in communities or regions with high unemployment rates.

This section discusses the anticipated employment impacts of the final rule, focusing on the impact of the SOCMI requirements. To the extent possible, it describes the baseline characteristics of affected labor markets in regulated industries, including trends in employment numbers and labor intensities. It also describes the rule's potential incremental impacts on employment in those same industries. As previously mentioned, nearly all synthetic organic chemicals are contained within the single 6-digit North American Industry Classification System (NAICS) code "All other basic organic chemical manufacturing" (NAICS 325199). Table 5-16 summarizes baseline employment characteristics in All other basic organic chemical

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

manufacturing (NAICS 325199) and in its 4-digit NAICS parent, the Basic chemical manufacturing industry (NAICS 3251) using data from the Bureau of Labor Statistics (BLS) and the U.S. Census' Annual Survey of Manufactures (ASM). Table 5-16 shows that across occupations, average wages in the Basic chemical manufacturing industry and in All other basic organic chemical manufacturing are high, and employment has been increasing since 2017, particularly in NAICS 325199. According to the ASM, the ratio of employees to the value of output in the Basic chemical manufacturing was just 0.576 employees per million dollars of output in 2021 (the most recent year of data available from the ASM), while the ratio of employees to value of output in NAICS 325199 was 0.771 per million dollars of output.

**Table 5-16 Chemical Sector Employment Information**

| Industry | NAICS | Employment in 2022 (1000s) | 5-Year Change in Employment (percent) | Avg. Annual Wage in 2022 (1000s) | Employment/Output in 2021 |
|---|---|---|---|---|---|
| Basic chemical manufacturing | 3251 | 151.4 | 1.65 | 117 | 0.576 |
| All other basic organic chemical manufacturing | 325199 | 41.8 | 10.33 | 107.7 | 0.771 |

Notes: NAICS is North American Industry Classification System. The data source for all columns except the final column is the Bureau of Labor Statistics Quarterly Census of Earnings and Wages (BLS QCEW), downloaded from https://www.bls.gov/cew/downloadable-data-files.htm. The data source for the final column is the U.S. Census Annual Survey of Manufactures, downloaded from the FTP site at https://www2.census.gov/programs-surveys/asm/data.

The figures in Table 5-16 can be combined with EPA's economic impact analysis in Section 5.2 to better understand the potential employment impacts of the rule. Table 5-1 displays the estimated annual value of output for seven of the largest SOCMI sectors, which totaled over $24 billion in 2021. To estimate total employment in these sectors, we multiply this total value by the employment-to-output ratio of 0.771 in Table 5-16, effectively assuming that SOCMI production has the same average employment intensity as the other basic organic chemical manufacturing industry more broadly. This results in an estimate of approximately 18,566 individuals employed in the SOCMI sectors analyzed in Section 5.2, or about 44% of employment in NAICS industry 325199. EPA's economic impact analysis also estimated percentage output and price changes for each SOCMI sector resulting from the combination of

HON and P&R compliance, presented in Table 5-4 through Table 5-10. EPA's modelled changes in output and prices suggest that the total value of production across all sectors may decline on the order of 1%, which suggests a reduction of approximately 186 employees across seven of the largest SOCMI sectors, as modelled.

It is important to caveat that the estimates presented above are unable to capture certain aspects of firm responses to the final rule. By applying a baseline average employment-to-production intensity, the analysis implicitly holds production technologies fixed even as output changes in the regulated industry. It also doesn't account for heterogeneity among regulated firms, which may lead individual firms to respond in a variety of ways to the control requirements. Lastly, the control costs presented in Table 5-2 may require increased labor (suggesting further incremental employment gains) or may result in a shift toward more capital-intensive production processes (suggesting potential incremental employment losses).

EPA also acknowledges that employment impacts, both positive and negative, are possible in indirectly affected sectors upstream and downstream from the regulated sector, or in sectors producing substitute or complementary products. This might include gains at upstream facilities that manufacture the equipment necessary for pollution control or conversions to alternative technologies, as well as losses in employment in oil and gas production due to reduced demand from SOCMI producers. Similarly, output price increases may lead to downstream adjustments in employment levels by plastics manufacturers or other industries that demand SOCs. Finally, EPA acknowledges that to the extent domestic SOC production is displaced by imports, this may result in some net employment loss in the short run (incorporated in the calculations above), as well as some potential shifts in domestic employment over the longer run.

# 6 COMPARISON OF COSTS AND BENEFITS

In this chapter, we present a comparison of the benefits and costs of this final action. We present benefits and costs for each final rule and their more and less stringent alternatives. We group the impacts of the IIIa, NNNa, and RRRa NSPS together for presentational clarity and consistency with the presentation of impacts for these three NSPS in the preamble and the remainder of the materials for this final action. As explained in the previous chapters, all costs and benefits outlined in this RIA are estimated as the change from the baseline, which reflects the current business practice for the affected sources as mentioned in Chapter 1, particularly with regard to emissions from flares. As stated earlier in this RIA, there is no monetized estimate of the benefits for the HAP emission reductions expected to occur as a result of this final action. We do present monetized estimates for other impacts of this action, such as benefits from both short- and long-term reduced exposure to ozone caused by VOC emissions reductions and benefits from decreases in $CH_4$ emissions and disbenefits from increases in $CO_2$, $N_2O$, and NOx emissions.

## 6.1 Results

As part of fulfilling analytical guidance with respect to E.O. 12866, EPA presents estimates of the present value (PV) of the benefits and costs over the period 2024 to 2038. To calculate the PV of the social net benefits of the final action, annual benefits and costs are in 2021 dollars and are discounted to 2023 at 3 percent and 7 percent discount rates as directed by OMB's Circular A-4.[42,43] The EPA also presents the equivalent annualized value (EAV), which represents a flow of constant annual values that would yield a sum equivalent to the PV. The EAV represents the value of a typical cost or benefit for each year of the analysis, consistent with the estimate of the PV, in contrast to year-specific estimates.

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[42] We note that this RIA uses the guidance in the previous Circular A-4 version that was issued on September 17, 2003. The effective date for the new, revised Circular A-4 version issued in November 2023 is at a date after the completion of this final rule RIA; hence, guidance in the previous Circular A-4 version is used in this RIA.

[43] The climate benefits and disbenefits from methane emission reductions and $CO_2$ and $N_2O$ emission increases are estimated at a 2 percent discount rate, reflecting the use of the updated SCC, and these estimates are included in the estimates of total and net benefits for this final action. Explanation of the use of a 2 percent discount rate for climate benefits and disbenefits is found in Chapter 4 of this RIA.

The presentation of impacts in this chapter includes those for more and less stringent options to those for the final as a whole (that is, across all final rules). The more stringent option is the same as the final rules except that tighter controls for HON process vents and storage vessels, and also such controls on P&R I process vents (or PV, when discussing types of affected sources) and storage vessels (SV), are included. The tighter process vent controls in the more stringent option are defined as option PV2 in Table 3-12 of this RIA, and the tighter storage vessels controls are defined as option SV3 in Table 3-8 of this RIA. The less stringent option is the same as the final except that weaker controls for storage vessels defined as option SV1 in Table 3-8 of this RIA are included. The less stringent option does not include any other differences in options and thus no change in costs and impacts between the proposal and the final. Thus, the differences in stringency for analyses in the RIA reflect different stringencies primarily in the final HON options as described in Chapter 3. Since the differences in stringency occur only for options considered under the final HON amendments, we present impacts below for the final HON, P&R I, and cumulative. More and less stringent options were not available for the other final rules.

Tables 6-1 through 6-3 presents a summary of the monetized benefits, compliance costs, and net benefits (including climate disbenefits) of the HON, P&R I, and cumulatively, and the more and less stringent alternatives in terms of present value (PV) and equivalent annualized value (EAV). Tables presenting benefits list both figures, with short-term benefits listed first.

**Table 6-1 Summary of Monetized Benefits, Compliance Costs, and Net Benefits PV/EAV for HON, 2024-2038 (million 2021$, discounted to 2023)**

| | **Final** | | **Less Stringent Alternative** | | **More Stringent Alternative** | |
|---|---|---|---|---|---|---|
| **3%** | **PV** | **EAV** | **PV** | **EAV** | **PV** | **EAV** |
| Monetized Health Benefits | 70 and 630 | 5.9 and 53 | 70 and 630 | 5.9 and 52 | 71 and 640 | 6 and 54 |
| Climate Disbenefits (2%) | 140 | 11 | 140 | 11 | 140 | 11 |
| Net Compliance Costs | 1,550 | 130 | 1,500 | 130 | 1,600 | 140 |
| Compliance Costs | 1,560 | 130 | 1,500 | 130 | 1,600 | 140 |
| Value of Product Recovery | 12 | 1 | 12 | 1 | 12 | 1 |
| **Net Benefits** | **(1,600) and (1,100)** | **(140) and (88)** | **(1,600) and (1,000)** | **(140) and (89)** | **(1,700) and (1,100)** | **(150) and (97)** |
| **7%** | **PV** | **EAV** | **PV** | **EAV** | **PV** | **EAV** |
| Monetized Health Benefits | 48 and 420 | 5.2 and 46 | 48 and 420 | 5.2 and 46 | 49 and 430 | 5.3 and 47 |
| Climate Disbenefits (2%) | 140 | 11 | 140 | 11 | 140 | 11 |
| Net Compliance Costs | 1,200 | 130 | 1,200 | 130 | 1,300 | 140 |
| Compliance Costs | 1,200 | 130 | 1,200 | 130 | 1,300 | 140 |
| Value of Product Recovery | 9 | 1 | 9 | 1 | 9 | 1 |
| **Net Benefits** | **(1,300) and (920)** | **(140) and (95)** | **(1,300) and (920)** | **(140) and (95)** | **(1,400) and (1,000)** | **(150) and (100)** |
| Nonmonetized Benefits | 1,107 tons of HAP emission reductions. Health effects from reduced exposure to ethylene oxide, chloroprene, benzene, 1,3-butadiene, vinyl chloride, ethylene dichloride, chlorine, maleicanhydride, and acrolein | | | | | |

Note: Monetized benefits (incorporating disbenefits) include those related to public health and climate. Monetized air quality related health benefits include ozone related health benefits associated with reductions in VOC emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The two benefits estimates are separated by the word “and” to signify that they are two separate estimates. The estimates do not represent lower- and upper-bound estimates. Benefits from HAP reductions and VOC reductions outside of the ozone season remain unmonetized and are thus not reflected in the table. The unmonetized effects also include disbenefits resulting from a secondary increase in CO emissions. Monetized net climate disbenefits are based on reductions in methane emissions and increases in $CO_2$ and $N_2O$ emissions and are calculated using three different estimates of the social cost of each greenhouse gas (SC-GHG) (under 1.5 percent, 2.0 percent, and 2.5 percent near-term Ramsey discount rates). For the presentational purposes of this table, we show the net climate disbenefits associated with the SC-GHG at a 2 percent Ramey discount rate, but climate benefits and disbenefits are presented using the other near-term discount rates in Section 4.7. Net compliance costs are the compliance costs minus the value of product recovery from compliance with the rule. Parentheses around a number denotes that is has a negative value. Rows may not appear to add correctly due to rounding.

**Table 6-2 Summary of Monetized Benefits, Compliance Costs, and Net Benefits PV/EAV for P&R I, 2024-2038 (million 2021$, discounted to 2023)**

| | **Final** | | **Less Stringent Alternative** | | **More Stringent Alternative** | |
|---|---|---|---|---|---|---|
| 3% | **PV** | **EAV** | **PV** | **EAV** | **PV** | **EAV** |
| Health Benefits | (0.2) and (1.7) | (0.02) and (0.1) | (0.5) and (4) | (0.04) and (0.3) | (0.4) and (3) | (0.03) and (0.3) |
| Climate Disbenefits (2%) | 22 | 2 | 22 | 2 | 22 | 2 |
| Net Compliance Costs | 140 | 12 | 140 | 12 | 150 | 12 |
| Compliance Costs | 140 | 12 | 140 | 12 | 150 | 12 |
| Value of Product Recovery | 1 | 0.2 | 1 | 0.2 | 1 | 0.2 |
| **Net Benefits** | **(160) and (160)** | **(14) and (14)** | **(160) and (170)** | **(14) and (14)** | **(170) and (180)** | **(14) and (14)** |
| 7% | PV | EAV | PV | EAV | PV | EAV |
| Health Benefits | (0.2) and (1.5) | (0.02) and (0.2) | (0.2) and (1.5) | (0.02) and (0.2) | (0.3) and (2.4) | (0.03) and (0.3) |
| Climate Disbenefits (2%) | 22 | 2 | 22 | 2 | 22 | 2 |
| Net Compliance Costs | 110 | 12 | 100 | 12 | 110 | 12 |
| Compliance Costs | 110 | 12 | 100 | 12 | 110 | 12 |
| Value of Product Recovery | 1 | 0.1 | 1 | 0.1 | 1 | 0.1 |
| **Net Benefits** | **(130) and (130)** | **(14) and (14)** | **(120) and (120)** | **(14) and (14)** | **(130) and (130)** | **(14) and (14)** |
| Nonmonetized Benefits | 264 tons per year (tpy) of HAP emission reductions, including an approximate 14 tpy reduction in chloroprene emissions | | | | | |

Note: Monetized benefits (incorporating disbenefits) include those related to public health and climate. Monetized air quality related health benefits include ozone related health benefits associated with reductions in VOC emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The two benefits estimates are separated by the word “and” to signify that they are two separate estimates. The estimates do not represent lower- and upper-bound estimates. Benefits from HAP reductions and VOC reductions outside of the ozone season remain unmonetized and are thus not reflected in the table. The unmonetized effects also include disbenefits resulting from a secondary increase in CO emissions. Monetized net climate disbenefits are based on reductions in methane emissions and increases in $CO_2$ and $N_2O$ emissions and are calculated using three different estimates of the social cost of each greenhouse gas (SC-GHG). For the presentational purposes of this table, we show the net climate disbenefits associated with the SC-GHG at a 2 percent Ramsey discount rate, but climate benefits and disbenefits are presented using the other near-term discount rates in Section 4.7. Net compliance costs are the compliance costs minus the value of product recovery from compliance with the rule. Rows may not appear to add correctly due to rounding. A number in parentheses denotes a negative value.

### Table 6-3 Summary of Monetized Benefits, Compliance Costs, and Net Benefits PV/EAV for All Rules, 2024-2038 (million 2021$, discounted to 2023)

| | **Final** | | **Less Stringent Alternative** | | **More Stringent Alternative** | |
|---|---|---|---|---|---|---|
| 3% | **PV** | **EAV** | **PV** | **EAV** | **PV** | **EAV** |
| Health Benefits | 77 and 690 | 6.5 and 58 | 76 and 680 | 6 and 53 | 77 and 690 | 6.1 and 55 |
| Climate Disbenefits (2%) | 160 | 13 | 160 | 13 | 160 | 13 |
| Net Compliance Costs | 1,770 | 150 | 1,770 | 150 | 1,880 | 160 |
| Compliance Costs | 1,790 | 150 | 1,790 | 150 | 1,900 | 160 |
| Value of Product Recovery | 16 | 1.3 | 16 | 1.3 | 16 | 1.3 |
| **Net Benefits** | **(1,900) and (1,200)** | **(160) and (110)** | **(1,900) and (1,300)** | **(160) and (110)** | **(2,000) and (1,400)** | **(170) and (120)** |
| 7% | PV | EAV | PV | EAV | PV | EAV |
| Health Benefits | 53 and 475 | 5.9 and 52 | 52 and 460 | 5.4 and 47 | 53 and 470 | 5.5 and 48 |
| Climate Disbenefits (2%) | 160 | 13 | 160 | 13 | 160 | 13 |
| Net Compliance Costs | 1,370 | 150 | 1,370 | 150 | 1,500 | 160 |
| Compliance Costs | 1,380 | 150 | 1,380 | 150 | *1,500* | *160* |
| Value of Product Recovery | 12 | 1.3 | 12 | 1.3 | 12 | 1.3 |
| **Net Benefits** | **(1,500) and (1,100)** | **(160) and (110)** | **(1,500) and (1,100)** | **(160) and (120)** | **(1,600) and (1,200)** | **(170) and (130)** |
| Nonmonetized Benefits | 6,230 tons/year of HAP emission reductions. Health effects of reduced exposure to ethylene oxide, chloroprene, benzene, 1,3-butadiene, vinyl chloride, ethylene dichloride, chlorine, maleic anhydride and acrolein | | | | | |

Note: Monetized benefits (incorporating disbenefits) include those related to public health and climate. Monetized air quality related health benefits include ozone related health benefits associated with reductions in VOC emissions. The health benefits are associated with several point estimates and are presented at real discount rates of 3 and 7 percent. The two benefits estimates are separated by the word “and” to signify that they are two separate estimates. The estimates do not represent lower- and upper-bound estimates. Benefits from HAP reductions and VOC reductions outside of the ozone season remain unmonetized. The unmonetized effects also include disbenefits resulting from a secondary increase in CO emissions. Monetized net climate disbenefits are based on reductions in methane emissions and increases in $CO_2$ and $N_2O$ emissions and are calculated using three different estimates of the social cost of each greenhouse gas (SC-GHG) (under 1.5 percent, 2.0 percent, and 2.5 percent near-term Ramsey discount rates). For the presentational purposes of this table, we show the net climate disbenefits associated with the SC-GHG at a 2 percent Ramsey discount rate, but climate benefits and disbenefits are presented using the other near-term discount rates in Section 4.7. Net compliance costs are the compliance costs minus the value of product recovery from compliance with the rule. A number in parentheses denotes a negative value. Rows may not appear to add correctly due to rounding.

Given these results, the EPA expects that implementation of the final HON, based solely on an economic efficiency criterion, should provide society with a relatively potential net gain in welfare, notwithstanding the expansive set of health and environmental benefits and other impacts we were unable to quantify such as monetization of benefits from VOC emission reductions occurring outside of the ozone season (the months of October-April). The same holds true for the final P&R I and II NESHAP and for all final amendments (including the NSPS) considered cumulatively. Further quantification of directly emitted VOC and HAP would increase the estimated net benefits of each final action and cumulatively.

## 6.2 Uncertainties and Limitations

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

**Projection methods and assumptions*:*** Over time, more facilities are newly established or modified in each year, and to the extent the facilities remain in operation in future years, the total number of facilities subject to the action could change. We assume 100 percent compliance as these final rules and existing rules are implemented, starting from when the source becomes affected. If sources do not comply with these rules, at all or as written, the cost impacts and emission reductions may be overestimated. Additionally, new control technology and approaches 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**: In addition, the counts of units projected to be affected by this final action are held constant. Given our analytical timeframe of 2024-2038, it is possible that the affected unit counts may change. The years of the cost analysis are 2024, to represent the first-year facilities that the NSPS proposed in this rulemaking will be effective, through 2038, to represent impacts of the action over the life of installed capital equipment, as discussed in Chapter 3. Extending the analysis beyond 2038 would introduce substantial and increasing uncertainties in projected impacts of the final regulations.

**Compliance Costs:** There may be an opportunity cost associated with the installation of environmental controls (for purposes of mitigating the emission of pollutants) that is not reflected in the compliance costs included in Chapter 3. If environmental investment displaces investment in productive capital, the difference between the rate of return on the marginal investment (which is discretionary in nature) displaced by the mandatory environmental investment is a measure of the opportunity cost of the environmental requirement to the regulated entity. To the extent that any opportunity costs are not included in the control costs, the compliance costs presented above for this final action may be underestimated.

**BPT estimates**: As discussed earlier in Chapter 4, all national-average BPT estimates reflect the geographic distribution of the modeled emissions, which may not exactly match the emission reductions that would occur due to the action, and they may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors for any specific location. Recently, the EPA systematically compared the changes in benefits, and concentrations where available, from its BPT technique and other reduced-form techniques to the changes in benefits and concentrations derived from full-form photochemical model representation of a few different specific emissions scenarios. Reduced form tools are less complex than the full air quality modeling, requiring less agency resources and time. That work, in which we also explore other reduced form models is referred to as the "Reduced Form Tool Evaluation Project" (Project), began in 2017, and the initial results were available at the end of 2018. The Agency's goal was to better understand the suitability of alternative reduced-form air quality modeling techniques for estimating the health impacts of criteria pollutant emissions changes in the EPA's benefit-cost analysis. The EPA continues to work to develop refined reduced-form approaches for estimating benefits. The scenario-specific emission inputs developed for this project are currently available online. The study design and methodology are described in the final report summarizing the results of the project, available at:

https://www.epa.gov/sites/production/files/2019-1/documents/rft_combined_report_10.31.19_final.pdf

**Non-monetized benefits:** Numerous categories of health and welfare, and climate-related benefits are not quantified and monetized in this RIA. These unquantified benefits, including benefits from reductions in emissions of pollutants such as HAP which are to be reduced by this final action, are described in detail in Chapter 4 of this RIA and various NAAQS RIAs.

**VOC health impacts***:* In this RIA, we quantify an array of adverse health impacts attributable to emissions of VOC. The Integrated Science Assessment for Particulate Matter ("ISA") (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.

**Monetized climate benefits and disbenefits:** The EPA considered the uncertainty associated with the social cost of greenhouse gas (SC-GHG) estimates, which were used to calculate the climate benefits and disbenefits from the increase in $CO_2$ and $N_2O$ emissions and the decrease in $CH_4$ emissions projected under the final amendments in this rulemaking. Some uncertainties are captured within the analysis, while other areas of uncertainty have not yet been quantified in a way that can be modeled. A full discussion of uncertainties in the analysis of monetized climate benefits and disbenefits can be found in Chapter 4 of this RIA.

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