Cost Analysis for Regulatory Changes to the Listing Status of High-GWP Alternatives used in Refrigeration and Air Conditioning, Foams, and Fire Suppression

PREPARED FOR:

Stratospheric Protection Division
Office of Air and Radiation
U.S. Environmental Protection Agency
Washington, D.C. 20460

PREPARED BY:

ICF International
1725 Eye Street, NW
Washington, DC 20006

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Executive Summary

This analysis presents an estimate of the overall potential costs associated with a rulemaking to change the listing status of certain high-GWP alternatives used in refrigeration and air conditioning, foams, and fire suppression. Exhibit 1 summarizes the regulatory changes analyzed. Using a 7% discount rate, total annualized compliance costs across the roughly 100 affected businesses are estimated to range from $59.2 million–$71.3 million. Using a 3% discount rate, total annualized compliance costs are estimated to range from $58.8 million–$70.6 million.

Exhibit 1: Summary of Regulatory Changes Analyzed

- List unacceptable 24 HFCs and HFC blends for new centrifugal chillers in 2024.
- List unacceptable 24 HFCs and HFC blends for new positive displacement chillers in 2024.
- List unacceptable 24 HFCs and HFC blends for new refrigerated food processing and dispensing equipment in 2021.
- List unacceptable 28 HFCs and HFC blends for new household refrigerators and freezers in 2021.
- List unacceptable 21 HFCs and HFC blends for new cold storage warehouses in 2023.
- List unacceptable HFC-134a, HFC-245fa, and certain HFC blends in 1) rigid polyurethane high-pressure two component spray foam, 2) rigid polyurethane low -pressure two component spray foam, and 3) rigid polyurethane one-component foam sealants in 2020, 2021, and 2020, respectively, except for certain military, space- and aeronautics- related applications.
- List unacceptable methylene chloride in flexible polyurethane foam 30 days from date of publication of a final rule.
- List unacceptable perfluorocarbons (C_3F_8 and C_4F_{10}) in total flooding uses one year after publication of a final rule.

Methodology

This analysis builds on the general approach taken previously to estimate potential economic impacts on small businesses—as described in the *Economic Impact Screening Analysis for Regulatory Changes to the Listing Status of High-GWP Alternatives used in Refrigeration and Air Conditioning, Foams, and Fire Suppression* —to extend the assessment to all-sized businesses potentially affected by the rulemaking. Industries potentially affected by these regulatory changes were primarily identified by North American Industry Classification System (NAICS) codes. Costs to affected businesses were calculated using a direct compliance cost method and then annualized. Costs or savings associated with changes in energy efficiency were not estimated because energy efficiency is related to a number of factors, including equipment design and performance characteristics, and not just due to the refrigerant or foam blowing agent used.

Apart from a few exceptions, this analysis uses the same assumptions as the small business screening analysis, including those about:

- Which industries might be affected by the regulatory changes;
- The proportion of businesses that could be directly affected by the regulatory changes, based on whether the HFCs, HFC blends, PFCs, and other halocarbons affected by the regulatory changes are still—or were ever—known to be in use, and what proportion of the market the affected substitutes are expected to represent at the time that the regulatory changes would come into effect;
- The alternatives that are implemented in the transition away from the HFCs, HFC blends, PFCs, and other halocarbons affected by the regulatory changes, for modeling purposes; and
- The capital, operating, maintenance, and other direct compliance costs incurred by affected businesses.

Table 1 provides the basic financial assumptions used in this analysis.

Table 1: Financial Assumptions used in Cost Analysis

Parameter	Assumption
Discount rates	3% and 7%
Constant Year Dollars	2015$
Lifetime for annualizing costs	Varies based on equipment type: 25 years for foam manufacturing and centrifugal chiller manufacturer, and 20 years for household refrigerator and freezer manufacturers.

The sections below briefly describe the cost assumptions to extend the small business economic impact screening assessment to those businesses not characterized as small under the Small Business Administration guidelines (hereafter referred to as "larger" businesses).

Refrigeration and Air Conditioning Assumptions

Cost assumptions for the refrigeration and air conditioning sector are summarized below; for more detail, see *Economic Impact Screening Analysis for Regulatory Changes to the Listing Status of High-GWP Alternatives used in Refrigeration and Air Conditioning, Foams, and Fire Suppression*.

- **Chillers (Centrifugal and Positive Displacement)**—Nine manufacturers of centrifugal and positive displacement chillers were identified based on an internet search. Compliance costs incurred as a result of the regulatory changes are based on the assumption that manufacturers would use R-450A (a blend of HFC-134a and HFO-1234ze) or R-513A (a blend of HFC-134a and HFO-1234yf) in centrifugal chillers in place of HFC-134a; Solstice™-1233zd(E) in low-pressure centrifugal chillers in place of HFC-245fa (or centrifugal chillers that historically used HCFC-123); and R-450A or R-513A in positive displacement chillers in place of R-407C and R-410A.[1] It is assumed that there is a one-time capital cost of approximately $51,000 associated with transitioning to Solstice™-1233zd(E) (UNEP 2012), and annual costs of $3,500 to $4,200 for centrifugal chillers and $1,100 to $1,400 for positive displacement chillers using R-450A or R-513A, and $7,800 to $8,500 for centrifugal chillers using Solstice™-1233zd(E), associated with charging the systems.[2] As a result, it is estimated that each manufacturer of centrifugal chillers and positive displacement chillers could incur an annual cost of roughly $2.9 million to $3.3 million and roughly $3.0 million to $3.8 million, respectively, as a result of the regulatory changes.[3]

- **Retail Food Refrigeration (Food Processing and Dispensing Equipment)**—Based on an internet search, it is assumed that there are 20 manufacturers of refrigerated food processing and dispensing equipment

[1] The Vintaging Model assumes that by 2024, new positive displacement chillers no longer use HFC-134a (EPA 2014).
[2] Chiller compressors can be charged at the manufacturing facility, shipped partially charged and filled on-site, or shipped dry and filled on site depending on the size and installation location of the system. For the purposes of this analysis, it is assumed that all charging costs will be incurred by the manufacturer, although it is likely that some of these costs would be passed on to the end-user.
[3] Annual costs are based on the assumption that manufacturers on average sell roughly 545 centrifugal chillers and 2,681 positive displacement chillers each year that will require transition to an alternative refrigerant. Approximately 41% of new chillers are assumed to transition to Solstice™-1233zd(E) and 59% are expected to transition to R-450A or R-513A. These assumptions are based on 2024 sales of centrifugal chillers and positive displacement chillers estimated by EPA's Vintaging Model (EPA 2014).

in the United States. Compliance costs incurred as a result of the regulatory changes are based on the assumption that manufacturers of refrigerated food processing and dispensing equipment will incur an incremental cost of $4-5 for each piece of equipment they produce associated with using R-450A in low temperature applications in place of R-404A (UNEP 2012; Alpine Freezer 2015). With units estimated to sell for $10,000 a piece on average, manufacturers are estimated to incur on average an annual incremental cost of roughly $200-$200,000, depending on the size of the firm.[4]

- **Household Refrigerators and Freezers**—According to the U.S. Census Bureau (2012), there are 23 manufacturers of domestic refrigeration equipment. Compliance costs incurred as a result of the regulatory changes are based on the assumption that small businesses will transition from HFC-134a to either R-450A or R-513A, and large businesses will transition to isobutane (R-600a). Assuming an average charge size of 0.16 kg (EPA 2014), it is estimated that small business manufacturers will incur an annual cost of roughly $1,400 to $1.7 million, depending on the size of the firm, associated with the incremental cost of the refrigerant.[5,6] Large business manufacturers are assumed to incur a one-time capital investment cost of $150,000 to $500,000 associated with (a) purchasing new charging equipment, (b) testing and certifying equipment to UL standards, and (c) converting their facilities to accommodate a flammable refrigerant, resulting in an annualized cost of about $31,000 to $102,000 per affected large business.[7]

- **Cold Storage Warehouses**—Given this industry's reliance on ammonia, it is estimated that only four manufacturers produce R-404A and R-507A cold storage refrigeration systems in the United States. In response to the regulatory changes, these manufacturers are assumed to transition to R-407F in new systems, which will cost each manufacturer $20,000 to $40,000 per year, due to the larger charge size of R-407F required (i.e., 1.07 times greater than the charge sizes of R-404A and R-507A systems) (Honeywell 2012).[8]

Foam Blowing Assumptions

In the foams sector, compliance costs generally include one-time capital costs for a production facility to transition to an alternative blowing agent. In some cases, these capital costs could be offset by annual savings associated with lower alternative blowing agent costs; however, these savings are not accounted for in this direct compliance cost approach. Assumptions are briefly described below; for more detail, please see *Economic*

[4] For the purposes of this analysis, it is assumed that all refrigerant costs will be incurred by the manufacturer, although it is possible that some of these costs would be passed on to the end-user.
[5] Annual costs are based on 2021 estimated sales of household refrigerators and freezers (approximately 11 million units) using EPA's Vintaging Model (EPA 2014). This analysis assumes that refrigerator sales are proportionally distributed among manufacturers based on average sales across each establishment size category.
[6] For the purposes of this analysis, it is assumed that all refrigerant costs will be incurred by the manufacturer, although it is possible that some of these costs would be passed on to the end-user.
[7] Using a 7% discount rate.
[8] For the purposes of this analysis, it is assumed that all refrigerant costs will be incurred by the manufacturer, although it is possible that some of these costs would be passed on to the end-user.

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- **High-pressure two-component spray foam**—It is assumed that companies still using HFC-245fa, HFC-365mfc and blends thereof would transition to Solstice™ Liquid Blowing Agent (LBA) 1233zd(E), *trans*-1-chloro-3,3,3-trifluoroprop-1-ene). Capital costs for transitioning to Solstice™ LBA are assumed to be $200,000–$300,000 per facility, associated with the cost of formulation development and compliance testing, which results in an annualized cost of about $20,000 to $70,000 per affected business.[9]

- **Low-pressure two-component spray foam**—Companies still using HFC-134a, HFC-245fa, and blends thereof are assumed to transition to Solstice™ Gaseous Blowing Agent (GBA) (HFO-1234ze). Capital costs for transitioning to HFO-1234ze are assumed to be $500,000–$600,000 per facility to cover the cost of extensive formulation development and compliance testing, which results in an annualized cost of about $40,000 to $175,000 per affected business.[10]

- **One-component foam sealants**—Companies still using HFC-134a and blends thereof are expected to transition to Solstice™ GBA (HFO-1234ze). Capital costs for transitioning to HFO-1234ze are assumed to be $200,000–$300,000 per facility to cover the cost of formulation development and compliance testing, which results in an annualized cost of about $20,000 to $70,000 per affected business.[11]

  Flexible polyurethane foam—Methylene chloride is not known to be used in any flexible polyurethane (PU) foam applications. Therefore, prohibiting the use of methylene chloride in this end-use is not expected to impact any businesses. The regulatory changes would serve to prevent uptake of methylene chloride into this foam end-use.

Fire Suppression and Explosion Protection Assumptions

No businesses are assumed to be affected by the regulatory changes. PFCs (i.e., C_3F_8 and C_4F_{10}) are not used currently in new fire extinguishing equipment. These assumptions are based on modeling by EPA's Vintaging Model, which is informed by industry input. The Vintaging Model estimates that 0.2% of the market uses HFC-23 in total flooding systems in 2015, with the remaining using halon 1301, other HFCs (e.g., HFC-227ea), and agents with zero ODP and low GWP, including fluoroketone, inert gas, CO_2, powdered aerosols, foam, and water mist (EPA 2014).

Results

Using the methodology and additional assumptions described above,

[9] Using a 7% discount rate. The range in annualized costs is dependent on the average number of establishments per business, which varies depending on the size of the business.
[10] *Ibid.*
[11] *Ibid.*

Table 2 below summarizes the estimated number of businesses potentially affected by the rulemaking as well as the estimated annualized costs by sector at a 7% discount rate. Table 3 summarizes the estimated annualized costs by sector at a 3% discount rate.

Using a 7% discount rate, total annualized compliance costs across affected businesses are estimated to range from $59.7 million–$71.9 million. Using a 3% discount rate, total annualized compliance costs across affected businesses are estimated to range from $59.3 million–$71.2 million. This analysis assumes the minimum cost to comply with the regulatory changes. Emissions reductions associated with the regulated community's compliance with these changes were also investigated.[12]

Table 2: Estimated Compliance Cost of the Regulatory Changes using a 7% Discount Rate

Sector	Estimated Number of Businesses Impacted by the Rule[a]	Higher Annualized Costs[b]	Lower Annualized Costs[b]
Refrigeration and Air Conditioning	**50**	**$69,878,000**	**$58,288,000**
Centrifugal Chillers	<10	$29,365,000	$25,892,000
Positive Displacement Chillers		$33,799,000	$27,039,000
Food Processing and Dispending Equipment	20	$419,000	$335,000
Household Refrigerators and Freezers	20	$5,810,000	$4,678,000
Cold Storage Warehouses	<10	$142,000	$69,000
Foams	**50**	**$2,026,000**	**$1,452,000**
High-Pressure Two-Component Spray Foam	40	$1,414,000	$943,000
Low-Pressure Two-Component Spray Foam	<10	$606,000	$505,000
One-Component Foam	<10	$6,000	$4,000
Flexible Polyurethane Foam	0	$0	$0
Fire Suppression	**0**	**$0**	**$0**
Total Flooding	0	$0	$0
ALL SECTORS	**100**	**$71,904,000**	**$59,739,000**

Totals may not sum due to independent rounding.

[a] It is possible that some businesses will be affected for multiple types of equipment, resulting in a lower total number of discrete businesses affected by the rule. However, since it is not known how many businesses would be affected by multiple equipment types, the total maximum number of businesses that could be affected is shown.

[b] Includes annualized upfront capital costs as well as recurring annual costs.

[12] See EPA 2016, 'Climate Benefits of the SNAP Program Status Change Rule'.

Table 3: Estimated Compliance Cost of the Regulatory Changes using a 3% Discount Rate

Sector	Estimated Number of Businesses Impacted by the Rule	Higher Annualized Costs[a]	Lower Annualized Costs[a]
Refrigeration and Air Conditioning	**50**	**$69,659,000**	**$58,213,000**
Centrifugal Chillers	<10	$29,352,000	$25,879,000
Positive Displacement Chillers		$33,799,000	$27,039,000
Food Processing and Dispending Equipment	20	$419,000	$335,000
Household Refrigerators and Freezers	20	$5,604,000	$4,616,000
Cold Storage Warehouses	<10	$142,000	$69,000
Foams	**50**	**$1,560,000**	**$1,118,000**
High-Pressure Two-Component Spray Foam	40	$1,089,000	$726,000
Low-Pressure Two-Component Spray Foam	<10	$467,000	$389,000
One-Component Foam	<10	$5,000	$3,000
Flexible Polyurethane Foam	0	$0	$0
Fire Suppression	**0**	**$0**	**$0**
Total Flooding	0	$0	$0
ALL SECTORS	**100**	**$71,219,000**	**$59,331,000**

Totals may not sum due to independent rounding.

[a] Includes annualized upfront capital costs as well as recurring annual costs.

References

The following references are cited in this memorandum; see also *Economic Impact Screening Analysis for Regulatory Changes to the Listing Status of High-GWP Alternatives used in Refrigeration and Air Conditioning, Foams, and Fire Suppression* for a full list of references used for this analysis.

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