April 2, 2020

The Honorable John Barrasso
Chairman
Committee on Environment & Public Works
United States Senate
Washington, DC 20510

The Honorable Thomas Carper
Ranking Member
Committee on Environment & Public Works
United States Senate
Washington, DC 20510

Dear Chairman Barrasso and Ranking Member Carper:

Thank you to the Committee for scheduling this important hearing to take comment on how the Congress can spur the Heating, Ventilation, Air Conditioning and Refrigeration (HVACR) industry to scale the manufacture of new, environmentally sustainable HVACR systems.

I am writing on behalf of Carrier Corporation to urge your support for favorable consideration and swift passage of *The American Innovation and Manufacturing Act of 2019* (AIM Act) (S.2754).

Carrier is a leading provider of heating, air conditioning and refrigeration systems (HVACR), building controls and automation, and fire and security systems leading to safer, smarter, sustainable and high-performance buildings.

The AIM Act provides a federal framework for phasing down hydrofluorocarbons (HFCs) and enabling an orderly transition to next generation refrigerant technologies. This is vital to the continued competitiveness of the U.S. HVACR sector.

According to a study by the Interindustry Forecasting group at the University of Maryland (Attachment A), the phase down of HFCs will:

- Create 33,000 new U.S. manufacturing jobs and sustain 138,400 existing jobs between now and 2027;
- Increase direct U.S. manufacturing output by $12.5 billion, and total (direct and indirect) U.S. manufacturing output by $38.8 billion between now and 2027; and,
- Improve the U.S. trade balance in equipment and chemicals by $12.5 billion.

These trade and economic benefits are why the AIM Act is broadly supported by a large, bipartisan group of more than 30 Republicans and Democrats in the United States Senate and has the support of the U.S. HVACR industry, the National Association of Manufacturers, and the U.S. Chamber of Commerce (Attachment A).

A national phasedown of HFC refrigerants ensures a predictable regulatory path and provides certainty to refrigerant producers, manufacturers and, most importantly, consumers on new residential and light commercial products underpinning the HVACR market. In specific states, such as Indiana and Tennessee where Carrier designs and manufacturer's residential and light commercial products, enactment of the AIM Act will result in new products and investments to manufacture high-performing, environmentally sustainable products.

Thank you again to the Committee for holding today's hearing and for the Committee's favorable consideration of the AIM Act.

Sincerely,

Justin Keppy

Justin Keppy
President
Carrier Corporation
Residential

cc:

The Honorable James M. Inhofe
The Honorable Shelley Moore Capito
The Honorable Kevin Cramer
The Honorable Mike Braun
The Honorable Mike Rounds
The Honorable Dan Sullivan
The Honorable John Boozman
The Honorable Roger F. Wicker
The Honorable Richard Shelby
The Honorable Joni Ernst
The Honorable Benjamin L. Cardin
The Honorable Bernard Sanders
The Honorable Sheldon Whitehouse
The Honorable Jeff Merkley
The Honorable Kristen Gillibrand
The Honorable Cory A. Booker
The Honorable Edward Markey
The Honorable Tammy Duckworth
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INFORUM®

Interindustry Forecasting at the University of Maryland

In Partnership with

JMS Consulting

Economic Impacts of U.S. Ratification of the Kigali Amendment

Report Prepared for the
Air-Conditioning, Heating, & Refrigeration Institute
and the
Alliance for Responsible Atmospheric Policy

April 19, 2018

Final Report

Economic Impacts of U.S. Ratification of the Kigali Amendment

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Abbreviations

A5	Classification for Developing Economies (Article 5)
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
ARAP	The Alliance for Responsible Atmospheric Policy
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
CAA	Clean Air Act
CFC	Chlorofluorocarbon
EC	Economic Census
EPA	Environmental Protection Agency
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
HS	Harmonized System
HVACR	Heating, Ventilation, Air-Conditioning, and Refrigeration
INFORUM	Interindustry Forecasting at the University of Maryland
IO	Input-Output
MAC	Mobile Air-Conditioning
NAICS	North American Industry Classification System
ODP	Ozone Depleting Potential
ODS	Ozone Depleting Substance
SNAP	Significant New Alternatives Policy (EPA)
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Climate Change Convention

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Executive Summary

Industries based on fluorocarbons play a large role in the U.S. economy. The broad industry using fluorocarbons as a refrigerant includes the Heating, Ventilation, Air-Conditioning, and Refrigeration (HVACR) industry, along with the related industries: household appliances and motor vehicle air-conditioning. HVACR equipment includes commercial and residential HVACR and commercial refrigeration and is the largest manufacturing industry using fluorocarbons. Insulating foams, medical metered-dose inhalers, aerosols, and several other applications, along with the production of the fluorocarbons themselves, comprise the rest of the broad fluorocarbon-based U.S. industry. The HVACR and fluorocarbon technologies used globally today are signature American technologies.

U.S. industry strongly supports ratification of the Kigali Amendment to the Montreal Protocol, followed by domestic implementation. The Kigali Amendment provides a global platform for gradual introduction and commercialization of next generation technologies in the U.S. and in the rapidly expanding global market. Prior transitions under the Montreal Protocol enabled these strong U.S. industries to maintain their technology leadership. The new Kigali Amendment, which creates a clear path toward global adoption, will have a similar effect.

The economic size of the U.S. industries based on fluorocarbons has been analyzed using Economic Census data and economic models. The impact of Kigali was assessed using industry interviews and surveys and additional modeling, based on current industry trends and the experience of prior transitions under the Montreal Protocol.

The economic analysis indicates that U.S. implementation of the Kigali Amendment is good for American jobs. It will both strengthen America's exports and weaken the market for imported products. Finally, it will enable U.S. technology to continue its world leadership role.

Background on the Kigali Amendment

The Kigali Amendment to the Montreal Protocol was agreed upon at a meeting of more than 170 countries in October 2016. It has since been ratified by a sufficient number of countries to enter into effect globally on January 1 2019, but it has not yet been ratified by the U.S. The agreement establishes timetables for all developed and developing countries to freeze and then to reduce their production and use of HFCs, chemicals that are used widely by the U.S. and global industries. HFCs will be eliminated over time for most uses, and they will be replaced with a new generation of alternative chemicals and products that are more climate-friendly and more energy-efficient.

Under the Montreal Protocol, the global fluorocarbon-using industries have undergone two prior transitions. In each case, U.S. industries were able to use their technological strengths to play a major role in defining the new generation technologies. New technology and manufacturing investments were made in the U.S., and U.S. manufacturers led the way as the world moved toward new technologies.

It is important that the transitions have been defined in such a way that older equipment can continue to be serviced with existing fluorocarbons and need not be replaced before the end of its useful life, minimizing consumer impact. In HVACR industries, gains in energy efficiency have helped balance added equipment and refrigerant costs when equipment does need to be replaced, with very short payback times. Kigali adopts the same phased approach.

The Montreal Protocol is recognized as perhaps the most successful global agreement of any kind. It has also been good for the U.S. economy. The Kigali Amendment will continue this economically beneficial effect.

Industry Summary

An analysis has been done of the broad fluorocarbon industries to determine their economic footprint in 2016. All segments of the using and producing industries were assessed, with a focus on HVACR, the largest component. The size of the direct industries is based on Economic Census data and industry interviews. Indirect and induced impacts have been estimated with Inforum economic models. Growth of the industries over time is based on economic models combined with industry input on observed trends. The growth information was used to bring the 2012 Economic Census data forward to 2016.

Fluorocarbon-based **manufacturing** industries in the U.S. include the broad HVACR industry, mobile air-conditioning, home appliances, insulating foams, medical metered-dose inhalers, aerosols, and other segments, plus fluorocarbon manufacture. A number of **downstream** businesses are also fully dependent on these products. HVACR installation and service contracting, distribution, repair, and maintenance comprise the rest of the industries' direct employment. Together, these industries directly employ 589,000 Americans, with a $39 billion per year payroll. Total **direct** output is $205 billion per year in products and services.

Each component of these industries also creates demand for its suppliers' products, resulting in a large supply chain contribution to the economy. These **indirect** effects add 494,000 jobs with a $36 billion per year payroll, and $126.5 billion per year in economic output.

The combined direct and indirect employment creates additional demand that, in turn, leads to additional economic activity. This **induced** economic activity is estimated to employ 1,463,000 people, with an $82 billion per year payroll and an additional output of $290 billion per year.

Figure E.1 Total Employment, 2016
Units: Thousand Persons

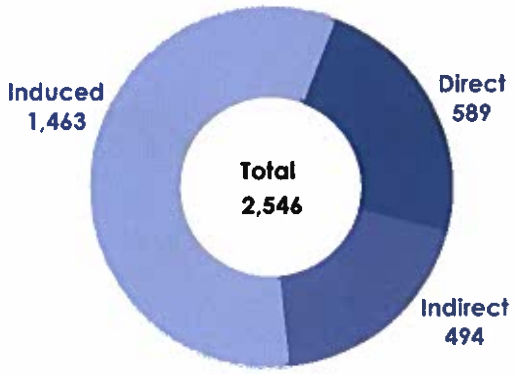
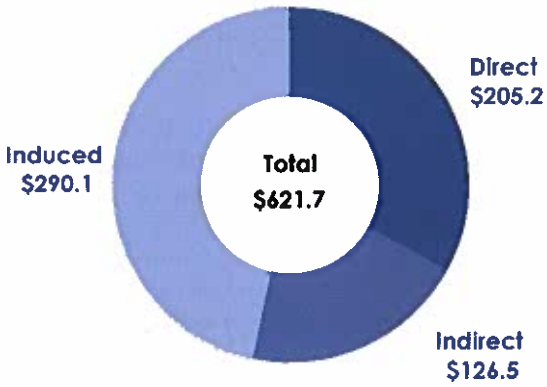


Figure E.2 Total Output, 2016
Units: Billion $



In **total**, the direct manufacturing and downstream industries, along with their indirect and induced contributions, account for more than 2.5 million U.S. jobs and a total economic output of $621 billion per year.

For manufacturing alone (excluding downstream businesses), the total direct, indirect, and induced contributions are 671,000 jobs with an economic output of $178 billion per year.

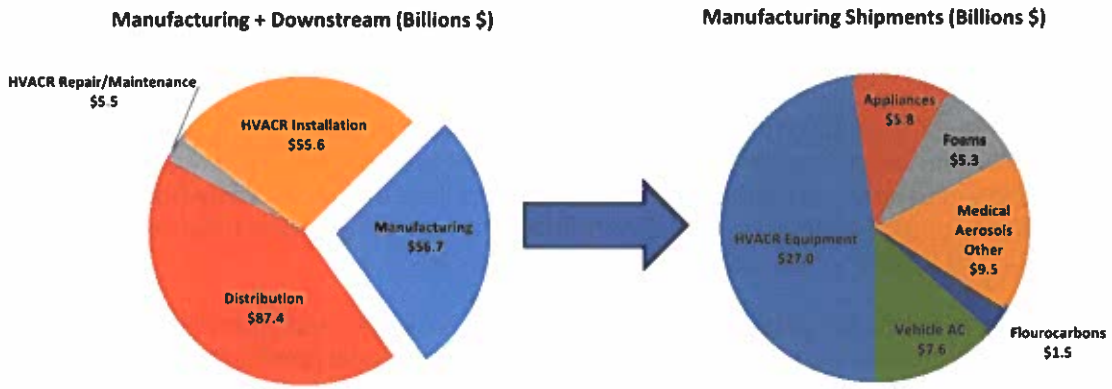
Industry Segments

The direct manufacturing output of the broad fluorocarbon industries is $56.7 billion per year in goods and services. Downstream distribution, installation contracting, repair, and maintenance are almost three times the manufacturing contribution and make up the remainder of the total direct output of $205 billion per year. All of the downstream industries provide services in support of HVACR equipment, vehicle AC, and appliances and can be considered part of a network of industries relying on fluorocarbons.

Within the manufacturing component, HVACR equipment contributes $27.0 billion, almost half the total. Manufacturing output of HVACR and related equipment – that is, including vehicle AC and appliances – is $40.4 billion, more than 70 percent of the total.

Fluorocarbons typically represent only a small, if essential, part of manufactured products, and their contribution is $1.5 billion. Insulating foams add $5.3 billion, and output of all other products is $9.5 billion.

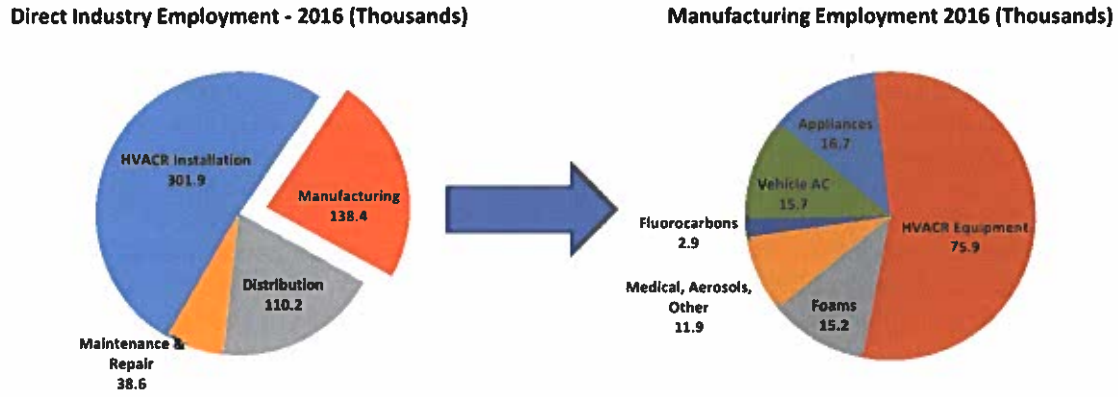
Figure E.3 Manufacturing and Downstream Output, 2016



Direct employment is distributed similarly. Manufacturing employs 138,400 Americans, with the downstream HVACR components adding 450,700 more. Most of the downstream jobs are in the labor-intensive HVACR installation contractor segment.

Within manufacturing, HVACR equipment, vehicle AC, and appliances together employ 108,400 of the 138,400 thousand total manufacturing employees. The manufacture of insulating foams employs 15,200, and fluorocarbon manufacture and specialized uses employ the remaining 14,800.

Figure E.4 Manufacturing and Downstream Employment, 2016



Industry Trends

Most of the fluorocarbon-based industries have significant growth opportunities in global markets. In particular, the international market for HVACR is expected to more than double over the next ten years, for a cumulative output of more than $1 trillion, driven by expanded use of cooling and refrigeration in the developing world.

Most developed countries are already transitioning to new technologies consistent with Kigali Amendment requirements. Developing countries, under the Montreal Protocol's staggered implementation, will be completing their transition away from ozone-depleting substances. This transition will be at its peak between now and 2047. The result is a large market opportunity for new technologies.

From the time of its creation, the U.S. HVACR industry has led global innovation. The industry's new technology capabilities enabled it to lead previous transitions under the Montreal Protocol, spreading U.S. technology throughout the world. Commercialization of next generation technologies is essential to complete the Montreal Protocol and Kigali Amendment transitions. With a typical design cycle of 5-10 years, decisions are being made now.

Investments in next generation refrigerants and equipment technologies are already underway. In 2015, members of the Air-Conditioning, Heating, and Refrigeration Institute (AHRI), representing 90% of U.S. HVACR manufacturing, committed $5 billion through 2025 in R&D and capital investment to commercialize high efficiency equipment using next generation refrigerants. American investments in R&D and capacity for Kigali-related growth will generate 1,400 jobs and $1 billion in capital investment if Kigali is ratified. These jobs and investment are at risk if the U.S. government fails to act. Without ratification by the U.S., manufacturing and R&D for new technologies will move to the international markets where local demand for the new technologies justifies the investment.

To be competitive in growing international markets, American industry must again lead the transition to new technologies. Without the regulatory certainty of a firm Kigali timetable, any transition in the U.S. will likely be delayed, allowing others to move into leadership roles or driving U.S. industry toward offshore rather than domestic investment and employment in order to stay competitive.

Impact of Kigali Ratification

The U.S. HVACR industry is expected to experience very different levels of economic growth and revenues depending on whether the U.S. ratifies the Kigali Amendment. To examine the impact of the decision of whether or not to ratify, the industry analysis has been carried forward to 2027, again based on both economic models and industry interviews, along with industry surveys. Two cases were examined: with Kigali ratification and without.

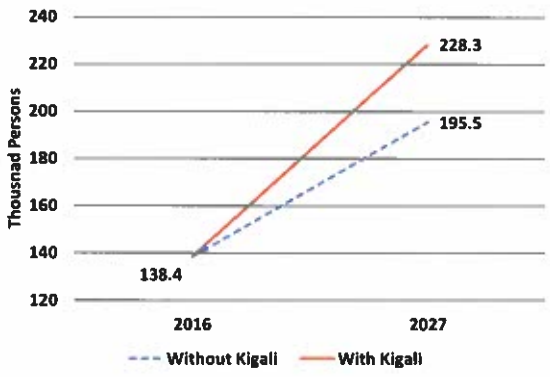
Ratification of Kigali will provide regulatory stability and long-term market information to support domestic investment in new technologies to serve both domestic and global markets. Implementation in the U.S. will support significantly increased exports to growing global markets. Similarly, the market for imported, mostly older technology will have limited growth. The improvement in net trade compared with a "without Kigali" forecast will lead to additional economic growth if Kigali is ratified.

Jobs and Economic Output

Global industry growth will drive an increase in U.S. jobs, even without Kigali ratification. The 138,000 direct manufacturing jobs in 2016 would grow to 195,000 by 2027. However, with U.S. ratification of Kigali, we expect that an additional 33,000 jobs would be created, for a total of 228,000. Adding in the indirect and induced effects to estimate the total impact, the number of additional jobs gained with Kigali ratification would rise to 150,000.

Although not included in the overall analysis, reclaimed refrigerants would also benefit from Kigali ratification. Reclaimed HFCs, now much lower in volume than older refrigerants, would become an important part of servicing existing equipment. Reclaim sales are estimated to increase by $0.8 billion per year with Kigali, adding another 4,000 jobs. The manufacturing and reclaim jobs are in addition to the 1,400 research and development jobs expected for the U.S. if Kigali is ratified.

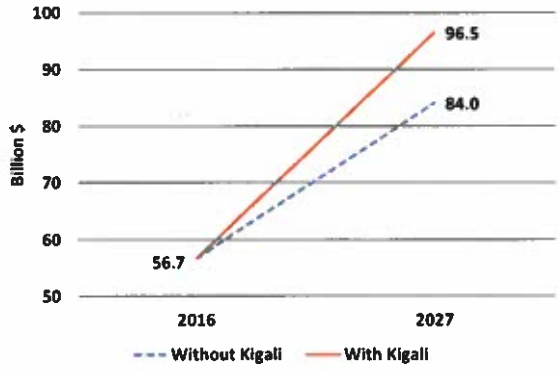
Figure E.5 Direct Manufacturing Employment
Units: Thousand Persons



Job growth is driven by similar growth in economic output. Direct manufacturing output of $56.7 billion per year is expected to grow to $84 billion even without ratification. Kigali ratification would add $12.5 billion per year in direct output, bringing the total to $96.5

billion. When the indirect and induced impacts are included, the benefit of Kigali ratification would rise to $38.8 billion per year in additional economic output.

Figure E.6 Direct Manufacturing Output
Units: Billion $

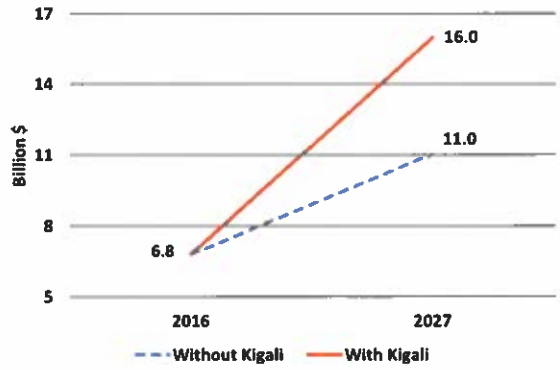


Global Trade

Kigali ratification in the U.S. will support domestic investment in HVACR not only to serve U.S. markets, but also to participate more fully in global market growth through exports. Global customers will be more eager to buy from the market's technology leaders as they make their transitions. U.S. industries will leverage their domestic investments to supply both local and export markets.

In 2016, U.S. exports of HVACR and related equipment and services totaled $6.8 billion. Without Kigali, overall market growth would drive an increase to $11.0 billion per year by 2027, although the U.S. share of the global export market would decline. Exports with Kigali will grow to $16.0 billion per year, a benefit of $5.0 billion from ratification.

Figure E.7 U.S. HVACR and Related Equipment Exports
Units: Billion $

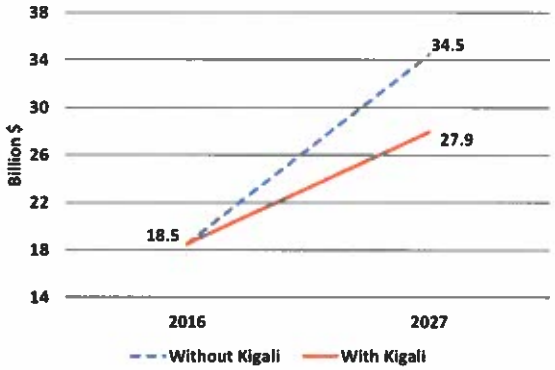


There is an even larger effect on imports. The U.S. in 2016 imported $18.5 billion worth of HVACR and related equipment. A significant part of the imports is made up of old technology products, which are lower in energy efficiency and will soon to be phased

out in developed countries that have ratified Kigali. Without Kigali ratification, those imports would grow to $34.5 billion in 2027.

Kigali ratification will inhibit import growth, with imports reaching only $27.9 billion by 2027, for a benefit of $6.5 billion in reduced imports. U.S. manufacturers will reap that benefit in additional sales to keep the U.S. market fully supplied.

Figure E.8 U.S. HVACR and Related Equipment Imports
Units: Billion $



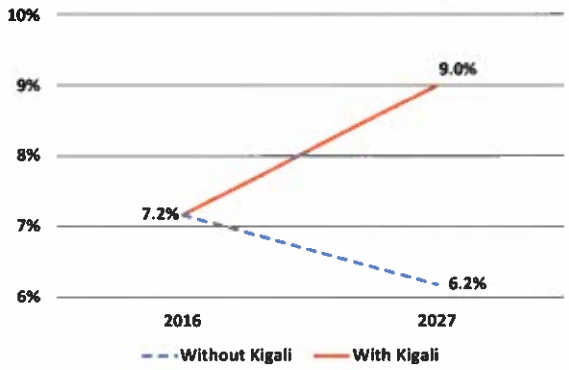
Although impacts on fluorocarbon manufacture were not included in the jobs and economic output numbers, this segment is also expected to experience a trade benefit through increased exports of new technology refrigerants and decreased imports of old technology products. The net improvement in trade balance is estimated to be $1.0 billion per year.

The total improvement in U.S. trade balance with Kigali ratification would be more than $12.5 billion per year.

Increased participation in global export markets is an important factor in maintaining the technological and economic strength of the U.S. HVACR industry. The export market will grow by 6 percent per year over the next decade to meet the needs of China, India, Latin America, and Africa. The U.S. share of that market is currently 7.2 percent as the use of old technology has continued to grow. Without Kigali ratification, the U.S.'s global market share will slip to 6.2 percent over the next decade.

Domestic investments in new technology to meet Kigali requirements will enable the U.S. to outperform in the export market, increasing the U.S. global export market share to 9.0 percent.

Figure E.9 U.S. Share of World HVACR and Related Equipment Export Markets



Conclusion

The manufacturing and service industries dependent upon fluorocarbons have been built on signature American technologies and have a history of leadership in global markets. Together they make large and important contributions to U.S. employment and economic output.

Like the Montreal Protocol, the Kigali Amendment will create demand for another new generation of technology. This is especially true for HVACR, which is experiencing significant global growth as developing countries around the world increasingly employ cooling and refrigeration.

The U.S. industry historically has been the global leader, building on a strong domestic base and expanding the use of new technology globally. The changes driven by the Montreal Protocol have strengthened and expanded that U.S. leadership. But now, the ratification of Kigali is crucial to continuing that pattern and maintaining U.S. leadership. Without Kigali ratification, growth opportunities will be lost along with the jobs to support that growth, the trade deficit will grow, and the U.S. share of global export markets will decline.

1. Introduction

The Montreal Protocol is an international treaty designed to protect the ozone layer. Taking effect in 1989, the agreement required the phase-out of chlorofluorocarbons (CFCs). Hydrofluorocarbons (HFCs) were originally introduced in order to achieve a rapid response as a replacement for ozone-depleting substances. In subsequent years, however, the science and technology communities shared concerns regarding the potential impacts of HFCs on the atmosphere and expressed the desire to replace them with next generation technologies.

On October 15, 2016, representatives from more than 170 countries met in Kigali, Rwanda, to develop the Kigali Amendment to the Montreal Protocol. The aim of the Amendment is to reduce worldwide use of HFCs. Under the agreement, developed countries would begin reducing their use of HFCs by 2019, while developing countries would start their reductions by 2024. The goal is to reduce HFC use by 85 percent by 2047 and replace them with hydrofluoroolefins (HFOs), which have far less impact on the atmosphere.

This Amendment is subject to Senate ratification in the U.S. but will formally take effect globally on January 1, 2019 whether or not the U.S. ratifies. Canada announced in November 2017 that it would join more than two dozen other countries in backing the agreement. Another significant signatory country is the UK, which ratified the amendment in October 2017.

The transition from CFCs to HFCs resulted in a 90 percent reduction of global warming potential (GWP). Replacing HFCs with next generation technologies such as HFOs is expected to reduce global warming potential an additional 90 percent.[1] Some concerns exist that replacement HFOs will cost more than the HFCs they are replacing.[2] However, history and past experience with these types of technology transitions in the U.S. demonstrate that, for most uses, the cost increase will be a marginal part of product cost, and that the costs will come down over time. Furthermore, because this is a phase-down transition rather than a phase-out, consumers will have significant latitude in choosing when to replace older equipment. The newer models of air conditioners, refrigerators, and other equipment will save money in other ways, such as reduced energy use.

1.1 Study Objectives

This study has two main objectives:

1. Establish the economic "footprint" of the fluorocarbon and refrigerants industries, as well as the industries that comprise the fluorocarbon "network" of industries, including HVACR equipment, vapor-compression home appliances (refrigerators, freezers, water heaters), mobile air conditioners (MACs), foams, and other specialized uses, such as aerosols and MDIs. We also look at the downstream industry impacts,

[1] See UNEP (2017).
[2] For example, Michaels (2018).

including wholesale distribution, repair and maintenance, and installation contractors.

2. Perform a scenario analysis of the potential impacts of the U.S. ratification of the Kigali Amendment. This scenario analysis will develop a "without Kigali" case that represents a continuation of current policy in the U.S. In this scenario the U.S. does not ratify, but the rest of the world implements Kigali. We contrast this with a case including Kigali adoption, which will be called "with Kigali". The driving assumption is the effects of Kigali ratification on enabling an increase in the U.S. exports of HVACR equipment and fluorocarbons, and a reduction in the share of imports.

In many ways, the achievement of the first objective sets the stage for the second, as it is through understanding and quantifying the current economic situation in the relevant industries that we can intelligently construct alternative scenarios.

1.2 Background

Although the goals of the Kigali Amendment are laudable, policymakers in the U.S. would like to understand better the economic consequences of Kigali ratification. The current study applies historical data from the U.S. Bureau of Census and the Bureau of Economic Analysis (BEA) to understand the current economic contribution of the fluorocarbon, HVACR, and related industries to the U.S. economy.

We then apply input-output (IO) tools developed by Inforum to project how these industries may change over a 10-year (or longer) period, with and without Kigali ratification.

JMS Consulting has extensive experience in working with the chemicals and HVACR industries. A study completed in 2013[3] provided an earlier analysis of the economic impact of the network of industries related to fluorocarbon production.

Inforum specializes in input-output and industry modeling at the national and regional levels, and also has extensive experience in international trade analysis. Inforum maintains a large database of bilateral imports and exports by Harmonized System (HS) 4-digit products, which is used for the Inforum bilateral trade model of the largest world economies. Inforum recently worked with the Center for Manufacturing Research of the National Association of Manufacturers to complete an industry analysis at the national and regional level for the Air-Conditioning, Heating, & Refrigeration Institute (AHRI).[4]

1.3 Footprint, World Trade, and Scenario Analysis

The footprint analysis, described in section 2, proceeds by first compiling Census data on the various focus industries classified in the manufacturing, wholesale trade, repair and maintenance, and contracting sectors. These data are based primarily on the 2012 Economic Census. We then construct a time series of compatible data, using annual

[3] See Steed (2013), *Fluorocarbon Industry Economic Analysis*,
[4] Center for Manufacturing Research and Inforum (2017).

data available from the Bureau of Census and the BEA. Most of these data have been compiled into a database for a large IO model developed by Inforum named *Iliad* that contains 352 industries comprising the U.S. economy. This model shows the sources of demand for each industry, as well as what they buy from upstream or supplier industries.

In section 3, we investigate patterns of world trade in fluorocarbons and HVACR equipment, primarily using data available from the United Nations (UN) Comtrade database. The goal in this analysis is to understand world trade patterns by country, particularly in relation to the U.S. This knowledge helps inform the development of the scenario analysis, in which changes in world trade are the driving factor.

The framing and execution of modeling the scenarios is described in section 4. We develop alternative trade scenarios based on interviews and conversations with industry economists from relevant producing companies. We then apply the key findings of these interviews to the construction of two alternative scenarios, "without Kigali" and "with Kigali", and calculate the total economic impact using IO analysis.

2. Current Economic Footprint

This section describes the set of manufacturing industries that produce and use fluorocarbons and other refrigerants. Manufacturing industries that are important users of fluorocarbons and refrigerants include:

- Refrigeration and air-conditioning equipment
- Household refrigerators and home freezers
- Water heaters
- Motor vehicle air conditioners
- Polystyrene and polyurethane foam
- Medical MDIs (Metered dose inhalers)
- Aerosols
- Fluoropolymers and process agents

The economic footprint also includes the important downstream industries that owe their existence to these manufacturers, such as wholesale trade, maintenance and repair, and installation and service contractors. The footprint measures the economic activity of these focus industries by several metrics. Economic activity can be measured as output (production), employment, payroll, and total value added.

2.1 Overview

This section provides important background information for the industries considered as part of the *fluorocarbon network*, which is defined as the industries that produce fluorocarbons and other refrigerants, the products that rely on fluorocarbons as an important and necessary component, and the downstream industries that sell, maintain, and install equipment. Section 2.2 describes the industry segments that comprise this fluorocarbon network. Section 2.3 presents data for these segments in historical context.

Finally, section 2.4 presents the footprint analysis for 2016, which is the last year of historical data.

2.2 Industry Segments

2.2.1 Manufacturing Industries

Refrigerants

Fluorocarbon Manufacturing includes all the hydrofluorocarbons (HFCs) and other fluorocarbons used as refrigerants.

The other manufacturing industries represent the markets into which fluorocarbons are sold.

Refrigeration and Air-Conditioning Equipment Manufacturing

Refrigeration and Air-Conditioning Equipment Manufacturing includes residential air conditioners as well as commercial applications like industrial chillers and rooftop units, commercial refrigeration, and refrigerated transport. The full range of air-conditioning applications is included, such as unitary air-conditioning, window units, split systems, heat pumps, and dehumidifiers. Beyond the direct manufacture of equipment in this category, it is important to consider the manufacture of compressors and other components designed for specific fluorocarbon refrigerants. All commercial and residential air-conditioning and refrigeration applications are grouped into a single segment for purposes of the study, except for mobile air-conditioning and home appliances. A very small percentage of commercial units may employ other refrigerants, but these have not been excluded.

Household Appliances

Household Refrigerators and Home Freezers and **Water Heaters** employ fluorocarbons either as a refrigerant or as a component of insulating foam. Although some appliances use alternate refrigerants or foam-blowing agents, there is no available measure of the portion containing no fluorocarbons in either use. Because the alternates are all chosen for their reduced GWP, the entire category is retained for the analysis.

Motor Vehicle Air-Conditioning Equipment Manufacturing

The vast majority of motor vehicles include air-conditioning in the U.S., comprising a significant application for fluorocarbons. The **Motor Vehicle Air-Conditioning Equipment** industry, including compressors and other components, is included in a separately reported segment. The reported estimates may also include a small portion of units employing other refrigerants.

Foams

The foam manufacturing industry uses fluorocarbons as blowing agents for certain types of foams where the fluorocarbons are retained within the foams for their insulating or cushioning value. These represent only a portion of all foams, primarily transportation and construction products made with either **Polyurethane Foam** or **Polystyrene Foam**, and shipping pads made with polyurethane foam.

Other

Fluorocarbons serve as propellants for metered dose inhalers (MDIs) used by the pharmaceutical industry for delivery of respiratory drugs. The **Medical – MDIs** segment as reported here includes only HFCs and not any remaining uses of CFCs or HCFCs.

The greater part of the fluorocarbon involvement in the **Aerosols** industry disappeared when CFCs were banned from this application several decades ago. However, HCFCs were employed for certain applications for a time and some remaining applications, especially hairsprays, colognes, perfumes, and room and personal deodorants use HFCs today.

Fluorocarbons are also used in the production of other materials, either as a raw material consumed to make the new materials or as a process agent that makes production of the new materials possible. Fluoropolymer manufacturing uses fluorocarbons as the raw material (consumed in the process) to manufacture thermoplastic resins, plastics, and elastomers. Fluorocarbons are used as process agents in the manufacture of certain nonwoven materials and manufactured fibers. Because there are relatively few manufacturers involved in these often-proprietary processes, these applications are grouped for reporting purposes as **Fluoropolymers and Process Agents**.

2.2.2 Repair and Maintenance

Most of the manufacturing industries served by fluorocarbons lead to retail products which are used and eventually disposed of without servicing or repair, or where any repairs do not involve the fluorocarbon components. However, the large manufacturing segments producing air-conditioning and refrigeration equipment, and household appliances lead to products that are often serviced repeatedly throughout their lifetimes. An important element is that the repair and maintenance activities generally involve the addition and/or recovery and replacement of refrigerants.

Heating, Air-Conditioning, and Radiator System Repair Services for Cars and Light Trucks are dedicated to servicing air-conditioning units in automobiles.

Commercial Refrigeration Equipment Maintenance and Repair service equipment, including industrial chillers and roof-top units, in commercial environments.

Appliances and Household Equipment Maintenance and Repair help ensure that home appliances (refrigerators, freezers, and water heaters) are maintained and functioning.

2.2.3 Wholesale

The wholesale distribution of air-conditioning and refrigeration equipment is often conducted by businesses covering the full range of heating, ventilation, and air-conditioning, of which air-conditioning is a large part and can be identified and reported separately as Air-Conditioning Wholesalers.

Household Appliances, Electric Housewares, and Consumer Electronics Merchant Wholesalers engage in the distribution of refrigerators, freezers, and water heaters.

Warm Air Heating and Air-Conditioning Equipment and Supplies Merchant Wholesalers sell air-conditioning and heating units for residential, commercial, and industrial customers.

Refrigeration Equipment and Supplies Merchant Wholesalers distribute refrigeration equipment and related parts to commercial industry.

2.2.4 Contractors

Air-Conditioning Installation contractors are responsible for the initial installation of air-conditioning and related equipment and may provide ongoing servicing as part of their contract offering.

2.3 Historical Data

2.3.1 Shipments and Receipts

Shipments and receipts data are available from the *Economic Census* and several annual surveys produced by the Bureau of Census. In table 2.1, we have summarized the shipments for the focus industries, and provided subtotals for manufacturing, wholesale trade, repair and maintenance, and contractors, from 2008 to 2016.[5]

Table 2.1 Value of Shipments/Receipts
Units: Million $

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fluorocarbon Mfg.	1,989	1,438	1,535	1,638	1,754	1,752	1,740	1,574	1,523
Refrig. & AC Equip.	24,312	21,872	22,760	24,080	25,273	26,055	25,720	26,933	27,033
Home Appliances	6,668	5,398	5,363	5,446	5,705	5,537	5,917	6,027	5,778
Motor Vehicle Air Conditioning	4,918	3,768	4,789	5,257	5,991	6,290	6,891	7,124	7,571
Polystyrene Foam	1,968	1,617	1,740	1,856	2,010	2,096	2,111	2,160	2,205
Polyurethane Foam	2,745	2,255	2,427	2,588	2,803	2,923	2,944	3,012	3,076
Medical - MDIs	4,450	4,004	4,166	4,408	4,626	4,769	4,708	4,930	4,949
Aerosols	1,447	1,302	1,355	1,434	1,505	1,551	1,531	1,604	1,610
Fluoropolymers and Process Agents	2,669	2,401	2,499	2,644	2,775	2,861	2,824	2,957	2,968
Manufacturing Subtotal	**51,167**	**44,055**	**46,635**	**49,350**	**52,442**	**53,835**	**54,386**	**56,321**	**56,712**
Household Appliances Wholesalers	20,285	18,249	18,990	20,091	21,087	21,739	21,460	22,472	22,554
Heating and AC equipment Wholesalers	43,493	39,128	40,716	43,078	45,212	46,611	46,013	48,182	48,359
Refrig. Equip. Wholesalers	14,810	13,324	13,865	14,669	15,396	15,872	15,668	16,407	16,467
Wholesale Subtotal	**78,588**	**70,700**	**73,571**	**77,839**	**81,695**	**84,223**	**83,141**	**87,061**	**87,381**
Auto Heating, AC, Radiator Repair	2,421	2,203	2,483	2,562	2,721	2,810	2,946	3,085	3,171
Commercial Refrig. Equip Repair	1,335	1,130	1,224	1,365	1,457	1,502	1,581	1,601	1,585
Appliances & Household Equip. Repair	574	514	541	567	605	635	662	700	723
Repair and Maintenance Subtotal	**4,330**	**3,847**	**4,249**	**4,494**	**4,782**	**4,947**	**5,189**	**5,386**	**5,480**
Air Conditioning Installation	47,345	42,593	44,673	45,282	49,120	51,330	53,046	54,378	55,586
Contractors Subtotal	**47,345**	**42,593**	**44,673**	**45,282**	**49,120**	**51,330**	**53,046**	**54,378**	**55,586**
Grand Total	**181,429**	**161,195**	**169,127**	**176,965**	**188,039**	**194,334**	**195,762**	**203,145**	**205,158**

Table 2.2 summarizes historical growth rates of the major segments, divided into several distinct periods that illustrate recent macroeconomic cyclical patterns. From 1998 to 2002, this set of industries showed a slight decline (-0.3 percent per year), with the strongest growth being in repair and maintenance (3.4 percent per year). Manufacturing growth was slightly positive, while wholesalers and contractors both declined. This was the period of the "dot-com" recession. During this period, telecommunications and computing services recorded steep declines. However, other investment goods and household durables, such as heating and air-conditioning, also experienced contraction. The period 2002 to 2008 showed fairly healthy growth, averaging 3.3 percent per year, with wholesalers and contractors growing more strongly, at 3.6 percent per year. All major segments experienced a large decline from 2008 to 2009, during the Great Recession. Growth since then has returned to an average of 3.4 percent per year, similar

[5] Appendix A.1 describes the derivation of these data in more detail.

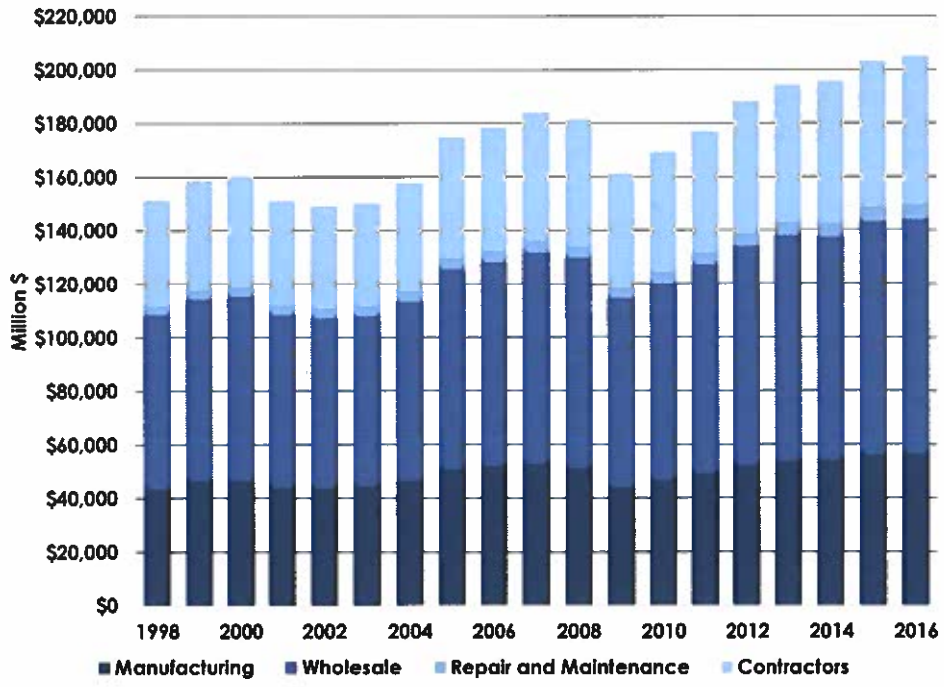
to that of the 2002 to 2008 period. Average growth for the combined set of industry segments from 1998 to 2016 was 1.7 percent per year. The fastest growing segment was repair and maintenance, at 2.8 percent per year.

Table 2.2 Shipments/Receipts Growth
Units: Average Annual Percent Change

	1998-2002	2002-2008	2008-2009	2009-2016	1998-2016
Manufacturing	0.2	2.6	-15.0	3.6	1.5
Wholesale	-0.7	3.6	-10.6	3.0	1.6
Repair and Maintenance	3.4	2.3	-11.8	5.1	2.8
Contractors	-0.7	3.6	-10.6	3.8	1.9
Total	-0.3	3.3	-11.8	3.4	1.7

Figure 2.1 illustrates the historical data in table 2.1. This graph shows clearly the large declines in shipments in 2008 and 2009, and the 7 years of expansion following 2009.

Figure 2.1 Value of Shipments/Receipts
Units: Million $



2.3.2 Employment

Total employment in the combined set of industry segments declined steadily between 2000 and 2010. The biggest drops in employment occurred in 2001 and 2009, both recession years. Since 2009, steady productivity growth has resulted in employment increasing more slowly than shipments. Employment in wholesale and repair maintenance has been flat. Table 2.3 shows historical data on employment by detailed

industry segment. The number of jobs in all years is still lower than that in 2008 for all segments except for contractors. Within manufacturing, the largest employment is found within refrigeration and air-conditioning equipment, at 75,900 jobs in 2016. Employment in motor vehicle air-conditioning (15,800) and home appliances (refrigerators, freezers, and water heaters) (16,700) were also significant in 2016. Total employment in all industry segments was about 589,100 in 2016.

Table 2.3 Employment
Units: Thousand Employees

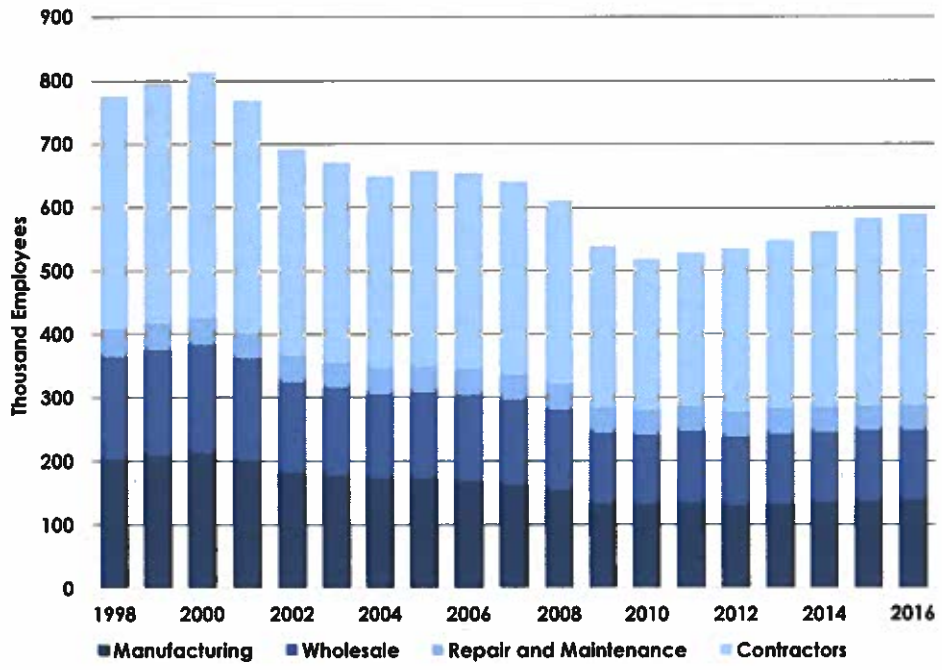
	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fluorocarbon Mfg	2.6	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.9
Refrig. & AC Equip	86.9	76.8	75.2	77.8	74.2	75.4	76.0	76.4	75.9
Home Appliances	20.3	16.7	17.0	15.5	14.4	15.2	15.6	16.2	16.7
Motor Vehicle Air Conditioning	14.8	11.4	11.4	12.2	13.2	13.7	14.5	15.3	15.8
Polystyrene Foam	6.9	5.8	5.8	5.8	5.9	5.9	5.9	6.1	6.3
Polyurethane Foam	9.7	8.1	8.0	8.1	8.2	8.2	8.2	8.5	8.8
Medical - MDIs	6.3	5.6	5.4	5.6	5.4	5.4	5.5	5.5	5.5
Aerosols	3.9	3.4	3.4	3.5	3.3	3.4	3.4	3.4	3.4
Fluoropolymers and Process Agents	3.5	3.1	3.0	3.1	3.0	3.0	3.1	3.1	3.1
Manufacturing Subtotal	**154.9**	**133.3**	**131.6**	**134.2**	**130.0**	**132.6**	**134.6**	**137.0**	**138.4**
Household Appliances Wholesalers	11.9	10.5	10.3	10.7	10.2	10.3	10.4	10.5	10.4
Heating and AC equipment Wholesalers	78.0	69.0	67.5	69.9	66.6	67.7	68.2	68.6	68.1
Refrig. Equip. Wholesalers	36.2	32.0	31.3	32.4	30.9	31.4	31.7	31.8	31.6
Wholesale Subtotal	**126.1**	**111.5**	**109.1**	**113.0**	**107.7**	**109.4**	**110.3**	**110.9**	**110.2**
Auto Heating, AC, Radiator Repair	27.2	25.5	24.6	25.3	25.0	25.3	24.3	24.7	23.7
Commercial Refrig. Equip Repair	9.0	8.6	8.7	8.0	9.0	8.7	9.1	8.2	9.3
Appliances & Household Equip. Repair	5.1	5.3	5.3	5.1	5.3	5.7	5.6	5.6	5.6
Repair and Maintenance Subtotal	**41.3**	**39.5**	**38.6**	**38.5**	**39.3**	**39.6**	**39.0**	**38.6**	**38.6**
Air Conditioning Installation	287.5	254.2	238.8	242.3	257.5	265.8	277.4	295.1	301.9
Contractors Subtotal	**287.5**	**254.2**	**238.8**	**242.3**	**257.5**	**265.8**	**277.4**	**295.1**	**301.9**
Grand Total	**609.8**	**538.5**	**518.0**	**527.9**	**534.5**	**547.4**	**561.3**	**581.6**	**589.1**

Table 2.4 summarizes historical growth rates of employment in the major industry segments, for the same periods as in table 2.2. From 1998 to 2002, employment in this set of industries declined at an average rate of 2.9 percent per year. The period 2002 to 2008 was characterized by strong labor productivity growth, so total employment declined at 2.1 percent per year on average, while shipments were increasing at 3.3 percent per year. Employment declined slightly more than shipments from 2008 to 2009, falling 12.4 percent. Since 2009, total employment increased every year, albeit by a mild rate of 1.3 percent annually. This growth was made possible by strong expansion of contractor jobs, which increased by 2.5 percent per year between 2009 and 2016. Recent employment gains could not overcome the effects of recession era losses and productivity growth. Consequently, combined employment slipped by an average of 1.5 percent per year between 1998 and 2016. Figure 2.2 shows the same data in stacked bar format.

Table 2.4 Employment Growth
Units: Average Annual Percent Change

	1998-2002	2002-2008	2008-2009	2009-2016	1998-2016
Manufacturing	-2.8	-2.7	-15.0	0.5	-2.1
Wholesale	-3.0	-2.1	-12.3	-0.2	-2.1
Repair and Maintenance	-1.2	-0.1	-4.5	0.3	-0.7
Contractors	-3.0	-2.1	-12.3	2.5	-1.1
Total	-2.9	-2.1	-12.4	1.3	-1.5

Figure 2.2 Employment
Units: Thousand Employees



2.4 Indirect and Induced Impacts

2.4.1 Definition of Indirect and Induced Impacts

The impact of fluorocarbon-related manufacturing, wholesaling, repair and maintenance, and contracting extends beyond the direct economic impacts as measured by the products and industries described above. In this analysis, the domestic production of the main industry segments is our starting point, which is called the *direct output*. This activity does not exist in isolation. Instead, it generates demand for goods and services from supplier industries. These supplier industries, in turn, generate demand from their supplier industries. All of the output generated beyond the *direct output* is called the *indirect output*. In addition to the direct and indirect impacts, we calculate *induced output*. This represents the additional demand generated by the disposable income earned in the industry (this may be both wage income and capital income).

To calculate these impacts, we use the Inforum *Iliad* model. *Iliad* maintains detail on 352 industries comprising the U.S. economy. It is based on detailed input-output (IO) tables maintained and updated by Inforum. It shows the interrelationships between industries and GDP in two ways:

1. *Demand Side*. Total output of each industry is sold to other industries or to final demand. Final demand consists of personal consumption, equipment investment, structures investment, intellectual property investment, government purchases, and exports less imports. The demand side of the model is used to determine how changes in final demand ultimately affect the production generated by each industry.
2. *Supply Side*. Total output of each industry is also shown according to the supplying industries, and the amount of value added generated by that industry. Value added consists of labor compensation, capital income, and indirect taxes. The supply side of the model is used to trace back the indirect output, employment, and other measures that contribute to production in a given industry. This is also known as *upstream analysis*.

2.4.2 Results for Manufacturing

The set of manufacturing industries shown in table 2.1 map to portions of several *Iliad* manufacturing industries. Direct output for each manufacturing industry was calculated and provided to the model to calculate employment and other variables, as well as to calculate the indirect and induced output. Total direct output of all manufacturing sectors was $56,712 million in 2016, as shown in the top left corner of table 2.5. Direct employment associated with this output was 138,000 jobs. Value added is about half of total output, or $23,787 million. The labor income portion of that value added was $12,346 million. Purchases from upstream suppliers generated an additional $47,406 million in output, 153,000 jobs, $23,632 million in value added and $12,920 million in labor income.

To calculate induced impacts, we start with the income earned from direct and indirect production. The *Iliad* model then calculates the amount of consumption expenditures that would result from this income, and what types of goods and services are purchased by those expenditures. Induced jobs, value added, and labor compensation then

correspond to this additional induced output. The induced results are shown in the third row of table 2.5. The total of direct, indirect, and induced impacts is shown in the last row of table 2.5.

Table 2.5 Direct, Indirect, and Induced Effects for Manufacturing Industries, 2016
Units: Million $

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	56,712	138	23,787	12,346
Indirect	47,406	153	23,632	12,920
Induced	73,711	380	43,449	21,788
Total	177,828	671	90,868	47,054

2.4.3 Results for Downstream Industries

The downstream industries in the fluorocarbon network consist of wholesale distributors, maintenance and repair, and contractors. To calculate the downstream footprint, we use a portion of the Iliad industries corresponding to wholesale distribution, maintenance and repair, and installation of HVAC and related equipment. Total direct output of these industries was $148,446 million in 2016, with total employment of 451,000, total value added of $100,271 million, and total labor income of $26,837 million. Indirect and induced impacts are calculated similarly to the procedure used for manufacturing. Total direct, indirect, and induced footprint is shown in the last line of table 2.6. Total combined downstream output is $443,920 million, and this is associated with 1,874,000 jobs.

Table 2.6 Direct, Indirect, and Induced Effects for Downstream Industries, 2016
Units: Million $

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	148,446	451	100,271	26,837
Indirect	79,073	341	44,592	23,396
Induced	216,400	1,083	128,003	59,811
Total	443,920	1,874	272,865	110,044

2.4.4 Results for Manufacturing and Downstream Combined

Table 2.7 summarizes the results of the previous two tables and shows the combined footprint of manufacturing and downstream industries. Total direct output in 2016 is $205,158 million, and the total employment is 589,000 workers. After including indirect and induced impacts, the total output figure is $621,748 million, with 2,546,000 jobs, $363,732 million in value added, and $157,098 million in payroll.

Table 2.7 Combined Footprint of Manufacturing and Downstream Industries, 2016
Units: Million $

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	205,158	589	124,057	39,183
Indirect	126,479	494	68,224	36,316
Induced	290,111	1,463	171,451	81,599
Total	621,748	2,546	363,732	157,098

3. World Trade Summary

The impacts of Kigali ratification are expected to come in large part from the effects on U.S. exports and imports. As with the markets for many manufacturing industries, the market for HVACR and related equipment is international. Most of the largest producer companies are multinationals. Even when they are headquartered in the U.S., companies typically have manufacturing facilities in many parts of the world.

3.1 Current US Imports and Exports

U.S. exports and imports by NAICS classification are identified in the U.S. Census Bureau's USA Trade database, which is also available classified by Harmonized System (HS) code.[6] These data are used by Inforum, in combination with BEA benchmark and annual input-output tables, to produce the series of current and constant price data used in the Inforum *Iliad* 352-sector model.

Bilateral trade by country is also available from the United Nations' Comtrade database.[7] Comtrade is not available in the NAICS classification. For this project, we have compiled imports and exports by trading partner based on the HS classification.

3.1.1 Fluorocarbons

Total U.S. production of fluorocarbons was just under 400,000 metric tons in 2016. Total production consists of HCFCs, HFCs, HFOs, and HFO blends. Production of HCFCs is being phased out. HFCs, which replace CFCs and HCFCs, do not contain chlorine and/or bromine and do not deplete the ozone layer. However, they have high global warming potential (GWP) and thus are considered greenhouse gases. The extent to which some HFCs, particularly HFC-134a, contribute to global warming has become the subject of significant environmental concern.

Many experts working in the industry predict that adoption of the Kigali Amendment will accelerate innovation and technology development, which should result in an HFC phasedown of about 40 percent by 2024 and double-digit growth of HFOs over the next five years. Some developing countries may leapfrog directly to such HFOs as HFO-1234yf,

[6] These data can be accessed at https://usatrade.census.gov/.
[7] UN Comtrade can be accessed at https://comtrade.un.org/.

which is used in mobile air-conditioning. U.S. companies hold significant patents in the production of HFOs. Adoption of Kigali will not only prevent dumping of old-technology foreign HFC products into the U.S. market, it should also enable the U.S. to expand its market of advanced HFO production considerably. Table 3.1 shows a summary of our preliminary estimates of exports in 2027 with and without Kigali ratification. The biggest change is in the exports of HFOs (+$550 million) although there is also a significant increase in HFO Blends (+$200 million) and HFCs (+$188 million). The total increase in exports is nearly $1 billion[8].

Table 3.1 Estimate of Increased Exports with Kigali Ratification
Units: Million $

Exports	HCFC	HFC	HFO	HFO Blend	Total Exports
2016	29.4	450.0	50.0	0.0	529.4
2027 (without Kigali)	29.4	462.0	300.0	400.0	1,191.4
2027 (with Kigali)	29.4	650.0	850.0	600.0	2,129.4
2027 Difference	0.0	188.0	550.0	200.0	938.0

3.1.2 Air-conditioning and Refrigeration Equipment

Bilateral trade data between the U.S. and its trading partners have been compiled for the following three HS codes for this study. The name in quotes at the end of each line is the title that will be used in the tables and charts that follow:

- 84143: Compressors used in refrigeration equipment ("Compressors")
- 8415: Air conditioners (including motor vehicle AC) ("AC")
- 8418: Refrigerators, freezers, and other refrigerating or freezing equipment ("Refrigeration")

Table 3.2 shows the breakdown of imports of these groups of products, ranked by country of origin, in 2016.

[8] Projections were developed using detailed information from Zhang, et. al (2017), and in consultation with industry experts. However, since the detailed projections are proprietary, only the aggregate figures are given here.

Table 3.2 Top Sources of Imports for HVACR and Related Equipment, 2016
Units: Million $

Compressors			AC			Refrigeration		
Rank	Partner	Imports (Mil $)	Rank	Partner	Imports (Mil $)	Rank	Partner	Imports (Mil $)
	World	2,123		World	7,288		World	8,723
1	Mexico	595	1	Mexico	3,138	1	Mexico	4,269
2	China	365	2	China	2,465	2	China	2,007
3	Japan	322	3	Canada	412	3	South Korea	1,236
4	South Korea	296	4	Thailand	340	4	Canada	274
5	Thailand	127	5	South Korea	325	5	Italy	180
6	Brazil	92	6	Japan	254	6	Turkey	172
7	Germany	69	7	United Kingdom	42	7	Japan	95
8	Slovakia	52	8	France	32	8	Germany	65
9	Hungary	39	9	Germany	31	9	Thailand	49
10	Singapore	37	10	Italy	30	10	Austria	44

Source: UN Comtrade data for 2016. Note that estimates include figures for home freezers and refrigerators, water heaters and motor vehicle air-conditioners.

The top source of imports for all three product groups is Mexico. Undoubtedly, much of these imports are production by firms also operating in the U.S., and conducting process trade in Mexico. The second largest source of imports for all three products is China, which is the largest exporter, as we will see in the next section. South Korea, Japan, Canada, and Thailand are also important sources of imports.

Figure 3.1 shows the sources of imports of all three sectors combined. Mexico is by far the largest source of imports, at about $8 billion in 2016. The next two largest sources are China ($4.8 billion) and South Korea ($1.9 billion). Canada, Japan, Thailand, and Italy are also important sources. Other countries make up the remaining $1.3 billion of imports. Total imports were just over $18 billion in 2016.

Figure 3.1 Top Source Countries for Total Imports of HVACR and Related Equipment, 2016
Units: Millions of Dollars

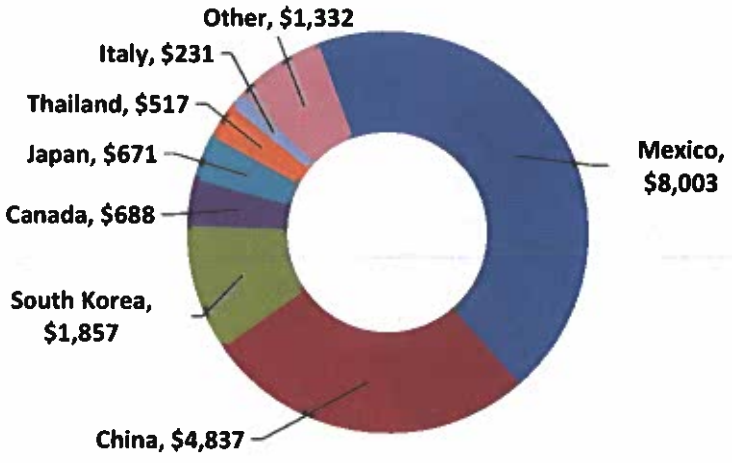


Table 3.3 Top Destinations for U.S. Exports of HVACR and Related Equipment, 2016
Units: Millions of Dollars

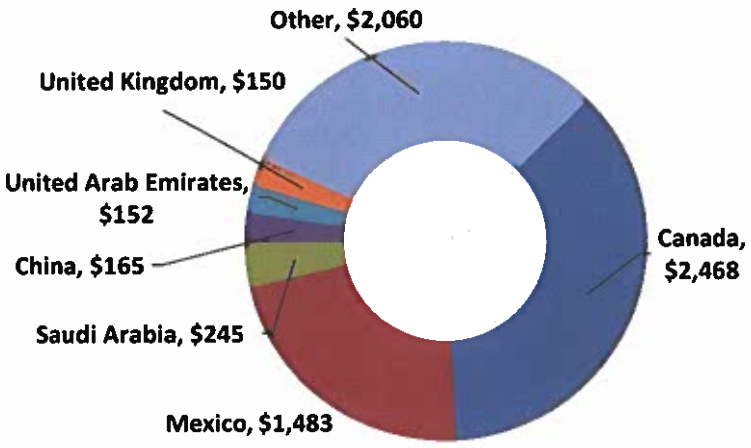
Compressors			AC			Refrigeration		
Rank	Partner	Exports (Mil $)	Rank	Partner	Exports (Mil $)	Rank	Partner	Exports (Mil $)
	World	1,298		World	2,729		World	2,697
1	Mexico	425	1	Canada	1,202	1	Canada	960
2	Canada	306	2	Mexico	554	2	Mexico	504
3	Saudi Arabia	60	3	United Arab Emirates	82	3	Saudi Arabia	118
4	South Korea	59	4	Saudi Arabia	67	4	China	87
5	China	36	5	United Kingdom	62	5	United Kingdom	74
6	United Arab Emirates	36	6	Brazil	42	6	Germany	64
7	France	35	7	China	42	7	Australia	54
8	Brazil	33	8	Panama	38	8	South Korea	49
9	Germany	31	9	Colombia	33	9	Other Asia, nes	44
10	Netherlands	26	10	Rep. of Korea	30	10	Japan	41

Source: UN Comtrade data for 2016. Note that estimates include figures for home freezers and refrigerators, water heaters and motor vehicle air-conditioners.

Table 3.3 is similar to table 3.2, but shows destinations for U.S. exports of HVACR and related equipment. The two largest destinations for all three product segments were Mexico and Canada. Again, these may not represent the ultimate markets for the equipment, but may represent a step in process trade, so we don't have full visibility on the ultimate market for this production. The other importing countries are relatively small. The largest of these are Saudi Arabia, the UK, China, and United Arab Emirates.

Figure 3.2 shows the distribution of exports of the combined market segments, which were about $6.8 billion in 2016.

Figure 3.2 Top Destination Countries for Total U.S. Exports of HVACR and Related Equipment, 2016
Units: Millions of Dollars



3.2 The World Export Market

To better understand what changes may occur to U.S. imports and exports with and without Kigali ratification, it is also helpful to understand the world export market.

3.2.1 Fluorocarbons

As shown in table 3.4, the top fluorocarbon exporting country in 2016 was China, followed by the U.S. and the Netherlands.

Table 3.4 Top Fluorocarbon Exporting Countries, 2016
Units: Millions of Dollars

Rank	Country	Export Value
1	China	668.4
2	USA	298.1
3	Netherlands	154.9
4	Belgium	115.3
5	Japan	111.5
6	France	85.6
7	Germany	58.1
8	India	50.7
9	Malaysia	28.8
10	United Kingdom	24.9
	Total	1,755.2

Source: UN Comtrade data for 2016.

This table does not differentiate between HFCs, HCFCs and HFOs[9]. The U.S. and China both have excess capacity and could increase their exports significantly.

3.2.2 Air-conditioning and Refrigeration Equipment

According to UN Comtrade data, the total world export market for HVACR and related equipment was about $94.9 billion in 2016. Currently, China has more than 25 percent of this total market, and the U.S. has about 7.2 percent. Table 3.5 shows the current distribution of exports by exporting country for the three major market segments identifiable in the Comtrade data. The U.S. is the second largest exporter of Compressors and holds fourth place for both Air-conditioning and Refrigeration. China's biggest lead is in the export market for Air-conditioning.

[9] The concordance used to extract these data from UN Comtrade is shown in Table A.6.

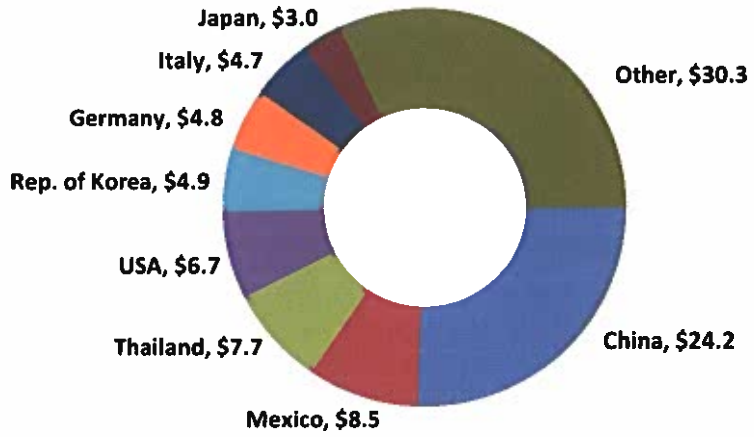
Table 3.5 Summary of World Export Market for HVACR and Related Equipment, 2016
Units: Millions of Dollars

Compressors			AC			Refrigeration		
Rank	Exporting Country	Exports (Mil $)	Rank	Exporting Country	Exports (Mil $)	Rank	Exporting Country	Exports (Mil $)
	World	**13,414**		**World**	**41,423**		**World**	**40,078**
1	China	3,210	1	China	13,121	1	China	7,909
2	USA	1,298	2	Thailand	4,845	2	Mexico	4,694
3	Japan	1,267	3	Mexico	3,126	3	Italy	3,017
4	Thailand	955	4	USA	2,729	4	USA	2,697
5	Germany	946	5	Czechia	1,833	5	South Korea	2,620
6	South Korea	876	6	Germany	1,615	6	Germany	2,254
7	Mexico	713	7	Italy	1,445	7	Thailand	1,872
8	France	562	8	South Korea	1,367	8	Turkey	1,740
9	Brazil	403	9	Malaysia	1,332	9	France	1,392
10	Singapore	383	10	Japan	1,228	10	Poland	1,048

Source: UN Comtrade data for 2016. Note that estimates include figures for home freezers and refrigerators, water heaters and motor vehicle air-conditioners.

Figure 3.3 shows the world export share for the top exports of all three product segments.

Figure 3.3 Top HVACR and Related Equipment Exporting Countries, 2016
Units: Billions of Dollars



3.3 World Market Outlook

We expect the overall world market to grow at about 6 percent annually for the next decade, which implies that the market will nearly double in 10 years.[10] The export market alone will amount to $200 billion.

Growth is expected to be particularly strong in developing regions, such as India, Africa, Other Asia, the Middle East, and Latin America. Market growth in the mature economies, which include North America, OECD countries, and Japan, is expected to be less than 2 percent per year.

4. Scenario Analysis

This scenario analysis looks at two possible paths that the economy may take, either with or without Kigali ratification. We examine the economic implications that may derive from differences in trading patterns, technology, or demand.

In order to evaluate the potential economic impact of the HFC phase-down scheme with and without Kigali Amendment ratification, we used the Inforum *Iliad* model. This model enables the evaluation of impacts at a detailed industry level.[11] Output (production) in each industry is determined by demands from consumers, investment, government, net exports, and other business sectors. The model also forecasts jobs, value added, and labor compensation by sector.

4.1 Framing of the Analysis and Assumptions

To frame the analysis, a scenario was constructed using the *Iliad* model combined with informed opinions from industry experts. This "without Kigali" scenario represents the expected development of the markets assuming the U.S. does not ratify Kigali. An alternative scenario was constructed to represent the expected development of the U.S. economy with Kigali ratification. The horizon of these two scenarios is from 2018 to 2027. The driving factors of this analysis were the impacts of regulatory certainty and a clear transition schedule on U.S. global competitiveness and the resulting effects on imports and exports. For this analysis, we consider only changes in the HVACR equipment market.[12]

Ratifying the Kigali Amendment would bolster regulatory stability and provide clear long-term market signals. This certainty will help domestic firms allocate resources and compete in the global market. Consequently, the "with Kigali" scenario assumes a 2 percent increase in the United States' share of the world HVACR equipment export

[10] It is helpful to remember the "rule of 70" in exponential growth. Divide 70 by the average growth rate, and that will tell you how many years it takes to double.
[11] The *Iliad* model database includes data for 352 industrial sectors, and currently has annual historical data through 2016.
[12] However, as described above, figures are shown for the combined HVACR and related equipment industry segment.

market in 2027. Additionally, it assumes a 10 percent reduction in the United States' HVACR imports by 2027.

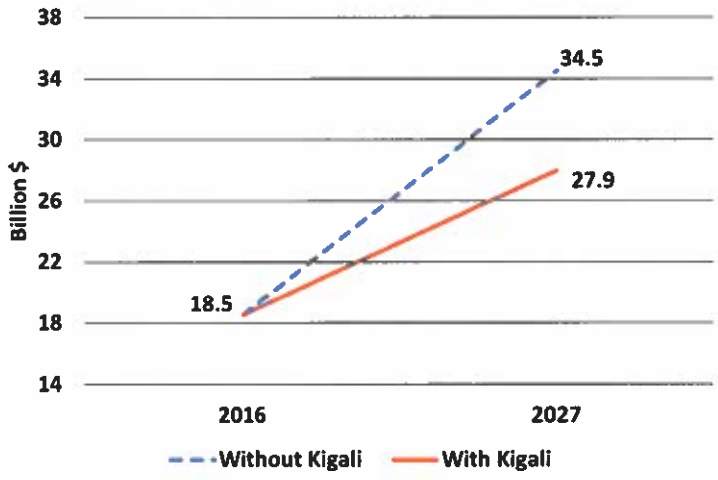
Imports are driven by the level of domestic demand, and the share of demand satisfied by imports. Domestic demand of the total of these four segments has grown from $28.3 billion in 1997 to $52.1 billion in 2016, an average growth rate of 3.2 percent.

Table 4.1 Domestic Demand and Imports of HVACR and Related Equipment
Units: Millions of Dollars & Percent Share

Year	Domestic Demand	Import Share	Total Imports
1997	28,300	12.0%	3,388
2000	34,232	14.8%	5,071
2005	40,747	22.2%	9,037
2010	39,269	30.0%	11,775
2015	51,265	35.3%	18,120
2016	52,137	35.5%	18,523
2027 (without)	76,195	45.2%	34,456
2027 (with)	76,195	36.7%	27,946

However, the share of demand satisfied by imports has tripled during this period, increasing from 12 percent in 1997 to 35.5 percent in 2016. Our baseline scenario (without Kigali ratification) calls for a continued increase in this import share, reaching 45.2 percent by 2027. Domestic demand is projected to grow to $76.2 billion, so that total imports in this scenario will reach $34.5 billion. Conversations with industry economists and responses to a questionnaire[13] led to the conclusion that U.S. ratification of Kigali could reduce the incursion of imports, perhaps by as much as a 10 percent share of demand. In the "with Kigali ratification" scenario, we let the import share grow only slightly, to 36.7 percent. Imports still increase, but to $27.9 billion instead of $34.5 billion (see figure 4.1).

Figure 4.1 HVACR and Related Equipment Imports: With and Without Kigali Ratification



[13] See Appendix A.4.

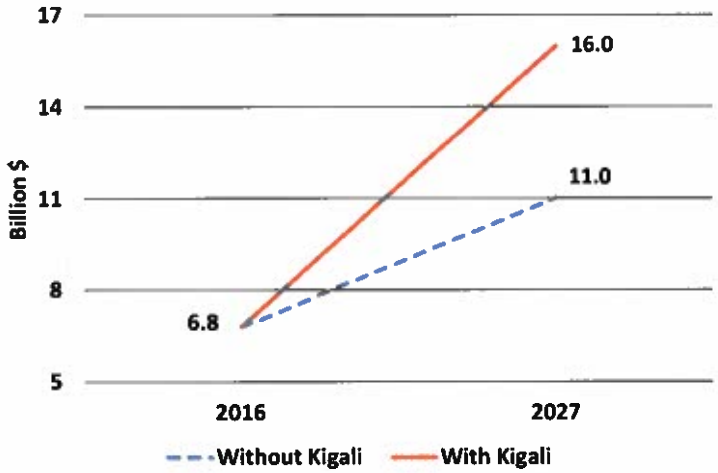
Exports are driven by the growth of the world market, and the U.S. share of that market. The global HVACR and related equipment market is expected to grow at slightly less than 6 percent per year over the next decade, primarily in markets such as China, India, Latin America, and Africa. Urbanization and the demand for comfort are growing. Many of these countries are reaching the point where their middle class can afford refrigeration and air-conditioning. Consequently, the demand for HVACR and related products is expected to almost double over the next decade.

Recently, other global exporters have made inroads in the world market share with less efficient, older technologies that would be limited under the Kigali agreement. Without Kigali ratification, we expect this trend to continue. Our estimates indicate that the world market for HVACR and related equipment in 2016 was about $94.9 billion. We project a market total of $177.7 billion by 2027. The U.S. share of this market in 2016 was about 7.2 percent, resulting in exports of about $6.8 billion. Without Kigali ratification, we expect a decline in world market share of about 1 percent, declining to 6.2 percent. This results in a projected figure for U.S. exports of HVACR and related equipment of $11 billion by 2027. With Kigali ratification, we have projected the world market share to increase to 9.0 percent, resulting in U.S. HVACR and related equipment exports of about $16.0 billion, as shown in figure 4.2.

By 2027, the combination of higher exports and lower imports in the Kigali ratification scenario results in an increase of U.S. net exports of HVACR and related equipment of about $11.5 billion, compared to not ratifying.

Based on interviews with industry economists, we have also assumed that U.S. net exports of fluorocarbons will be about $1 billion higher by 2027 in the scenario with Kigali ratification. The total increase in net exports is the sum of HVACR equipment and fluorocarbons, or about $12.5 billion.

Figure 4.2 HVACR and Related Equipment Exports: With and Without Kigali Ratification



4.2 Impact Analysis

Although some of the most important differences between the two scenarios are net exports of the HVACR and related equipment producing industries, we also show total results below for all of the manufacturing segments discussed in section 2.2. These include fluorocarbons, foam, HVACR equipment, vapor-compression home appliances, mobile air-conditioners, medical MDIs, aerosols, and fluoropolymers and process agents. We call this group of industries the "fluorocarbon-related manufacturing industries".

The *Iliad* model was used to calculate direct impacts on output, employment, value added, and payroll, based on the two scenarios. Tables 4.2 to 4.4 show the estimates for 2016, the estimates for 2027 without Kigali, and the estimates for 2027 with Kigali.

From direct output, estimates of indirect (upstream) output were calculated using the input-output solution. This includes purchases from the industries that directly supply goods and services to the fluorocarbon industries, as well as the suppliers upstream from those industries. Employment, value added, and labor compensation associated with this indirect output were also calculated. Indirect output and other variables are shown in the second line of each table below.

Finally, induced output, employment, value added, and labor compensation are calculated by estimating the consumer spending by those employed either directly or indirectly by fluorocarbon-related manufacturing industries. This is shown in line 3 of each table.

Table 4.2 Manufacturing Summary - 2016

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	56,712	138	23,787	12,346
Indirect	47,406	153	23,632	12,920
Induced	73,711	380	43,449	21,788
Total	177,828	671	90,868	47,054

For example, table 4.2 shows that direct output of the fluorocarbon-related manufacturing industries amounted to $56.7 billion in 2016. Total direct employment was 138,000, with value added of $23.8 billion and labor income of $12.3 billion. After including indirect and induced spending, total output is $177.8 billion, with total employment of 671,000 workers and value added of $90.9 billion, and labor income of $47.1 billion.

Table 4.3 Manufacturing Summary – 2027, Without Kigali Ratification

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	**84,001**	**195**	**37,004**	**17,792**
Indirect	**68,631**	**221**	**34,283**	**18,800**
Induced	**106,754**	**550**	**62,927**	**31,555**
Total	**259,387**	**966**	**134,214**	**68,148**

By 2027, without ratification, we estimate the same table for the fluorocarbon-related manufacturing industries as shown in table 4.3. The results with ratification are shown in table 4.4.

Table 4.4 Manufacturing Summary – 2027, With Kigali Ratification

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	**96,475**	**228**	**41,968**	**20,756**
Indirect	**78,445**	**253**	**39,292**	**21,501**
Induced	**123,280**	**635**	**72,667**	**36,440**
Total	**298,200**	**1,117**	**153,927**	**78,697**

The increase in net exports with Kigali ratification leads to an increase in direct output of $12.5 billion by 2027 (Kigali compared to without Kigali), which generates an additional 33,000 jobs. This is associated with an increase of $5.0 billion in value added and $3.0 billion in additional labor income.

Total direct, indirect, and induced impacts due to improvements in manufacturing net exports are: $38.8 billion increase in domestic output, 150,000 increase in jobs, $19.7 billion increase in value added (GDP), and a $10.5 billion increase in labor income. These differences are for 2027.

In addition to the manufacturing impacts, there are important impacts in the downstream industries. These include Wholesale trade, Maintenance and Repair, and Contractor activities. The specific industries of interest and their NAICS codes are shown in Table 4.5.

Table 4.5 Downstream Industries

Wholesalers	
423620	Household appliances, electric housewares, and consumer electronics merchant wholesalers
423730	Warm air heating and air-conditioning equipment and supplies merchant wholesalers
423740	Refrigeration equipment and supplies merchant wholesalers
Repair and Maintenance	
811198	Heating, air conditioning, and radiator system repair services for cars and light trucks
811310	Maintenance and Repair - Commercial refrigeration equipment
811412	Maintenance and Repair - Appliances and household equipment
Contractors	
238220	Air Conditioning Installation

Table 4.6 shows the summary of direct, indirect, and induced impacts from these industries for 2016.

Table 4.6 Downstream Summary – 2016

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	**148,446**	**451**	**100,271**	**26,837**
Indirect	**79,073**	**341**	**44,592**	**23,396**
Induced	**216,400**	**1,083**	**128,003**	**59,811**
Total	**443,920**	**1,874**	**272,865**	**110,044**

Total output of the downstream industries in 2016 is $148.4 billion, generating 451,000 jobs, $100.3 billion of value added (GDP), and $26.8 billion in labor income. Although there are many more jobs created in these industries than in manufacturing, the average salaries and value added per job are lower than in manufacturing. There are more than three times as many jobs in downstream activities, but labor income is only about 25 percent higher.

Table 4.7 shows the projection of the downstream direct, indirect, and induced impacts for 2027.

Table 4.7 Downstream Summary – 2027

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	**216,945**	**659**	**146,539**	**39,220**
Indirect	**115,561**	**498**	**65,168**	**34,191**
Induced	**316,255**	**1,583**	**187,068**	**87,410**
Total	**648,761**	**2,739**	**398,775**	**160,822**

Finally, Tables 4.8, 4.9, and 4.10 show the combined (manufacturing plus downstream) summary for 2016, and for 2027 with and without Kigali ratification.

Table 4.8 Combined Summary – 2016

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	**205,158**	**589**	**124,057**	**39,183**
Indirect	**126,479**	**494**	**68,224**	**36,316**
Induced	**290,111**	**1,463**	**171,451**	**81,599**
Total	**621,748**	**2,546**	**363,732**	**157,098**

Table 4.9 Combined Summary – 2027, Without Kigali

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	**300,947**	**854**	**183,543**	**57,013**
Indirect	**184,192**	**719**	**99,451**	**52,992**
Induced	**423,010**	**2,133**	**249,994**	**118,966**
Total	**908,149**	**3,706**	**532,989**	**228,970**

Table 4.10 Combined Summary – 2027, With Kigali

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	**313,420**	**887**	**188,507**	**59,977**
Indirect	**194,006**	**751**	**104,460**	**55,692**
Induced	**439,535**	**2,218**	**259,735**	**123,850**
Total	**946,961**	**3,856**	**552,702**	**239,519**

5. *Summary and Main Findings*

In this study we present an economic analysis of the current footprint of the industries that are dependent on the production of fluorocarbons, which is called the fluorocarbon network. We also perform a scenario analysis comparing two states of the world in 2027, with and without the ratification of the Kigali Amendment by the U.S.

The current economic footprint of the focus industries consists of the output, jobs, value added, and payroll of fluorocarbon-related manufacturing industries, wholesale distribution, repair and maintenance, and contractor installation and service of equipment.

The manufacturing industries include fluorocarbons and other refrigerants, refrigeration and air-conditioning equipment, household refrigerators and home freezers, water heaters, mobile air-conditioners, polystyrene and polyurethane foam, medical MDIs, aerosols, and fluoropolymers and process agents. Total direct output of these industries in 2016 is calculated to be $56.7 billion, generating employment of 138,000 jobs (table 4.2). Associated with this direct output is value added of $23.8 billion and $12.3 billion of labor income.

The wholesale, repair and maintenance, and contractor industries owe their existence to the fluorocarbon, refrigerant, and equipment industries. Considered as a whole, they are called the downstream industries. Total direct output of these industries in 2016 came to

$148.4 billion, generating employment of 451,000 jobs (table 4.6). Downstream value added amounts to $100.3 billion, with labor income of $26.8 billion.

The impact of the HFCs, air-conditioning and refrigeration equipment, and related industries certainly extends beyond the direct economic impacts as measured by the products and industries described above. In this analysis, the domestic production of the main industry segments is our starting point, which is called the *direct output*. This activity does not exist in isolation. Instead, it generates demand for supplier industries. These supplier industries in turn generate demand for their supplier industries. All of the output generated beyond the *direct output* is called the *indirect output*. In addition to the direct and indirect impacts, we calculate *induced output*. This represents the additional demand generated by the disposable income earned in the industry (this may be both wage income and capital income).

Combining the manufacturing and downstream industries, and considering direct, indirect, and induced economic activity, we reach the results shown in table 5.1[14].

Table 5.1 Combined Footprint of Manufacturing and Downstream Industries, 2016
Units: Million $

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	205,158	589	124,057	39,183
Indirect	126,479	494	68,224	36,316
Induced	290,111	1,463	171,451	81,599
Total	621,748	2,546	363,732	157,098

Think of the results shown in this table as the *total economic activity* associated with the network of industries related to fluorocarbon and refrigerant production. Total economic activity as measured here translates into $621.7 billion of output, 2.5 million jobs, $363.7 billion of value added, and $157.1 billion of labor income.

The analysis of the economic impact of Kigali ratification was done by specifying two scenarios. The first, "without Kigali" scenario, is consistent with a policy of the U.S. failing to ratify the Kigali Amendment. In this scenario, although U.S. exports continue to increase, the share of U.S. exports in world trade is projected to decline from 7.2 percent in 2016 to 6.2 percent in 2027. On the import side, without Kigali we project a continued encroachment of imports into the domestic market. The import share of domestic demand has already increased from 12 percent in 1997 to 35.5 percent in 2016. In the "without Kigali" scenario, we project a continued increase in import share to 45.2 percent by 2027.

With Kigali ratification, industry experts agree that the continued rise of import share can be slowed or prevented. We have modeled this by letting the import share grow only slightly in this case. Note that imports continue to increase, but not as fast as in the "without Kigali" case. With Kigali ratification, we expect the U.S. export share to increase from 7.2 percent to 9.0 percent, driven by the relative strength of U.S. manufacturing plants in low-GWP fluorocarbons and the HVACR equipment that uses them.

[14] Shown earlier as table 2.7.

The net result is an additional $5.0 billion of U.S. HVACR equipment exports, and a reduction of $6.5 billion of HVACR equipment imports, for a combined increase of $11.5 billion. We also project a net improvement of $1 billion in net fluorocarbon exports, which brings the total effect to $12.5 billion.

An economic footprint analysis is performed on both scenarios for the year 2027. For the current analysis, we assume no changes in the downstream industries, but limit our focus to what happens in manufacturing. Tables 5.2 and 5.3 show the summaries for manufacturing with and without Kigali ratification in 2027.

Table 5.2 Manufacturing Summary – 2027, Without Kigali Ratification

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	**84,001**	**195**	**37,004**	**17,792**
Indirect	**68,631**	**221**	**34,283**	**18,800**
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Total	**259,387**	**966**	**134,214**	**68,148**

Table 5.3 Manufacturing Summary – 2027, With Kigali Ratification

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	**96,475**	**228**	**41,968**	**20,756**
Indirect	**78,445**	**253**	**39,292**	**21,501**
Induced	**123,280**	**635**	**72,667**	**36,440**
Total	**298,200**	**1,117**	**153,927**	**78,697**

With regard to direct effects, Kigali ratification results in an improvement of $12.4 billion in direct output, 33,000 jobs, $5.0 billion in value added, and $3.0 billion in labor income. The change in total economic activity is $38.8 billion in output, 150,000 jobs, $19.7 billion in value added, and $10.6 billion in labor income.

Table 5.4 Manufacturing Summary – 2027, Differences

	Output (Million $)	Employment (thousand persons)	Value Added (Million $)	Labor Income (Million $)
Direct	**12,474**	**33**	**4,964**	**2,964**
Indirect	**9,813**	**32**	**5,009**	**2,701**
Induced	**16,525**	**85**	**9,741**	**4,885**
Total	**38,812**	**150**	**19,713**	**10,549**

In addition to the impacts described above, ratification of Kigali would also affect R&D and reclaim activities.

Domestic manufacturers are already making investments in next-generation refrigerants and equipment. In 2015, Air-Conditioning, Heating, and Refrigeration Institute's (AHRI) member companies pledged $5 billion through 2025 in R&D and capital investment with the goal of commercializing high efficiency equipment using next-generation refrigerants. If Kigali is ratified, such investment would support 1,400 jobs and $1 billion in capital investment. However, these jobs and investment are in jeopardy if the U.S. government fails to act. Without ratification by the U.S., manufacturing and R&D for new technologies will move to the international markets where local demand for the new technologies justifies the investment.

Ratification of Kigali would also benefit the reclaimed refrigerants industry. Reclaim sales are projected to rise by roughly $0.8 billion per year with Kigali, supporting an additional 4,000 jobs. This activity, while currently small, would become an important part of servicing existing equipment.

Other impacts of Kigali ratification that we have not yet considered are known to be positive, but haven't yet been quantified. They include:

- Investment in U.S. manufacturing capacity would be higher
- Activity of downstream industries would likely be higher

The U.S. HVACR industry historically has been the global leader, building on a strong domestic base and expanding the use of new technology globally. The changes driven by the Montreal Protocol have strengthened and expanded that U.S. leadership. But now, the ratification of Kigali is crucial to continuing that pattern and maintaining U.S. leadership. Without Kigali ratification, growth opportunities will be lost along with the jobs to support that growth, the trade deficit will grow, and the U.S. share of global export markets will decline.

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Appendix A – Data Sources and Methodology

A.1 Data Sources

The Annual Dollar Volume of Goods and Services is determined for each industry by utilizing the data from the 2012 Economic Census sorted by product line, supplemented by industry expert input where necessary.

The payroll and employment figures for each industry are estimated by using the productivity figures derived from 2012 Economic Census data sorted by industry. It is assumed that companies citing that industry as primary are representative of productivity in production of that product line by all companies. That is, the Annual Payroll and Number of Employees are estimated by multiplying the annual dollar volume of shipments or sales of goods and services for a given product line by the corresponding industry productivity figures.

Payroll and employment figures thus assume that productivity measures are similar for all companies manufacturing a given product line, regardless of the company's reported primary industry. They also assume in some cases that productivity measured across a broad product line can be applied to all subcategories within that product line. Although these are both reasonable assumptions, they do imply that employment and payroll are somewhat more uncertain than sales of goods and services.

Table A-1 shows the segment summary of the industries in our focus group, which are divided into 1) Manufacturing; 2) Wholesalers; 3) Repair and Maintenance; and 4) Contractors.

Manufacturing data are derived from several tables of the 2012 *Census of Manufacturing*. Selected shipments data were used from the table EC1231SP1 - *Product Summary: Products or Services Statistics: 2012*[15]. This table has the most detailed breakdown available by Census NAICS Product code. However, in some cases, the products that we need to focus on for this study were at a finer level of detail than what is shown in that table. In these cases, the Census data were supplemented by informed estimates from industry experts or company representatives. This is the case for the following segments:

1. Other Refrigerants
2. Medical – MDIs
3. Aerosols
4. Fluoropolymers and Process Agents

Table A-2 shows selected rows of the *Product Summary* table that comprise the totals in table A-1.

The Product Summary does not include information on payroll or employment. To estimate these figures, we used the table EC1231SG1 – *Manufacturing Industry Summary Statistics*, which includes sales, payroll, employment, and several other pieces of

[15] Available from https://www2.census.gov/econ2012/EC/sector31/EC1231SP1.zip.

information by 6-digit NAICS code[16]. From these data we constructed ratios of employment and payroll to shipments which were applied to the sales estimates, to obtain the figures in the payroll and employment columns of table A-1.

Table A-1 Segment Summary, Based on the 2012 Economic Census

Parent NAICS Code	Segment	Value of Shipments / Receipts ($Million)	Estimated Annual Payroll (Census, $Million)	Estimated Paid Employees (Census, Thousands)
Manufacturing				
3251	Fluorocarbons and Other Refrigerants	1,754.1	163.3	2.3
333415	Refrigeration and Air Conditioning Equipment	25,272.9	3,200.5	71.0
3352	Home Appliances	5,705.3	692.9	13.8
336390	Motor Vehicle Air Conditioning	5,991.0	574.0	12.6
326140	Polystyrene Foam	2,009.7	221.0	5.6
326150	Polyurethane Foam	2,803.0	354.7	7.8
325412	Medical - MDIs	4,626.3	387.0	5.1
325998	Aerosols	1,504.7	164.6	3.2
	Fluoropolymers and Process Agents	2,774.8	173.4	2.9
	Manufacturing Subtotal	**52,441.8**	**5,931.5**	**124.3**
Wholesalers				
423620	Household appliances, electric housewares, and consumer electronics merchant wholesalers	21,086.7	658.8	10.2
423730	Warm air heating and air-conditioning equipment and supplies merchant wholesalers	45,212.4	4,214.0	66.6
423740	Refrigeration equipment and supplies merchant wholesalers	15,395.7	3,371.6	30.9
	Wholesale Subtotal	**81,694.9**	**8,244.4**	**107.7**
Repair and Maintenance				
811198	Heating, air conditioning, and radiator system repair services for cars and light trucks	2,720.9	757.9	25.0
811310	M&R - Commercial refrigeration equipment	1,456.7	440.7	9.0
811412	M&R: Appliances and Household Equipment	604.8	167.9	5.3
	Repair and Maintenance Subtotal	**4,782.4**	**1,366.5**	**39.3**
Contractors				
238220	Air Conditioning Installation	49,119.7	12,732.4	257.5
	TOTAL	**188,038.8**	**28,274.8**	**528.8**

[16] At https://www2.census.gov/econ2012/EC/sector31/EC1231SG1.zip.

Table A-2 Manufacturing Product Lines and Estimated Shipments

Segment	NAICS Product Line	Description	2012 Values	Total
Fluorocarbons and Other Refrigerants				
	325120G	Fluorocarbon gases	1,169,404	
	325199R	Other synthetic organic chemicals	212,909	(part, estimated)
	325199T	Miscellaneous end-use chemicals and chemical products, excluding urea	371,793	(part, estimated)
				1,754,106
Refrigeration and Air-Conditioning Equipment				
	3334152	Heat transfer equipment (excluding electrically operated dehumidifiers), mechanically refrigerated, self-contained, excluding motor vehicle mechanical air-conditioning systems	7,135,378	
	3334152193	Heat transfer factory-fabricated water cooling towers	166,918	Excluded
	3334152195	Other heat transfer equipment, including room air-induction units, mechanical refrigeration systems used on all types of vehicles, and absorption refrigeration and dehydration systems	1,228,204	Excluded
	3334153	Commercial refrigerators and related equipment	3,446,526	
	3334155	Refrigeration condensing units, all refrigerants, excluding ammonia (complete)	728,949	
	3334156	Room air conditioners and dehumidifiers, excluding portable dehumidifiers	395,814	
	3334159	All other miscellaneous refrigeration and air-conditioning equipment	962,825	
	3334159121	Evaporative air coolers	127,538	Excluded
	333415A	Compressors and compressor units, all refrigerants, excluding automotive	2,565,208	
	333415D	Parts and accessories for air-conditioning and heat transfer equipment	1,633,970	
	333415D181	Parts for warm air furnaces, including duct furnaces (excluding complete humidi	203,740	Excluded
	333415E	Unitary air conditioners, excluding air source heat pumps	6,192,293	
	333415F	Air-source heat pumps, excluding room air conditioners	1,797,099	
	333415G	Ground and ground water source heat pumps (single and split systems)	205,695	
	333415W	Air-conditioning and warm air heating equipment and commercial and industrial	1,935,570	
				25,272,927
Home Appliances				
	335222	Household refrigerator and home freezer manufacturing	3,497,263	
	3352281	Household water heaters, electric, for permanent installation	957,459	
	3352283	Household water heaters, excluding electric	1,250,608	
				5,705,330

Table A-2 Manufacturing Product Lines and Estimated Shipments (Continued)

Segment	NAICS Product Line	Description	2012 Values	Total
Motor Vehicle Air-Conditioning				
	3363902	Motor vehicle air-conditioning systems	4,626,572	
	3363903	Automotive air-conditioning compressors (open-type, with or without motor)	1,028,384	
	3363909514	Motor vehicle air-conditioning hose assemblies, new	336,074	
				5,991,030
Polystyrene Foam				
	3261401	Transportation polystyrene foam products (including seating, dash, and other interior-exterior components)	597,078	
	3261403	Building and construction polystyrene foam products	1,412,624	
				2,009,702
Polyurethane Foam				
	3261501	Transportation polyurethane foam products	1,398,278	
	3261502116	Polyurethane foam protective shipping pads and shaped cushioning (peanuts, disks, etc.)	190,597	
	3261503	Building and construction polyurethane foam products	1,214,110	
				2,802,985
Medical - MDIs				
	325412A1	Pharmaceutical preparations, acting on the respiratory system, for human use	4,626,273 (part, estimated)	
				4,626,273
Aerosols				
	325998J1H1	Filling pressurized aerosol containers with materials owned by others (excluding interplant transfers)	640,138	
	325998J1V1	Chemical preparations, other	864,557 (part, estimated)	
				1,504,695
Fluoropolymers and Process Agents				
	3252111160	Other thermoplastic resins and plastics materials	2,424,717 (part, estimated)	
	32521203	Butyl, polychloroprene, and stereo polyisoprene elastomers, and nitrile rubber, including latex	265,261 (part, estimated)	
	325220A115	Other manufactured noncellulosic fibers, yarn (including strip), monofilament and group (multi) filament, made by filament yarn producers	84,810 (part, estimated)	
				2,774,788

Estimates of relevant wholesale activity were derived using the 2012 *Census of Wholesale Trade*. The table EC1242SLLS1 - *Wholesale Trade: Subject Series - Product Lines: Product Lines Statistics by Industry for the U.S. and States: 2012*[17] shows sales by product line (type of good) by different kinds of wholesale businesses. The sales estimates were totals of relevant product lines, as shown in table A-3.

The report EC1242I1 - *Wholesale Trade: Industry Series: Preliminary Summary Statistics for the U.S.: 2012*, contains information on sales, payroll, employment, and many other characteristics of wholesale businesses by NAICS code. Payroll and employment to sales ratios were calculated to apply to the sales estimates in table A-1 to estimate these variables.

[17] At https://www2.census.gov/econ2012/EC/sector42/EC1242SLLS1.zip.

Table A-3 Wholesale Product Lines and Sales for HVACR

(primary) NAICS	NAICS Title	Product Line	Product Line Title	Value of Sales	Totals
423620	Household appliances, electric housewares, and consumer electronics merchant wholesalers	11515	Household refrigerators and freezers	21086.7	21086.7
423730	Warm air heating and air-conditioning equipment and supplies merchant wholesalers	11912	Central air-conditioners	27027.8	
		11914	Heat pumps	6167.0	
		11917	Compressors for air-conditioners	5766.8	
		11918	Condensing units for air-conditioners	6250.9	45212.4
423740	Refrigeration equipment and supplies merchant wholesalers	12011	Commercial refrigerators	3102.7	
		12012	Unit coolers for commercial refrigerators	2327.0	
		12013	Condensing units for commercial refrigerators	550.9	
		12014	Refrigerants	2519.9	
		12015	Other commercial refrigeration equipment and supplies	6895.1	15395.7

Table A-4 Repair and Maintenance

NAICS	NAICS Title	Product Line	Product Line Title	Value of Receipts
8111	All other automotive repair and maintenance	31785	Heating, air conditioning, and radiator system repair services for cars and light trucks	2,720,922
811310	Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance	32031	M&R - Commercial refrigeration equipment	1,456,676
811412	Appliance Repair and Maintenance	32052	M&R: Major Household Type Appliances	1,675,285
				604,778

A.2 Methodology for the Economic Impact Analysis

The tool used for the economic impact analysis is the Inforum *Iliad* model, which is a detailed model of the U.S. economy. For each of 352 industries, it shows the demand and supply structure for each industry. The demand structure includes the sales to other industries (intermediate), and sales to final demand. Final demand includes personal consumption (household) expenditures, equipment investment, construction investment (residential and nonresidential), federal and state and local government spending, and exports less imports. The supply structure of each industry includes the other industries it buys from, the labor cost, indirect taxes, and capital income.

The input-output (IO) relationships are arrayed as a matrix, with each industry showing up both as a column and a row of the matrix. Each row of the matrix shows the distribution of sales of that industry's product or service. Each column of the matrix shows the purchases made by that industry.

The *Iliad* model is built on a detailed industry database, which draws from the U.S. Benchmark Input-Output Accounts, the U.S. Annual Input-Output Accounts, gross output by industry, and Census merchandise trade statistics. Both domestic and import prices have been compiled for each sector, so results can be expressed either in nominal (current prices) or real (constant prices) form.

The economic impact analysis consists of several parts:

1. *Upstream analysis* – This traces the impact of a given producing industry on supplier industries, including the suppliers to those suppliers. For each industry, calculations are made on output, jobs, earnings, and value added impacts.
2. *Downstream analysis* – This traces the impact of purchases of products through wholesale and retail trade distribution channels. The input-output table is used to estimate the distribution and total level of wholesale and retail trade activity generated through the distribution of a given product.
3. *Induced analysis* – This additional level of impact comes about through the earnings generated in the upstream or downstream industries. It represents the impact of consumer spending from the capital and labor earnings in these industries.

The initial analysis is done for 2016, and all results are in 2016 dollars. The impact analysis begins with the output of each industry segment. In the first iteration, all supplier industries' output is calculated, using the input-output coefficients from the column of the matrix. Note that not all of the output of the focus industry goes to domestic suppliers. Some is supplied by imports, which are calculated in each iteration according to the average import share of that industry. Some of the output is paid out in value added. Both imports and value added can be thought of as leakages that reduce the total output required from domestic suppliers. In each subsequent iteration, the suppliers to the previous round of suppliers are calculated. Because of the leakages just described, the amount necessary to supply each further round becomes smaller and smaller. At some point, the additional supplier output is very small, and the process converges.

Associated with each round of direct and supplier (indirect) output are the employment, earnings, and value added necessary to supply that output. When the solution has

completed, the model shows the total direct and indirect effects, as well as detailed impacts by supplying industry.

A.3 The UN Comtrade Database

UN Comtrade[18] is the pseudonym for United Nations International Trade Statistics Database. Over 170 reporter countries/areas provide the United Nations Statistics Division (UNSD) with their annual international trade statistics data detailed by commodities/service categories and partner countries. These data are subsequently transformed into the United Nations Statistics Division standard format with consistent coding and valuation using the processing system.

The UN COMTRADE is the largest depository of international trade data. It contains well over 3 billion data records since 1962 and is available publicly on the internet. In addition, it offers public and premium data API for easier integration/download.

All commodity values are converted from national currency into US dollars using exchange rates supplied by the reporter countries, or derived from monthly market rates and volume of trade. Quantities, when provided with the reporter country data and when possible, are converted into metric units. Commodities are reported in the current classification and revision (HS 2012 in most cases as of 2016). For this study, we used the HS 2012 classification

The concordance of HS 2012 to NAICS is not one-to-one, so some judgement needs to be applied to choose the appropriate HS codes. Tables A.5 and A.6 indicate the sets of HS codes we have used in this study to determine international trade in the relevant fluorocarbon, HVACR, and related product categories.

Table A.5 HS Codes Used to Represent Trade in HVACR and Related Equipment

HS Code	Title
841430	Compressors of a kind used in refrigerating equipment
841510	Air conditioning machines; comprising a motor-driven fan and elements for changing the temperature and humidity, window or wall types, self-contained or split-system
841520	Air conditioning machines; comprising a motor driven fan and elements for changing the temperature and humidity, of a kind used for persons, in motor vehicles
841581	Air conditioning machines; containing a motor driven fan, other than window or wall types, incorporating a refrigerating unit and a valve for reversal of the cooling/heat cycle (reversible heat pumps)
841582	Air conditioning machines; containing a motor driven fan, other than window or wall types, incorporating a refrigerating unit
841583	Air conditioning machines; containing a motor driven fan, other than window or wall types, not incorporating a refrigerating unit
841590	Air conditioning machines; with motor driven fan and elements for temperature control, parts thereof
841810	Refrigerators and freezers; combined refrigerator-freezers, fitted with separate external doors, electric or other
841821	Refrigerators; for household use, compression-type, electric or other
841829	Refrigerators; household, electric or not, other than compression-type
841830	Freezers; of the chest type, not exceeding 800l capacity
841840	Freezers; of the upright type, not exceeding 900l capacity
841861	Heat pumps; other than air conditioning machines of heading no. 8415
841869	Refrigerating or freezing equipment; n.e.c. in heading no. 8418
841891	Refrigerating or freezing equipment; parts, furniture designed to receive refrigerating or freezing equipment
841899	Refrigerating or freezing equipment, parts thereof, other than furniture

[18] These data can be freely accessed at http://comtrade.un.org.

Table A.6 HS Codes Used to Represent Trade in Fluorocarbons

HS Code	Title
290371	Halogenated derivatives of acyclic hydrocarbons containing two or more different halogens; chlorodifluoromethane
290372	Halogenated derivatives of acyclic hydrocarbons containing two or more different halogens; dichlorotrifluoroethane
290373	Halogenated derivatives of acyclic hydrocarbons containing two or more different halogens; dichlorofluoroethanes
290374	Halogenated derivatives of acyclic hydrocarbons containing two or more different halogens; chlorodifluoroethanes
290375	Halogenated derivatives of acyclic hydrocarbons containing two or more different halogens; dichloropentafluoropropanes
290376	Halogenated derivatives of acyclic hydrocarbons containing two or more different halogens; bromochlorodifluoromethane, bromotrifluoromethane, and dibromotetrafluoroethanes
290377	Halogenated derivatives of acyclic hydrocarbons containing two or more different halogens; n.e.c. in headings 290371 to 290376, perhalogenated only with fluorine and chlorine
290379	Halogenated derivatives of acyclic hydrocarbons containing two or more different halogens; n.e.c. in item no. 2903.7
382471	Mixtures containing halogenated derivatives of methane, ethane or propane; containing chlorofluorocarbons (CFCs), whether or not containing hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs) or hydrofluorocarbons (HFCs)
382474	Mixtures containing halogenated derivatives of methane, ethane or propane; containing hydrochlorofluorocarbons (HCFCs), whether or not containing perfluorocarbons (PFCs) or hydrofluorocarbons (HFCs), but not containing chlorofluorocarbons (CFCs)
382478	Mixtures containing halogenated derivatives of methane, ethane or propane; containing perfluorocarbons (PFCs) or hydrofluorocarbons (HFCs), but not containing chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs)
390490	Vinyl chloride, other halogenated olefin polymers, n.e.c. in heading no. 3904

A.4 Questionnaire for Industry Experts

We developed assumptions for the model scenarios by canvassing industry experts on a set of questions relating to trade and competitiveness.

These questions were as follows:

1. The U.S. Bureau of Census trade data indicate a trade deficit of a little over $10 billion in 2016 in air-conditioning and refrigeration equipment, starting from almost balance in 2000. If the US does not ratify Kigali, do you expect the trade deficit in equipment to continue to get worse?

a. Knowing that it was $5 billion in 2010, what figure would you expect for 2025?

a) parity
b) deficit of $5 billion
c) deficit of $10 billion
d) deficit of $20 billion

b. If the US does ratify Kigali, do you expect the US to become more competitive?

<Yes/No>

c. If so, by how much would you expect the trade balance to improve from the situation without ratification by 2025?

a) $5 billion
b) $10 billion
c) $20 billion
d) 40 billion

2. UN World trade data indicate that the current export market for air-conditioning, refrigeration, freezers, compressors and motor vehicle air-conditioners totaled about $95

billion in 2016. How rapidly do you see the world export market growing per year on average to 2025?

a) 2 percent
b) 3 percent
c) 4 percent
d) 6 percent

3. The same UN world trade data show the US exports of these in 2016 totaling $6.7 billion, or about 7.1 percent of the world market.

a. Without Kigali ratification, do you expect this share to:

a) decline (and by how much?) by 2025
b) stay the same
c) increase (and by how much?)

b. With Kigali ratification, how much do you expect the share of world market to increase by 2025:

a) not at all
b) 1 percent
c) 5 percent
d) 10 percent
e) other amount

4. Due to special customer relationships between US fluorochemical firms and US equipment producers, do you see the US equipment producers enjoying a special competitive edge due to advanced US research in fluorochemicals? <yes/no>. Will the importance of these relationships increase with Kigali ratification?

A.5

Kigali Specified Controlled Substances

Table A.7 provides a list of the substances specifically mentioned in the Annex to the Montreal Protocol in relation to the Kigali amendment. The table provides the common substance name and the 100-year global warming potential (GWP).[19]

Table A.7 Annex F to the Montreal Protocol

HFCs (Group I)		HCFCs	
Substance	**GWP value (100 year)**	**Substance**	**GWP value (100 year)**
HFC-134	1100	HCFC-21	151
HFC-134a	1430	HCFC-22	1810
HFC-143	353	HCFC-123	77
HFC-245fa	1030	HCFC-124	609
HFC-365mfc	794	HCFC-141b	725
HFC-227ea	3220	HCFC-142b	2310
HFC-236cb	1340	HCFC-225ca	122
HFC-236ea	1370	HCFC-225cb	595
HFC-236fa	9810		
HFC-245ca	693	CFCs	
HFC-43-10mee	1640	**Substance**	**GWP value**
HFC-32	675	CFC-11	4750
HFC-125	3500	CFC-12	10 900
HFC-143a	4470	CFC-113	6130
HFC-41	92	CFC-114	10 000
HFC-152	53	CFC-115	7370
HFC-152a	124		
HFCs (Group II)			
HFC-23	14 800		

[19] Source: Polonara et al. (2017).

A.6 Principal Investigators

Joseph M. Steed was architect and lead implementer of DuPont's corporate response to stratospheric ozone depletion concerns during the 1980s, including the ultimate science-based decision to lead the global industry in committing to complete phase-out of CFC production in advance of regulatory requirements. He is an expert in developing broad industry and government support for economically driven international and domestic regulations that achieve a smooth transition for customers.

He has over 20 years of experience as a leader of strategic change in diverse industries and organizations. As CEO of startup International Titanium Powder, LLC, Dr. Steed built on both technical and business background to develop business and financial plans and successfully initiate the transition from development toward commercial operation. As Manager of e-Ventures at DuPont, Dr. Steed served as a catalyst to drive profitable adoption by business leaders of internet transaction tools.

Lent by DuPont to the chemical industry-financed marketplace startup Elemica, Inc., Dr. Steed led marketing strategy, segmentation, customer relationship management (CRM) strategy, and branding for a successful startup that has now outlasted the majority of its imitators. Dr. Steed led Global Strategic Planning for a $2 billion DuPont business, implementing a strategic redirection toward higher value offerings, with a modern ERP infrastructure to drive cost efficiency and customer service. In technology, Dr. Steed led process R&D for a major business resulting in implementation of proprietary and highly profitable cost reductions, waste reduction programs, and novel feedstocks. As Corporate R&D Planning Manager, Dr. Steed drove corporate growth through a funding mechanism for entrepreneurial developments and effective networking of new business development leaders across the corporation.

He also served as a general manager at the technology development company EarthShell Corporation. His recent consulting includes work with the private equity firm Texas Pacific Group, providing chemical industry expertise to assist in their evaluation of a $1B+ buyout. He also served as a principal in a project for AHRI to design a mechanism for stimulating the rate of recycle of HFCs and HCFCs in the United States. Dr. Steed has a Ph.D. in Chemical Physics from Harvard and Sc.B. and Sc.M. degrees from Brown, along with executive training from Columbia's Graduate School of Business. He has published numerous peer-reviewed technical articles and book chapters, including both atmospheric modeling and estimates of global CFC emissions.

Douglas S. Meade is the executive director of Inforum (**In**terindustry **For**ecasting at the **U**niversity of **M**aryland). Dr. Meade has over 30 years of experience in private sector and government in the areas of econometric modeling, economic analysis, and the development of economic data. He was the principal investigator for a previous study done for AHRI, analyzing the national and state level contribution of the HVAC industries within the U.S. economy. Dr. Meade also has extensive experience in international modeling, having helped develop the Inforum bilateral trade model, as well as developing and performing studies with models of Japan, Vietnam, Ukraine, Tanzania, North Korea, and Myanmar.

Prior to his current period at Inforum, he was Deputy Directory of the Industry Division at the Bureau of Economic Analysis, where he was responsible for the development of the 2002 benchmark input-output table. Other previous experience includes work with Data Resources, Inc., an econometric consulting firm which is now part of IHS Global, and with

the Census Bureau, serving a research function in the development of manufacturing statistics. He received his B.S. in Economics from George Mason University in 1980, and his Ph.D. in Economics from the University of Maryland in 1990.

Troy A. Wittek graduated with a Criminal Justice degree from the University of Maryland in 2007. He completed a master's degree in Applied Information Technology from Towson University in 2012. He joined Inforum in 2006 and became a full-time Research Assistant in 2009. Troy's responsibilities include collecting and analyzing statistical data for use in policy analysis, business planning, and academic research. He has helped to write and edit reports for a variety of audiences in the academic, government, and private sectors. Troy is one of the main researchers responsible for maintaining the Inforum *Lift* and *Iliad* models of the U.S. economy. He works with the Department of Defense to project defense purchases and skilled labor requirements by industry and by region using Inforum economic models. Other projects include providing forecasts for domestic industries and analyzing the impact of major soft drink bottler operations in Asia. Additional responsibilities include literature review, software testing, and website development.

November 14, 2019

The Honorable John Kennedy
United States Senate
Washington, DC 20510

The Honorable Thomas Carper
United States Senate
Washington, DC 20510

Dear Senators Kennedy and Carper:

We are pleased that you and your colleagues recently introduced S. 2754, the American Innovation and Manufacturing Act of 2019, to phase down hydrofluorocarbons (HFCs). There is broad support for such a measure across the business and environmental communities and bipartisan support in Congress.

Affordable replacements for HFCs already exist or are close to market. The approach outlined in S. 2754 would ensure that U.S. manufacturers remain the world leaders and that our foreign competitors would be subject to the same rules we are as we transition out of HFCs.

Phasing out HFCs would directly add 33,000 U.S. manufacturing jobs over the next decade, as well as indirectly adding 117,000 jobs, on top of an already-projected 47% baseline increase over that same period. Total industry output is projected to grow over 70% by 2027. This legislation would grow the U.S. share of the world market for heating, air-conditioning, and refrigeration equipment 25% over its current share.

Thank you for your leadership in addressing next generation refrigerant technologies. The National Association of Manufacturers (NAM) and the U.S. Chamber of Commerce (the Chamber) stand ready to assist to move this important bipartisan legislation through Congress and to the President's desk.

Chuck Chaitovitz, the Chamber's Vice President for Environmental Affairs and Sustainability, and Ross Eisenberg, NAM's Vice President of Energy and Resources Policy, will follow up with you and your office to answer any questions you may have.

Sincerely,

Ross Eisenberg
Vice President of Energy
and Resources Policy
National Association of Manufacturers

Chuck Chaitovitz
Vice President for Environmental Affairs
and Sustainability
U.S. Chamber of Commerce

October 7, 2019

The Honorable John Barrasso
Chairman
Committee on Environment & Public Works
United States Senate
Washington, D.C. 20510

The Honorable Frank Pallone
Chairman
Committee on Energy & Commerce
United States House of Representatives
Washington, D.C. 20515

The Honorable Thomas Carper
Ranking Member
Committee on Environment & Public Works
United States Senate
Washington, D.C. 20510

The Honorable Greg Walden
Ranking Member
Committee on Energy & Commerce
United States House of Representatives
Washington, D.C. 20515

Dear Chairman Barrasso, Chairman Pallone, Ranking Member Carper, and Ranking Member Walden:

We, the undersigned member manufacturers of the Alliance for Responsible Atmospheric Policy and the Air-Conditioning, Heating, and Refrigeration Institute, are writing to urge your support for proposed Federal legislation phasing down a class of industrial products known as hydrofluorocarbons (HFCs), commonly used as refrigerants and in other industrial applications. We believe legislative action will provide regulatory certainty for U.S. businesses, and secure a position of strength for American companies in a highly competitive global market for next generation fluorocarbon technologies by creating new U.S. manufacturing jobs and stimulating further investment in the U.S. economy.

U.S. companies that produce and use fluorocarbons have been preparing for a transition from HFCs for more than a decade, investing billions in R&D to be the first to bring to market next generation fluorocarbon products and equipment. American companies have led the world in fluorocarbon technology development for decades, but that leadership – and the advantages it confers to the U.S. economy – is jeopardized by the lack of a Federal policy for HFCs. In the wake of U.S. inaction, foreign competitors are poised to fill the technology void and displace American companies in a global fluorocarbon market expected to reach $1 trillion in size.

The blueprint for the global market transformation is contained in the Montreal Protocol, which was developed with significant U.S. industry and government leadership. The Protocol has also had continuous bipartisan support since its original signing during the Reagan Administration.

Federal legislation phasing down HFCs represents a chance to put America first, and to keep American workers at the forefront of this important global industry. A recent industry economic study showed that a new Federal standard for the phasedown of HFCs would create 33,000 new U.S. manufacturing jobs, add $12.5 billion per year to the U.S. economy, and expand U.S. exports in this sector by 25 percent. Failure to do so will cost U.S. businesses and jobs.

On behalf of the 1.3 million Americans currently employed in the overall heating, ventilation, air-conditioning, and refrigeration industry, we urge your support for action on proposed Federal legislation to phase down HFCs. It is our goal to protect U.S. global technology leadership, and create American jobs, a goal that we know you share. We look forward to working together to achieve this goal.

Sincerely,

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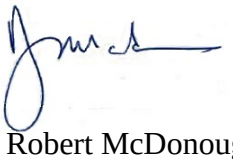

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President & CEO
The Chemours Company

Mr. Yasuhiro Utsumi
President & CEO
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Michael Schwartz
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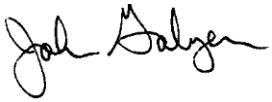

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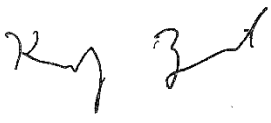

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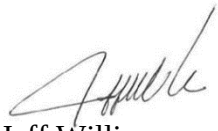

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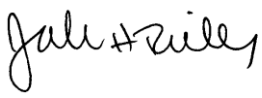

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