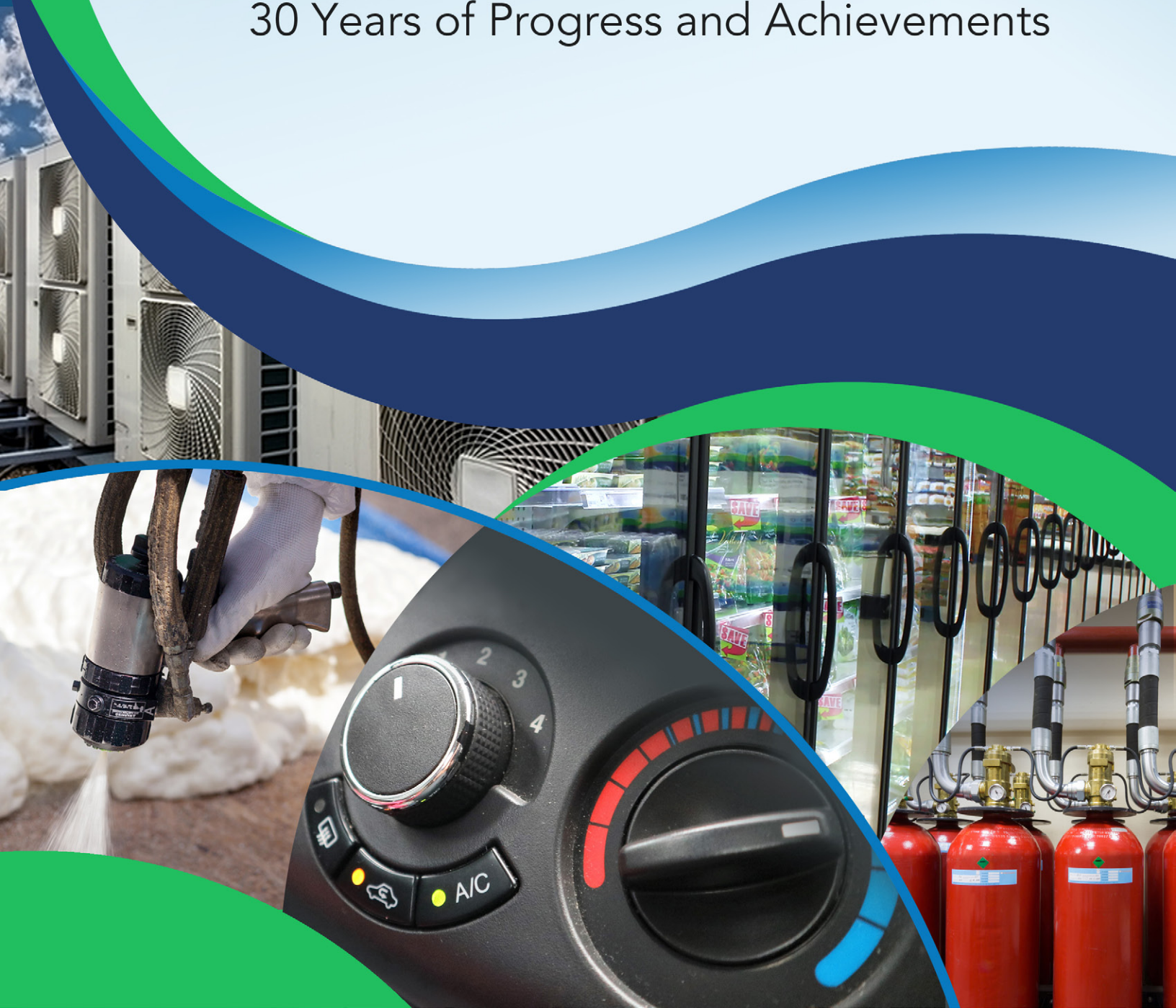




# Stratospheric Ozone Protection

30 Years of Progress and Achievements



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<https://www.epa.gov/ozone-layer-protection>  
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## Introduction

Overexposure to ultraviolet (UV) radiation is a threat to human health. It can cause skin damage, eye damage, and even suppress the immune system. UV overexposure also interferes with environmental cycles, affecting organisms—such as plants and phytoplankton—that move nutrients and energy through the biosphere.

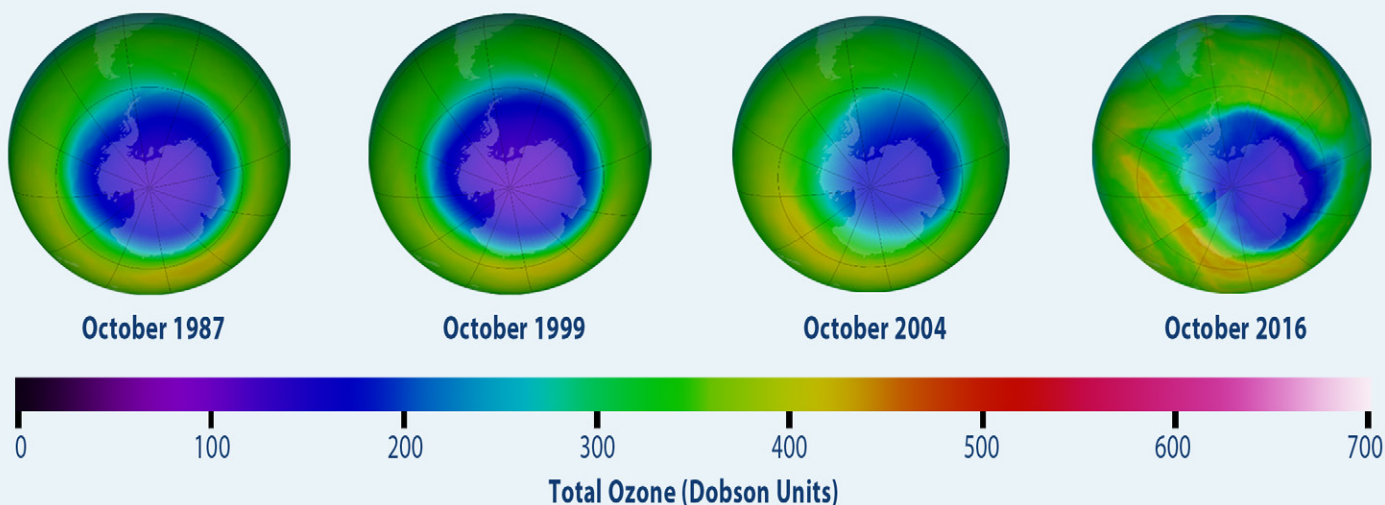
In the 1970s, scientists discovered that Earth's primary protection from UV radiation, the stratospheric ozone layer, was thinning as a result of the use of chemicals that contained chlorine and bromine, which when broken down could destroy ozone molecules. The most common of these ozone-depleting substances (ODS) was a class of chemicals called chlorofluorocarbons

(CFCs), which were widely used in a variety of industrial and household applications, such as aerosol sprays, plastic foams, and the refrigerant in refrigerators, air conditioning units in cars and buildings, and elsewhere.

Scientific observations of the rapid thinning of the ozone layer over Antarctica from the late 1970s onward—often referred to as the “ozone hole”—catalyzed international action to discontinue the use of CFCs. In 1987, the United States joined 23 other countries and the European Union to sign the *Montreal Protocol on Substances that Deplete the Ozone Layer* (Montreal Protocol). This international treaty protects and restores the ozone layer by phasing out the

## Changes in the Antarctic Ozone Hole, 1987 to Today

The following images illustrate the change in the Antarctic Ozone Hole between 1987 and today.<sup>1</sup> Assuming continued international compliance with the Montreal Protocol, Antarctic ozone levels are expected to return to pre-1980 levels by 2050.



<sup>1</sup>NASA, “NASA Ozone Watch,” NASA.gov. <https://ozonewatch.gsfc.nasa.gov/> (accessed August 31, 2017).

production and consumption of certain ODS including CFCs, halons, methyl bromide, and hydrochlorofluorocarbons (HCFCs).

The Protocol has been signed by all 197 countries of the United Nations (UN), and its parent treaty, the *Vienna Convention for the Protection of the Ozone Layer*, are the only international treaties to ever achieve this distinction.

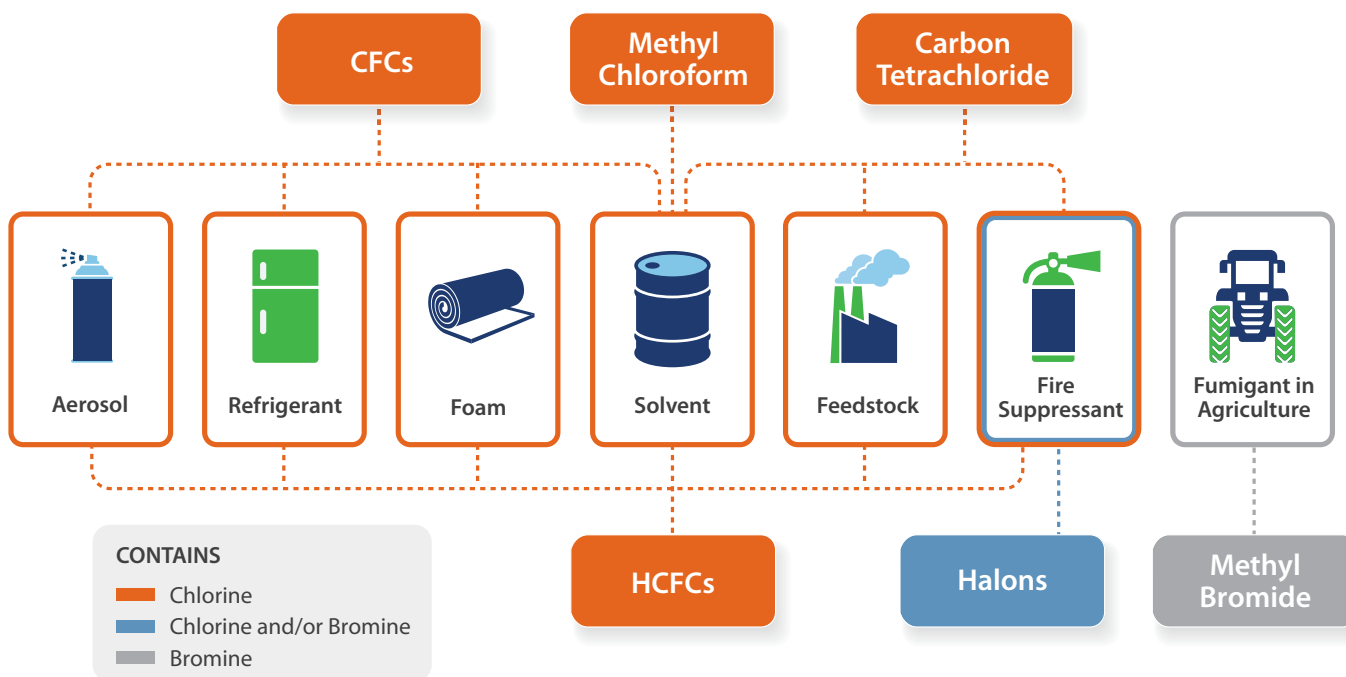
Former United Nations Secretary-General Kofi Annan remarked on the success of this global response by saying, "perhaps the single most successful international environmental agreement to date has been the Montreal Protocol." The ozone layer is on the path to recovery, which

benefits human health and the environment. This year we celebrate the 30<sup>th</sup> anniversary of the Montreal Protocol and all it has enabled us to achieve to protect life on Earth.

*"Perhaps the single most successful international environmental agreement to date has been the Montreal Protocol."*

Kofi Annan, UN Secretary-General, 1997-2006

### Common Applications of Ozone-Depleting Substances



## The Montreal Protocol: from 1987 to Today

Since 1987, the Montreal Protocol has been strengthened to reflect the latest scientific information and technological advances. In the beginning, the Protocol addressed the production and consumption of primarily CFCs. Over the past thirty years, the global community has worked together to add amendments to the Protocol that address the use of additional chemicals and adjust the timeframes for phasing out certain chemicals (see amendments and milestones map). Today, the Protocol provides a clear pathway for global reductions in the consumption and production of nearly 100 substances, including CFCs, HCFCs, halons, methyl bromide and other ODS. The most recent amendment to the Protocol was adopted in October 2016.<sup>2</sup>

As ODS have been controlled for gradual phase out by the Montreal Protocol and the international community has demanded new, safer alternatives to replace ODS, industries that have used ODS have responded with significant technological innovations. Many non-ozone-depleting alternatives have come onto the market, and equipment manufacturers have used the transition away from ODS as an opportunity to make other technological improvements, including improvements to energy efficiency and product design. In some cases, a new chemical alternative was not necessary because a “not-in-kind” replacement was developed that created an entirely new type of delivery system.

### Technological Improvements Stimulated by the Montreal Protocol



#### Refrigeration and Air Conditioning Equipment Manufacturers

Manufacturers of refrigeration and air conditioning equipment re-designed their equipment to improve energy efficiency and reduce refrigerant leakage rates, which also resulted in reduced operating costs.<sup>3</sup>



#### Aerosols Industry

Industry developed “not-in-kind” alternative delivery systems to ODS-propelled aerosol cans, such as spray pumps and roll-on deodorants, which are safe for human and environmental health and more cost-effective than aerosols.<sup>4</sup>



#### Solvents Industry

To reduce the use of solvents to clean metal parts, deflux wiring assemblies, and remove contaminants from precision mechanical parts in the electronics industry, the solvent cleaning industry developed new solder fluxes and pastes that do not require cleaning, or can be cleaned with water.<sup>5</sup>



#### Agricultural Fumigants

High-barrier tarps are now used in the agriculture industry in response to the phaseout of methyl bromide. These tarps are laid on top of a fumigated field and significantly reduce atmospheric emissions and bystander exposure to fumigants while achieving effective pest control.

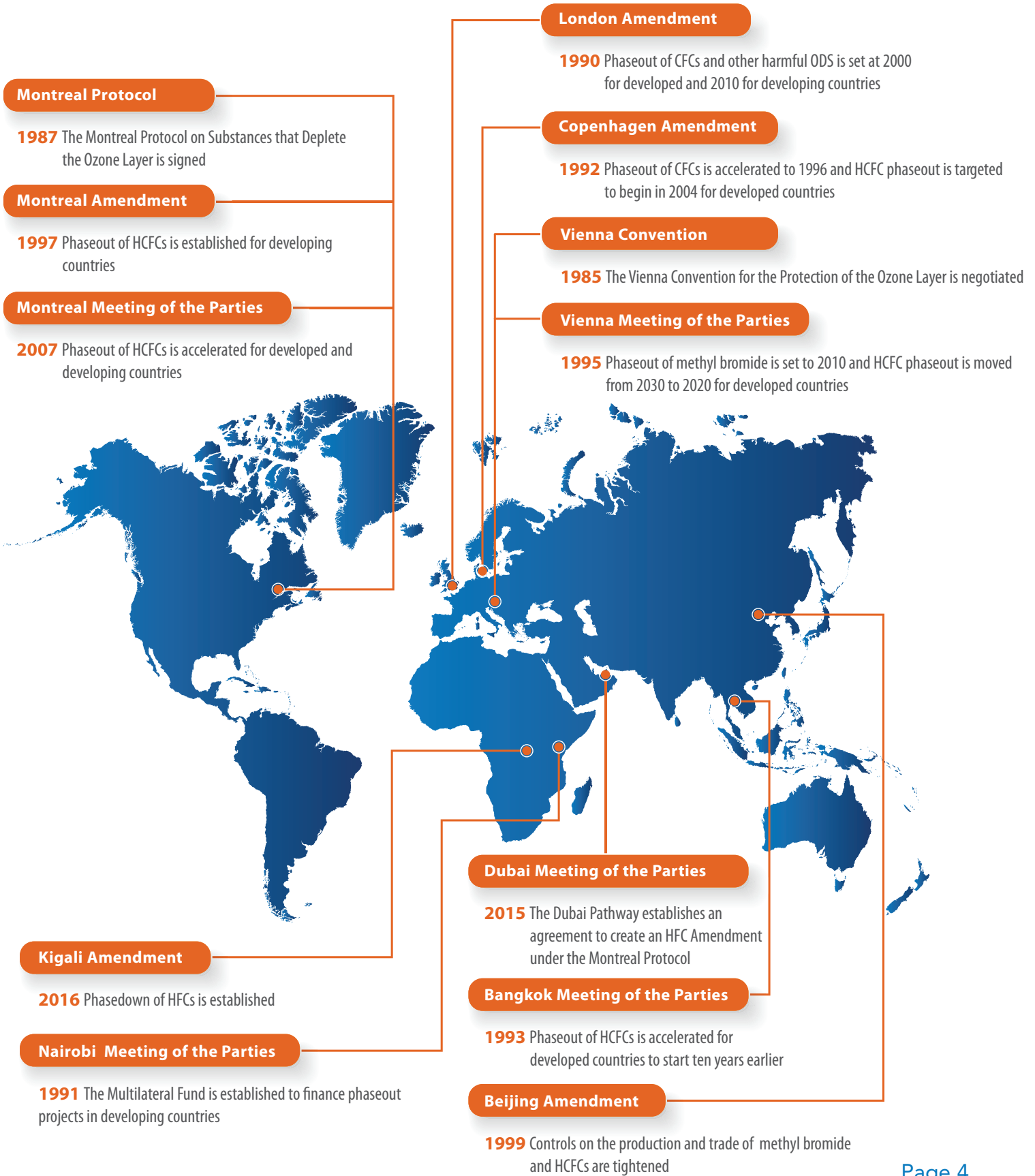
<sup>2</sup>The Kigali Amendment to the Montreal Protocol outlines a global phase down of the production and consumption of a class of powerful greenhouse gases called hydrofluorocarbons (HFCs), which are often used as replacements for ODS.

<sup>3</sup>Cook, E. and Kimes, J.D., Dangling the Carrot; and Forte, R. and Livernash, R., Chilling Out (1996). In E. Cook (Ed.), *Ozone Protection in the United States: Elements of Success*. World Resources Institute: Washington, DC.

<sup>4</sup>United Nations Environment Programme (2015). Decision XXVI/9 Update Task Force Report on Additional Information on Alternatives to Ozone-Depleting Substances. Technology and Economic Assessment Panel, September 2015.

<sup>5</sup>United Nations Environment Programme. (2015). Synthesis of the 2014 Reports of the Scientific, Environmental Effects, and Technology & Economic Assessment Panels of the Montreal Protocol. United Nations Environment Programme, Nairobi.

# Montreal Protocol Amendments and Milestones



## U.S. Achievements in Stratospheric Ozone Protection

### Exceeding the Phaseout

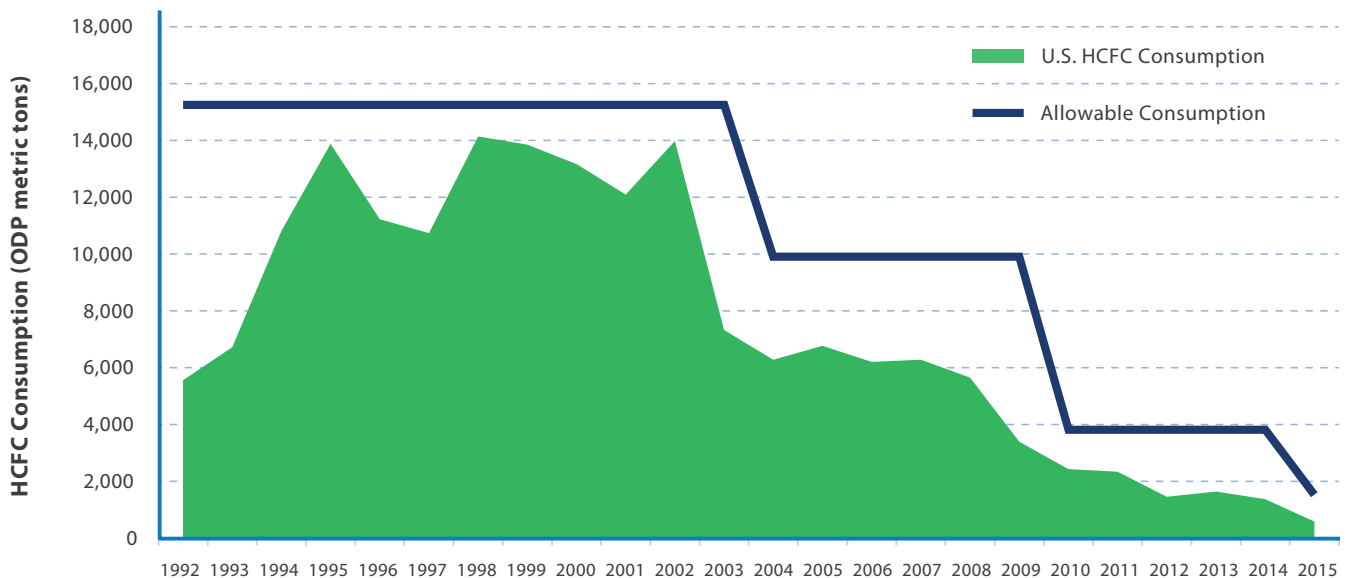
Since signing the Montreal Protocol in September 1987, the United States has played a leadership role in the global effort to protect and restore the stratospheric ozone layer. In response to the adoption of the Montreal Protocol, the U.S. Congress added Title VI, *Stratospheric Ozone Protection*, to the Clean Air Act (CAA) Amendments of 1990. The United States has now implemented a range of domestic actions under Title VI that have enabled us to meet and exceed the ODS phaseout outlined under the Montreal Protocol (see graph below), and at a lower cost than originally anticipated.<sup>6</sup> Many of these programs have served as a model for other countries seeking to phase out their own use of ODS.

<sup>6</sup>U.S. Environmental Protection Agency, National Center for Environmental Economics (2001). The United States Experience with Economic Incentives for Protecting the Environment. EPA-240-R-01-001.



### The United States Exceeding its Phaseout Obligations

The figure shows the United States' success in reducing HCFC consumption in accordance to allowable consumption levels under the Montreal Protocol.





## Benefits to Human Health and the Environment

In addition to serving as a policy leader, the United States has led efforts resulting in significant health and environmental benefits. These include reductions in the number of skin cancer cases and improved agricultural production. These benefits have far outweighed the cost of the transition from ODS to alternative substances.

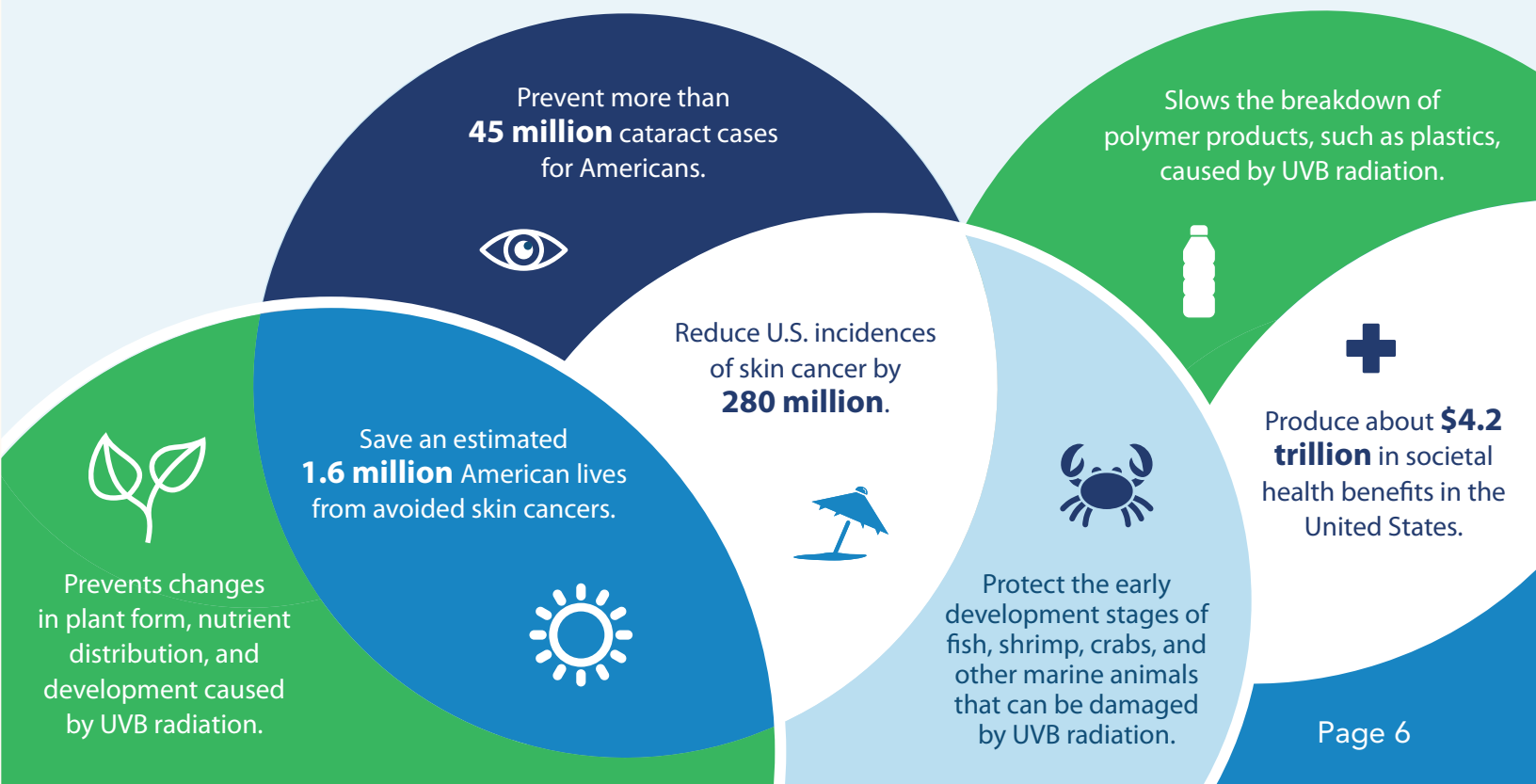
EPA modeled the effects of a depleted ozone layer on Americans born between 1890 and 2100, a timeframe that includes those who were very old when the ozone hole was discovered and those who will be very young when the ozone layer is fully recovered. The modeling showed that full implementation of the Montreal Protocol is expected to result in the avoidance of more than 280 million cases of skin cancer, approximately 1.6 million skin cancer deaths, and more than 45 million cases of cataracts in the United States,<sup>7</sup> resulting in hundreds of billions of dollars in societal health benefits in the United States over the period 1990 to 2165.<sup>8</sup>

A team of atmospheric scientists led by the National Aeronautics and Space Administration (NASA) also modeled the effects of what would have happened to the ozone layer if the Montreal Protocol had not been enacted. They found that ozone levels worldwide would have fallen to dangerously low levels, and by 2065, the UV radiation hitting mid-latitude cities like Washington, D.C. would have been strong enough to cause sunburn in just five minutes.<sup>9</sup>

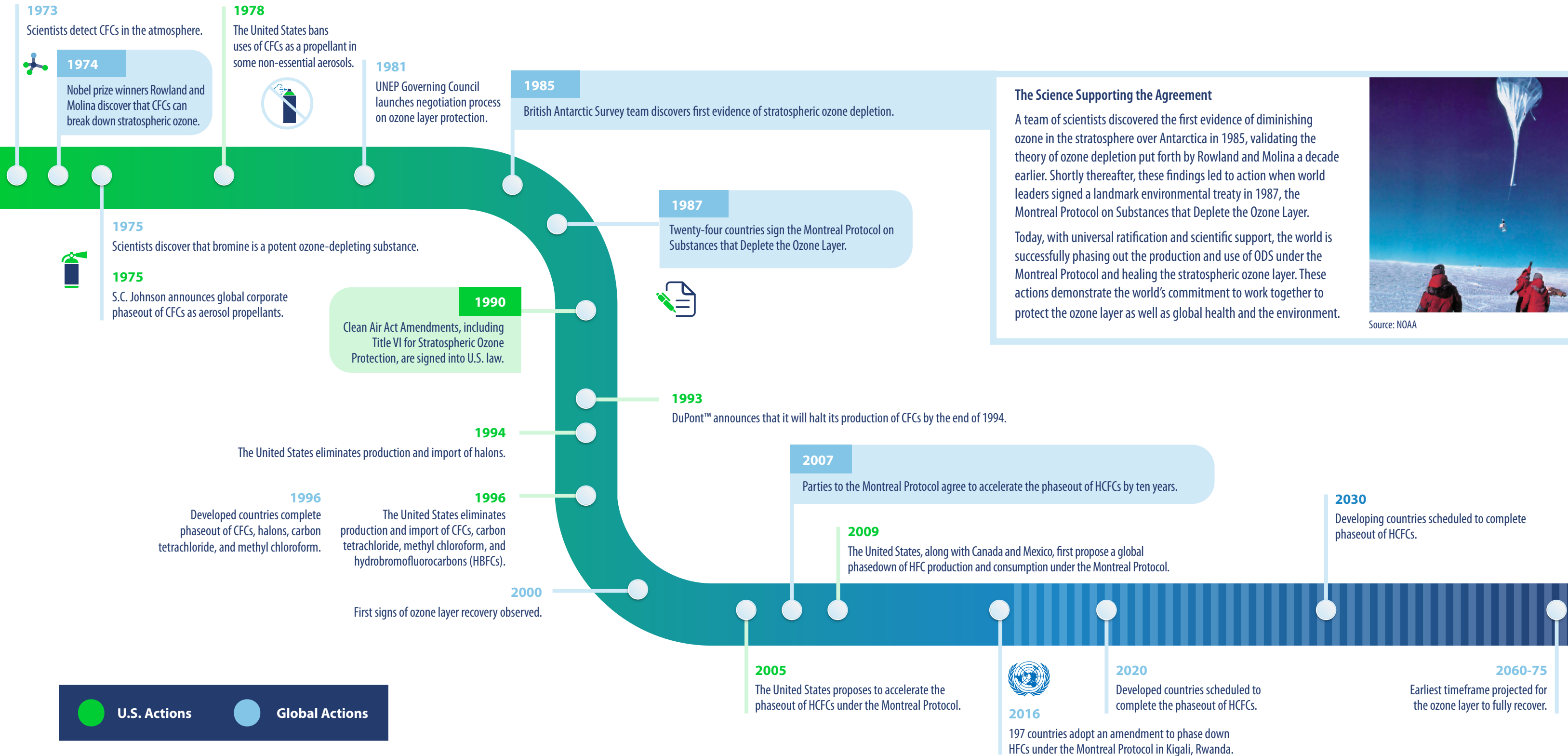
<sup>7</sup>U.S. Environmental Protection Agency (2015). Updating Ozone Calculations and Emissions Profiles for Use in the Atmospheric and Health Effects Framework Model.

<sup>8</sup>U.S. Environmental Protection Agency (1999). The Benefits and Costs of the Clean Air Act 1990 to 2010. EPA-410-R-99-001.

<sup>9</sup>Newman, P.A., L.D. Oman, A.R. Douglass, E.L. Fleming, S.M. Frith, M.M. Hurwitz, S.R. Kawa, C.H. Jackman, N.A. Krotkov, E.R. Nash, J.E. Nielsen, S. Pawson, R.S. Stolarski, and G.J.M. Velders. "What Would Have Happened to the Ozone Layer if Chlorofluorocarbons (CFCs) Had Not Been Regulated?" *Atmospheric Chemistry and Physics* 9 (2009). doi:10.5194/acp-9-2113-2009



## Progress and Achievements in Protecting the Ozone Layer



### The Science Supporting the Agreement

A team of scientists discovered the first evidence of diminishing ozone in the stratosphere over Antarctica in 1985, validating the theory of ozone depletion put forth by Rowland and Molina a decade earlier. Shortly thereafter, these findings led to action when world leaders signed a landmark environmental treaty in 1987, the Montreal Protocol on Substances that Deplete the Ozone Layer.

Today, with universal ratification and scientific support, the world is successfully phasing out the production and use of ODS under the Montreal Protocol and healing the stratospheric ozone layer. These actions demonstrate the world's commitment to work together to protect the ozone layer as well as global health and the environment.



Source: NOAA



U.S. Actions



Global Actions

## Regulatory Efforts in the United States to Protect the Stratospheric Ozone Layer

The United States has been able to achieve—and exceed—its Montreal Protocol targets through a two-pronged policy approach: implementing the framework enacted under the CAA coupled with effective industry partnership programs that enable companies to exceed regulatory requirements. The implementation of the Montreal Protocol in the United States is a truly cooperative endeavor between the U.S. Environmental Protection Agency (EPA) and other government agencies, industries, trade associations, and environmental organizations, which have all worked together to meet phaseout targets, develop transition plans away from ODS, and identify acceptable alternatives.

The primary vehicle for achieving ODS reductions in the United States is CAA Title VI, *Stratospheric Ozone Protection*, enacted by the U.S. Congress in 1990. So the United States can meet its Montreal Protocol commitments, Title VI requires the EPA to: issue federal regulations to phase out the production and import of ODS; ban the use of ODS in certain nonessential products like party streamers, aerosols, and plastic foams; require labeling of containers and products containing or manufactured with certain ODS for consumer awareness; reduce ODS emissions from existing equipment; and approve alternatives to ODS.



Thirty years after the signing of the Montreal Protocol, the EPA currently is focusing on three major regulatory efforts that continue to ensure that we achieve the Montreal Protocol phaseout schedule, support the transition to safer alternatives, and minimize emissions of ODS currently in use in appliances: the HCFC Allowance System, refrigerant management requirements, and the Significant New Alternatives Policy (SNAP) program.

## HCFC Allowance System

The HCFC Allowance System focuses on phasing out HCFCs over time. Under this system, producers and importers receive HCFC allowances

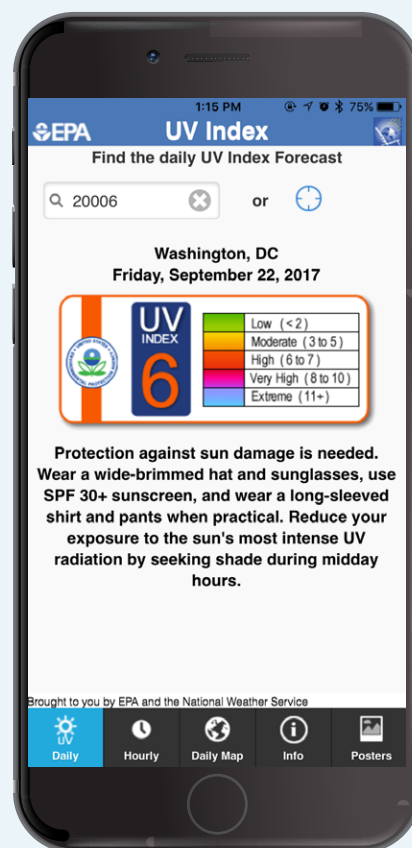
based on historical production and import activity. A company expends one allowance for each kilogram of HCFC it produces or imports. Allowances can be traded among producers and importers.

EPA has allocated annual allowances for HCFC production, import, and export several times since the system was established in 2003. These allowance allocations have enabled the United States to meet its commitments under the Montreal Protocol through an accelerated HCFC phaseout schedule. New production and import of most HCFCs will be phased out by 2030.

## EPA's UV Index App and Widget

EPA developed a widely-used smartphone app and widget to promote awareness of the UV Index, a numeric indicator of the strength of the sun's cancer-causing ultraviolet rays. The app and widget provide a U.S. National Weather Service forecast of daily and hourly levels of UV solar radiation for a user's location, along with accompanying sun-safety action steps. The UV Index is one of EPA's most-viewed websites.

You can download EPA's UV Index smartphone app from iTunes or Google Play (use the search term: EPA's UV Index), and the widget from: <http://developer.epa.gov/envirofacts-uv-index-widget/>.



## Refrigerant Management

Refrigerant management regulations are one of the regulatory tools used in the United States to help ensure we avoid unnecessary emissions from existing refrigeration and air conditioning equipment while also allowing for their continued, responsible use. These regulations apply to sources that use stationary refrigeration and air conditioning appliances as well as motor vehicle air conditioning. Together, these sectors account for approximately 60% of ODS emissions in the United States. The EPA's refrigerant management regulations require that refrigerants are properly handled, recovered, and disposed of in order to limit emissions. These regulations were most recently updated in November 2016 to ensure repair of leaking equipment along with improved inspection and prevention of leaks from equipment using ODS and substitute refrigerants.



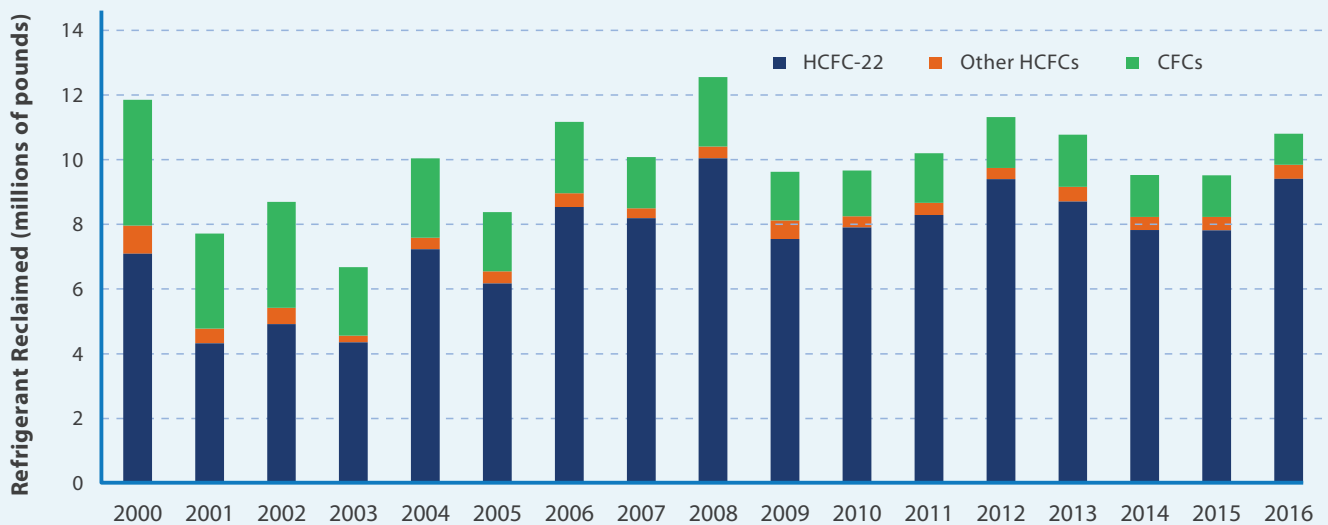
Responsible refrigerant management supports the ODS phaseout because it leads to increased recovery and reclamation of used refrigerants, which reduces the need to produce new refrigerants. Reclamation standards ensure confidence that refrigerants that are re-used meet high purity standards. EPA-certified reclaiming businesses have reclaimed more than 168 million pounds of refrigerant from 2000 to 2016, avoiding ODS emissions equivalent to 18,000 Ozone Depletion Potential (ODP) metric tons. These reclaimers have also supported the development of new state-of-the-art technologies to responsibly manage purification of refrigerants and refrigerant blends entering the market.



## Refrigerant Management Requirements of the Clean Air Act



## Reclaimed ODS Refrigerant in the United States



## Promoting the Development of Safe Alternatives

Another major regulatory effort focuses on smoothing the transition to safer alternatives. The Significant New Alternatives Policy (SNAP) program evaluates and regulates the use of alternatives to ODS. Under SNAP, EPA evaluates substitutes that are used in eight major industrial, commercial, and consumer sectors using a comparative risk framework to ensure substitutes pose lower overall risk to human health and the environment than other available alternatives for the same uses.

SNAP's evaluations and listings of acceptable and unacceptable ODS substitutes are used not only in the United States, but are often looked to by many other countries around the world as they consider their own transitions to alternatives. The SNAP program has facilitated a smooth and timely transition away from ODS across a variety of end-uses.



In addition to impacts on the ozone layer, **EPA considers many criteria** in its SNAP evaluations of substitute chemicals:

<p><b>Toxicity</b></p>	<p><b>Ozone Depletion Potential</b></p>
<p><b>Occupational &amp; Consumer Health/Safety</b></p>	<p><b>Flammability</b></p>
<p><b>Ecosystem Effects</b></p>	<p><b>Atmospheric Effects</b></p>

## Industrial Sectors under the SNAP Program

Foam Blowing Agents



Aerosols



Refrigeration and Air Conditioning



Fire Suppression



Tobacco Expansion



Adhesives, Coatings, and Inks



Sterilants



Cleaning Solvents



# EPA Partnerships that Protect the Ozone Layer

## GreenChill Partnership

EPA's GreenChill Partnership works with the supermarket industry to reduce refrigerant emissions and decrease their impact on the ozone layer and environment. The goals of GreenChill are to provide industry stakeholders with information and assistance to:

- Transition to environmentally friendlier refrigerants
- Reduce the amount of refrigerant used by stores and eliminate leaks
- Adopt green refrigeration technologies and environmental best practices



If the 38,441 supermarkets in the United States reduced their emissions to the GreenChill average, there would be an annual industry-wide savings of:



**\$213 million**

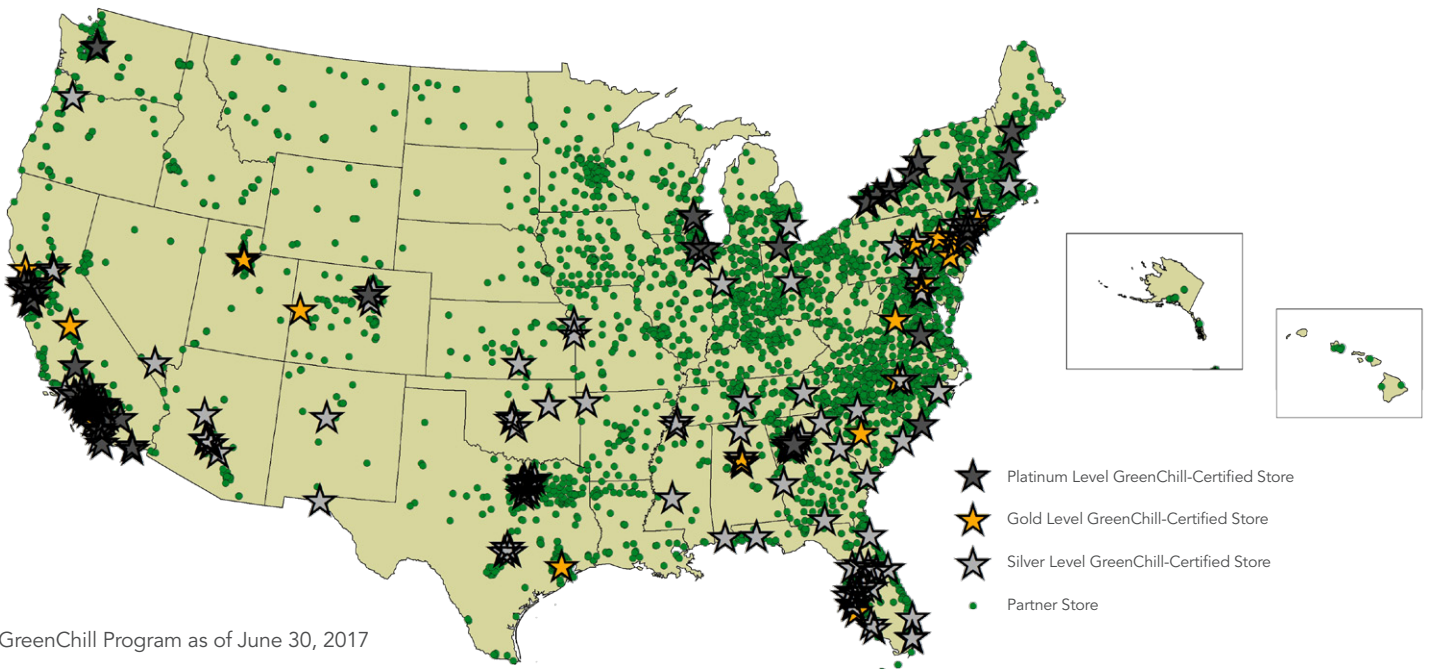


**29 million** metric tons of carbon dioxide equivalent of emissions, equal to the emissions from over **6.2 million** passenger vehicles



**151 ODP metric tons** of ODS emissions

**GreenChill Partners account for approximately 28% of all stores in the United States**

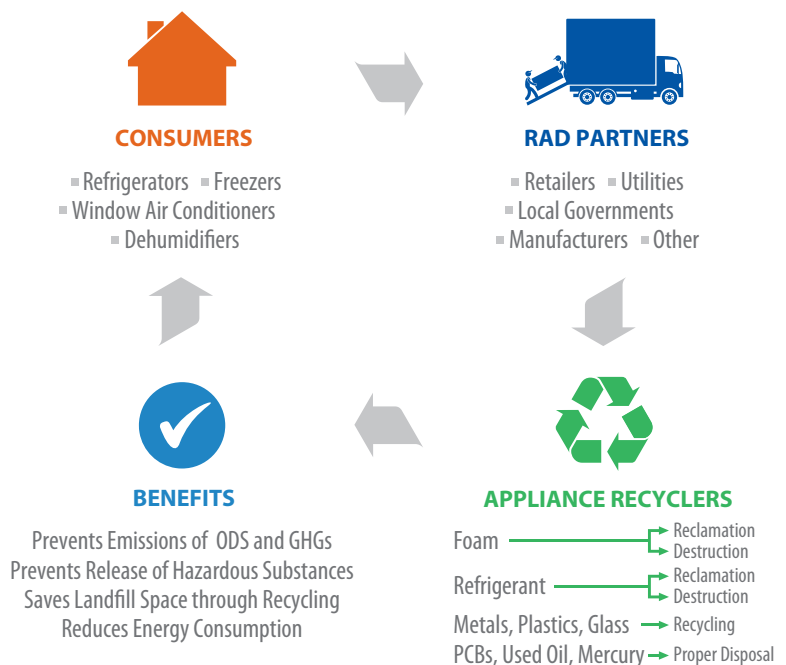


GreenChill Program as of June 30, 2017



## Responsible Appliance Disposal (RAD) Program

EPA launched the Responsible Appliance Disposal (RAD) Program in October 2006 to help protect the ozone layer, reduce greenhouse gas (GHG) emissions, and benefit communities. Partners, including utilities, manufacturers, retailers, and states, go beyond regulatory requirements by ensuring that old refrigerators, freezers, window air conditioners, and dehumidifiers are recycled using the best environmental practices available.



Since the RAD Program's inception in 2006, over **7 million** refrigerated appliances have been recycled the "RAD way," resulting in many benefits:



**1.1 billion pounds** of material diverted from landfills



**1,721 ODP metric tons** of ODS emissions avoided



**31.6 million** metric tons of carbon dioxide equivalent of emissions avoided, equal to the emissions from over **6.7 million** passenger vehicles



**23.8 billion kWh** saved and **\$2.9 billion** in consumer savings from removing old units from the grid

## Looking Ahead

EPA and its partners have made great progress in their protection of the ozone layer through the Montreal Protocol, domestic regulations, and public-private partnership programs. However, repairing the ozone layer is an ongoing effort that will take many years and continued worldwide cooperation to accomplish.

EPA looks forward to continuing working with its partners at other government agencies at the federal and state levels, as well as with industry, international organizations, NGOs, and academia, to protect the ozone layer and make our world a safer place for generations to come.



