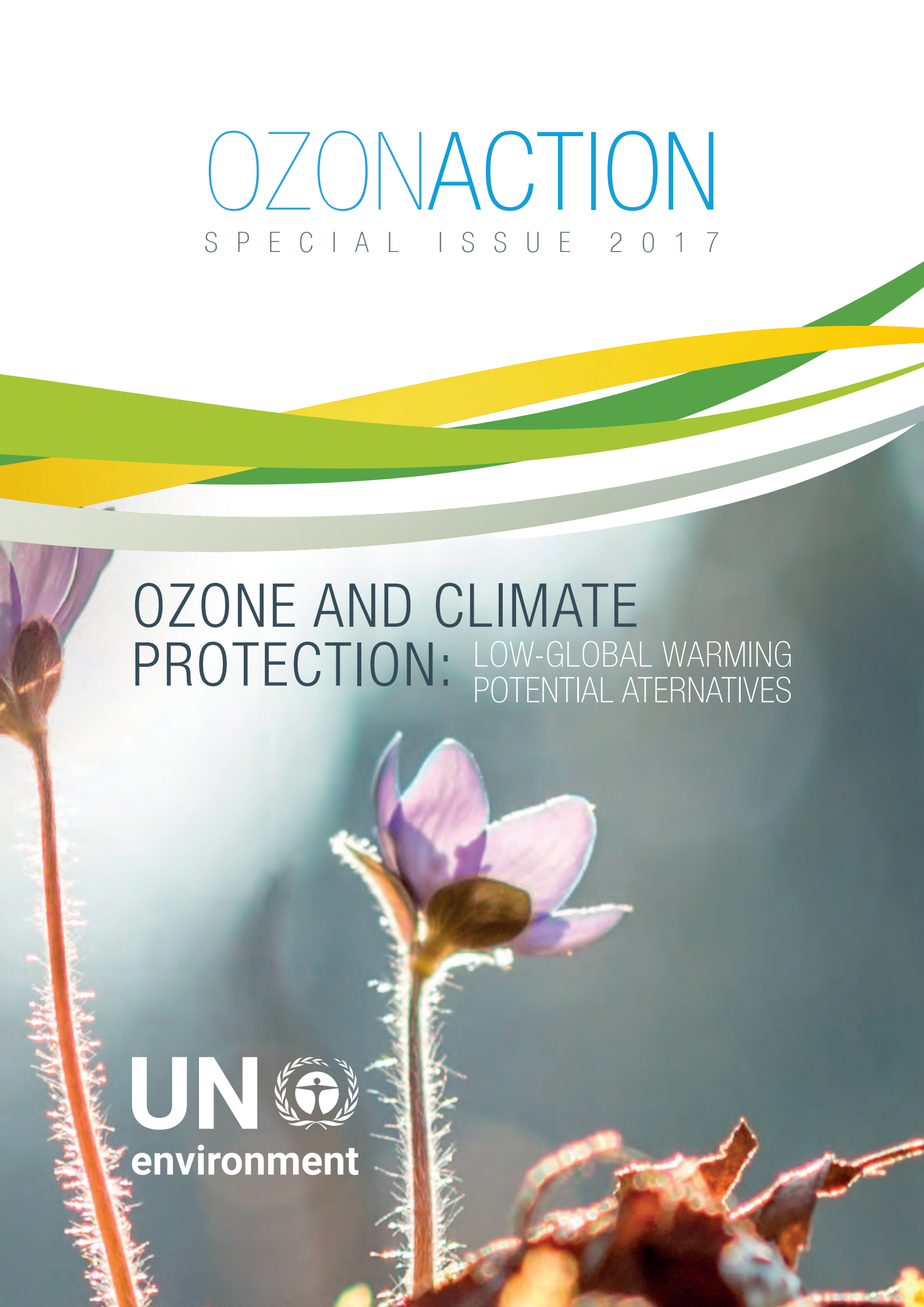
OZONACTION

SPECIAL ISSUE 2017

OZONE AND CLIMATE PROTECTION: LOW-GLOBAL WARMING POTENTIAL ATERNATIVES



UN environment

Table of Contents

Remarkable role of the National Ozone Officers - Sentinels of ozone layer protection

Shamila Nair-Bedouelle, UN Environment, Economy Division, OzonAction

Like nature's hard-working ecological guardians, the bees, members of the unique regional networks of National Ozone Officers (NOOs) set up by the UN Environment OzonAction Compliance Assistance Programme (CAP), play a key role as sentinels of ozone layer protection under the Montreal Protocol, helping make it one of the most successful multilateral environmental agreements.

A vibrant community supporting the phase-out of ozone-depleting substances (ODS) in Article 5 (developing) countries in compliance with Protocol obligations, the National Ozone Units, are now promoting the synergy between ozone protection, climate change mitigation and energy efficiency.

As climate change impacts communities, ecosystems and economies, the NOOs, already advising their governments on the technology trajectory towards low-global warming potential (GWP), non-ODS refrigerant alternatives, are well-positioned to support implementation of the next phase of the Montreal Protocol after its landmark at the Kigali meeting of the Parties in October 2016. National climate focal points have already been involved in some discussions in these networks and this cooperation will be extended and reinforced at national and regional levels.

Refrigeration and air-conditioning (RAC) technologies are the cornerstone of modern life, ensuring comfort, food safety and security, and access to safe medicines. Good practices in the RAC servicing sector will make a difference in not only minimising emissions, hence limiting new production of refrigerants, but also maintaining appliance energy efficiency, thereby saving energy and money.

It is important for NOOs to understand the interactions between ozone, climate change and energy efficiency, and envisage the consequences of technology choices for their countries and the climate system. This requires them to have access to reliable national data, knowledge of international processes and be aware of the latest scientific technological data on 'future refrigerants'. A variety of climate-friendly and energy-efficient, non-ODS refrigerant alternatives are available. These include carbon dioxide, ammonia, hydrocarbons, low-GWP hydrofluorocarbons (HFCs) and some 'not-in-kind' technologies such as solar technologies and District Cooling. There is no "one-size-fits-all" approach and a country's choice of ODS alternatives will depend upon the national situation which includes legislation, standards, market availability, suitably trained technicians and the economy. OzonAction assesses the impact of interventions and activities while providing the flexibility for re-orientation based on country needs.

The regional networks of NOOs are an OzonAction flagship activity along with its clearinghouse mandate under the Montreal Protocol and provide a unique forum for sharing of experiences and knowledge transfer between countries and South-South cooperation.

Working with NOOs, OzonAction is promoting responsible use of refrigerants and good practices in training and certification systems for technicians and this will be a priority in the coming years. Without skilled and trained technicians, higher energy efficiency products will not function at the designed capacity. OzonAction is cooperating with international / national organizations and associations working in the field of technician training, safety issues and standards to better assist developing countries to reach the common goals of climate and ozone protection. Moreover, OzonAction has been invited to make a key presentation on challenges faced by developing countries in the context of the recent industry move towards unified refrigerant management, particularly through the Global Refrigerant Management Plan initiative.

An historic decision was taken by the Parties in October 2016 in Kigali, Rwanda. They agreed to phase-down the production and consumption of hydrofluorocarbons (HFCs). This will require all countries, both developed and developing to phase down the production and consumption of HFCs following various specific schedules. These chemicals are commonly used alternatives to ODS and while not ozone depleting substances themselves, they are greenhouse gases which can have high or very high GWPs, ranging from about 121 to 14,800 times more powerful that carbon dioxide at causing climate change. It has been estimated that this agreement will help nations avoid up to 0.5°C of global warming by 2100, which very much continues the historic legacy of the Montreal Protocol.

The Montreal Protocol has far exceeded its original aims. It has protected the ozone layer, contributed to climate mitigation, social development, food security, public health and the creation of 'green jobs'. In the next phase of the Protocol, the National Ozone Units will be strategically placed to support the climate, energy-efficiency and ozone nexus.

The road to low-global warming potential alternatives: If you want to walk fast, walk alone; but if you want to walk far, walk together

Eduardo Ganem, Multilateral Fund Secretariat

It was over 30 years ago when the Vienna Convention for the Protection of the Ozone Layer obligated Parties to protect human health and the environment against the adverse effects of human activities that modify or are likely to modify the ozone layer. The Vienna Convention, which was negotiated at a time of scientific uncertainty and doubts surrounding the ozone depletion process and our capacity to address it, defines "adverse effects" as changes in the physical environment or biota, including changes in climate, so it could be said that we have been walking together on the road to climate benefits since 1988.

As a result of the work done so far under the Montreal Protocol's Multilateral Fund, the ozone-depleting substances (ODS) phase-out has resulted in substantial ozone and climate benefits without disrupting the industrial and agricultural sectors within Article 5 countries that had been dependent on ODS. The next step for Article 5 countries to reduce hydrochlorofluorocarbon (HCFC) consumption and production by 35 per cent by 1 January 2020 is already under implementation to the extent that there are already approved national plans in place that will address 30 per cent of the aggregate HCFC consumption and 89 per cent of the aggregate HCFC production baselines in Article 5 countries. In approving those plans, the Executive Committee of the Multilateral Fund paid careful attention to alternatives to HCFCs that minimize environmental impacts and provided additional funding for the introduction of low-global warming potential (GWP) technologies.

Article 5 countries face challenges as some energy-efficient and climate-friendly alternative technologies they may wish to adopt are still being developed, tested and adapted to local markets. In this respect, the Multilateral Fund has funded demonstration projects to independently assess alternatives to HCFC technologies in different industrial sectors and to overcome inherent challenges such as flammability, toxicity, or corrosiveness. A number of countries have already made choices to adopt low-GWP alternatives as a result of such projects and, based on this success, the Executive Committee approved further demonstration projects, giving priority to those in the refrigeration and air-conditioning sector, and to address the needs of countries with high-ambient temperatures.

To enable the uptake of these low-GWP alternatives, it is essential that Article 5 countries develop regulations and standards on good practices for safe use of alternatives and arrange sustainable and comprehensive training in the refrigeration servicing sector to ensure an adequate number of technicians trained in the safe handling of alternative flammable and toxic refrigerants. Otherwise, there is a risk that the lack of appropriate standards and training could become a significant barrier to the safe adoption of low-GWP alternatives.

Over the past 25 years, a key feature of the Multilateral Fund has been its immediate adaptability to the changing needs and challenges presented by the London, Copenhagen, Montreal and Beijing Amendments, and the adjustment to accelerate the phase-out of HCFC consumption and production. As we journey forward on the path to low-GWP alternatives following the Kigali Amendment, it is certain that the Multilateral Fund will adapt to the new challenge placed before it and continue providing technical assistance to Article 5 Parties to continuously be in compliance with their obligations under the Montreal Protocol and fulfil the principles of the Vienna Convention.

Kigali Amendment: We did it!

Tina Birmpili, Ozone Secretariat

We did it! Together we accomplished a major milestone of international cooperation and global environmental protection in 2016 – the Kigali Amendment to the Montreal Protocol.

The Amendment will phase down hydrofluorocarbons (HFCs) under the Montreal Protocol, helping to avoid up to 0.5 degree Celsius of global warming by 2100, while continuing to protect the ozone layer.

To all the parties to the Montreal Protocol who pulled together in Kigali and made their contributions to make the Amendment a reality, we say thank you.

In beautiful Kigali, during the early hours of 15 October 2016, you chose the path of compromise and consensus and wrote a new script for a greener and healthier future.

Thank you for your commitment to act for the common good and for making your individual voices part of a collective message to protect our planet from climate change.

In Kigali, you ensured that the solutions you found to your national challenges of phasing down HFCs were accurately reflected in the final agreement without leaving any country behind.

Thank you for adopting an Amendment that ensures that:

- HFCs with high global warming potential (GWP) will be phased down;
- developed countries will assist developing nations in their transition out of powerful global-warming HFCs;
- developing nations commit to HFC reduction schedules by putting their growth on a greener path;
- the industry will choose the most efficient technologies and innovative approaches will be in place.

The Amendment was made possible by the political will of 197 countries and passionate and committed individuals who believe in this cause.

To all these individuals, delegates and country representatives, who stayed the course during lengthy and extensive negotiations for the sake of our planet and its people, we say thank you.

Thank you for working tirelessly and enduring long negotiation sessions to bring about the Amendment.

You answered the call of history with courage and vision and we are all grateful to you for getting it done.

As we look to mark the 30th anniversary of the Montreal Protocol in 2017, the once endangered ozone layer is recovering. Ours is an extraordinary success story of governments, experts and ordinary people coming together, responding to scientific findings, and acting together to protect life on the planet from the sun's harmful ultraviolet rays.

In the next 30 years, our defining mandate under the Montreal Protocol will be to phase down HFCs so that the planet and its people may be better protected against climate change. We will all contribute through the Montreal Protocol to combating climate change and achieving the Sustainable Development Goals.

As we begin the task of implementing the Amendment, you can always count on the Ozone Secretariat. We will continue supporting all countries and ozone officers with energy and resolve to implement what they agreed on.

We look forward to working with all of you – governments, industry and NGOs – to ensure the vision of the Amendment becomes a reality, to make our work relevant to the lives of the people of our nations, and to deliver more and better for the global climate under the Montreal Protocol.

The Kigali Amendment to the Montreal Protocol

1. What is the Kigali Amendment?

The Kigali Amendment is an amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer. It was adopted by the 28th Meeting of Parties to the Montreal Protocol (MOP28) on 15 October 2016 in Kigali, Rwanda. The Amendment adds powerful greenhouse gases hydrofluorocarbons (HFCs) to the list of substances controlled under the Protocol and which are to be phased down. The Amendment will enter into force when the conditions indicated under question 6 below are met.

The text of the Kigali Amendment as issued by the Depositary of the Amendment, the Secretary-General of the United Nations, on 23 November 2016 in all the six official languages of the United Nations is available *here*.

2. What is the expected impact of the Kigali Amendment?

The Amendment will phase down HFCs under the Montreal Protocol. Use of HFCs is increasing rapidly as substitutes for ozone-depleting substances. HFC phasedown is expected to avoid up to 0.5 degree Celsius of global temperature rise by 2100, while continuing to protect the ozone layer.

3. How will the Kigali Amendment work?

Under the Amendment, Montreal Protocol parties are required to gradually reduce HFC use by 80-85 per cent by the late 2040s. First reductions by most developed countries are expected in 2019. Most developing countries will follow suit by a freeze of HFCs consumption levels in 2024, and in 2028 for some of them. Details of the elements of the agreed HFC phase-down schedule are provided in table 1 below:

Table 1: Phase-down schedule for HFCs applicable to Article 5 and non-Article 5 parties

	A5 parties (developing countries) - Group 1	A5 parties (developing countries) - Group 2	Non-A5 parties (developed countries)
Baseline formula	Average HFC consumption levels for 2020-2022 + 65% of hydrochlorofluorocarbon (HCFC) baseline	Average HFC consumption levels for 2024-2026 + 65% of HCFC baseline	Average HFC consumption levels for 2011-2013 + 15% of HCFC baseline*
Freeze	2024	2028	-
1st step	2029 – 10%	2032 – 10%	2019 – 10%
2nd step	2035 – 30%	2037 – 20%	2024 – 40%
3rd step	2040 – 50%	2042 – 30%	2029 – 70%
4th step	-	-	2034 – 80%
Plateau	2045 – 80%	2047 – 85%	2036 – 85%

* For Belarus, Russian Federation, Kazakhstan, Tajikistan, Uzbekistan, 25% HCFC component of baseline and different initial two steps (1) 5% reduction in 2020 and (2) 35% reduction in 2025

Notes:

1. Group 1: Article 5 parties not part of Group 2
2. Group 2: Bahrain, India, the Islamic Republic of Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia and the United Arab Emirates
3. Technology review in 2022 and every five years
4. Technology review four to five years before 2028 to consider the compliance deferral of two years from the freeze of 2028 of Article 5 Group 2 to address growth in relevant sectors above certain threshold.

4. What are the next steps after adoption of the Kigali Amendment?

The Depositary of the Amendment, the Secretary-General of the United Nations on 23 November 2016 issued a depositary *notification* along with the certified copies of the Kigali Amendment to the Montreal Protocol in all the six official languages of the United Nations to the Ministries of Foreign Affairs of the Parties to the Montreal Protocol. Following this notification, the parties are now in a position to take the necessary steps at the national level towards ratification of the Amendment as described under question 5 below.

5. What is ratification?

"Ratification" (or acceptance or approval) is the action taken by a party to an international treaty to confirm that it consents to be bound by the treaty. Ratification of the Kigali Amendment to the Montreal Protocol by at least 20 parties is required before the Amendment can enter into force.

The process by which parties ratify the amendment involves the following steps:

1. First, a party will take the necessary steps at the national level, as specified in their constitutional arrangements, to allow it to move ahead with ratification of the amendment at the international level.
2. The party will then execute an instrument of ratification (or acceptance or approval). The instrument includes a statement to the effect that the Government concerned ratifies the Amendment and undertakes to comply with its provisions. A model form for this instrument, based on the format provided by the United Nations Office of Legal Affairs, can be found *here*.
3. The party will later deposit its duly executed instrument of ratification (or acceptance or approval) with the Depositary. This is done by delivering the original instrument, by hand or by mail, directly or through its Permanent Mission to the United Nations, to:

   Treaty Section
   Office of Legal Affairs
   United Nations
   New York, NY 10017
   USA

PLEASE NOTE: Instruments of ratification, acceptance or approval are not deposited with the Ozone Secretariat.

The Secretariat stands by to inform, advise and support every party on the ratification process. For this purpose, a *briefing note* describing the ratification process is available on the Secretariat website.

6. What is required for the Kigali Amendment to enter into force?

The Kigali Amendment will enter into force on 1 January 2019, provided that it is ratified by at least 20 parties to the Montreal Protocol. If that condition is not met by that date, the Amendment will become effective on the 90th day following the date of ratification by the 20th party.

7. How can I find out if my country has deposited an instrument of ratification, acceptance or approval of the Kigali Amendment?

The United Nations Treaty Collection website maintains all information on the status of ratification of international treaties, including the Kigali Amendment. The Ozone Secretariat also publishes the status of ratification on its *website*.

8. Until when does my country have to complete this procedure?

Ratification of the Kigali Amendment by parties to the Montreal Protocol should take place as soon as possible to enable full implementation of the amendment by 2019.

For further information, please contact the Secretariat at:
ozoneinfo@unep.org

Hydrofluorocarbon phase-down feasible with technology cooperation and finance for Article 5 Parties

Stephen O. Andersen, Institute for Governance & Sustainable Development (IGSD)
Alexander Hillbrand, Natural Resources Defense Council (NRDC)

The Kigali Amendment to the Montreal Protocol has made HFC phase-down a global obligation for all Parties, with finance for Article 5 Parties through the Multilateral Fund (MLF). Funds will begin to flow in 2017, with US$ 80 million for 'Fast Start' funding from philanthropists and governments, followed by MLF replenishments for 2018-2020 and every three years thereafter. Together, these funds will allow Article 5 Parties to leap-frog over HFCs while re-tooling and redesigning for the HCFC phase-out. The replenishment should also be sufficient to strengthen Montreal Protocol institutions like OzonAction, National Ozone Offices, Regional Networks, the MLF and the Technology and Economic Assessment Panel (TEAP). Additional financial support for research and development, demonstration projects, energy efficiency measures and special deployment projects in low-consuming countries would expand the traditional role of the MLF and ensure that the Kigali Amendment achieves the largest possible environmental benefits.

It is technically and economically feasible to immediately phase down the production and consumption of high global warming potential (GWP) hydrofluorocarbons (HFCs) – potent greenhouse gases (GHGs) that warm the climate thousands of times more than carbon dioxide (CO_2), kilogramme for kilogramme. In fact, governments and leading companies in Australia, the European Union, Japan, the United States of America and elsewhere are phasing down HFCs and promoting alternatives that can save money while improving climate performance, reliability and energy efficiency.

Government-industry leadership is emerging to replace ozone-depleting hydrochlorofluorocarbons (HCFCs) and HFCs with energy-efficient, low-GWP alternatives. For example, the first commercialization of HC-290 room air-conditioners (ACs), in India by Godrej and in China by Gree, was carried out in cooperation with the German overseas development authority Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). The first commercialization of HFC-32 room ACs, at the request of the Government of Indonesia, was carried out by Daikin, Panasonic and other Japanese companies in cooperation with the United Nations Development Programme (UNDP), the Japan Ministry of International Trade and Industry (MITI) and the Institute for Governance & Sustainable Development (IGSD).

HFCs are factory-made gases that were once necessary to replace ozone-depleting substances (ODS) but are no longer needed because environmentally superior alternatives are available in the air-conditioning, refrigeration and foam insulation sectors. HFCs have high GWP, typically far lower than CFCs but higher than the HCFCs they replaced. HFC refrigerants also tend to cool less and use more energy, which increases dangerous power plant pollution like CO_2, sulfur oxides (SOx), nitrous oxides (NOx) and particulates like black carbon.

Today, HFCs are the fastest-growing GHGs in much of the world, with their use increasing at a rate of 10-15 per cent per year.[1] Taking no action to curb HFC growth would have resulted in GHG emissions equivalent to at least 125 billion tonnes of CO_2 between now and 2050[2], contributing an expected 0.5°C increase in global average temperature by the century's end.[3]

Following the Kigali Amendment to the Montreal Protocol to phase down HFCs, developing countries will no longer replace HCFCs with unsustainable HFCs. Instead, they will choose more climate-friendly alternatives like CO_2, ammonia, hydrocarbons and hydrofluoroolefins (HFOs), thereby avoiding HFC appliances and infrastructure that will soon be obsolete.

The Kigali Amendment builds on the ODS phase-out in the important way of promoting energy efficiency. Historically, the

1 Velders, Guus, et al. *Preserving Montreal Protocol Climate Benefits by Limiting HFCs.* Science Magazine, AAAS 2012. http://www.igsd.org/documents/Science-2012-Velders-922-3.pdf

2 Velders, Guus J.M., David W. Fahey, John S. Daniel, Stephen O. Andersen, and Mack McFarland. *Future atmospheric abundances and climate forcings from scenarios of global and regional hydrofluorocarbon (HFC) emissions.* Atmospheric Environment, 2015. http://ac.els-cdn.com/S135223101530488X/1-s2.0-S135223101530488X-main.pdf?_tid=e79d900c-1856-11e6-8a09-00000aab0f6c&acdnat=1463067401_05bba860ed95d43ce2141c7e05bd12a7

3 Wu, Yang, Durwood Zaelke, Guus. J. M. Velders, and Veerabhadran Ramanathan. *The role of HFCs in mitigating 21st century climate change.* Atmospheric Chemistry and Physics, 2013. http://www.atmos-chem-phys.net/13/6083/2013/acp-13-6083-2013.pdf

4 Shah, Nihar Max Wei, Virginie Letschert, and Amol Phadke. *Benefits of Leapfrogging to Superefficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning.* Lawrence Berkeley National Laboratory, 2015. http://eetd.lbl.gov/sites/all/files/lbnl-1003671_0.pdf

MLF, which funds conversions of factories from production of ODS to available alternatives, has not financed many energy efficiency upgrades. Doing so would help developing countries (Article 5 Parties) limit the amount of additional electricity needed to meet growing air-conditioning and refrigeration demands. For example, a 30 per cent increase in the energy efficiency of room air-conditioners would avoid the need for up to 1,500 medium-sized power plants worldwide.[4]

The Kigali Amendment includes a faster phase-down schedule by non-Article 5 Parties. The faster developed countries make the transition, the faster global markets for alternatives will reach maturity. The long HFC phase-down period for developing countries will allow them to choose the best technologies.

In the ODS phase-out, about 85 per cent of production and consumption was replaced by not-in-kind (NIK) options, with only 15 per cent replaced with HFCs, principally in refrigeration and air-conditioning and some foam, medical, and fire protection applications. In the next decade, the case will be similar, with many HFC foam, refrigeration and air-conditioning applications being replaced by NIK, low-GWP substances including hydrocarbons, CO_2 and ammonia. The remaining HFC use will be replaced by low-GWP HFOs and mid-GWP HFCs and HFO/HFC blends, which can be considered transitional substances.

Hydrocarbon HC-290, for example, is an excellent room air conditioner refrigerant without intellectual property claims on the chemical application or the production process. However, HC-290 flammability currently limits the unit size to below about 5 to 7 kilowatt (kW) (~1.5 to 2 tonnes). HFC-32, patented by Daikin but now available free of charge to any company, is energy-efficient and currently approved in larger units of up to about 16 kW (~4.5 tonnes). R-452B, patented by Ingersoll Rand but now available free of charge to any company, is energy-efficient and safe in air-conditioner systems larger than 4.5 tonnes. New research and development will help international standards increase the safe unit size of flammable refrigerants by assessing the role of refrigerant detectors, shut-off valves, smart ventilation and other flammability mitigation schemes. Larger allowable units mean faster and deeper cuts in the use of HFCs by replacing them with the most energy-efficient refrigerants with the lowest GWP.

Developments in patent-protected, low-GWP alternatives may also affect the speed and depth of the phase-down. For mobile air-conditioners (MACs), HFO-1234yf has emerged as the pre-eminent HFC-134a alternative. HFO-1234yf requires few design changes but is subject to numerous worldwide production and application patents. However, HFO-1234yf is already produced in China by a joint venture of Shanghai 3F New Material Company (Shanghai 3F) and Chemours and will soon be produced in India by a joint venture of Navin Fluorine and Honeywell. HFO-1234yf will also be independently produced in India by SRF using its own chemical pathway and technology and will be produced in Europe and North America by companies not claiming application patents. Furthermore, technologies unencumbered by intellectual property constraints are emerging, such as CO_2 MACs promoted by Daimler and HFC-152a investigated by Tata Motors Limited, MAHLE and others.

Congratulations to the Parties to the Montreal Protocol for helping make the world safe and sustainable for future generations!

Ozone and climate benefits from the refrigeration servicing sector – achieved and achievable

Klas Berglöf, ClimaCheck Sweden AB

The Montreal Protocol brought a paradigm shift to the global refrigeration and air-conditioning (RAC) sector. This sector was largely unregulated and fragmented prior to the control of ozone-depleting substances (ODS) by the Protocol. There were a few global players but RAC services were and are still largely provided by small local companies in most markets. In many developing countries, a large part of the services were provided by the "informal sector"; "technicians" trained on the job and training capabilities limited by the lack of demand. The result was high leakage rates of refrigerants, high levels of energy consumption, frequent failures and loss of perishable goods and industrial production.

Air-conditioning and refrigeration sector moves up from the informal sector

The Montreal Protocol supported Article 5 (developing) countries with the introduction of training capabilities, together with legal frameworks regulating the import of ODS refrigerants and requiring certification. This created a new reality that contributed to structuring the industry and moving the business from the informal sector to certified companies with better trained staff. It is obvious that this process is not smooth but it has benefited not only the ozone layer but also the climate. Decreased leakage rates reduce both imports of expensive refrigerants and energy consumption while failure rates decrease. The benefits of improved service for operational costs and national trade balances are significant although partly offset by the use of costlier alternatives.

ODS phase-out is just the start of the transition

There are still challenges and opportunities for countries and the industry in a post-ODS market. The industry faces the following three challenges following the Kigali Amendment to the Montreal Protocol:

- Reduce the emissions of high-global warming potential (GWP) refrigerants;
- Decrease energy consumption; and
- Minimise food wastage in the supply chain from the farm to consumer in growing urban areas

RAC systems are estimated to account for 20 per cent of global electricity use and significantly more in urban areas with warm climates. To minimise the climate change impact, refrigerants with minimal GWP and systems with the highest possible energy efficiency are essential.

Refrigerant leak detection and prevention has become standard practice and the introduction of low-GWP alternatives is well advanced in many countries. The use of ammonia, carbon dioxide and hydrocarbons has increased in several sectors. The uncontrolled introduction of hydrocarbons in some markets has caused a backlash when accidents push regulators to try to catch up with market situation. **All refrigerants can be used safely but this requires competence and selection should be based on safety and environmental impact, including efficiency and cost.**

Energy optimisation is a challenge for sustainable refrigeration and air-conditioning

In all countries, industrialised as well as developing, the difference between design and actual efficiency is significant. Thousands of performance measurements around the world show an average energy saving potential of 20-30 per cent in existing systems with low or no-investment measures. A major cause is the equipment owners' focus on keeping initial costs low and the expectation that if the building or goods are kept at the desired temperature, the system is working well. That a poorly commissioned system can increase energy consumption, sometimes by more than 50 per cent, is not expected. The cost of measurement and validation is seen as unnecessary when highly rated expensive equipment is purchased. The result is that nobody is requested and paid to validate performance which causes a lack of competence in optimisation. Efficient operation requires performance analysis and optimisation for different load and climate conditions in each project as design conditions rarely occur in 'real world' operating conditions and have a minor impact on annual operating costs. Understanding the interaction between different systems in buildings and supermarkets requires measurements and competent interpretation of the information. **Upgrading commissioning and preventive maintenance, including measurement and validation of performance, are the low hanging fruits in energy saving.** The general lack of detailed technical refrigeration competence among equipment owners reduces their willingness to pay "extra" when the cooling "works". There is, at the same time no incentive for the service sector to promote higher quality preventive maintenance as failures are profitable business. The company that has the service contract for a plant typically gets to repair the system after failure without price competition. The lack of preventive maintenance and optimisation is, for obvious reasons, rarely identified as the cause of the failure that resulted in loss of perishable goods. This would place the blame on the company maintaining the system. The service sector today, in general, lacks competence, experience and business incentives to promote performance measurements as their customers are not asking for them. An increased focus on energy costs and the carbon footprint following the Kigali Amendment, requires capacity building in the service sector of the same magnitude as that achieved for phasing out ODS. Energy efficiency is as important as reducing emissions of high-GWP refrigerants. There are huge potential benefits for equipment owners and nations in upgrading commissioning and preventive maintenance practices in order to reduce energy costs, ensure less failures and reduce waste of perishable goods.

Safe use of flammable, toxic and high-pressure refrigerants: Back to the future?

Michael Moller, Praxis Vocational

The continuing phase-out of ozone-depleting hydrochlorofluorocarbons (HCFCs) has seen an increase in the use of hydrofluorocarbon (HFC) refrigerants with high global warming potential (GWP). The October 2016 Kigali Amendment to include a phase down in the use of HFCs sees a move towards climate-friendly alternatives. However many low-GWP refrigerants have safety requirements associated with their use such as flammability, toxicity or high pressures. With the rapid changes in refrigerant technology, many Article 5 countries are looking to adopt technology options that their industries may not be ready for.

Although not new to the refrigeration and air-conditioning (RAC) industry, refrigerants with safety issues involving toxicity, flammability and high pressures have been mostly used in the industrial sector where safety procedures are routine and well documented.

The use of flammable and toxic refrigerants such as chloromethane and sulphur dioxide was common in domestic refrigeration appliances in the 1930s and technicians were trained in the safe use of these refrigerants. However, safe working practices did not get as much attention after the introduction of CFC-based refrigerants which are non-toxic and non-flammable.

The introduction of low-GWP refrigerants into the RAC industry requires a 'return to the past' with regard to identification, legislation and education of associated safety issues regarding the use these refrigerants.

Many countries have legislation in place to control the handling and use of ozone-depleting substance (ODS). However, the increased safety concerns associated with low-GWP alternatives require legal regulation of all refrigerants.

Recognising the safety issues, governments have moved to introduce new policies for safe handling of refrigerant gases. Standards and licensing for refrigeration technicians have been introduced to ensure the safety of service technicians and of consumers. Policy and legislation options will have a large impact in shaping RAC technology choices for Article 5 countries.

Standards

Standards and regulations guide technicians in the safe application of technology. Standards are based on international experience, but may need to be modified to suit regional or national circumstances and can be applied either as guidelines or as regulatory requirements. The adoption of standards in the RAC industry will become increasingly important in decision-making processes related to the adoption of low-GWP technologies. The adoption of standards can also encourage markets to choose the safest technology options for the country, taking into account local capacities.

Standards are used as guidelines for training and education, to help develop certification systems and define minimum requirements for safe working practices. Standards can be enacted into legislation by governments or adopted voluntarily by associations into codes of good practice. Promotion of standards helps to reassure consumers that RAC systems are safe, efficient and good for the environment.

Training and education

Critical to the adoption of standards and introduction of legislation, is the building of RAC sector capacity with skills and education. The curriculum for training and education in safe practices for low-GWP alternatives should be part of every training programme. Strategic implementation plans, based on local capacities, technology choices and sectoral responses to market forces, will assist in shaping the educational programmes. For example, the fisheries sector in Fiji may opt for ammonia as an alternative refrigerant, necessitating training and education in toxic refrigerant use. Whereas, the predominant split-system air-conditioning market in Samoa may choose R-32-based systems, necessitating training and education in flammable refrigerant use. Indeed, R600 hydrocarbon-based domestic refrigerators are already entering markets across the Pacific, despite the requisite training and education not being available in many local training institutions.

While the climate benefits of moving to low-GWP refrigerants are undisputed, safety considerations in the adoption of the alternatives must be considered in a country-specific context.

PRAHA: the Way to Promote Alternative Refrigerants for the Air-Conditioning Industry in High Ambient Temperature Climates

Ayman Eltalouny, UN Environment, OzonAction, Ole Reinholdt Nielsen, United Nations Industrial Development Organization (UNIDO), Bassam ELASSAAD, RTOC member, Walid Chakroun, Kuwait University, Fellow ASHRAE

Background

The project entitled "Promoting low GWP Refrigerants for Air-Conditioning Sectors in High-Ambient Temperature Countries", also known as PRAHA was approved by the Multilateral Fund (MLF) of the Montreal Protocol, with the aim of assessing the feasibility of low-GWP refrigerants suitable for high-ambient temperature countries and, in particular, for air- conditioning applications. The table below shows the prototypes built for each type of refrigerant examined under this project.

	60 Hz		50 Hz	
Refrigerant	Window 18,000 BTU/ HR	Split 24,000 BTU/ HR	Ducted Split 36,000 BTU/ HR	Package 90,000 BTU/HR
HFC-32	N/A	Tested	Tested	N/A
R-444B (L-20)	Tested	Tested	Tested	Tested
R-447A (L-41)	N/A	Tested	N/A	N/A
DR-3	Tested	Tested	Tested	Tested
HC-290	N/A	Tested	N/A	N/A
Base Units				
HCFC-22	Tested	Tested	Tested	Tested
R-410A	N/A	Tested	Tested	N/A

Six local Original Equipment Manufacturers (OEMs) built 14 prototypes), using five alternative refrigerants and also shipped nine "base units" running on HCFC or HFC for direct comparison purposes. Testing was conducted at 35°C, 46°C and 50°C ambient temperatures with an "endurance" test at 55°C ambient temperature. Indoor conditions were kept the same for all tests: dry bulb temperature of 27°C and relative humidity of 50 per cent as per AHRI (Air-Conditioning, Heating and Refrigerating Institute) test procedures for T1 conditions (35°C) and 29°C and 50 per cent humidity for T3 (46°C and 50°C) conditions. All prototypes in each category were built with the same cooling capacity and fit in the same box dimensions as their respective base units, with the design condition to meet minimum energy efficiency (EER) of 7 at 46°C. The tests were conducted at an independent laboratory, Intertek, which was selected through a competitive bidding process. Verification of repeatability (reliability of results) was performed to ensure that the results were within acceptable accuracy levels. Some categories were not tested under PRAHA due to the non-availability of compressors or concerns over the refrigerant charge size and associated safety characteristics related to flammability of the refrigerants.

Results from Testing

The results from the testing of each category can be found in detail in the project final report while the overall concluding remarks from the testing process are summarised as follows:

I. There are potential alternatives that have cooling capacities and energy efficiency performances close to the baseline refrigerants, or even better in some cases. These are worth further investigation. With further engineering, these alternatives can be strong candidates to replace HCFC-22 and the main focus for phase-out activities in Article 5 (developing) countries.

II. There is a need for significant improvement in the research and development capacity of the local air-conditioning industries in high-ambient temperature countries in terms of re-designing and optimising products using low-GWP alternatives with their specific characteristics, such as flammability, higher pressures, temperature glide, and excess discharge temperature.

III. Economic and technology transfer barriers such as intellectual property rights will continue to be an issue for some time before international and regional markets stabilise and focus on a limited group of alternative refrigerant candidates that can continue to be marketed, compared to the current long list of options currently being examined.

IV. Due to the specific characteristics of the future alternatives, there is a need for comprehensive risk assessment tailored to the needs of Article 5 countries and high-ambient temperature conditions, in particular. Such an assessment should address the size of the industry, the markets, servicing and the end of life of the equipment.

V. There is a lack of institutional programmes that address alternative technologies and reduce dependence on high-GWP alternatives in high-ambient temperature countries. The continued marketing of available options reflects the limited research into alternatives.

VI. The improvement in energy efficiency (EE) standards for air-conditioning applications in high-ambient temperature countries is progressing at a much quicker pace than the speed of assessing alternative refrigerants. A smart approach is needed in addressing EE in conjunction with low-GWP alternatives in order to avoid promotion of higher-GWP alternatives that are commercially available at present.

District Cooling: An Opportunity to reduce dependency on high-GWP Refrigerants

PRAHA included another regional dimension – investigating the potential of District Cooling (DC) systems using low-GWP and/or non-vapour compression options as long-term energy-efficient solutions. The resources available for this component were limited and allowed only a desk analysis comprising compiling information, market analyses and expert views from several reliable sources as well as organising a dedicated District Cooling Symposium for industry and relevant governmental authorities in West Asia region.

The study found that as of 2012, 14 per cent of the estimated total installed air-conditioning systems in the Gulf Cooperation Council countries were DC systems, 45 per cent of which were in the residential sector and 31 per cent in the commercial sector. Air-conditioning system installations in the region are estimated to double by 2030 and if all systems are conventionally built, the power requirement will increase by 60 per cent, which is equivalent to 1.5 million barrels of oil per day. DC systems consume less energy than conventional air-conditioning systems and reduce power demand by 50 to 87 per cent. DC projects in high-ambient countries mostly use high-GWP based technologies due to the unwillingness of technology providers or suppliers to promote low-GWP refrigerants or non-vapour compression technologies. The Kigali Amendment Agreement on phasing-down HFCs might provide an opportunity to start promoting such concepts. The global phase down HFCs and F-gases in general, is a golden opportunity to start promoting the use of not-in-kind technologies through the DC concept.

The main success of PRAHA is that it went beyond being an individual project and evolved into a PROCESS involving governments, local industry and institutions as well as international technology providers.

Priorities of Future Work

Taking into account the key findings of PRAHA as well as other ongoing research projects and initiatives at regional and/or international levels, it is clear that there are priority areas and others area that need time to be addressed and cannot be expedited ahead of the ongoing pace of business. The table below identifies the priority areas for future work under the PRAHA process. This list is not exhaustive, but represents the most significant issues identified as priorities for advancing the process of promoting low-GWP alternatives in the air-conditioning industry.

PRAHA-II: Mission goes on

As PRAHA evolved to be a “Process”, the next phase of it, which is called PRAHA-II, is designed to address and deal with the findings and priority areas identified of PRAHA-I. It will mainly continue the process of optimising prototypes that were built, to elevate their cooling capacity and efficiency in comparison with HCFC-22 and HFC-410A baseline air-conditioners through means of re-engineering the designs and adjusting its operating parameters. PRAHA-II also includes a comprehensive training programme for the Research & Development engineers of air-conditioning manufacturers to better understand design and production aspects associated with low-GWP alternative refrigerants. The project will establish, for the first time, a model for building dedicated risk assessment model for high ambient countries with focus on the risks related to production, installations and servicing. Finally, an outreach platforms and tools will be maintained by, PRAHA-II, to ensure sound transfer of knowledge and wider consultation process amongst all stakeholders.

District Cooling: A not-in-kind technology or a mechanical vapour compression technology?

Alaa A. Olama, Refrigeration, Air conditioning and Heat Pumps Technical Options Committee (RTOC)

A District Cooling system is a central air-conditioning system that produces and distributes chilled water from a plant(s) to buildings, thus centralising the production of chilled water and maximising economy of scale. Although district cooling systems have higher capital costs than individual central air-conditioning stations located in buildings, the former have higher energy efficiency, particularly when the building is situated in a dense area with a high cooling load per surface area. The higher energy efficiency of district cooling systems is an important issue, especially in countries where energy supply is a factor to be taken into account. Reduced carbon dioxide emissions from district cooling systems compared to individual or central air-conditioners is another important issue. This is mainly due to the diversity factors of district cooling plants compared to individual central air-conditioning stations located in buildings, which makes the comparable installed capacity of a district cooling station smaller by as much as a third in some cases.

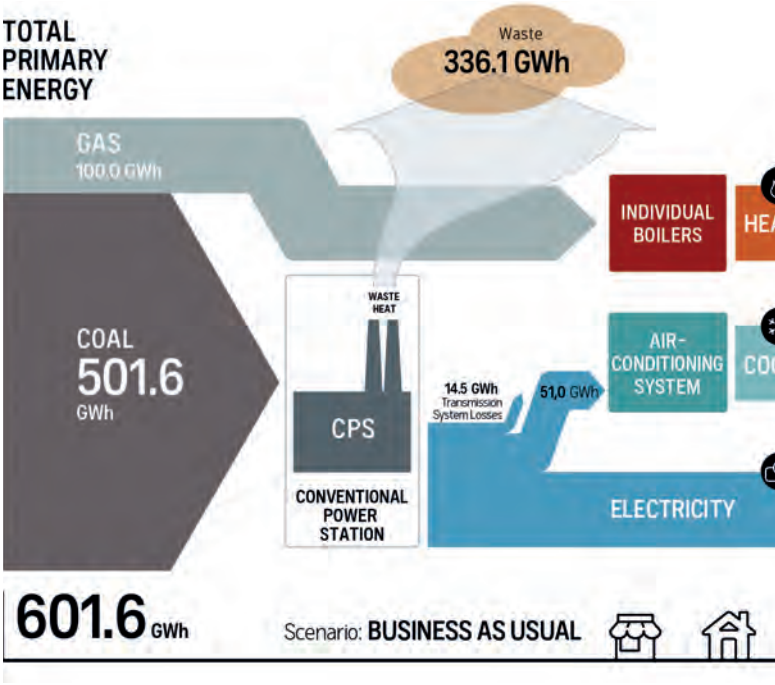
District cooling is a relatively new technology. The Connecticut Natural Gas Company, utilising natural gas for air-conditioning, introduced it in Hartford, Connecticut, United States of America in 1963. District cooling has been available for a much shorter time compared to district heating, which is about 140 years old.

District cooling has benefited from recent technological improvements, making it an important cooling technology. These include:

- Improvements in the efficiency of new chillers, improved efficiency in distribution systems pumping and better quality prefabricated, pre-insulated piping suitable for direct burial, resulting in cheaper distribution systems.
- Other technological developments include higher thermal efficiency (70 to 85 per cent) of co-generation systems, increased importance of trigeneration, the simultaneous production of heating, cooling and electric energy, and improvements in large, stratified chilled water thermal storage tanks.

Interest in district cooling is increasing in Asia and the Middle East, especially in the Gulf region where its use has grown exponentially since the 1990s.

The Gulf Cooperation Council (GCC) countries expect all cooling capacities to triple between 2010 and 2030. This would be an increase from 127 million to 352 million kilowatt (kW). This is expected to increase additional installed district cooling capacity by 85.43 million kW (24.27 million TR) as shown below[1]:



Expected increase in district cooling capacity 2010-2030

Country	Increase in installed district cooling capacity - 2010 to 2030 kW (TR), million.
Kingdom of Saudi Arabia (KSA)	**44.88 (12.75)**
United Arab Emirates (UAE)	**30.20 (8.58)**
Qatar	**10.35 (2.94)**
Total	**85.43 (24.27)**

In Europe, more projects are contemplating the use of district cooling, especially with increased awareness of the environmental benefits of district cooling. The United States has pioneered district cooling and heating, setting the pace for many years with the adoption of innovative technologies. Many U.S. States are deregulating electric utilities. A building owner will be able to buy electricity from producers other than the local provider. Utilities are creating subsidies that provide district cooling systems, electricity driven, offering customers an alternative service using electric power. Demand for district cooling is expected to increase once these measures are taken.

Why is district cooling becoming such an important technology worldwide? The reason is that, although it started as an

1 Booz & Co. (now Strategy&), 2012: Unlocking the potential of District Cooling, the need for GCC governments to take action, 2012.

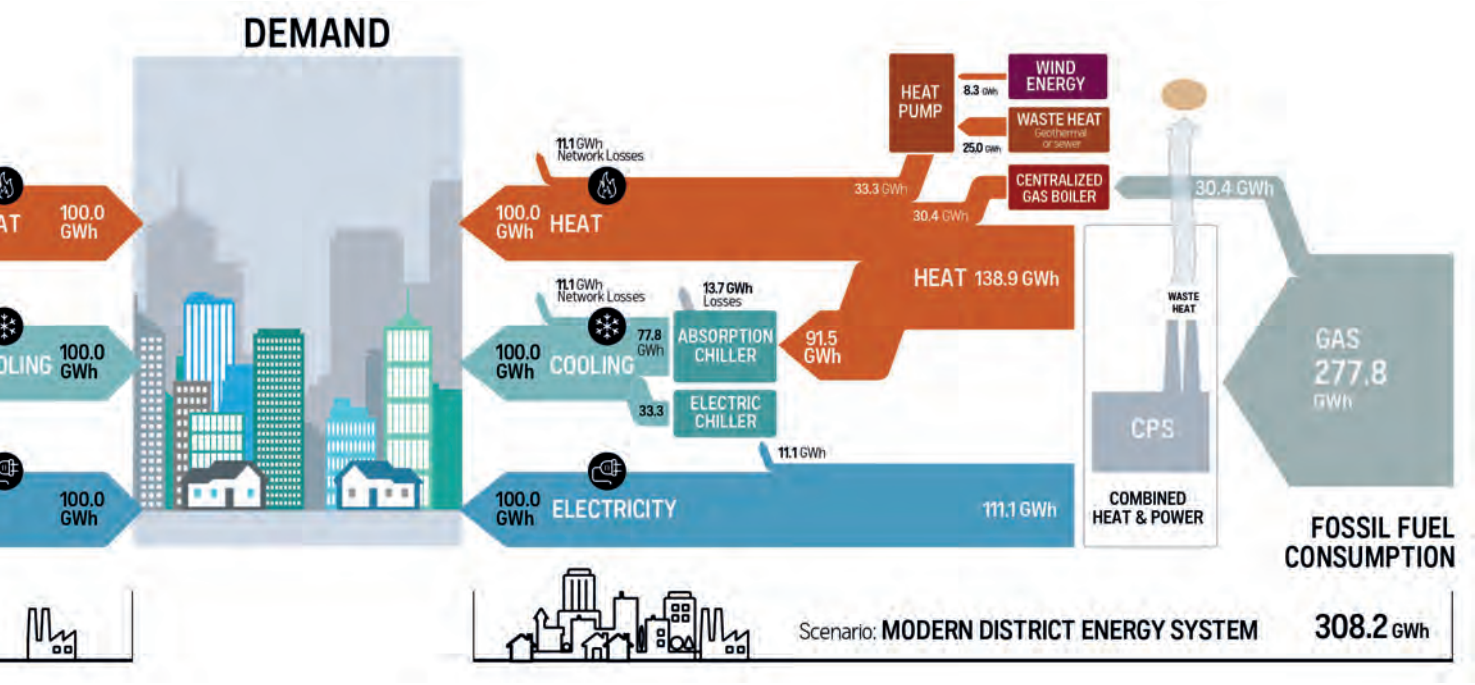


Figure 1: The economic and environmental benefits of district cooling in a modern power station for a city

application for mechanical vapour compression technology, utilising electric power to drive a compressor, it is slowly changing into a mixed power driven technology. Both electric and heat power are used. This is shown in the figure 1 below, comparing two power stations, one utilising a traditional approach design and the other a modern district energy design. In the modern station, both cooling and heating capacities are primarily obtained from exhaust-rejected heat. For cooling, the station utilises absorption chillers, fired by rejected heat to obtain 77.8 per cent of its cooling capacity. As shown in figure 1, electricity-driven chillers, in-kind technology, provide the remaining 33.3 per cent. For heating, a heat pump driven by wind or sewer waste-generated or geothermal heat, provides 33.3 per cent and 36.3 per cent is obtained from station exhaust rejected heat. Both stations have an output of 100 gigawatt hour (GWh) heating, 100 GWh cooling and 100 GWh electricity, although the modern design utilises 48.76 per cent energy compared to the business-as-usual design, and has a smaller carbon footprint.

Finally, is district cooling a not-in-kind technology or a mechanical vapour compression in-kind technology? It can be said it was an in-kind technology and is becoming progressively a mixed-kind technology with not-in-kind playing an increasingly dominant part.

Passive design approach for energy-efficient buildings

Doaa M. El-Sherif, Ministry of Housing, Utilities & Urban Communities, Cairo, Egypt

Introduction

Energy is essential to our daily lives. It heats our homes, fuels our transport and supplies our electricity. Most of the energy we use comes from fossil fuels such as oil, gas, coal and peat. Besides their limited supply, another downside to fossil fuels is that their use produces carbon dioxide (CO_2), a greenhouse gas responsible for climate change.

The building sector is estimated to account for more than one third of global energy consumption[1], making it the biggest single contributor to total energy consumption. Since the year 2000, primary energy consumption has increased by nearly 50 per cent[2] and final electricity consumption has nearly doubled[3]. A "business-as-usual" approach will, accordingly, lead to another doubling of final electricity demand by 2020.

The energy efficiency of a building is the extent to which the energy consumption per square metre floor area of the building, measures up to established energy consumption benchmarks for that particular type of building under defined climatic conditions. Building energy consumption benchmarks are representative values for common building types against which a building's actual performance can be compared. The benchmarks are derived by analysing data for different building types within a country. Benchmarks are applied mainly to heating, cooling, air-conditioning, ventilation, lighting, fans, pumps and controls, office or other electrical equipment, and electricity consumption for external lighting. The benchmarks vary with the country and type of building.

Planning for a cost-effective, energy-efficient building needs to start with the architectural design and the construction of the building envelope.

Therefore, **the right approach would logically** start with the architectural design, in the preliminary stages. By using only simple design strategies such as orientation, size of window openings, shading and insulation, the net energy demand can easily be reduced by around 30 per cent and indoor comfort improved at the same time. This is **the passive design approach**.

A 'passive' design approach is most cost-effective in reducing the energy consumption of a building. A good design can even reduce the investment cost of a building, when considering compactness, efficient layout and orientation. Once a building is designed with an optimal energy demand, 'active systems' such as heating, cooling and lighting equipment can be added for indoor thermal comfort.

The passive design approach consists of different climate responsive strategies to **reduce the energy demand of a building** and avoid heat transfer through the building envelope, as follows:

- **Orientation:** reduces solar radiation on the building envelope.
- **Ventilation:** uses airflow to release heat and humidity.
- **Thermal zoning:** allocates functions related to time of use and solar gain.
- **Building form and typology:** reduces solar radiation on the building envelope and optimises daylight access.
- **Building envelope design** (size and location of windows and shading): provides minimum required daylight access, together with minimal heat gain and maximal external reflection.
- **Materials selection:** reduces heat transfer to the indoor space.
- **Landscaping:** provides shade to the building, reducing heat gain and creating a pleasant outdoor space.

1 MED-ENEC: "Energy Efficient Building Guideline for MENA Region", EU, Cairo, November 2013.

2 Ibid

3 Ibid

Refrigerants and Building Codes Nexus

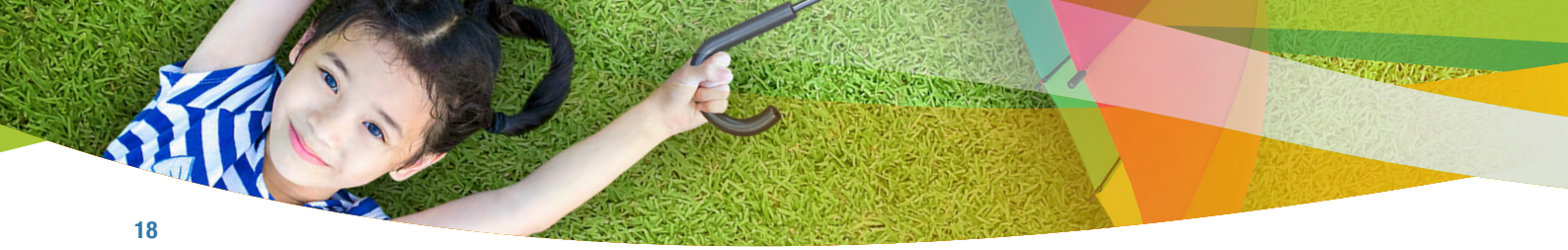
Essam E.Khalil, Cairo University

Energy-efficient building codes are meant to guide building designers, construction managers and real estate operators in promoting best energy efficiency practices in the construction industry. The built environment is designed as a shelter for humans as well as a filter to control environmentally undesirable conditions. Building technology also involves carbon emissions during the transport of materials and the generation of electricity used for most buildings' applications. Building energy codes and labeling can significantly reduce such carbon emissions. To improve living conditions in built environments, thermal management is applied through air-conditioning and refrigeration technologies. Some hydrofluorocarbons (HFCs), being used as refrigerants, have a high global warming potentials (GWP).

All countries must keep their commitments under the Paris Agreement to pursue aggressive cuts in greenhouse gas emissions. Yet, even with full implementation, global temperatures will likely increase by between 2 to 4.5 degrees Celsius. The best and quickest way to prevent climate destabiliation is to cut back emissions of super climate pollutants that make a disproportionate contribution to global warming despite being produced in much smaller quantities than carbon dioxide. These include ground-level ozone and black carbon soot from sources such as power plants and diesel engines, as well as methane (often from natural gas systems and agriculture) and HFC refrigerants used in air-conditioning and other cooling systems. These four super pollutants are between 28 and several thousand times more potent than carbon dioxide as climate warmers. And because some are short-lived, slowing their release into the atmosphere can curb warming quickly. The October 2016 Kigali Amendment to the Montreal Protocol has now committed all Parties to phase down HFC production and consumption.

Naturally occurring refrigerants are one type of alternatives to fluorocarbon refrigerants. Natural refrigerants include carbon dioxide, ammonia and hydrocarbons which have zero ozone depletion potential (ODP) These refrigerants have a broad range of application, including in cold storage and freezing as well as commercial and industrial refrigeration. Although natural refrigerants have been used for more than 100 years, they are more relevant today than ever before. Given the need for refrigerants having low GWP, the use of natural refrigerants can improve the environmental performance of refrigeration systems.

Building codes comprise instructions for designing and implementing air-conditioning and refrigeration systems, but should also include requirements to address flammability issues and explosion risks. Building systems designers should balance the use of low-global warming potential (GWP) with non-ozone depleting substances (ODS) in aiming for an energy-efficient built environment.



China is actively promoting ozone- and climate-friendly technologies

Chen Liang, Ministry of Environmental Protection of China

Regarded as the most successful multilateral environmental agreement, the Montreal Protocol (MP) boasts of several pillars that have supported this achievement. One of the pillars is the development of alternative technologies and alternatives to replace ozone depleting substances (ODS). As the largest ODS producer and consumer among Article 5 countries, China has, since the very beginning, recognised the importance of taking the right decision in the selection of alternative technologies and alternatives for the smooth phase out of ODS. Even when China could only depend on developed countries for advanced alternative technologies, it upheld the principle of taking into consideration all the likely environmental impacts.

A good example is the use in the 1990s of R-600a and cyclopentane in refrigerator manufacturing to replace CFC-12 refrigerant and CFC-11 foaming agent. Today, 90 per cent of refrigerators manufactured in China use environment-friendly technology. With the right choice of alternatives in this sector, China has avoided the use of almost 100 million tonnes of carbon dioxide (CO_2)-eq greenhouse gases (GHGs) per year.

In the phase-out of hydrochlorofluorocarbons (HCFCs) and the implementation of HCFC Phase-Out Management Plan (HPMP) stage I, China has continued to actively promote low-(GWP) alternatives, taking into account the lifecycle climate performance. The selected alternatives include 76 per cent low-GWP alternatives, 10 per cent alternatives with medium GWP and less than 14 per cent are transitional alternatives with high GWPs. For example, the cold storage market in China has widely adopted the ammonia/CO_2 cascade system following successful implementation of a demonstration project supported by the Multilateral Fund (MLF). In the room air-conditioning (RAC) sector, R-290 has been selected as the main alternative due to its good cooling and energy performance and environmental benefits. To address challenges related to its flammability, the government and industry in China has been making efforts including safety assessment, product certification, standards review and revision, market promotion and training of technicians. In the foam and solvent sectors, all selected alternative technologies have low GWPs. For HPMP stage II, China proposes to use the best available environmentally-friendly and emerging technologies in the next 5-10 years with MLF funding. According to estimates by the implementing agencies responsible for various sectors, the climate benefits from HPMP stage I and stage II could be as much as 86.3 million tonnes of CO_2-eq and 221 million tonnes of CO_2-eq per year, respectively, when the conversions are completed.

In implementing the Vienna Convention and the Montreal Protocol, China actively promotes technology innovation, encourages enterprises to adopt advanced and green technologies from developed countries, and develops its own technologies based on national circumstances. The Ministry of Environmental Protection has issued a catalogue of recommended alternatives to encourage and guide industries in selecting environmentally-friendly technologies for conversion. Therefore, China's journey of implementing the Convention and the Protocol can also be seen as a journey to promote a green transformation in relevant industries.

Adapting Today for the Future

Tim Wentz, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

Since 2007, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and UN Environment have been working under a cooperative agreement to support countries around the world to fulfil their obligations toward phasing out ozone-depleting substances and to comply with the control measures set by the Montreal Protocol and its amendments. ASHRAE is uniquely positioned to assist UN Environment in its important mission.

Founded in 1894, ASHRAE has more than 56,000 members residing in more than 130 countries. ASHRAE's sole objective is to advance technology related to the creation and control of building environments and the thermal conditions for industrial processes and refrigeration. The influence of ASHRAE among engineers, technicians and scientists around the world is further extended through ASHRAE's relationship with 62 global societies.

Within the current work plan agreed to by UN Environment and ASHRAE, several important initiatives are underway.

As a participant in the UN Environment *Stakeholder Workshop to Streamline Training for the Refrigerant Service Sector*, ASHRAE contributed technical expertise drawing upon the knowledge of its members in the safe handling of refrigerants. The need for the workshop results from the rapid pace of refrigerant technology development, which impacts the need for skill development in the servicing sector. There will always be locally driven qualification and certification, but training can be harmonised globally since the content is the same.

One of ASHRAE's most important contributions to the industry in general is American National Standards Institute ANSI/ ASHRAE Standard 34, D*esignation and Safety Classification of Refrigerants*. This document, which is adopted and referenced worldwide, establishes a simple means of referring to common refrigerants rather than by their chemical name, formula or trade name. ASHRAE assigns numbers and safety classifications to the refrigerants based on toxicity and flammability data submitted by the refrigerant's producer. ASHRAE's companion standard, Standard 15, *Safety Standard for Refrigeration Systems*, sets forth requirements to help protect people and property where refrigeration facilities are located.

Being aware of Standards 34 and 15 is especially critical in light of new refrigerants being introduced into the market which have greater environmental benefit but which also have higher flammability characteristics. Besides Standards 34 and 15, there are numerous references to or adoptions of ASHRAE standards and other resources (such as ASHRAE Handbooks, ASHRAE guidelines and design guides) in national standards and the industry's practice manuals.

In April 2017, ASHRAE will help organise an international conference on Sustainable Management of Refrigeration Technologies in Marine and Off-shore Fisheries Sectors together with UN Environment, United Nations Industrial Development Organization (UNIDO), the International Institute of Refrigeration (IIR) and the Government of Thailand's Department of Industrial Works. The purpose of the conference is to address practices and future developments in the management of existing systems and trends towards longer-term, energy-efficient, climate- and ozone-friendly alternatives in commercial on-board marine mobile refrigeration.

Another joint UN Environment and ASHRAE activity is the launch of a web-based interactive training portal. The first course available on the portal is aimed at meeting the needs of Article 5 (A5) countries. "Refrigerant Literacy" will be 4.5 hours in duration and intended for non-technicians (policymakers). Upon completion of this course, the student should be able to:

- Explain why the list of available refrigerants has changed;
- Characterise refrigerants according to ANSI/ASHRAE Standard 34;
- Determine the maximum refrigerant concentration in air, based on the refrigerant's toxicity level;
- Identify two standards that are important in the selection of refrigerants and in the servicing of refrigeration systems; and
- Identify safe handling procedures for the refrigeration servicing sector.

A second web-based interactive course of eight hours duration will be developed for technicians on refrigerant practices.

ASHRAE and UN Environment have developed a revised work plan focused on cooperative efforts from 2017 to 2018.

Global partnerships are vital in implementing the Montreal Protocol

Stephen Yurek, Air-Conditioning, Heating, and Refrigeration Institute (AHRI), United States of America

It might seem strange for the industry that both produces and uses the vast majority of refrigerants to call for a global phase down in the dominant class of refrigerants for the purpose of protecting the environment. And yet, that is exactly what the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) did in 2009 when it called for including a hydrofluorocarbon (HFC) phase-down in the Montreal Protocol (MP).

Between then and October 2016, when the Meeting of the Parties of the MP agreed to the amendment to include HFCs, AHRI has worked on several different fronts to advance the concept of a phase-down, while establishing and conducting a comprehensive global research programme to identify promising alternative refrigerants.

While HFCs are used in air-conditioning and in some refrigeration applications in developing nations, their use is not widespread in Article 5 nations. Most of these countries are still using hydrochlorofluorocarbons (HCFCs), which have already been phased out in developed nations under the Montreal Protocol.

AHRI played a major role, first in supporting the partnership between the Government of the United States of America and its neighbours Canada and Mexico in advancing an HFC phase-down proposal. At many different roundtable events around the world, senior AHRI officials discussed the many challenges associated with phasing down such a dominant class of refrigerants, including their replacement with alternatives having positive characteristics such as energy efficiency, availability and reasonable price while being more environmentally-friendly. It was a tall order, but the industry, including refrigerant producers and manufacturers were confident it could be achieved.

In 2011, even as negotiations were under way on an MP amendment, AHRI gathered stakeholders and embarked on an ambitious research project known as the Low-GWP Alternative Refrigerants Evaluation Program. The two phases of the project have identified many alternative refrigerants. This prompted an additional phase of the research programme, this time into the practical effects of using these refrigerants in the normal places – in residences and buildings. And this involves another partnership, this time between AHRI, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the U.S. Department of Energy, in a US$ 5.2 million research programme. The major US code development organisations – the International Code Council and ASHRAE – have agreed to accelerate the next code development cycle to accommodate the findings of the research.

As our industry becomes more globalised and challenges and opportunities more intertwined, partnerships, such as those we have established with UN Environment and with refrigerant research stakeholders, become vital for accomplishing goals, meeting challenges and sharing critical information to move the industry forward for the betterment of all.

AHRI is proud to have played such a vital role in this phase-down endeavour and looks forward to continued collaboration with is global partners including UN Environment.

European industry and UN Environment join forces to model phase-out of ozone-depleting substances

Andrea Voigt, European Partnership for Energy and the Environment (EPEE)

According to recent findings, a significant increase in global hydrofluorocarbon (HFC) emissions was expected over the next decades if no action had been taken. The main growth will occur in developing countries due to the phase-out of ozone-depleting substances (ODS) and the anticipated strong market growth. The October 2016 Kigali Amendment to the Montreal Protocol is a crucial step to counter this trend.

The European Partnership for Energy and the Environment (EPEE), representing the refrigeration, air-conditioning and heat pump industry in Europe, has always supported global action to reduce HFC emissions. Based on experiences in the European Union (EU) and Japan, for example, we believe that such action should incorporate three main pillars, namely containment (tightness of installations), competence (skills) of the workforce and a move towards lower global warming potential (GWP) refrigerants with attention to safety concerns.

To achieve emission reductions, it is of key importance to understand and take into account, local specificities in terms of particular needs, climate and market dynamics. This requires detailed knowledge and data to design appropriate equipment and avoid hasty decisions that foreclose future options. A thorough segmentation of the market is part of this data gathering process and required to evaluate available technologies per application and to anticipate market dynamics.

This approach has proved to be effective for EPEE. Over the past years, and in particular in the run-up to the new fluorinated greenhouse gases (F-Gas) rules in Europe, EPEE has developed extensive experience in modelling future refrigerant consumption scenarios which are based on such careful segmentation of the market. Our model, developed together with SKM Enviros allows us to better understand how the market may develop in Europe over the next decades. It assesses more than 40 product segments and takes into account a number of key parameters including, but not limited to, refrigerant types, charge sizes, leakage rates and equipment lifetime. The model has now been taken a step further to help us recognise key priorities for the European HFC phase-down such as, for example, the rapid transition from R-404A to lower GWP alternatives, both in existing and new equipment (EPEE Roadmap)[1]

Based on this experience, EPEE is proud to partner UN Environment in a new project to model future consumption scenarios for ODS alternatives in developing countries, taking into account economic growth and other relevant parameters. The project will be limited to Bahrain and Kuwait, but will create a platform which could be a basis for modelling for other countries or larger geographic regions after populating it with country-specific data.

We look forward to our cooperation with UN Environment and hope that it will provide industry, users and governments with valuable insights on how to make the best of the HCFC phase-out without repeating the mistakes of the developed countries and taking into account all relevant parameters such as energy efficiency, safety and affordability of new solutions and technologies.

1 http://www.epeeglobal.org/news/videos/the-gapometer-roadmap/

The role of the refrigeration service sector in the transition to alternative refrigerants

Marco Buoni, Air conditioning and Refrigeration European Association (AREA)

Many industries have already switched or are planning to switch to the use of alternative refrigerants; that is refrigerants which are non-ozone depleting and have low to zero global warming potential (GWP). One of the sectors most affected by such a change is the service and maintenance sector of the refrigeration and air-conditioning (RAC) industry, especially the small and medium-sized segments which lack access to appropriate information and training systems, making them incapable of following the changes.

The Air-conditioning and Refrigeration European Association (AREA) oversees the homogenous implementation of high quality standards in the work of RAC technicians worldwide.

UN Environment and AREA have been cooperating in a number of areas for a significant period of time, with the common goal of protecting the global environment through initiatives aimed at stratospheric ozone layer protection and related climate change mitigation, with a particular focus on training, certification and strengthening national and local associations.

- **Technician competence:** UN Environment and AREA cooperate in encouraging and assisting countries in establishing national certification schemes for RAC servicing technicians. This cooperation has on several occasions taken the form of, inter alia, sharing an AREA member's experience in designing and operating certification and training schemes according to European Union (EU) standards, through direct technical assistance to national governments and/or refrigeration associations (e.g. missions to those countries, dedicated meetings during regional or international conferences, or through online conferencing, telephone or email), or sponsoring or facilitating country representatives' participation in AREA general meetings or visits to AREA member associations.
- **National RAC associations:** UN Environment and AREA cooperate in encouraging and assisting
  (a) the establishment of national and local RAC associations in countries that do not have them; and
  (b) strengthening and developing existing RAC associations. This is achieved by sharing information, guidelines and experiences from AREA members about issues including possible structural schemes, management, financing, by-laws, membership and activities, etc. AREA and UN Environment also cooperate in establishing and stimulating networking among national RAC associations in developing countries and between those associations and AREA members.

In consequence, AREA has included in its statute, a new status of membership namely, "International Observer". This membership status provides the opportunity to receive the latest news, professional guidelines and information on upcoming changes in technologies. The EU has already taken the decision to phase down hydrofluorocarbons (HFCs) and other fluorinated gases. The October 2016 Kigali Amendment to the Montreal Protocol has now committed all Parties to a phase-down of HFCs.

AREA decided to issue a guide to provide service technicians with information/advice on installation, maintenance and repair of equipment containing flammable, low-GWP refrigerants. At the same time, this guide can be used to understand the equipment that should be used to service refrigeration plants containing refrigerants in the 'A2L' category (lower flammability) or 'A3' category (higher flammability). This guide complements the AREA *Guidance on minimum requirements for contractors' training & certification*, which deals with competence of personnel. The guides can be downloaded from the new AREA website *www.area-eur.be*

Ozone Layer Protectors in Europe and Central Asia Honoured for their Commitment

Halvart Koppen, UN Environment, OzonAction

Their watchful eyes foil law-dodgers who threaten the Earth's ozone layer which protects human health and well-being. Be it foreign fishing vessels furtively buying ozone- depleting substances (ODS) on Spain's northwest Atlantic coast, ships unloading smuggled ODS refrigerants in the Gulf of Finland or online ODS sellers in Europe, customs and enforcement officers in Europe and Central Asia (ECA) are making gains in their battle against the illegal and unwanted trade in these internationally banned chemicals.

In recognition of this achievement, customs and enforcement officers from Bosnia & Herzegovina, China, Croatia, European Union, Georgia, Kyrgyzstan, Romania, Russia, Serbia, Spain, Turkey, Turkmenistan, Ukraine and Uzbekistan were awarded the prestigious ECA Ozone Protection Award for Custom & Enforcement Officers during the ECA Customs Cooperation Meeting held in Ashgabat, Turkmenistan on 24-25 May 2016. The ceremony was attended by ozone, customs and enforcement officers from 20 European and Central Asian countries.

Launched in 2010 by UN Environment, Economy Division, OzonAction, the biennial award honours customs and enforcement officers for supporting implementation of the Montreal Protocol and is endorsed by the World Customs Organization, the Ozone Secretariat and the Multilateral Fund Secretariat.

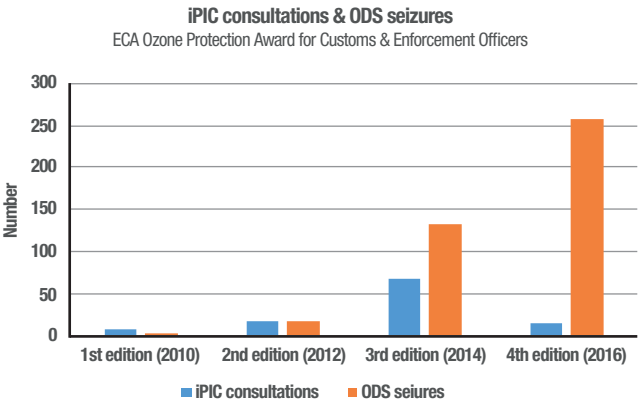
Between May 2014 and April 2016, the awardees were responsible for 258 seizures comprising 9947 items of equipment and more than 70 tonnes of ODS – mainly hydrochlorofluorocarbon 22 (HCFC-22 or R-22). Informal Prior Informed Consent (iPIC) consultations also avoided 16 unwanted/illegal shipments of more than 174 tonnes of ODS. Nearly 200 seizures were reported in Belgium and Germany, which included about 10,000 refrigerators, freezers, air-conditioners and cooling compressors confiscated in Belgium that were to be shipped to Africa.

For the first time, online sales of ODS were prevented in Romania, Spain and Germany. The Nature Protection Service of the Civil Guard in Spain (SEPRONA) arrested four people and seized R-22 refrigerant cylinders advertised on websites while Romania's National Environmental Guard detained an online seller of R-12, R-22 and R-407C refrigerants. In Germany, 15 kg of halon offered for sale on the Internet was seized.

Investigations by Spain's SEPRONA also found R-22 being sold to fishing vessels from different countries of origin docking in ports of the Autonomous Community of Galicia, leading to the seizure of 37,000 kg of R-22 and the identification of 25 companies possibly involved in the illegal ODS trade.

Russian customs officers in Vyborg seized 15,640 kg of R-22 in 1150 cylinders disguised as non-ODS R-134a, which had come by ship from China and was unloaded at Finland's Kotka port before being trucked to Russia. In Turkey, customs officials seized a shipment of 327 cylinders of R-22 from China, marked as non-ODS refrigerants.

The number of ODS seizures has increased significantly over the four editions of the ECA Ozone Protection Award (see figure).



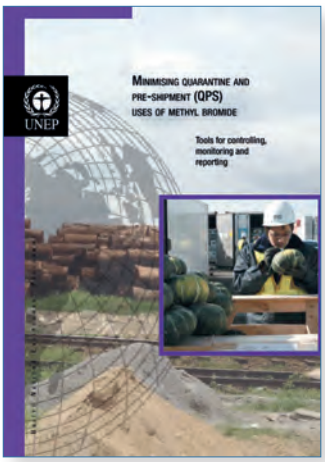
"Congratulations to the winners of the ECA Ozone Protection Award for their vigilance and commitment. Without their dedicated enforcement action, the successful implementation of the Montreal Protocol in phasing out ODS might be jeopardised," Dr. Shamila Nair-Bedouelle, Head of OzonAction.

Details of seizures available at *www.unep.org/ozonaction/ecanetwork/*

Outreach tools

New Publications:

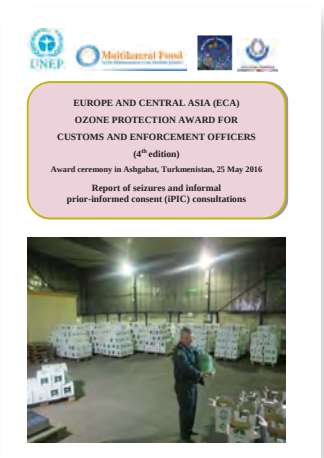
Minimising quarantine and pre-shipment (QPS) uses of methyl bromide Tools for controlling, monitoring and reporting



Under the Montreal Protocol, 1 January 2015 was the deadline for phasing out of controlled uses of methyl bromide. The Protocol however exempts MB use for quarantine and pre-shipment (QPS) applications. Supporting MP compliance, this booklet delivers on the management of data reporting of MB in QPS applications and tracking MB use for this purpose. Detailed information on suitable alternatives to MB is included. It is a useful reference tool for National Ozone Units, bio-security and plant quarantine officers, fumigating companies, students and other stakeholders, promoting transition to more environmentally friendly alternatives.

http://www.unep.fr/ozonaction/information/mmcfiles/7792-e-Minimisingquarantineandpre-shipment(QPS)usesofmethylbromide.pdf

The Europe and Central Asia (ECA) Ozone Protection Award for Customs and Enforcement Officers: Report of Seizures and Informal Prior-informed consent (iPIC) Consultations



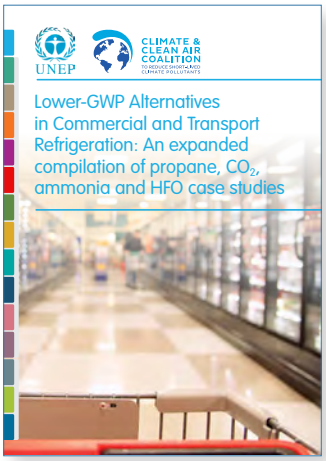
The Europe and Central Asia (ECA) Ozone Protection Award for Customs and Enforcement Officers aims to provide incentive and recognition to customs and enforcement officers and their respective organizations for successfully preventing illegal / unwanted trade of ozone-depleting substances (ODS) as well as equipment and products containing them.

This report summarizes the seizures and informal Prior Informed Consent (iPIC) consultations reported by Bosnia and Herzegovina, China, Croatia, European Union, Georgia, Kyrgyzstan, Romania, Russia, Serbia, Spain, Turkey, Turkmenistan, Ukraine and Uzbekistan during the period from May 2014 to April 2016.

The winners of the Ozone Protection Award 2016 (4th edition) reported 258 seizures of 9,947 pieces of equipment and 10,201 refrigerant cylinders / cans containing more than 70 tonnes of ODS, products and equipment. In addition, iPIC consultations before the issuance of trade licenses avoided 16 unwanted / illegal shipments of more than 174 tonnes of ODS.

http://www.unep.fr/ozonaction/information/mmcfiles/7810-e-iPIC_ECASeizuresReport.pdf

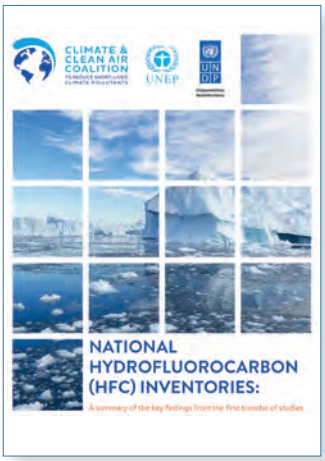
Lower-GWP Alternatives in Commercial and Transport Refrigeration: An expanded compilation of propane, CO2, ammonia and HFO case studies



This booklet presents a series of case studies on lower-GWP energy efficient alternatives and technologies in the commercial and transport refrigeration sectors. It is an information resource intended to assist relevant decision makers, especially those in developing countries, in selecting the most appropriate climate-friendly alternatives. The publication provides an update to the first compilation of case studies which was published by UN Environment OzonAction/ CCAC in 2014. It provides a number of new commercial refrigeration case studies and case studies from the transport refrigeration sector, including alternatives not previously considered. All the case studies from the first compilation are maintained.

http://www.unep.fr/ozonaction/information/mmcfiles/7806-e-Lower-GWP_Alternatives_in_Commercial_and_Transport_Ref.n.pdf

National hydrofluorocarbon (HFC) inventories: A summary of the key findings from the first tranche of studies



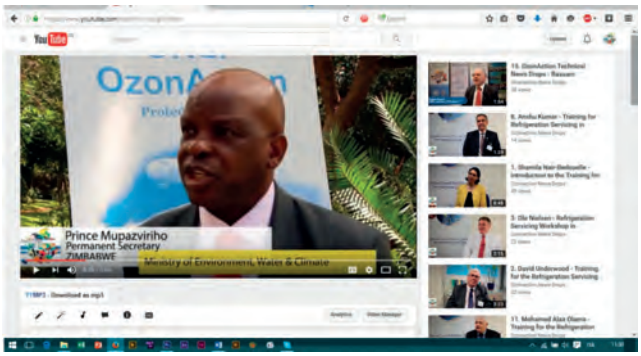
Hydrofluorocarbons (HFCs) are potent greenhouse gases used as alternatives to ozone-depleting substances being phased out under the Montreal Protocol. HFC emissions to the atmosphere are increasing rapidly, at a rate of about 10–15 per cent per year, and significant increases in HFC use is expected in developing countries because of population growth, rapid urbanisation, electrification and changing consumer patterns. The increased use of refrigerants will also result in increased energy consumption and greenhouse gas emissions. If no measures are taken, it is estimated that HFCs will amount to 9–19 per cent of total CO2 emissions by 2050. The Climate and Clean Air Coalition (CCAC) is supporting the development of national HFC inventories to help countries better understand the present situation and inform decision-making about policies and technologies to replace or avoid HFCs. This booklet presents a summary of the key findings from the first tranche of inventories completed to date – Bangladesh, Chile, Colombia, Ghana, Indonesia and Nigeria – plus initial draft findings from other countries whose inventories are still under way. This is a joint publication of UN Environment, CCAC and UNDP.

http://www.unep.fr/ozonaction/information/mmcfiles/7803-e-HFC_%20Summary.pdf

New Fact Sheets

These short information sheets contain technical information on the Montreal Protocol issues. STAY TUNED, available in English, French, Spanish, Arabic and Russian. *http://www.unep.org/ozonaction/* or OzonApp eDocs in Android or IOS.

NEW Videos



Regional News Drops

The Regional Networks of National Ozone Units (NOUs) under the Multilateral Fund are a path-breaking mechanism for North-South and South-South cooperation. Networking provides a platform for NOUs from Article 5 countries to exchange experiences, develop their skills and tap the expertise of their peers in both developing and developed countries. Conducted at the regional level, the Networking activity builds the Ozone Officers' skills for implementing and managing their national ODS phase-out activities.

During 2016 these videos were filmed at the regional network meetings around the world. The NOUs were asked about their success stories, alternative refrigerants selected and their personal messages for national ozone day celebrations.
https://www.youtube.com/playlist?list=PLnZfeRt_Y8dkTEQrr_NqmaQF5O-spAaqQ

OzonAction Training for Refrigeration Servicing

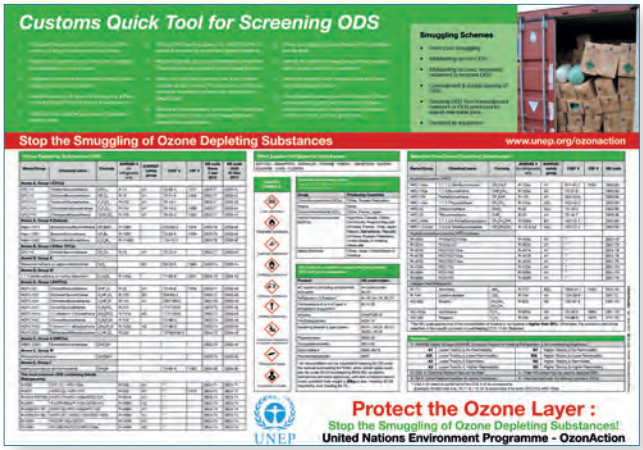
The Refrigeration Servicing Sector (RSS), especially small and medium-sized segments of this sector, is one of the most affected sectors by technological changes in the refrigeration and air-conditioning RAC) industry. The recent developments within the industry requires different approaches that need to go beyond the typical good practices training. All future refrigerants are coming with safety considerations, and this involves a change in the mindset of operators and technicians when installing, operating and servicing RAC applications.

The big question for the RSS training programmes, that all involved stakeholders need to answer: Are We Ready?
https://www.youtube.com/playlist?list=PLnZfeRt_Y8dmivERrR4hyCKNYB8a8DrV1

OzonAction Technical News Drops

The governments and industry from countries, with high-ambient conditions, have raised serious concerns about the availability of alternative refrigerants that can assist them meeting the compliance targets of the Montreal Protocol, as well as leapfrogging the dependency on higher GWP options. Refrigeration and, in particular, air-conditioning is of high importance to high-ambient countries and the air-condoning sector is the major consumer of the domestic energy demand. The uncertainty about long-term and sustainable refrigerants, for high- ambient countries, has created a sense of uncertainty about policies and technologies to be considered by respective governments and industry.

The government of Emirates, in cooperation with UNEP, UNIDO, AHRI and ASHRAE Falcon Chapter as well as support of several international associations, responded to this issue by organising a series of specialised events, since 2012, to address the concern of alternative refrigerants in high ambient countries. Technical forum was organised on 31 October 2015 in Dubai, UAE with particular focus on the research projects for alternative refrigerants in high ambient countries. These short videos were filmed there. UNEP and ASHRAE Falcon Chapter produced these videos for wider distribution and interviewed members of governments, industry associations, industry representatives and experts.
*https://www.youtube.com/playlist?list=PLnZfeRt_Y8dnYFzpd5cgslGWlmetzQ9m_*



Posters

Customs poster

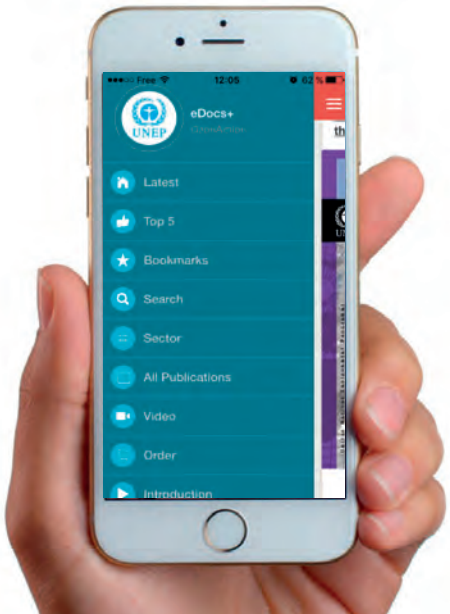
The updated poster serves as an easy reference for customs and enforcement officers as it provides a short checklist of what to do particularly when inspecting ODS shipment. It also carries the latest HS codes to facilitate screening of ODS. We suggest that the poster be displayed prominently, especially in border offices through which ODS shipments are known or suspected to pass/transit.

Smart phone applications

OzonApp eDocs+

Consult the latest OzonAction publications and awareness materials directly on your mobile device Download for free from Google Play and Apple Store/iTunes

Just search “OzonAction” and install



New OzonAction multimedia video application

Refrigeration and Air-conditioning Technician Video Series

OzonAction launched an exciting new application which hosts series of short instructional videos on techniques, safety and best practice for refrigeration and air-conditioning technicians.

This application, consisting of short instructional videos on techniques, safety and best practice, serves as a complementary training tool for refrigeration and air-conditioning (RAC) sector servicing technicians to help them revise and retain the skills they have acquired during hands-on training.

The application forms a part of UN Environment (UNEP) OzonAction’s portfolio of activities and tools to help enhance the knowledge and skills of technicians in the servicing and maintenance of refrigeration and air-conditioning systems. OzonAction provides assistance to various stakeholders in developing countries, including technicians, to achieve and maintain compliance with the Montreal Protocol on Substances the Deplete the Ozone Layer. The videos were produced in collaboration with Bundesfachschule Kälte Klima Technik

www.unep.org/ozonaction

The OzonAction Special Issue (OASI) is published once a year in English.

OASI is available online at:
www.unep.org/ozonaction/resources/ozonaction-special-issue-oasi

The OASI was supervised by:
Shamila Nair-Bedouelle, Head of OzonAction
Anne Fenner, Information Manager of OzonAction

Review team:
Ezra Clark, Capacity-Building Manager
James S. Curlin, Network and Policy Manager
Claudia Dumitru, Consultant
Leo Lisac, Consultant
Jean Paul Martial, Consultant
Jemal Purliyeva, Programme Assistant
Sonja Wagner, Consultant

Editor: Mahesh C. Uniyal, Consultant
Designer: UNOG
Credits for photos and graphics: Shutterstock

The views expressed in articles written by external authors are solely the viewpoints of those authors and do not necessarily represent the policy or viewpoint of UN Environment.

Please send comments to:
Anne Fenner
OzonAction

UN Environment
Economy Division
1, rue Miollis, 75015 Paris 15,
France

Tel: +33 1 44 37 14 50
Fax: +33 1 44 37 14 74
ozonaction@unep.org

UNEP promotes environmentally sound practices globally and in its own activities.

This publication is printed on 100% recycled paper, using vegetable -based inks and other eco-friendly practices.

Our distribution policy aims to reduce UNEP's carbon footprint.

Designed and Printed at United Nations, Geneva – 1620050**(E)** – April 2016 – 500 – **UNEP/OA/2016/10**