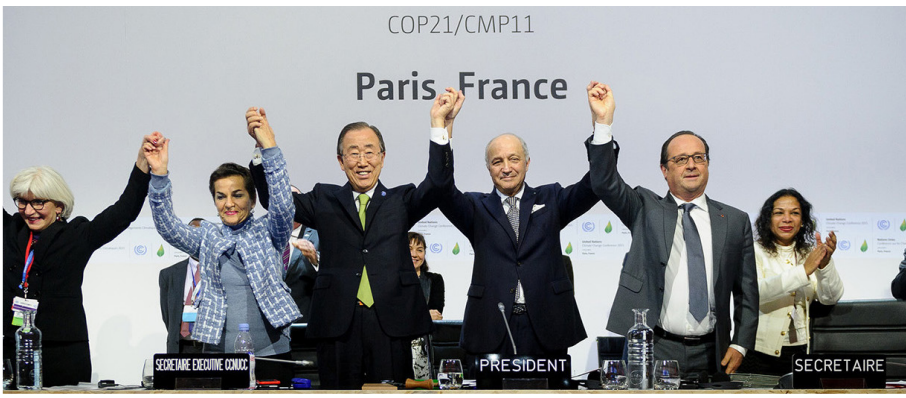

Advancing nationally determined contributions (NDCs) through climate-friendly refrigeration and air conditioning

Guidance for policymakers

Version 1.0

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On behalf of:

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INTRODUCTION

With the objective to hold the increase in global average temperature well below 2°C and the ambition to limit it to 1.5°C, parties to the United Nations Framework Convention on Climate Change (UNFCCC) agreed at the 21st Conference of the Parties in Paris in December 2015 to undertake and communicate more ambitious efforts to contribute to the global response to climate change. Parties are now asked to review and update their intended nationally determined contributions (INDCs) and submit them as nationally determined contributions (NDCs) until the global agreement officially starts in 2020.[1] At the same time, parties are advised to immediately assess economy-wide and sector-specific mitigation potential in order to comprehensively define ambition levels and engage in early mitigation action.

Population growth, urbanisation, an increasing middle class, changing lifestyles and rising ambient temperatures drive a growing demand for refrigeration, air conditioning and foam (RAC&F) products – a development that cannot be disregarded any longer. RAC&F applications are responsible for large amounts of CO_2 and hydrofluorocarbon (HFC) emissions – two greenhouse gases (GHG) reported under the UNFCCC. As the demand for cooling rises, the GHG emissions – resulting from both electricity consumption and the use of refrigerants and blowing agents with high global warming potential (GWP) – are also growing rapidly. Specifically HFCs have high GWPs of up to 4000 CO_2eq, which are these times increasingly used as substitutes to phase out hydrochlorofluorocarbons (HCFCs) - as ozone depleting substances (ODS) under the Montreal Protocol (MP).

At the 28th Meeting of the Parties to the MP in October 2016 in Kigali, parties agreed to phase down HFC emissions over the next three decades, thereby building a fundamental pillar to achieving the ultimate goal set out in the Paris Agreement about a year earlier. According to an analysis by G. Velders et al (2016), the Kigali Amendment will avoid nearly 90 per cent of the temperature increase that HFCs could have caused.

The following guidance assists policymakers to design national mitigation strategies for their RAC&F sector to meet the increasing ambition levels expected in revised NDCs. By aligning efforts taken under the two relevant international regimes, the UNFCCC and the Montreal Protocol, the RAC&F sector can make a significant contribution towards reaching the 2°C target, or even better, the enhanced 1,5°C target.

1 See: www.green-cooling-initiative.org

SPECIFICALLY, THIS GUIDE IS USEFUL FOR:

Political decision makers who act as focal points to the **UNFCCC** and who administer the overarching national policy framework for **climate change mitigation**, in particular the GHG emissions accounting and the **NDC planning** and implementation.

National Ozone Officers who coordinate the HCFC Phase-out Management Plan (HPMP) and are now confronted with the further development of HFC phase down schedules and related regulations as part of the **Kigali Amendment**.

Ministries or departments which are responsible for policies and regulations relating to the **energy performance** of RAC appliances, as well as finance related policies and regulations addressing the RAC&F sector, including NAMAs.

THIS GUIDE WILL ADDRESS THE FOLLOWING QUESTIONS:

- How and to what extent does the RAC&F sector impact global climate change? Chapter 1
- How are CO_2 and HFC emissions of the RAC&F sectors addressed internationally, specifically in the Montreal Protocol and the Paris Agreement? Chapter 2
- How does the Kigali (HFC) Amendment under the MP impact market trends in the RAC&F sector? Chapter 2
- What do national government actors need to do? Chapter 3
- What are the main elements of a RAC&F mitigation strategy? Chapter 4
- What tools and methods exist to implement such strategies? Chapter 4
- How can Nationally Appropriate Mitigation Actions (NAMAs) be instrumental for mitigating emissions in RAC&F sectors? Chapter 5
- How to finance the implementation of RAC&F mitigation? Chapter 5

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1. BACKGROUND: THE RAC&F SECTOR AND ITS IMPACT ON CLIMATE AND SUSTAINABLE DEVELOPMENT

Refrigeration, air conditioning, and foam for insulation can be found almost everywhere and are essential to reach or maintain adequate human living standards. Refrigeration includes applications that preserve food, beverages or medicine at a certain required temperature. Air conditioning includes cooling applications that maintain temperatures in buildings. Foams are used to insulate cooled spaces. Population growth, an increasing middle class, changing lifestyles and rising ambient temperatures are responsible for the rapid growth of each of these domains.

The growing use of RAC&F appliances leads to increasing greenhouse gas (GHG) emissions due to two reasons: First, most RAC&F applications consume electricity. Up to date, this electricity is mainly generated through fossil fuel combustion, resulting in large amounts of CO_2 emissions (indirect emissions). Second, most of the applications use fluorinated gases – HCFCs or HFCs – as refrigerants to transfer the heat. As these gases leak – for example during servicing or when an appliance is scrapped – they cause substantial emissions as well (direct emissions).
Figure 1 shows at which points in the life-cycle of a RAC appliance, such as a chiller used to cool buildings, emissions occur.

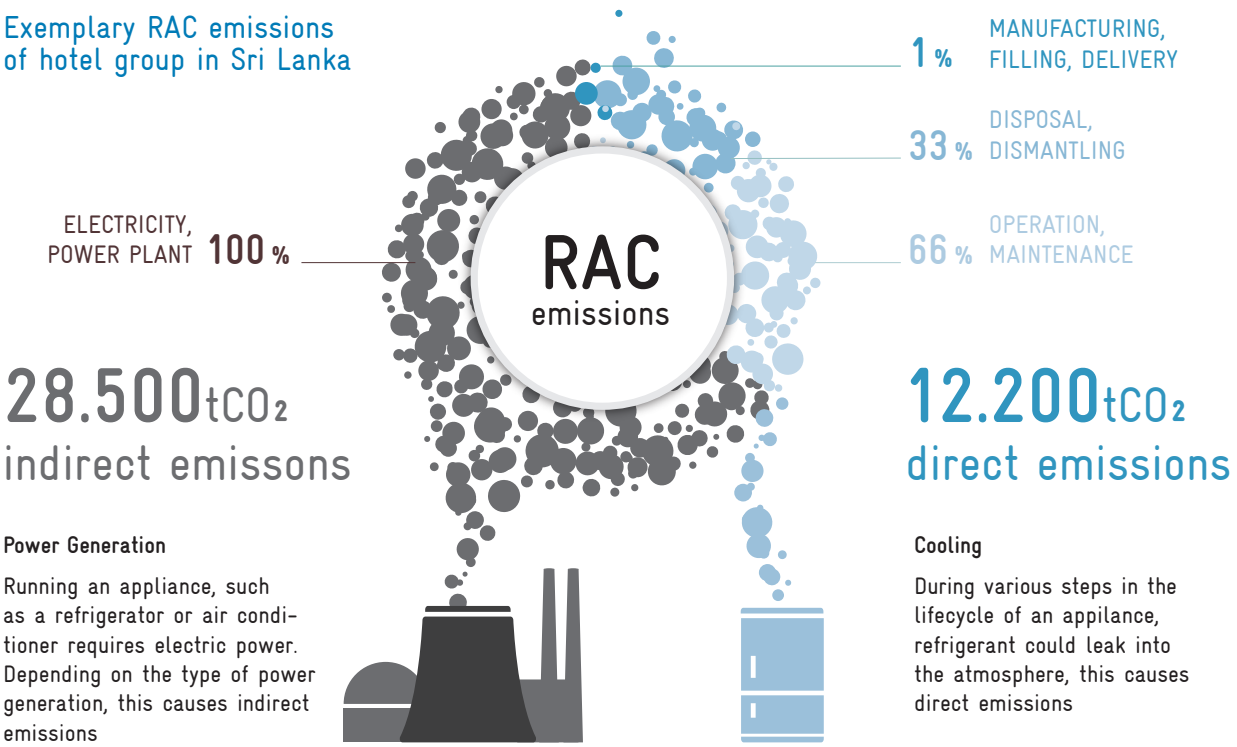

Figure 1: Life-cycle emissions (tCO_2eq) of air conditioning (chillers and condensing units) and refrigeration units calculated for a hotel group in Sri Lanka (Source: GCI, 2016)

HFCs – primarily used as refrigerants and for making insulating foams – are the fastest growing GHGs in many parts of the world, increasing at a rate of 10 to 15% per year (Velders et al. 2012). Some of the most common HFCs include HFC-134a, HFC-404A, HFC-410A, HFC-407C and HFC-507A. It was estimated that without the recently adopted Kigali Amendment to the Montreal Protocol, the continuing growth of HFCs would be responsible for a 0.1°C temperature rise in 2050, with a potential to increase up to 0.5°C by 2100 (Xu et al. 2013). This development would have neutralized much of the climate mitigation achieved by reducing other GHGs. A phase down of the production and consumption of HFCs can provide an estimated 6 to 10% of the total GHG reductions by 2050 (Zaelke et al. 2014).

By 2030, the RAC&F sector as a whole could be responsible for 13% of global GHG emissions (GCI, 2014). This can be avoided by cost-effective mitigation, such as substitution of HFCs with natural refrigerants and increased energy efficiency. Direct HFC emissions alone are expected to account with approx. 20% for the largest single source of non-CO_2 abatement potential across all non-CO_2 emitting sectors in 2030 (EPA, 2014). Policy instruments to advance more sustainable RAC&F solutions have proven effective, and as a result, climate-friendly systems that combine high energy efficiency with natural refrigerants and blowing agents are already established in a number of applications.

As previously highlighted, the RAC&F sector has become an essential part of reaching and maintaining adequate human living standards. Consequently, increased cooling needs are coupled with development, especially in countries that experience hot ambient temperatures. As such, the RAC&F sector provides numerous opportunities to support many of the Sustainable Development Goals carried forward by the United Nations:

1 No Poverty – RAC&F sector transformation involves the creation and formalization of jobs, providing better income for workers and their families. At the same time, energy-efficient appliances save electricity costs for households and thereby free up resources for other needs.

3 Good Health and Well-being – A sustainable and reliable RAC&F sector provides cold chains that ensure the quality and shelf life of food items; it also improves the storage and provision of medical goods, even in remote areas.

4 Quality Education – Capacity building activities such as training and further qualification of technicians as well as with the relevant policymakers are central to a sustainable RAC&F sector transformation.

7 Affordable and Clean Energy – Sustainable RAC&F solutions focus on innovative, energy-efficient technologies and encourage the use of renewable energy sources in various areas.

8 Decent Work and Economic Growth – The sustainable introduction of climate-friendly RAC&F technologies involves the creation and formalization of jobs as well as strengthening local capacities and infrastructure for production.

9 Innovation and Infrastructure – One of the advantages of using natural refrigerant based technologies is that there are no intellectual property rights associated with them. There are also less patent rights on products using natural refrigerants compared to synthetic substances.

11 Sustainable Cities and Commitments – Introducing sustainable RAC&F technologies such as climate-friendly air-conditioning and building insulation improve human living environments. Enhancing the sustainability of the sector by promoting long-term solutions also provides opportunities to move towards a circular economy.

12 Responsible Consumption – Natural refrigerants have zero Ozone Depleting Potential (ODP) and a negligible GWP; they are part of natural biogeochemical cycles and do not form persistent substances in the atmosphere, water or biosphere.

17 Partnerships for the Goals – RAC&F sector transformation relies strongly on the involvement of both the public and the private sector as well as multi-stakeholder partnerships.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) supports the Sustainable Development Goals.

Table 1: Relevance of refrigeration and air conditioning for the Sustainable Development Goals (SDG)

2. THE RAC&F SECTOR IN THE CONTEXT OF THE MONTREAL PROTOCOL AND THE PARIS AGREEMENT UNDER THE UNFCCC

This chapter introduces the Montreal Protocol and the Paris Agreement under the UNFCCC, their relevance for the RAC&F sector and provides recommendations with view to national RAC&F mitigation strategy planning.

Montreal Protocol

The Montreal Protocol that entered into force in 1989 effectively controls the use of ozone depleting chlorofluorocarbons (CFCs) and HCFCs. The worldwide phase-out of CFCs has been completed in 2010. HCFCs, initially used as substitutes for CFCs, have been forbidden in most non-Article 5 ("developed") countries since 2010 but are still widely used in Article 5 ("developing") countries where they must be phased out by 2030. In 2007, the Parties to the MP agreed to accelerate the phase-out of HCFCs (initially targeted for 2040) largely because of the substantive climate benefits this would bring about. Article 5 countries may receive financial assistance from the Multilateral Fund (MLF) for the implementation of the MP to formulate their overarching strategy and prepare HCFC Phase-out Management Plans (HPMPs). These parties are required to "freeze" HCFC production and consumption by 2013 (the baseline being the average of 2009 and 2010), and consequently to achieve a reduction of 10% by 1 January 2015; 35% by 2020; 67.5% by 2025, 97.5% by 2030; and, finally, 100% phase-out by 2040.[2]

While HCFCs had initially been used as substitutes for CFCs, they were increasingly replaced by HFCs under the Montreal Protocol, predominantly as refrigerants in the RAC&F sector. Although HFCs have no ozone depleting potential, they have a substantial global warming potential. Without regulating the HFC production and consumption, the resulting emissions would contribute substantially to global GHG emissions. Aware of this fact, Parties to the Montreal Protocol agreed during the 28th MOP in Kigali in October 2016 to globally phase down HFCs. The Kigali Amendment to the MP, which comprises different baselines, freeze dates and HFC phase down schedules for different country groups, enters into force at the beginning of 2019.

2 Further information on MP measures at: http://ozone.unep.org/en/handbook-montreal-protocol-substances-deplete-ozone-layer/44

3 Further information about the Kigali amendment at: http://www.unep.org/newscentre/Default.aspx?DocumentID=27086&ArticleID=36283&l=en

Group of Parties	Baseline (ø HFC consumption)	HFC freeze year
Most Article 2 Parties	Average HFC consumption for the years 2011, 2012 and 2013 plus 15% of their baseline consumption of HCFCs	No freeze
Article 2 Parties: Belarus, the Russian Federation, Kazakhstan, Tajikistan, and Uzbekistan	Average HFC consumption for the years 2011, 2012 and 2013 plus 25% of their baseline consumption of HCFCs	No freeze
Most Article 5 Parties	Average HFC consumption for the years 2020, 2021, and 2022, plus 65% of their baseline consumption of HCFCs	2024
Article 5 Parties: Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, and the UAE	Average HFC consumption for the years 2024, 2025, and 2026, plus 65% of their baseline consumption of HCFCs.	2028

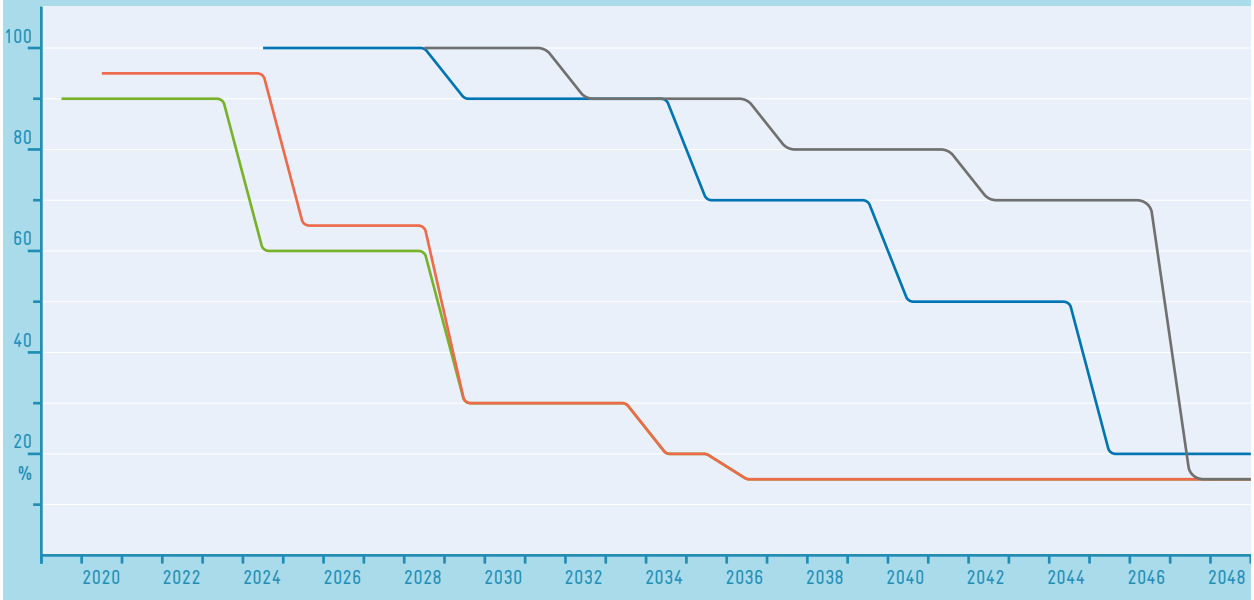

Figure 2: Baselines, freeze years and HFC phase down schedules in Kigali Amendment to MP (Source: UNEP 2016, Kigali Amendment[3])

UNFCCC

The use of HFCs and their resulting emissions are reported to the UNFCCC as substances to be limited or reduced. This also applies to CO_2 emissions resulting from the fossil fuel based electricity generation needed to run cooling appliances.

In the run up to the Paris climate negotiations in 2015, parties representing over 90% of global GHG emissions had communicated targets for reducing national emissions in their INDCs which are the fundament of the Paris Agreement. Analyses have shown that the collective effort – if all INDCs were to be fully implemented – would not be enough to limit the global temperature increase to 2˚C, let alone 1.5°C. Therefore, the Paris Agreement must not only ensure full implementation of the INDCs as they are but also help to increase the level of ambition of individual commitments significantly over time. Parties are mandated to revise their national contributions every five years, starting in 2021 (with the option to do so before on a voluntary basis), and to prepare concrete implementation plans. INDCs become Nationally Determined Contributions (NDC) upon presentation of the ratification instrument or formal accession to the Paris Agreement.

As part of their NDCs, countries are encouraged to present their commitments or targets to reduce GHG emissions over time. Some countries opted to present economy wide GHG reduction targets, citing either absolute or relative targets (e.g. related to a BAU scenario), some countries also presented sector based targets. Other countries, mostly least developed countries, chose specific policy commitments or actions as their mitigation contribution. Generally, countries are encouraged to move towards economy wide targets covering key mitigation sectors over time.

Many of the countries have included energy efficiency plans in their NDC, which may provide a framework for national energy efficiency policies. Some countries such as Ghana, Jordan and Viet Nam, have specifically addressed mitigation in the RAC&F sector. Eighty-three (83) out of 197 parties[4] have mentioned HFCs in their current submissions, even though most of them haven't framed them explicitly in mitigation measures.

At this point, the Kigali Amendment to the MP allows countries to align mitigation actions in the RAC&F sectors with their targets under the MP and the Paris Agreement under the UNFCCC. Reducing the consumption of HFCs and HCFCs could be combined with effective energy efficiency policies in the RAC&F sectors. This would result in maximized climate benefits and early mitigation action that is needed to stay on an emissions pathway towards a global average temperature increase of well below 2°C.

The following Figure 3 summarizes relevant milestones in the Paris Agreement and the Montreal Protocol's Kigali Amendment for the development of national RAC&F mitigation strategies in A5 countries. From these milestones, recommended steps are drawn for RAC&F policy decision makers in A5 countries.

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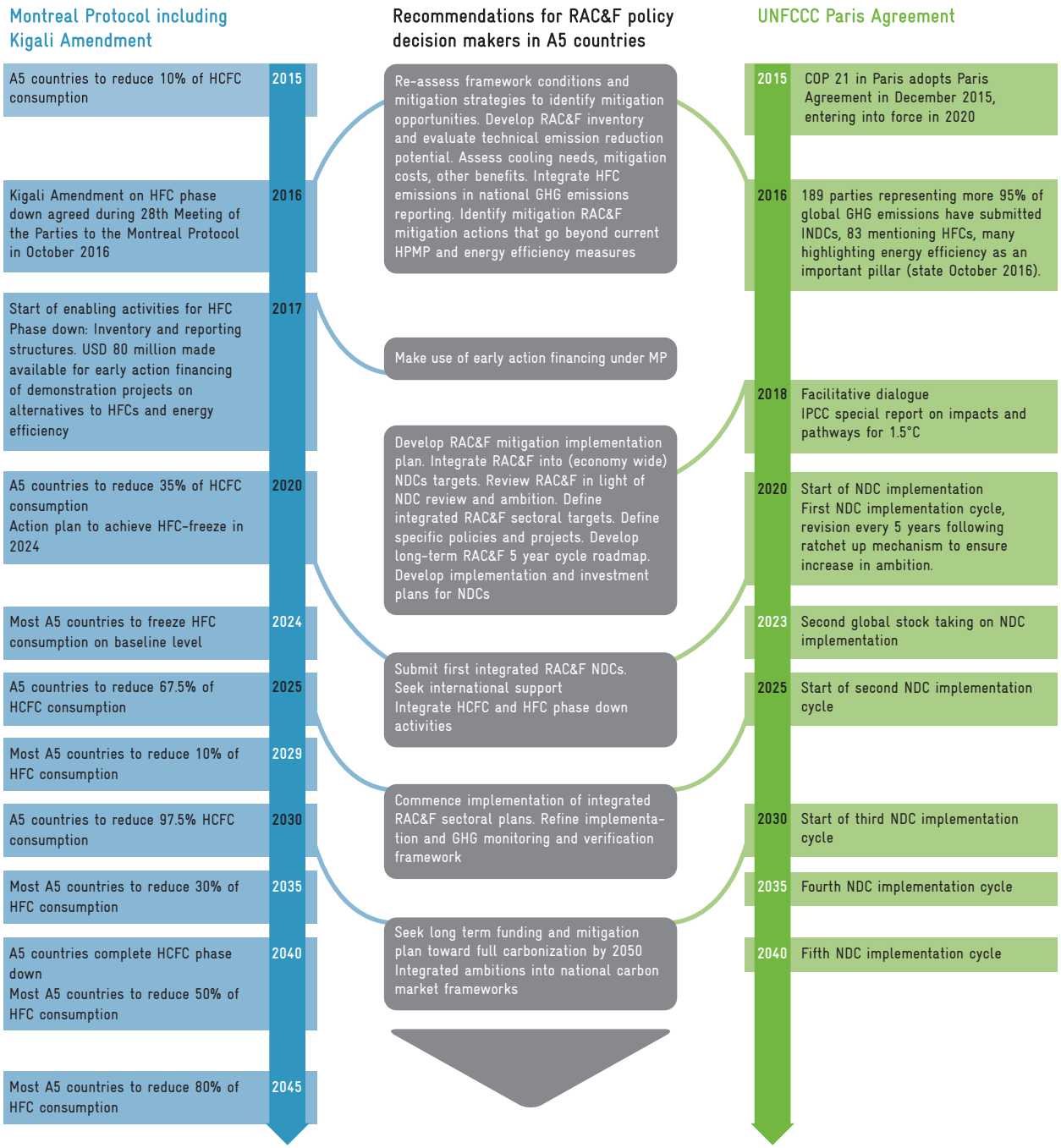

Figure 3: Relevant milestones in UNFCCC Paris Agreement and MP for RAC&F mitigation strategy development in A5 countries

3. JOINING FORCES: KEY ACTORS NEED TO COORDINATE

The RAC&F sector usually involves a variety of different actors. Each of them has a role in shaping a more sustainable development path. This chapter provides a brief overview of key actors and their roles.

Government actors

Emissions originating from the RAC&F sectors are relevant within the context of both the UNFCCC as well as the MP (see chapter 2). Typically, the following key actors of national governments are involved in the coordination of activities under the two regimes:

- **National Ozone Units (NOUs):** HFCs are used as substitute for the ozone-depleting HCFCs which are phased out under the MP. The compliance mechanism of the MP obliges its parties to implement HCFC Phase-out Management Plans (HPMP) which are coordinated by the NOUs. NOUs are now also involved in further preparing the HFC phase down schedules agreed in the Kigali Amendment. NOUs are often part of Environment Ministries, but they may also be part of Ministries of Industry or others.

- **Climate policy departments:** The accounting of national GHG emissions and the (I)NDC planning and implementation are usually coordinated by the climate change/UNFCCC focal points that are typically located within the Ministry of Environment. In some cases, inter-ministerial working groups or committees are in place to coordinate efforts across key ministries. The climate change/UNFCCC focal points are often, but not always, located in the same department as national ozone officers.

- **Ministries of Energy, Industry, or Technology:** Policies and regulations on energy efficiency are relevant in terms of energy consumption of cooling equipment. Responsible offices are usually located in the Energy Ministry or related departments. Safety and application standards are often being addressed in Industry and Technology Ministries.

A lack of coordination among these key actors can result in contradicting positions of a country in the MP and UNFCCC. It is, therefore, recommended to pool competences, join forces and coordinate closely among climate, energy-efficiency and ozone policymakers to ensure a coherent mitigation strategy with direct (HFC) and indirect (CO_2) emissions reductions going hand in hand.

Private sector and other key national actors

Involvement of and interaction with the private sector is key to achieving a sustainable transformation of the RAC&F sector towards low GWP technical solutions. Agreeing on voluntary commitments can be a good possibility to initiate cooperation between the public and private sector. Besides securing business opportunities by providing future-proof technology solutions, appliance manufacturers, for example, are also keen on optimizing their supply chain in order for their products to comply with present and upcoming regulations.

Ensuring the participation and commitment of relevant industries in early stages of strategic RAC&F policy design helps to build trust for a robust legal framework and provides industries with long-term planning certainty. In this regard, cooperating with local players is essential in enhancing local capacities to produce and maintain new technologies. The interests of different private enterprises are usually bundled and represented by industrial associations. In the RAC&F sector, industrial associations are usually involved in the further development of product and safety standards as well as of training and certification programs as initiated by the corresponding government institutions.

Close coordination among the key technology-related government institutions as described above is the basis for integrated and convergent RAC&F policies (standards, regulations and support programmes) addressing RAC&F

manufacturing and servicing industries and other relevant national actors. Other relevant national actors include:

- **Training institutions and facilities** train and certify personnel involved in the manufacturing, installation, and servicing of RAC&F technologies. The introduction of low GWP and natural refrigerants as well as the improvement of the energy performance of RAC&F technologies require additional technical skills which need to be integrated into the related training and certification programmes.

- **Research and academic institutions** are involved in improving knowledge and capacity that lead towards local technology innovation. Adapting the climate-friendly and energy-efficient RAC&F technologies to local conditions support in maximizing the corresponding socio-economic benefits from them.

- **Standards committees** are mandated in reviewing and preparing safety and energy performance standards for RAC&F products. They are normally composed of technical and academic experts in the field as well as representatives from the related government institutions.

- **Operators** are in charge of overseeing and maintaining requirements for RAC&F equipment to be in a safe and functional condition. They are either outsourced or integrated as part of facility management in a building.

- **Non-governmental organizations** (NGOs) such as those advocating resource efficiency, sustainability, improvement of education and access to it, and enhancement of safety and working conditions could play a key role in bringing together different stakeholders involved in the RAC&F sector.

More information on policy options can be found in chapter 4.4.

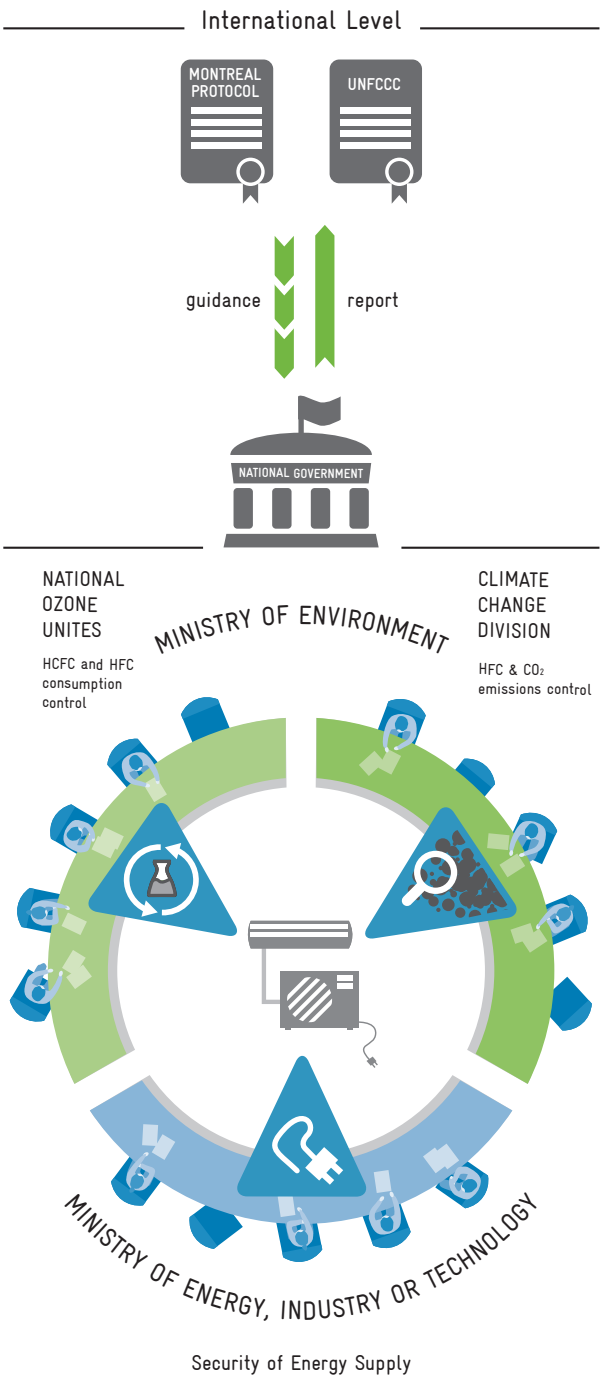

Figure 4: Typical RAC&F technology related key government actors

4. DEVELOPING A RAC&F MITIGATION STRATEGY FOR NDCS

In the course of further development of NDCs, many countries are now in the process of prioritizing potential mitigation actions according to their technical mitigation potential and other socio-economic factors. This process shall enable policymakers to make informed decisions about the next steps for NDC implementation. In many countries, the RAC&F sector is responsible for an increasingly large share of emissions, which, at the same time, can be mitigated effectively at a low cost. This makes the sector highly appealing for early mitigation within NDC implementation. This chapter will introduce key steps to specifically address the RAC&F sector in NDC formulation, strategy and implementation:

- RAC&F sector GHG inventory;
- Technology options and economic assessment;
- GHG mitigation scenarios;
- RAC&F policies and regulations;
- Technology roadmap for the RAC&F sector;
- Measurement, reporting and verification;
- Financing implementation.

Further information for developing a RAC&F mitigation strategy:

The GIZ Proklima NAMA handbook for the RAC&F sectors – published as a series of modules – can be found here: https://www.giz.de/expertise/html/4809.html

The UNEP United for Efficiency (U4E) program in cooperation with the Green Cooling Initiative (GCI) developed policy guides on accelerating the use of climate-friendly and energy-efficient room air conditioners and domestic refrigerators (forthcoming)

In each step, this guidance provides links to relevant tools and handbooks that shall help the user to get an overview of relevant material and to carry out the proposed steps.

4.1. RAC&F sector inventory

Despite significantly growing emissions and high mitigation potential, many countries do not account for HFCs in their national GHG inventories or have not included them in their (I)NDCs. Equally, CO_2 emissions occurring from fossil fuel combustion for electricity for RAC appliances are usually not accounted for explicitly in national GHG inventories. Also, most energy efficiency action plans within the current (I)NDC submissions are not sector specific. Consequently, the sectoral GHG share emitted by RAC appliances often remains unknown. Specific HFC emissions are either covered as potential emissions (HFC consumption) in the GHG inventory of National Communications or are not accounted for at all. A comprehensive RAC&F sector inventory covering direct and indirect emissions is still an exception.

A RAC&F sector inventory needs to include both the indirect CO_2 emissions resulting from the electricity generation for cooling appliances as well as the direct HFC emissions caused by leakage of refrigerant gases during manufacturing, servicing/operation, and at end-of-life of cooling appliances (see chapter 1). In establishing a reliable inventory, the total stock of appliances and annual sales of units in key subsectors[5] as well as their unit based GHG emissions and energy consumption need to be considered.

The IPCC Guidelines for National Greenhouse Gas Inventories[6] differentiate between a Tier 1 and a Tier 2 approach (see Figure 5). While Tier 1 considers chemical sales data on an aggregated level, often on a country basis, the Tier 2 approach focuses on appliance unit data on a disaggregated level (subsector /appliance level). The data collected using the Tier 1 approach stems from production and consumption of HFCs, where the nationally consumed HFC equals potential emissions.[7] This information helps to estimate HFC emissions originating from the sector and serves as a

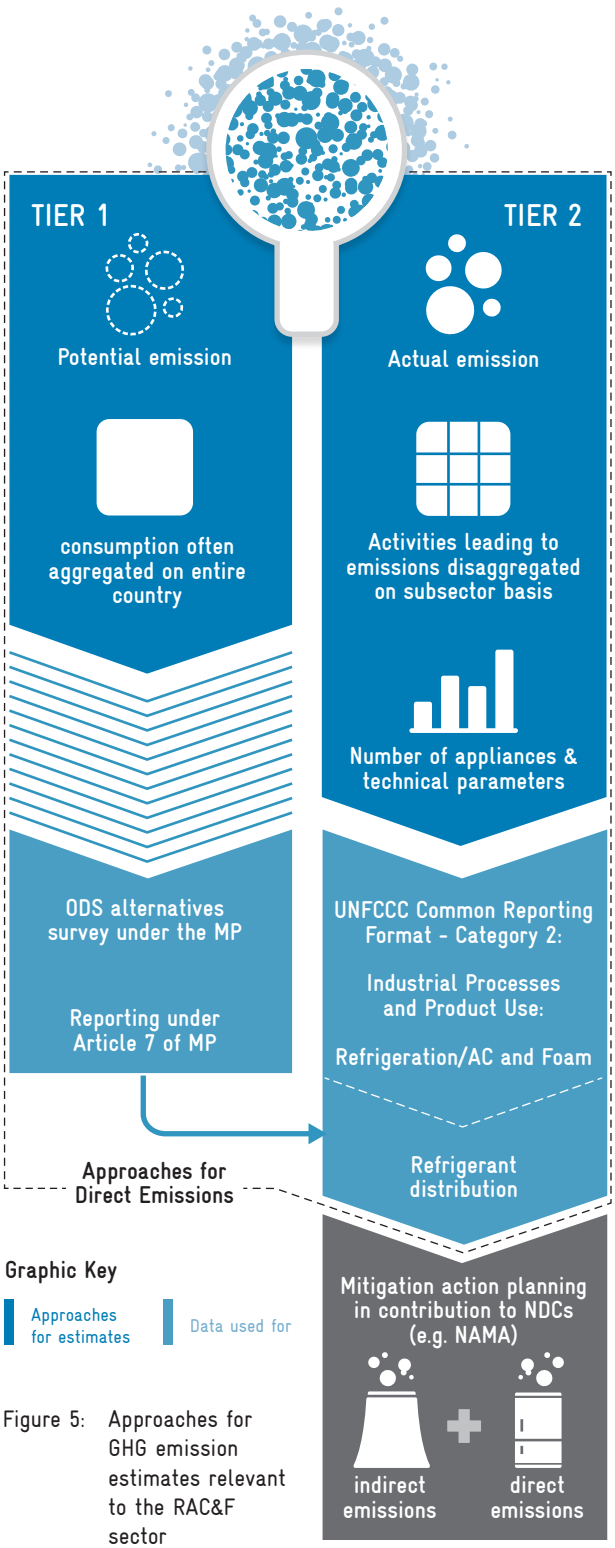

Figure 5: Approaches for GHG emission estimates relevant to the RAC&F sector

foundation for preparing and managing HFC phase down schedules, as agreed in the Kigali Amendment.

Tier 2 data based on units is required for the development of mitigation strategies and measures (such as NAMAs) as part of NDCs. The disaggregated Tier 2 data allow the verification of mitigated GHG emissions.[8] It considers market data on the subsector level (e.g. stock and sales figures) together with technical parameters of appliances, such as type of refrigerant and initial charge. Combining Tier 2 data with information on cooling capacity and energy efficiency/energy consumption of the unit stock, mitigation from energy efficiency improvement measures (e.g. NAMA/NDC) can be accounted to the RAC sector.

Under the UNFCCC reporting, the development of a Tier 2 data set for non-Annex 1 parties is encouraged for their National Communications. The Common Reporting Format (CRF) for the GHG Inventory currently applied by Annex I parties, requires the accounting for the amount of HFCs for the following:

- Filled into new manufactured products;
- In operating systems (average annual stocks);
- Remaining in products at decommissioning;
- Applied emission factors (%).

While an inventory in the foam sector is devised along the same lines as in the RAC sectors, some specificities such as foam cell types have to be accounted for when dealing with emissions from foam production.

5 Some key subsectors that have a significant environmental impact are: unitary air conditioning, mobile air conditioning, domestic refrigeration, transport refrigeration, and chillers. For more information on each subsector, see: http://www.green-cooling-initiative.org/technology/technology/

6 http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.html

7 The IPCC 2006 Guidelines introduce a formula to calculate actual emission under the Tier 1 approach, however this is difficult and rarely used, due to the associated uncertainty with the needed composite emission factor.

8 Results from a Tier 1 survey can be used as supporting information for the Tier 2 approach if the amount and type of consumed refrigerants have been identified at the subsector level.

When the amount of blowing agent is unknown, it can be estimated from the volume of foam produced in the country. Indirect emissions are usually not considered for foam products as they occur only during manufacturing and not – as with RAC appliances – during their lifetime.

In contrast to the reporting requested under the UNFCCC, which only comprises GHG regulated under the Kyoto Protocol (including HFCs), it is recommended to also include the ozone depleting substances (ODS) – mainly HCFCs – into the RAC&F sector inventory. As mentioned before, the uses of HCFCs and HFCs are strongly related as HCFCs are increasingly being replaced by HFCs. Thus, the CFC and HCFC data are an important source to get a first estimate of the historical and current refrigerant consumption and emissions. Furthermore, CFCs and HCFCs must be considered when designing a mitigation strategy or action. A business-as-usual scenario (BAU), to which mitigation actions are compared must include the activities under the Montreal Protocol, i.e. the phase-out of ODS such as HCFC and CFC. All parties to the MP have set up HCFC Phase-out Management Plans (HPMP), which provide further detailed and valuable information on how and where transformations will take place in terms of replacing HCFCs by alternative substances.

Calculating the RAC&F sector related GHG emissions will help to understand to what extent the RAC&F sector can contribute to national GHG emissions. Furthermore, the inventory provides an overview of the technologies and appliances that are used in the country, their energy consumption, and the types and amounts of refrigerants or blowing agents used in foams. This information is needed for the following:

- Mitigating data uncertainties related to RAC&F sector technologies in production, manufacturing, use and with regard to energy consumption and overall GHG emissions;
- Assessing the potential economic and environmental benefits of moving to climate friendly, energy-efficient alternative RAC technologies;
- Identifying the country's technology needs in the area of climate friendly RAC technologies;
- Identifying, prioritizing, and agreeing with relevant stakeholders on the ambition level of mitigation targets in a national roadmap for the various RAC subsectors;
- Designing appropriate policy measures with regard to energy efficiency, Minimum Energy Performance Standards (MEPS), labels, and introducing low GWP refrigerants;
- Identifying fields of action to be covered with domestic efforts or international support.

Further information:

- Module 1 of the GIZ Proklima NAMA handbook for the RAC&F sectors provides detailed guidance for developing an RAC&F inventory which can be found here: https://www.giz.de/expertise/html/4809.html
- The Data Input Sheet (DIS) tool provides guidance on what data are needed and where to get them as well as a template for all relevant data to complete a Tier 2 inventory. The tool may be requested at proklima@giz.de
- The HFC inventory & projection tool builds on the DIS tool and calculates HFC emissions for the National Communications (UNFCCC) as well as the refrigerant bank and refrigerant demand. The tool may be requested at proklima@giz.de
- The Green Cooling Initiative provides an online world map on GHG emissions in the RAC&F sector including country data sheets including estimated current GHG emissions and future developments. See individual country data sheets at: http://www.green-cooling-initiative.org/country-data/

4.2. Technology options and economic assessment

Climate-friendly and more energy-efficient technology alternatives exist for almost every RAC&F field of application. Module 3 of the GIZ Proklima NAMA handbook gives a list of alternative technologies that can be applied in the various subsectors. Specifically, natural refrigerants offer climate-friendly and energy-efficient technology solutions throughout the RAC&F sectors. Whilst not every natural refrigerant can be used in each application, there is at least one natural refrigerant suitable for most applications (with the exception of multi-splits, Variable Refrigerant Flow (VRF) systems and centrifugal chillers). In some subsectors, such as domestic and commercial appliances or industrial process cooling, natural refrigerants are increasingly becoming the global standard.

The most suitable technology depends on country-specific aspects such as climate and seasonal conditions, building styles, and/or industry sectors. Some technologies might be more useful because of existing financing mechanisms (e.g. green public procurement for chillers) or appropriate legislation and training institutes (e.g. where hydrocarbon training is included in official training programs).

The establishment of well-founded policies and related financing mechanisms go hand in hand with choosing the most promising technology to overcome barriers and promote the market uptake of these technology alternatives.

Economic Assessment

Economic assessments help to identify and prioritize the most cost-effective options for mitigation. For many RAC systems, the introduction of a climate-friendly alternative will result in no or insignificant incremental upfront costs. Once the increased energy efficiency during the operation of the systems is also taken into account, climate-friendly technologies can be more economically attractive than conventional systems. In such cases, investment in climate-friendly RAC technologies will – in the long run – lead to reduction of both costs and emissions and could yield negative marginal abatement costs per t CO_2eq avoided (see Figure 10).

To assess the economic impact of the replacement of a technology, costs regarding energy consumption as well as refrigerants need to be considered throughout the lifetime of a system. To compare the costs for the conventional technology to those of the alternative technology (incremental costs)[9], the following costs should be considered:

- Manufacturing
  - of components
  - of refrigerants
- Installation
- Product or System use
  - during operation
  - repair
  - servicing
- Energy consumption
  - during entire lifetime
- End-of-life
  - Dismantling
  - Refrigerant recovery, recycling

The following considerations should be taken into account, among others, when assessing technical options:

- Investment in energy efficiency: RAC appliances, systems and components pay off increasingly fast where subsidies in fossil fuels are reduced. This is particularly relevant in cases where the use of energy-efficient RAC&F technology components (such as heat exchangers and variable speed compressors) is highly effective.

- Natural refrigerants are a sustainable and attractive alternative on the market with many advantages in comparison to synthetic refrigerants, for example:
  - They can be more easily recycled, since mostly pure refrigerants are used.
  - They have negligible effects when released to the atmosphere.
  - They require no intellectual property rights for production and use and in general no patents on components and application (with the exception of some rare cases).
  - With increasing economies of scale, natural refrigerant technologies are becoming highly cost effective in the future. Choosing a natural refrigerant is the sustainable and long-term solution, through which manufacturers can develop a long standing competence and avoid the need for additional conversions when international or national environmental regulations on HFCs become even more restrictive in the future.

9 Incremental costs refer to additional costs caused by a particular action or change implemented.

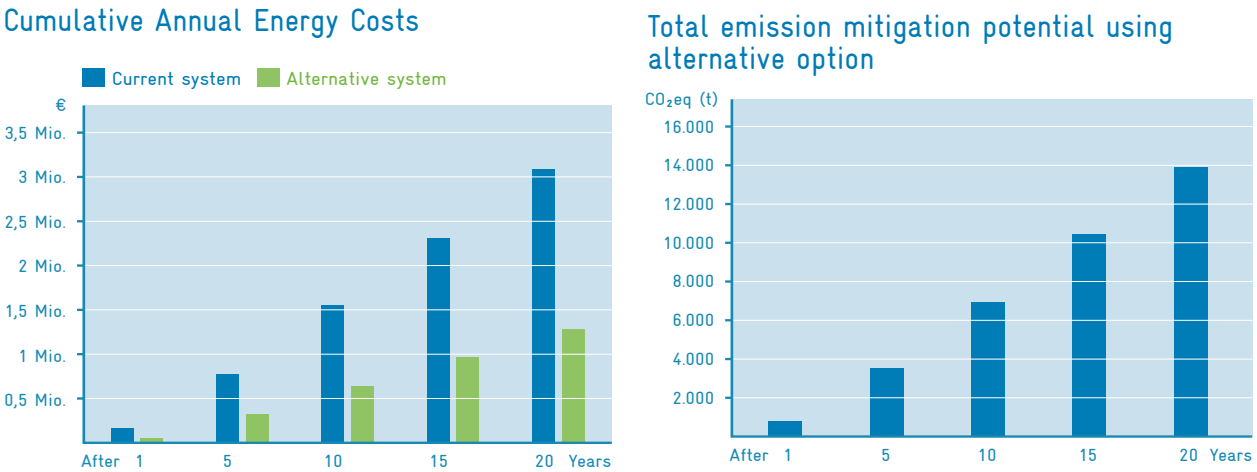

Figure 6: Exemplary calculation to assess energy savings and mitigation reduction for the replacement of an HFC-407c chiller with a hydrocarbon R-290 chiller in a government administration building

Based on a specific example, Figure 6 illustrates the typical economic and climate benefits of replacing an old chiller using R-407c (an HFC refrigerant with a GWP of 1774) with an energy-efficient chiller R290 (a hydrocarbon refrigerant with a GWP of 3) in a developing country. The economic benefit can usually quickly pay off the investment costs, typically in less than five years. The climate benefits result from the nearly complete avoidance of direct emissions and energy efficiency improvements in the range of 10 to 50%.

Further information:

- The GIZ Proklima NAMA handbook for the RAC&F sectors: https://www.giz.de/expertise/html/4809.html
- Technology options - Module 3: https://www.giz.de/expertise/downloads/giz2014-en-NAMA-Handbook-Module-3_WEB.pdf
- Economic assessment - Module 4: https://www.giz.de/expertise/downloads/giz2014-en-NAMA-Handbook-Module-4_WEB.pdf
- Green Cooling Initiative: Green Cooling technologies – Market trends in selected RAC subsectors: https://www.green-cooling-initiative.org/technology/overview/study-download/

4.3. GHG mitigation scenarios

Mitigation scenarios are developed on the basis of countries GHG inventories (see Chapter 4.1). In a first step, expected growth rates are applied to stock and sales figures to create future emission projections in a so-called BAU scenario. The BAU emission scenario functions as a reference scenario and reflects the RAC&F sector development without any intervention of a RAC&F mitigation action. In a second step, mitigation scenarios are developed assuming penetration and diffusion of more climate-friendly technology alternatives. Comparing the BAU to the mitigation scenario shows the emission reduction potential: the more they deviate from one another, the higher the emission reduction potential. Given that HFCs are potent GHGs with GWP values often up to 4000 CO_2eq and that natural refrigerants have negligible GWP values (ranging from 0 to 3), leapfrogging to natural refrigerants holds a large mitigation potential. It is, therefore, worthwhile assessing mitigation pathways that take into account an accelerated uptake of climate-friendly refrigerants.

Further information:

- The GIZ technical handbook on NAMAs in the RAC&F sector guides readers in generating mitigation scenarios. Module 5 (https://www.giz.de/expertise/downloads/giz2014-en-NAMA-Handbook-Module-5_WEB.pdf)

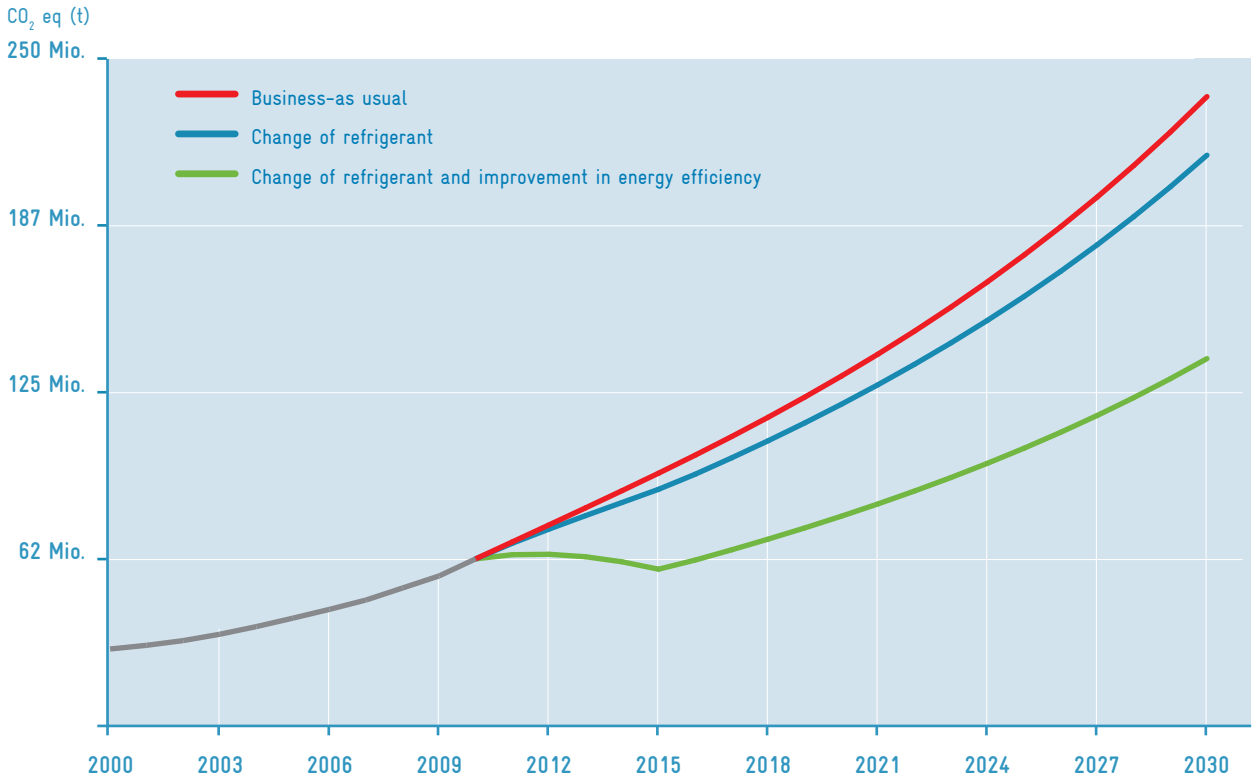

Figure 7: Exemplary calculation of mitigation scenarios regarding the introduction of hydrocarbon refrigerant and energy efficiency measures for split air conditioners in Thailand.

4.4. RAC&F policies and regulations

There are various policies and regulations that could help to increase the use of natural refrigerants and increase the efficiency of RAC appliances. The following figure 8 provides an overview of possible policy measures in the RAC&F sector. Such measures focus on a phase down of HFCs (refrigerants or foam blowing agents) and the efficiency of the appliances (products).

Gases (direct emissions)

To reduce the commonly high refrigerant leakage (direct emissions) during operation and service, policies also need to be able to address the competences of RAC technicians. For example, a regulation which allows only certified technicians to work with RAC appliances (such as during installation, service/repair, end-of-life treatment) will effectively reduce emissions from appliances. The prohibition of venting of HFC at any time and claiming leak check intervals depending on the charge size/GWP is another instrument to reduce the loss of refrigerants or foam blowing agents. To implement these policies effectively, enforcement measures are indispensable.

Effective implementation also relies on the developed standards and codes of practice in the RAC&F sector. Often national standards are missing or outdated, thereby being obstructive for the introduction of innovative climate friendly solutions. Thus, frequent exchange among industries and related government bodies is essential to ensure that latest technology developments and practices are adequately reflected in related RAC&F performance and safety standards.

The establishment of a regulatory framework for recycling and destruction of refrigerants is also required in preventing harmful refrigerants and blowing agents from escaping to the atmosphere when the equipment reaches the end of its lifespan.

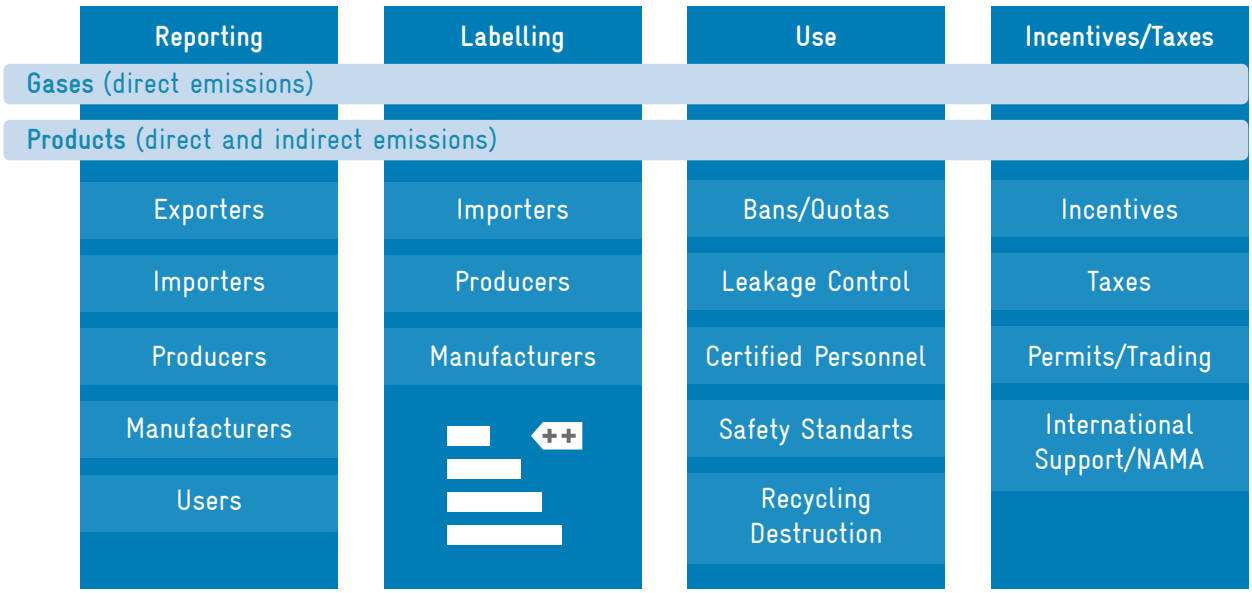

Figure 8: Overview of policy tools for GHG mitigation in the RAC&F sectors

Examples of successful implementation

To phase down the use of fluorinated gases including HFCs, the European Union (EU) has introduced regulations such as the "MAC Directive" which deals with air conditioning systems used in small motor vehicles, and the "F-gas Regulation" that covers most other applications in which fluorinated gases including HFCs are used.

In Germany, the Federal Office for Economic Affairs and Export Control (BAFA) carries out a clean technology subsidy programme for energy-efficient chillers. This programme rewards both the reduction of indirect emissions through improvements in energy efficiency as well as the reduction of direct emissions through the use of natural refrigerants.[10] The following table 2 gives an overview of policies and actions to reduce direct emissions in the RAC&F sectors.

Products and energy efficiency (indirect emissions)

In addressing products and their efficiency, information is the best foundation for any action. To obtain the corresponding information basis, policymakers are well advised to introduce obligatory reporting schemes related to energy efficiency of RAC appliances that enter the market. A sound understanding of the efficiency range would, for example, allow the introduction of energy labelling schemes and consequently the introduction of Minimum Energy Performance Standards (MEPS). Informative ecolabels (or voluntary endorsement labels) could also be introduced to push the market towards climate friendly appliances. Where MEPS do not allow inefficient appliances below a certain threshold, it is the ecolabels which pull the market. Ideally both instruments are used in parallel to transform the market.

For example, the EU has implemented various policies to promote the sustainability of energy related products, including refrigeration and air conditioning equipment as well as heat pumps:

- The **Ecodesign Directive**[11] initiated a process to develop a framework for environmental friendly performance criteria of energy-related products. This process starts with a preparatory study for each product und ultimately leads to an implementing measure (IM), i.e. regulations which are legally binding for all EU member states.

- Similarly, the **Energy Labelling Directive**[12] has led to the launch of several regulations, requiring energy labelling of RAC equipment. The labelling scheme aims at providing information about the key performance criteria from the Ecodesign process, e.g. efficiency, annual energy consumption and noise impact.

- **Green Public Procurement (GPP)**[13] is a voluntary policy instrument of the European Commission. It defines product specifications which go far beyond the minimum performance requirements as defined in the Ecodesign process and serves to pull the market towards environmentally innovative products, considering the entire life-cycle of the products.

- Finally, the **European Ecolabel**[14] is a voluntary endorsement label. Only products which comply with very ambitious environmental performance criteria are awarded with the EU ecolabel. Similar to GPP, the environmental impact of the product is considered from cradle to grave, aiming to reduce negative impacts as far as possible. EU member states may formulate their own national requirements for GPP and ecolabels. For example, the German ecolabel "Blauer Engel" requires high energy efficiency (i.e. Seasonal Energy Efficiency Ratio or SEER ≥ 7) and use of non-halogenated refrigerants.

The combination of these policy instruments is meant to shift the market. On the one hand, the Ecodesign Directive with its MEPS advances product sustainability by pushing inefficient products out of the market. On the other hand, Green Public Procurement (GPP) and ecolabels pull the market by awarding most environmentally friendly products (Figure 9).

The abovementioned policy instruments address different RAC&F appliances in the market. The following capacity building measures help to further optimize the performance of these appliances during stages of planning, installation and, maintenance:

- Promotion of energy audits, trainings, and programmes aimed at changing behaviour which can ease the enforcements of standards and labelling;

- Training of engineers and technicians on cooling needs assessments and fine-tuning system designs at various construction stages;

- Training on energy efficiency practices (e.g. improvement of refrigeration cycles and reduction of parasitic losses in operation stages).

10 http://www.bafa.de/bafa/de/energie/kaelteanlagen/

11 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0125

12 http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32010L0030

13 http://ec.europa.eu/environment/gpp/what_en.htm

14 http://www.eu-ecolabel.de/

	Selected policies and actions to reduce fluorinated GHG emissions in the RAC&F sectors
RAC&F manufacturing, supply and distribution	Phase down of F-gas supply through: • Import regulations for HFC based refrigerants • Bans on new applications operating on HFCs • Supporting manufacturers in converting production lines from HFCs to natural refrigerants • Inform and train distributors and servicing industry on how to properly install and maintain RAC equipment with natural refrigerants
RAC operation	• Incentives (e.g. accelerated depreciation, tax rebate, waving import duties or concessional loan programmes) for purchase and installation of low GWP cooling equipment • Adoption, issuance, and enforcement of safety standards • Training and certification of RAC technicians with regard to installation and maintenance of RAC equipment with low GWP/natural refrigerants (leakage checks, safety measures)
RAC&F disposal (End-of-life)	• Standards on end-of-life treatment of HFCs and their recovery from cooling equipment • Training on proper disposal of contaminated RAC equipment • Creation of destruction facilities for waste fluorinated refrigerants

Table 2: Policies and actions to reduce direct F-GHG emissions in the RAC&F sector

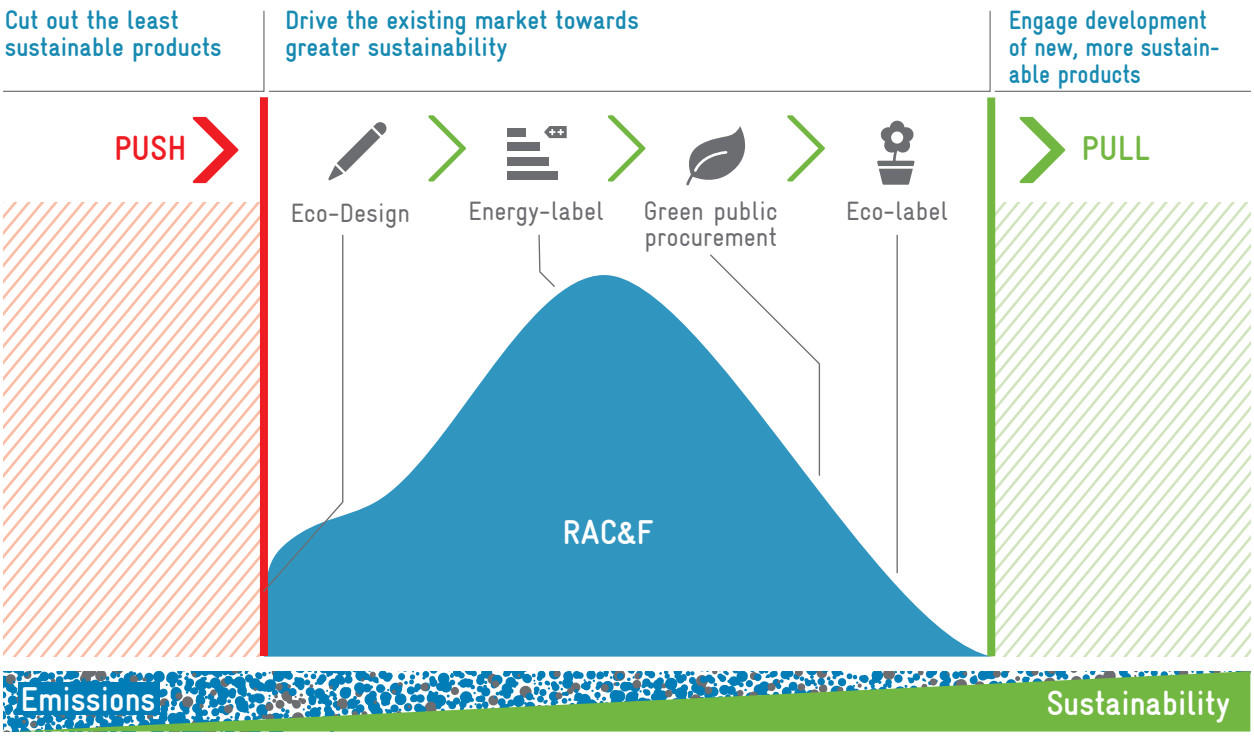

Figure 9: Interventions to increase sustainability of RAC appliances (Source: adopted from European Commission, 2011)

Strengthening capacities of institutions and individuals involved in the life cycle of RAC&F appliances is fundamental for a sustainable market transition.

Further information:

- RAC&F NAMA handbook: Policy framework. Module 8.1 (https://www.giz.de/expertise/downloads/giz2014-en-NAMA-Handbook-Module-8.1_WEB.pdf)
- EU F-gas legislation: http://ec.europa.eu/clima/policies/f-gas/legislation/index_en.htm
- UNEP United for Efficiency: Climate-friendly and energy-efficient refrigerator policy guide book (forthcoming)
- UNEP United for Efficiency: Climate-friendly and energy-efficient room air conditioner policy guide book (forthcoming)

4.5 Technology roadmap for the RAC&F sector

RAC&F technology roadmaps aim to bundle effective technology actions and timelines as well as milestones for a sector- and subsector-specific emission reduction pathway. RAC&F technology roadmaps can also help to illustrate goals and strategies to support regulatory, technology and market environments. Such roadmaps will be based on the information collected in the RAC&F sector inventory (4.1), technology options and economic assessment (4.2), and mitigation scenarios and emission reduction potential (4.3).

Further information:

- Module 6 (https://www.giz.de/expertise/downloads/giz2014-en-NAMA-Handbook-Module-6_WEB.pdf) of the GIZ technical handbook on NAMAs in the RAC&F sector supports policymakers in developing sector specific technology roadmaps as a strategic tool for planning and decision-making.

- Country specific RAC&F emission pathways and emission reduction goals can be based on the recommendations of the global RAC&F roadmap developed by GIZ Proklima. This global roadmap suggests aligning national roadmaps for the RAC sector with the national climate action plans and global emissions targets (see GIZ technical handbook on

4.6 Measurement, reporting and verification (MRV)

A credible MRV system does not only provide for the measurement and reporting of emissions over time, it should allow for the identification of promising opportunities, mobilising the required resources, and tracking the effectiveness GHG mitigation actions and strategies. Considering national circumstances during the design process of an MRV system is essential to ensure practical and sustainable application. This highly depends on consulting with and properly informing the involved stakeholders of the data that is needed as well as their specific responsibilities. The establishment and enforcement of a credible and reliable MRV system needs complementary policies that safeguard transparency and accountability.

Ensuring transparency in such a framework is a key pillar of the Paris Agreement. Parties are expected to report their progress on NDC implementation regularly. Existing processes such as preparation and submission of National Communications (NC) and Biennial Update Reports (BURs) need to be fulfilled by all countries. Regular stock-takes to check collective progress towards the global goal are to take place every five years with the first one in 2018. The establishment of robust MRV systems which allow for continuous monitoring and reporting of emission reduction activities in key sectors are, therefore, of crucial importance.

With established processes and structures under the Montreal Protocol for monitoring the consumption and production of ODS, the RAC&F sector already possesses a reliable foundation for building MRV systems. However, an MRV system in the RAC&F sector should go beyond the reporting of consumption (potential emissions) of HFC and also account for actual direct emissions and indirect emissions. Therefore market data (e.g. stock and sales figures) and technical parameters of the RAC appliances (e.g. type of refrigerants, energy efficiency) should be accounted for in MRV systems (see also inventory, chapter 4.1). Ideally, the energy consumption level and the refrigerants used would be reported within a mandatory registry for sellers of new equipment. Within such a registry the energy consumption level of the sold equipment and the refrigerants used are recorded. Together with statistical data on appliances run-time and assessed leakage rates of refrigerants, a robust database for emissions and mitigation action can be established. The data can be fed into bottom-up stock models to quantify ex-ante and post-ante emission reductions.

Further information:

- RAC&F NAMA handbook module 7: MRV - Module 7 (https://www.giz.de/expertise/downloads/giz2014-en-NAMA-Handbook-Module-7_WEB.pdf)

- GIZ MRV Tool: Measurement, Reporting, Verification - How to set-up National MRV Systems (https://mitigationpartnership.net/mrv-tool-how-set-national-mrv-systems)

- GIZ (2014): Biennial Update Report Template (https://mitigationpartnership.net/giz-2014-biennial-update-report-template)

- International Partnership on Mitigation and MRV: www.mitigationpartnership.net

5. FINANCING IMPLEMENTATION

Key actors in developing countries often require additional financial assistance to initiate the transition to a more climate-friendly RAC&F market. This chapter gives a brief overview of costs related to introducing technology alternatives. Second, it informs about relevant international funds, their scope of funding and recent related developments. Finally, this chapter concludes with considerations for financial planning.

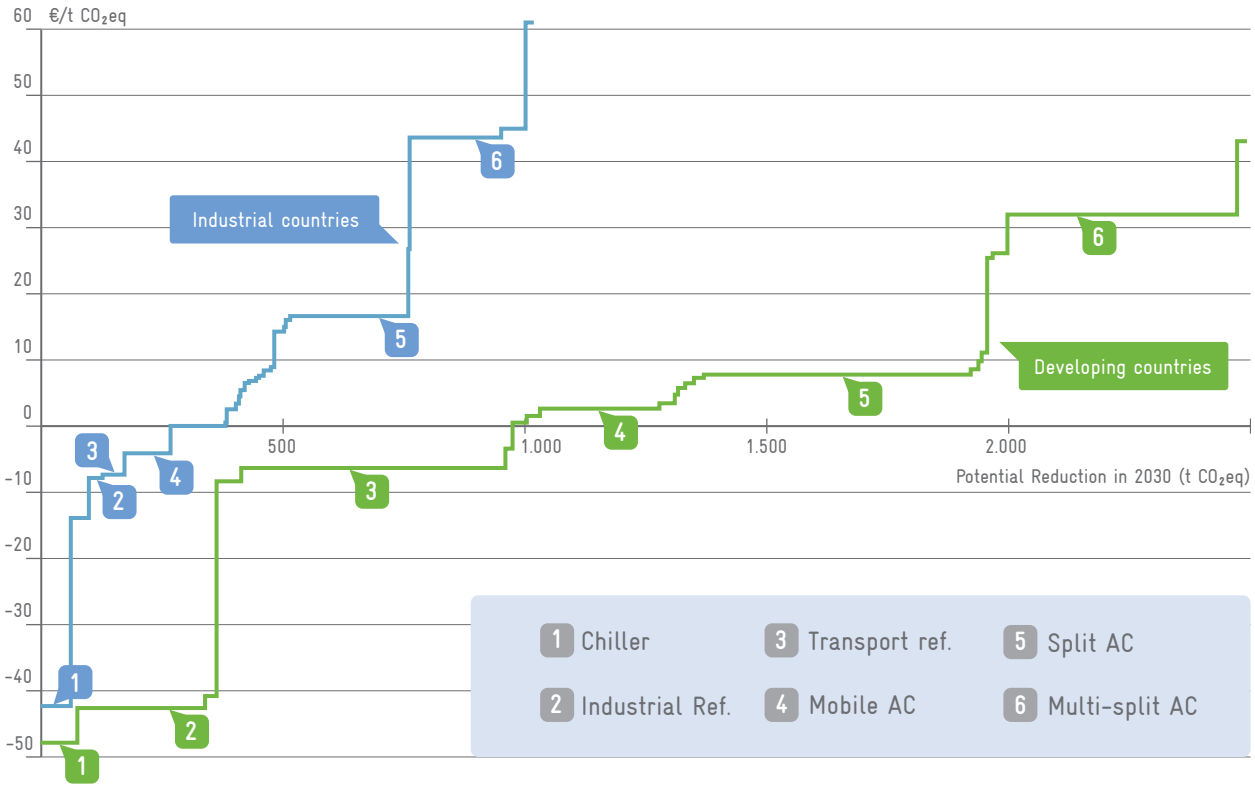

Figure 10: Marginal abatement cost curve in the RAC&F sector (HEAT GmbH, adopted from Schwarz et al., 2011: Preparatory study for European Commission)

GHG mitigation costs in the RAC&F sector

GHG mitigation in the RAC&F sector belongs to the most cost effective mitigation actions, as illustrated in Figure 10 on abatement costs for key RAC&F subsectors (considering refrigerant transition and energy efficiency). However, often barriers such as lack of capital, lack of information and high risk perceptions prevent end-users from purchasing more climate-friendly and efficient RAC products. Once these barriers have been addressed and overcome, actions as outlined in Figure 10 can be implemented with a net benefit to the operators and the overall economy.

An effective mitigation framework for the RAC&F sector must be based on an integrated approach, covering financing for mitigation of both direct and indirect emissions, within the NDC framework. Thereby both the climate and socio-economic benefits can be maximized.

Financing of HFC reductions under the Montreal Protocol

The financing of activities to reduce HFC emissions will be funded under the Montreal Protocol in the future. Developing countries (Article 5 of the MP) are supported through the Multilateral Fund (MLF) with finance for technology transfer to enable their compliance with the Protocol's control measures. The eligible funding is provided on the basis of the total baseline consumption and in view of subsector specific incremental cost guidelines.

Figure 11 illustrates an exemplary pathway for the planned HFC phase down. Developing countries have agreed on a baseline approach which sets the level of allowable HFCs for consumption and production. Under this approach, developing countries responsible for approx. 87% of the HFC consumption (in developing countries) apply a baseline based on the years 2020 to 2022, while a remaining number of countries with specific difficulties take the years 2024 to 2026 as a basis for their baseline. In both cases, two years after the last baseline year the consumption will be capped at 100% of the baseline, the so called "freeze". In the following years the consumption will be gradually reduced to a final plateau of 20% or respectively 15% of the baseline in the years 2045 and 2047.

During the phase down of HFCs, Article 5 Parties will have the flexibility to individually select HFC sectors and replacement technologies, and adapt their strategies to their needs and national circumstances.

Funding the phase down of HFC may include incentives for energy efficiency improvements when appropriate and cost effective. Since the MLF has no capacity to control the impact of energy efficiency measures, it is likely that funding for energy efficiency will depend on a supporting framework in the beneficiary country.

In addition, it is expected that MLF support for capacity building in the servicing and repair sector will substantively improve the energy efficiency of installations and equipment.

In summary, funding may include the following elements, as illustrated in Figure 11:

- Costs for setting up inventories, reporting and ratification processes;
- Demonstration projects and regulative action;

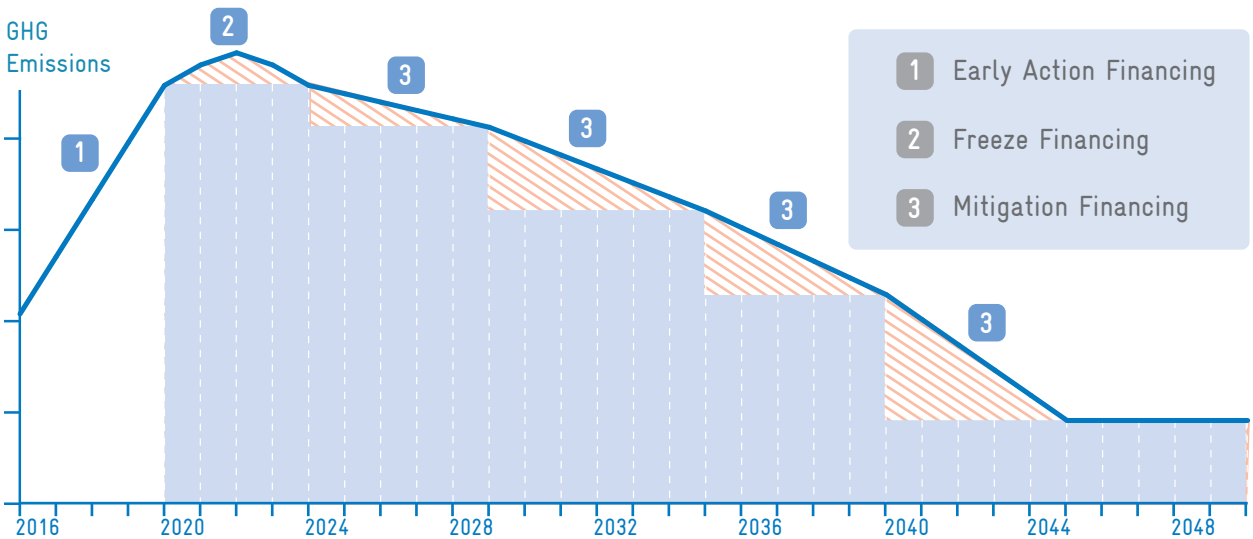

Figure 11: Indicative pathway of HFC phase down and potential MLF financing

- Institutional strengthening;
- Incremental costs necessary to achieve the first control step (freeze) and the individual phase down steps until the final plateau is achieved. Incremental costs are provided for the close down of HFC production capacities and for reducing consumption in the manufacturing sector, including costs for building capacity in the servicing sector. End-user funding is not obligatory under the MLF and only demonstration projects are financed in exceptional cases.

Energy efficiency incentives are evaluated in the context of incremental costs resulting from HFC conversions, giving consideration to limited upgrades of components and parts of alternative technologies, where it is cost effective and represents only a smaller percentage of the total conversion costs.

It is not planned to fund an exhaustive and ambitious range of energy efficiency measures. Thus, ambitious energy efficiency will typically depend on additional measures such as NAMAs, which can provide additional funding from outside the MLF.

Climate finance under the UNFCCC

The provision of financial support for mitigation activities in developing countries is a cornerstone of the international climate policy process and the Paris Agreement. Developed countries committed to jointly mobilize US$100 billion per annum until 2020 to support climate action in developing countries. This commitment was reiterated in the Paris Agreement and extended through to 2025. Before 2025, a new collective finance goal is to be defined with the US$100 billion constituting the minimum.

The HFC phase down is expected to significantly contribute to global mitigation targets with an expected reduction of 0.5°C by the year 2100. This is without reductions that could be achieved through energy efficiency and a replacement of fossil energy by renewable energy.

In developing countries, the aggregated reductions until 2050 achieved by HFC reduction and the combined introduction of EE measures and renewable energy production are projected to be equally high. In the energy sector, absolute reductions are difficult to achieve under steady high economic growth as seen in developing countries.

Because of the outstanding importance of cooling in developing countries, the massive replacement of fossil energy production with renewable energy in combination with high energy-efficient cooling systems is the only option for achieving the 2050 targets.

Therefore, the major part of funding for energy related mitigation in the RAC&F sector will need to come from climate finance sources.

Green Climate Fund

One of the main sources of support is the Green Climate Fund (GCF) which was adopted as the financial mechanism of the UNFCCC at the end of 2011. The initial resource mobilisation raised over US$ 10 billion and is expected to increase substantially in future. The GCF has a goal to fund climate action equally across mitigation and adaptation sectors with at least half of available resources to be made available to the Least Developed Countries (LDC), Small Island Developing States (SIDS), and African States.

The funding framework is continuously evolving and funding for several projects has already been agreed. A Private Sector Facility (PSF) is also being established to allow direct engagement of the private sector.

The GCF will operate a variety of financial instruments including grants, concessional loans, subordinate debt, and equity and guarantees depending on specific project and funding needs. A higher risk bearing capacity is expected to support innovative approaches and crowd in finance from other, in particular private, sources.

Nationally Appropriate Mitigation Actions (NAMAs)

NAMAs can serve as a tool to package policies and measures that have been designed in the RAC&F mitigation strategy to achieve national climate targets. More than a third of developing country parties proposed to use NAMAs to achieve their NDC targets. Some directly formulated their NDC in the form of specific mitigation actions.

NAMAs are a flexible instrument which typically combines (government driven) measures to address barriers to mitigation or barriers to investment in low carbon alternatives in a specific sector. Ultimately, NAMAs seek the transformation of entire sectors or subsectors through a comprehensive policy approach.

	Montreal Protocol	UNFCCC / NDCs
Control	• Consumption and production	• Emissions of HFCs and indirect emissions (fossil fuel based emissions)
Financing basis	• the Multilateral Fund provides funding for compliance related action on a incremental cost basis for the conversion of production and consumption sectors	• Source specific, i.e. depends on finance provider (e.g. ODA finance, dedicated climate finance) • Climate finance often incremental cost based (e.g. NAMAs) • Results based approaches also used, e.g. based on avoided CO_2 emissions (USD/ tCO_2eq)
Conditions	• Establishment of licensing and quota systems as a prerequisite	• Supporting policy implementation (e.g. MEPS / Labels for RAC appliances and components/ building standards) • Supporting incentive schemes for deployment of efficient equipment
Refrigerant related investments	• Financed on sector specific cost effectiveness criteria (USD per kilogram consumed refrigerant)	• Ideally to be considered with a comprehensive approach (e.g. Total Equivalent Warming Impact for appliances)
Energy efficiency related investments	• Additional incentives for maintaining/ enhancing energy efficiency of alternatives is constrained to conversions in the manufacturing sector	• Ideally based on reaching top energy efficiency label classes or endorsement labels
Future reductions	• The Kigali amendment will result in a final cap of consumption and production as a percentage of the respective baseline values. Presently a range of 15 to 20% is proposed as the final reduction step in the years 2045/2047	• Financing focused on enhanced energy efficiency • Enhanced financing options to include the use of natural, low GWP refrigerants (below GWP 10) as a precondition.
Compliance and enforcement	• Economic Sanctions when continuously remain in Non- compliance • Trade restrictions with non-party countries	• No compliance measures under UNFCCC • Compliance measures (e.g. sanctions or fines) depending on conditions of respective finance source

Table 3: Financing scope under the Montreal Protocol and the UNFCCC/NDCs

Under the RAC&F NAMA approach as set out in the GIZ Proklima NAMA handbook, countries aim for a sectoral or sub-sectoral approach to comprehensively address GHG emissions from the RAC&F sector, covering direct and indirect emissions. Here, both the effects of the HFC phase down and the countries' efforts to mitigate indirect emission (e.g. from the energy use of RAC appliances) are comprehensively addressed.

Under the UNFCCC, NAMAs have emerged as a flexible mechanism to channel finance, capacity and technology support. There are few dedicated NAMA finance sources available, one of which is the German-UK NAMA Facility. Among the first NAMA projects financed by this facility is a RAC NAMA in Thailand carried out by GIZ.[15] NAMAs and "NAMA-like" activities are also typically funded through other climate finance channels, including multilateral and bilateral development banks as well as potentially the GCF. It is key for the successful formulation of NAMAs to ensure that proposals are developed in sufficient detail, in particular setting out the funding requirements and any finance and support mechanisms to be deployed.

The design of a NAMA or any climate finance proposal should include a comprehensive view of how sector emissions are planned to be reduced, including short-, medium-, and long-term targets. This should also include activities foreseen to be funded under the MLF (as described above), as well as the planned use of domestic – including both public and private – financial sources. International climate finance particularly addresses finance gaps and should be designed to leverage private sector investments and other public funds most effectively.

Table 3 illustrates the likely funding scope of the Montreal Protocol for the transition to HFC alternatives and related energy efficiency enhancements as well as the funding scope of the UNFCCC / NDCs on energy efficiency enhancement beyond the measures taken by the Montreal Protocol.

15 http://www.nama-facility.org/projects/thailand.html

Considerations for financial planning

Developing a comprehensive understanding of the national RAC&F sector, its GHG emissions, and potential barriers when introducing mitigation actions are fundamental for planning financial support. Generally, financial support is insufficient without a holistic combination of other interventions such as capacity building, awareness-raising, and regulatory measures.

Further, it is recommended to undertake a detailed analysis of the needs for financial support. It is particularly important to consider needs in the context of available domestic sources, capabilities, and sustainability to attract the interest of financial supporters in a proposal. A detailed description is needed to illustrate the effectiveness when linking types and levels of incentives with the desired shift in investment or behaviour by targeted end users.

Finally, a comprehensive finance strategy should include an implementation plan which will combine various potential sources (e.g. domestic, climate finance, MLF) and describe mechanisms to channel the support. The finance strategy and its RAC&F specific sectoral targets should be closely aligned with the defined schedules of the Montreal Protocol and the Paris Agreement of the UNFCCC (see Chapter 2, Figure 3).

Further information:

- Nationally Appropriate Mitigation Actions (NAMAs). Steps for moving a NAMA from idea towards implementation. Version 10.0. GIZ Nama tool (https://mitigationpartnership.net/sites/default/files/2016-nama-tool-10.0-draft.pdf)
- RAC&F NAMA handbook module 8.2. Financial framework: Module 8.2 (https://www.giz.de/expertise/downloads/giz2014-en-NAMA-Handbook-Module-8.2_WEB.pdf)
- International Partnership on Mitigation and MRV: www.mitigationpartnership.net
- Green Climate Fund: www.greenclimate.fund
- NAMA Facility: www.nama-facility.org

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TABLE OF ABBREVIATIONS

B	BAFA	The Federal Office for Economic Affairs and Export Control
	BAU	Business-As-Usual
	BURs	Biennial Update Reports
C	CFCs	Chlorofluorocarbons
	CO2	Carbon dioxide
	CRF	Common Reporting Format
D	DIS-tool	Data Input Sheet tool
E	EPA	Environmental Protection Agency
	EU	European Union
F	F-gas	Fluorinated greenhouse gas
	F-GHG	Fluorinated greenhouse gas
G	GCF	Green Climate Fund
	GCI	Green Cooling Initiative
	GHG	Greenhouse Gases
	GIZ	Gesellschaft für Internationale Zusammenarbeit (GmbH)
	GPP	Green Public Procurement
	GWP	Global Warming Potential
H	HCFC	Hydrochlorofluorocarbons
	HEAT	Habitat, Energy Application & Technology
	HFC	Hydrofluorocarbon
	HPMP	HCFC Phase-out Management Plan
I	INDC	Intended Nationally Determined Contribution
	IPCC	Intergovernmental Panel on Climate Change
K	kg	kilogram
L	LDC	Least Developed Countries
M	MAC	Mobile Air Conditioning
	MEPS	Minimum Energy Performance Standards
	MLF	Multilateral Fund
	MOP	Meetings of Parties
	MP	Montreal Protocol
	MRV	Measurement, reporting and verification
N	NAMAs	Nationally Appropriate Mitigation Actions
	NC	National Communications
	NDC	Nationally Determined Contributions
	NGOs	Non-governmental Organizations
	NOUs	National Ozone Units
O	ODA	Official Development Assistance
	ODP	Ozone Depleting Potential
	ODS	Ozone Depleting Substances
P	PSF	Private Sector Facility
R	RAC	Refrigeration, Air conditioning
	RAC&F	Refrigeration, Air conditioning and Foam
S	SEER	Seasonal Energy Efficiency Ratio
	SIDS	Small Island Developing States
U	U4E	United for Efficiency
	UN	United Nations
	UNEP	United Nations Environmental Programme
	UNFCCC	United Nations Framework Convention on Climate Change
	USD	US-Dollar
V	VRF	Variable Refrigerant Flow

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