Raising ambition in NDCs through holistic mitigation approaches in the cooling sector –

Guidance for policymakers

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Executive summary

Refrigeration and air conditioning (RAC) is vital for human well-being, for example, to prevent food loss and guarantee supply of medical care with functioning cold chains and alleviate heat stress through space cooling. Cooling sector specific mitigation targets and measures can significantly contribute to achieving a country's overall climate targets and therefore, need to be considered when defining and updating Nationally Determined Contributions (NDCs).

The RAC sector is responsible for a considerable amount of global greenhouse gas (GHG) emissions – from refrigerant use (direct emissions) and the operation of the equipment with fossil-fuel based energy sources (indirect emissions). The consumption and production of most synthetic refrigerants, and more specifically hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs), are controlled by the Montreal Protocol (MP) and its Kigali Amendment (KA). Nonetheless, recent studies reveal that the emission reductions resulting from a stringent phase-down of HFCs according to the KA schedule are not in line with the 1.5°C goal of the Paris Agreement (PA) under the United Nations Framework Convention on Climate Change (UNFCCC). Full compliance with the KA would translate into HFC emission reductions of 56% by 2050. But for a 1.5°C-consistent pathway, a reduction of 70-80% would be required (Purohit et al., 2022). In addition, indirect emissions of the RAC sector caused by equipment electricity consumption are rising steadily. Thus, energy demand for space cooling is projected to triple by 2050, if no action is taken to address energy efficiency (IEA 2018). Consequently, it is crucial for countries to enhance their NDCs with Green Cooling solutions based on two principals: using natural refrigerants in combination with highly energy-efficienct appliances and buildings.

To date, more than half of the countries that developed an updated NDC have recognised the relevance of the cooling sector and included HFCs in the scope of gases covered. However, most NDCs lack concrete actions and implementation strategies for the RAC sector.

This guideline intends to provide political decision-makers with a step-by-step guidance on how to integrate and appropriately cover the cooling sector in a NDC. Moreover, it offers benchmarks for the degree of ambition of actions targeting direct and indirect emissions of the RAC sector.

More specifically, it

- describes key elements for the development of comprehensive and holistic approaches to address RAC sector emissions in the NDCs
- gives an overview of the latest technology trends and technical possibilities for sustainable cooling solutions in key sub-sectors and appliances
- suggests methods for the selection of most relevant and effective policy instruments to set ambitious quantified reduction targets
- explains the possibility to benefit from international carbon markets, while considering an integrated cooling sector strategy in line with the KA and the PA
- points to relevant publicly available information and resources as well as best practice examples that demonstrate effective and ambitious mitigation action in the cooling sector.

The key strategic components and steps for the integration of the RAC sector into a NDC that are described in the guideline include:

Step 1: A **solid data base**, ideally in the form of a **detailed RAC sector GHG inventory**;

Step 2: A **comprehensive cooling sector mitigation approach** including **long-term strategies** and **implementation plans** that build on the HFC reduction obligations mandated by the KA and at the same time consider emissions generated by energy use.

Step 3: The **anchoring of the cooling sector in the NDC update process** by highlighting its relevance in terms of mitigation potential and joint decision-making by all key stakeholders to determine the best position of the sector in the respective NDC.

Step 4: The **linkage** of cooling sector related mitigation measures and plans **with other relevant sectors** and targets set for them, especially the building sector and demand side energy efficiency, including the consideration of institutional structures and **coordination with the respective (governmental) actors**.

Step 5: The development of a **tracking and Monitoring, Reporting and Verification (MRV) system for HFC emissions** that is in line with the requirements of both the MP and the PA.

The guideline is complemented by an excel-based benchmarking tool that aims at enabling decision-makers to do a self-analysis on the level of ambition of the cooling sector-related measures included in the current or future updated NDCs.

Read the whole publication here:

www.green-cooling-initiative.org/news-media/publications

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A

A6.4 ERs Article 6.4 Emission Reductions
AC Air Conditioner

B

BAT Best Available Technology
BAU Business-As-Usual
BTR Biennial Transparency Report
BTU/hr British Thermal Units/hour

C

CC Cooling Capacity
CDACC Curriculum Development Assessment and Certificate and Council
CDM Clean Development Mechanism
CFC Chlorofluorocarbons
CMA Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
CO_2 Carbon dioxide
CO_2eq Carbon dioxide equivalent
COPA Climate and Ozone Protection Alliance
CORSIA Carbon Offsetting and Reduction Scheme for International Aviation
CSPF Cooling Season Performance Factor

D

DKK Danish Krone
DOE Designated Operational Entity

E

EEI Energy Efficiency Index
EER Energy Efficiency Ratio
EPR Extended Producer Responsibility
ETF Enhanced Transparency Framework
ETS Emissions Trading System
EU European Union
EUR Euro

F

F-gas Fluorinated gases

G

GEF Global Environment Facility
GHG Greenhouse Gas
GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit
GPP Green Public Procurement
GWP Global Warming Potential

H

HC Hydrocarbon
HCFC Hydrocholoroflurocarbon
HFC Hydrofluorocarbon
HFO Hydrofluoroolefines
HPMP HCFC Phase-out Management Plan

I

IIASA International Institute for Applied Systems Analysis
IKI International Climate Initiative
IPCC Intergovernmental Panel on Climate Change
IPPU Industrial Processes and Product Use
ISEER Indian Seasonal Energy Efficiency Ratio
ISO International Organization for Standardization
ITMO Internationally Transferred Mitigation Outcome

K

KA Kigali Amendment
KNEC Kenya National Examination Council
KNQA Kenya Qualification Authority
KNQF Kenya National Qualification Framework
KIP Kigali Implementation Plan
kW Kilowatt

M

MEPS Minimum Energy Performance Standard
MLF Multilateral Fund
MP Montreal Protocol
MRV Monitoring, Reporting and Verification
MPGs Modalities, Procedures, and Guidelines
MSA Market Surveillance Authority

N

NAMA Nationally Appropriate Mitigation Action
NCAP National Cooling Action Plan
NDC Nationally Determined Contribution
NIR National Inventory Report
NITA National Industrial Training Authority
NOU National Ozone Unit

O

ODS Ozone Depleting Substances
OMGE Overall Mitigation in Global Emissions

P

PA Paris Agreement

Q

QCR Qualification, Certification and Registration

R	RAC	Refrigeration and Air Conditioning
	RACHP	Refrigeration, Air Conditioning and Heat Pumps
	RDC	Refrigerated Display Cabinet
	RIS	Regulation Impact Statement
	RSC	Refrigerated Storage Cabinet
S	SB	Supervisory Body
	SE4All	Sustainable Energy for All
	SEER	Seasonal Energy Efficiency Ratio
	SME	Small and Medium-sized Businesses
	SPP	Sustainable Public Procurement
T	TACCC	Transparency, Accuracy, Completeness, Comparability, Consistency
	TOT	Training of Trainers
	TVET	Technical and Vocational Training and Education
U	U4E	United for Efficiency
	UNEP	United Nations Environmental Programme
	UNFCCC	United Nations Framework Convention on Climate Change
	USD	US Dollar
W	WEEE	Waste Electric and Electronic Equipment

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1 Introduction

1.1. The importance of climate action in the cooling sector

Cooling technologies are used in various areas of our everyday lives, be it for the proper storage of food or medicines and vaccines, for space cooling or in large-scale plants in industry. Therefore, access to cooling is considered to be indispensable for sustainable development. Particularly in view of the constantly rising ambient temperatures, people suffer from food losses, insufficient supply with medical care and heat stress, if they do not dispose of suitable cooling technologies. Assessments of access to cooling and linkage with vulnerability show that currently, over one billion people across 54 countries suffer from inexistent or inadequate cold chains and space cooling (SE4ALL 2022). Cooling is thus an essential resource for the development of a society and for coping with the impacts of climate change.

Yet the use of cooling technologies can also have downsides. Refrigeration and air conditioning (RAC) equipment is a dual emissions source. Firstly, the operation of cooling appliances usually requires the use of refrigerants. There are different kinds of refrigerants and technologies available which have different climate impacts. Synthetic refrigerants, such as hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs), are often very damaging to the climate due to their high global warming potential (GWP), and thus are leading to significant greenhouse gas (GHG) emissions, so-called direct emissions. Natural refrigerants such as propane, isobutane, carbon dioxide or ammonia are climate-friendly alternatives. Secondly, fossil-fuel based energy use and electricity consumption of cooling equipment, especially of inefficient appliances, generate significant additional GHG emissions. Against the background of a projected increase in ambient temperature, the number of cooling applications is also expected to increase in the next decades. Consequently, emissions originating from the RAC sector including emissions from refrigerants from operating and old appliances that are not properly disposed of (so called banks) will significantly rise, if not enough effort is made towards sustainable cooling.

Several studies analysing the impact of the Kigali Amendment (KA) to the Montreal Protocol (MP) on hydrofluorocarbon emissions at the global level stress that the HFC phase-down has a substantial effect in terms of achieving the 1.5°C goal of the Paris Agreement (PA). The KA is expected to prevent 0.4°C of global warming, if fully implemented (World Meteorological Organization et al., 2018). However, there is still a significant gap to reach the 1.5°C goal, as for instance a recent study of the International Institute for Applied Systems Analysis (IIASA) shows (Purohit et al., 2022). The emission reductions by 2050 that can be realised through full compliance with the KA are estimated at 56% (compared to 2010 levels). But to be in line with a 1.5°C-consistent pathway, a reduction of 70-80% would be required. At the same time, emissions stemming from fossil-fuel based electricity consumption of cooling devices account for a large share of countries' energy sector emissions. For instance, the use of air conditioning and electric fans for space cooling represents almost 20% of total electricity consumption in buildings globally today. Even more, energy demand for space cooling is projected to triple by 2050, if no action is taken to address energy efficiency (IEA 2018). As with refrigerant-related emissions, the subject of energy efficiency in the cooling sector must also be given greater prominence in order to make a corresponding contribution to the 1.5°C goal. Therefore, it is essential for countries to take further action, including the accelerated reduction of direct emissions related to HFC use and the promotion of energy efficient cooling equipment. Only through a holistic climate policy approach, which addresses refrigerant GWP, appliance efficiency, the proper management of in-use and end-of-life refrigerants and decarbonization of energy supply at the same time, GHG emissions can be decoupled from a growing cooling demand. Consequently, it is pivotal to develop cooling sector specific mitigation targets and measures that are integrated in the Nationally Determined Contribution (NDC)[1].

1 Nationally Determined Contributions (NDC) are the cornerstone of the Paris Agreement and the basis for the achievement of its long-term goals. Each Party is requested to express its efforts to reduce national emissions and adapt to the impacts of climate change in its NDC. The documents are submitted every five years to the UNFCCC secretariat. To increase ambition over time, the Paris Agreement stipulates that successive NDCs represent progress over the previous NDC and reflect its highest possible ambition.

Although more than half the countries that developed an updated NDC have recognised the relevance of the cooling sector, and specifically the importance of HFC emissions, there is still a huge gap in terms of concrete actions and implementation strategies. Detailed action plans that underpin quantitative mitigation targets in the cooling sector are rarely found in the current versions of updated NDCs (GIZ 2021c). Reasons might be the lack of financial resources as well as the political willingness and power to promote climate action in the RAC sector and to prominently position it in the NDC. Nevertheless, there are many good practice examples that can serve as valuable guidance in setting ambitious mitigation actions in the cooling sector and integrating them into enhanced NDCs, as this guideline will show. Further information on the cooling sector in the international context and more specifically in the framework of the Kigali Amendment to the Montreal Protocol and the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) can be found in the → Technical Annex.

1.2. Objectives of the guideline

Building on the first RAC NDC guidance published by GIZ in 2016, this guideline shall provide political decision makers with a step-by-step guidance on how to appropriately cover the cooling sector in a NDC. It further addresses the question how the ambition of cooling sectors targets can be increased once the NDC is updated. Thus, the guideline

- maps out key elements for the development of holistic approaches to address direct and indirect RAC sector emissions;
- describes approaches how to select most relevant and effective policy instruments to set ambitious quantified reduction targets;
- provides an overview of the latest technology trends and technical possibilities to reduce direct and indirect emissions for key sub-sectors and appliances;
- addresses baseline setting and the possibility to harness international carbon markets, while considering an integrated cooling sector strategy in line with the KA and the PA;
- offers references to relevant publicly available information resources and best practice examples that demonstrate effective and ambitious mitigation action in the cooling sector.

Source: Shutterstock

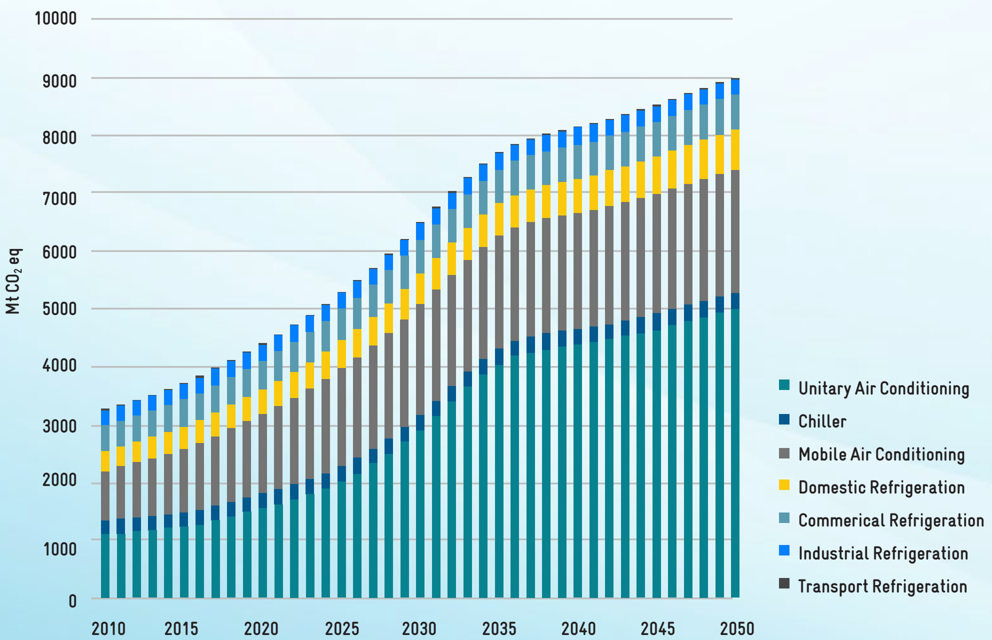
2. Background, key measures and technology options

As outlined above, emissions from the RAC sector are projected to rise tremendously. Several studies (IEA 2018, Xu et al. 2013, Purohit et al. 2020) provide alarming scenarios of emissions from refrigerants and energy use to reach unprecedented dimensions by the mid of this century.

On the other hand, the fight against climate change demands immediate cuts of GHG gas emissions. Large areas of the cooling sector are considered low-hanging fruits, meaning that a high impact can be achieved with relatively low cost (Hawken 2017, Purohit et al. 2022). In the case of refrigerants, it is the high GWP of conventional refrigerants versus available alternatives, so-called natural refrigerants. In the case of energy efficiency, it is the resulting low lifecycle costs that makes measures in the RAC sector low-hanging fruits. At the same time, access to cooling is relevant for sustainable development. Food loss, access to medicine, well-being, productivity, and thermal comfort are all connected to refrigeration and cooling applications (SE4ALL 2018).

RAC equipment is responsible for about 4.7 Gt carbon dioxide equivalent (CO_2eq) in 2022 (GCI 2013), as shown in Figure 1. On the global average, one third originates from direct refrigerant emissions while the remaining two thirds are from energy use. This ratio is depending on the national grid emission factor, where a low grid emission factor puts more weight on refrigerant emissions. Within the RAC sector, 28% of emission are estimated to come from room air conditioners (ACs) (GCI 2013), whose number of currently estimated 850 million is expected to rise to 3.7 billion by 2050 (IEA 2018). Other large contributors are mobile ACs, followed by commercial and domestic refrigeration. While the performance of mobile ACs is difficult to influence on a national level, as vehicle manufacturers are multinational players, action to reduce emissions from room ACs, domestic, commercial and industrial refrigeration is required on the national level. This guideline focuses on low-hanging fruits, where national policies can strongly influence consumer investment into readily available highly efficient mass-produced appliances for room ACs, domestic refrigeration and commercial plug-in refrigerators. Large commercial and industrial refrigeration equipment is often custom-made and more difficult to regulate. They are often the source of high refrigerant emissions during the use phase and require a different approach for regulation, focusing on tight installations, leakage checking and on-site recovery of refrigerants along with the promotion of energy efficiency.

Figure 1: Projected GHG emissions from RAC sector



Source: GCI 2013a

2.1. Key Measures

The technology to turn to a more sustainable path in providing RAC services is available. This chapter puts the spotlights on key measures listed below as well as the largest subsectors and provides links to further information. After a general overview on these key measures along with links to further information, selected aspects will be looked at per sub-sector:

- Reduce cooling load (long-term) through adequate housing (insulation, shading, cool roofs, other passive cooling options)
- Shift to natural refrigerants
- Use efficient cooling appliances, electrified by an increasing share of renewable energy
- Improve the management of HCFC and HFC banks to reduce emission during servicing and at end-of-life

The improvement of building design to climate-neutral, resilient buildings combines many aspects, from (urban) design and embodied carbon of buildings materials to passive cooling options and overall resource efficiency during use. As this topic exceeds the focus of the RAC sector NDC, this is not pursued here further, but the interested reader is directed to third party information that is provided by the international initiative Sustainable Energy for All (SE4ALL).

Recommendation for further reading:

- SE4ALL (2022). Chilling Prospects: Tracking Sustainable Cooling for All 2022, https://www.seforall.org/chilling-prospects-2022
- SE4ALL (2018). Chilling prospects: Providing sustainable cooling for all, https://www.seforall.org/sites/default/files/SEforALL_CoolingForAll-Report_0.pdf

Shift to natural refrigerants

Using natural refrigerants with almost no GWP instead of fluorinated refrigerants with medium to high GWP, whose break down products irreversibly accumulate in the environment, is an important measure within a cooling NDC. Alternatives to HFCs that are also energy efficient exist for many applications, as documented below. Policy action is required to transform the market towards a wide-spread use of natural refrigerants. Dedicated promotion of capacity building is an integral component to ensure the safe use of natural refrigerants.

Cross-references within this guidance:

- → Regulatory instruments to reduce HFC consumption, Chapter I.A
- → Capacity building for technicians, Chapter I.E

Recommendation for further reading:

- GIZ (2010). Hasse, V., Ederberg, L., Kirch, R.: Good Practices in Refrigeration
- GIZ (2010). Colbourn, D.: Guidelines for the safe use of hydrocarbon refrigerants

Use efficient cooling appliances, electrified by an increasing share of renewable energy

Curbing electricity use of RAC applications by enhancing sales of energy efficient appliances is often part of broader NDC measures on energy efficiency. Ambition levels can differ greatly, depending on the defined national minimum energy performance standard (MEPS). Field studies have revealed that energy efficiency is not primarily proportional to the cost of an appliance (GIZ 2018b). Thus, investing in energy efficient RAC appliances often has short pay-back periods and relieves the strain on national electricity grids. The further reduction of energy-related emissions will only succeed with the transformation of the energy supply towards renewable energy sources. In this regard, heating and cooling could be integrated with thermal storage solutions that support stable grids in the face of volatile wind and photovoltaic power supply.

Cross-references within this guidance:

- → Regulatory instruments to promote higher energy efficiency of equipment, Chapter II.A
- → Enforcement of energy efficiency regulation, Chapter II.B

Recommendation for further reading:

- United for Efficiency (2019). Model Regulation Guidelines, Energy-Efficient and Climate Friendly Air Conditioners, https://united4efficiency.org/wp-content/uploads/2021/11/U4E_AC_Model-Regulation_EN_2021-11-08.pdf
- United for Efficiency (2019). Supporting Information on the Model Regulation Guidelines for Energy-Efficient and Climate-Friendly Air Conditioners, https://united4efficiency.org/wp-content/uploads/2020/05/U4E_AC_Model-Reg-Supporting-Info_20200227.pdf
- United for Efficiency (2019). Model Regulation Guidelines for Energy-Efficient and Climate Friendly Refrigerating Appliances, https://united4efficiency.org/wp-content/uploads/2019/11/U4E_Refrigerators_Model-Regulation_20191029.pdf
- United for Efficiency (2019). Supporting Information on the Model Regulation Guidelines for Energy-Efficient and Climate-Friendly Refrigerating Appliances, https://united4efficiency.org/wp-content/uploads/2019/11/U4E_Refrigerators_Supporting-Info_20191029.pdf
- United for Efficiency (2021). Model Regulation Guidelines for Energy-Efficient and Climate-Friendly Commercial Refrigeration Equipment, https://united4efficiency.org/wp-content/uploads/2021/11/U4E_CommercialRefrig_ModelRegulation_20211109.pdf
- United for Efficiency (2021). Supporting Information on the Model Regulation Guidelines for Energy-Efficient and Climate-Friendly Commercial Refrigeration Equipment, https://united4efficiency.org/wp-content/uploads/2021/11/U4E_CommercialRefrig_Supporting-Info_20211109.pdf

Improve the management of HCFC and HFC banks to reduce emissions during servicing and end-of-life

Ozone depleting substances (ODS) and HFC bank management concerns the limitation of emissions from appliances in use or at the time of decommissioning. Currently, only few countries have incentive systems to encourage the RAC technician to exert maximum care to avoid refrigerant emissions during servicing or at decommissioning. On a global scale, it is estimated that more than 0.5 Gt CO_2eq could be avoided annually (GIZ 2017). ODS and HFC bank management is a complex issue requiring sound policies, financing, collection infrastructure as well as reclamation and destruction facilities. The Climate and Ozone Protection Alliance (COPA) brings together diverse actors to advance the holistic solutions needed to reduce ODS and HFC banks and provides technical and financial support to countries that set ambitious targets towards a sustainable ODS and HFC bank management.

Cross-references within this guidance:

- → Regulatory instruments to promote containment and re-use of HFC refrigerants, Chapter I.D
- → Regulatory instruments to manage end-of-life treatment of refrigerants (and appliances), Chapter I.F

Recommendation for further reading:

- Climate and Ozone Protection Alliance (COPA): https://www.copalliance.org/
- GIZ (2018). Papst, I.: Global banks of ozone depleting substances. A country level estimate, https://www.international-climate-initiative.com/en/iki-media/publication/global_banks_of_ozone_depleting_substances/
- GIZ (2017). Heubes, J., Gloel, J., Papst, I.: Global roadmap on ODS bank management, https://www.international-climate-initiative.com/en/iki-media/publication/global_roadmap_on_ods_bank_management/
- GIZ (2017). Heubes, J.: Guideline to conduct an ODS bank inventory, https://www.international-climate-initiative.com/en/iki-media/publication/guideline_to_conduct_an_ods_bank_inventory/
- GIZ (2017). Gloel, J., Heubes, J.: Guideline on policy measures for the management and destruction of ODS, https://www.international-climate-initiative.com/en/iki-media/publication/guideline_on_policy_measures_for_the_management_and_destruction_of_ozone_depleting_substances/
- GIZ (2017). V. Heinemann, S., Beckmann, J., Heubes, J.: Guideline to establish a collection system for equipment containing ODS, https://www.international-climate-initiative.com/en/iki-media/publication/guideline_to_establish_a_collection_system_for_equipment_containing_ozone_depleting_substances/
- GIZ (2017). Gloel, J.: Guideline for the transboundary movement of ODS waste, https://www.international-climate-initiative.com/en/iki-media/publication/guideline_for_the_transboundary_movement_of_ods_waste/

2.2. Sustainable technology options

Alternatives in RAC applications that usually have the highest shares of national RAC sector emissions are described in the following.

Air-conditioning can be done via centralised chiller systems or by using small devices that only cool one room. Such room ACs are usually moveables, window type and split ACs. The latter is by far the most common across the world, with currently close to 1 billion units and a predicted increase to 3.7 billion in 2050 (IEA 2018). Nevertheless, as the smaller units are factory-sealed and do not require a RAC technician for installation, they are still popular and should not be disregarded as niche with around 200 million moveables (GCI 2016) and 160 million window type AC in use globally[2].

2 Window type AC study: Event recording: Left out in the cold – the Green Cooling potential of the global window type air conditioner market – Green Cooling Initiative (green-cooling-initiative.org)

Room ACs (moveable, window, split units)

We consider “high efficiency” as proposed by the “United 4 Efficiency” (U4E) initiative led by the United Nations Environmental Programme (UNEP). Setting energy efficiency limits and label requirements is usually done at a national level and thus, the requirements differ substantially across countries. Some regional initiatives aim to harmonise requirements to reduce transaction costs and market surveillance. U4E provides background studies and model regulations to support countries in setting up ambitious requirements. Based on U4E, an efficient split or a self-contained air-cooled AC below 16 kilowatt (kW) shall meet or exceed the energy performance level in Table 1. The equipment is tested according to the International Organization for Standardization (ISO) standard 16358:2013. The applied metric is the Cooling Season Performance Factor (CSPF), which takes the cooling needs during an entire cooling season into account (see “box on metrics for energy efficiency”). Several primary and secondary temperature profiles are available to account for different climatic conditions. Hence, efficiency levels are specified based on the climate group and the cooling capacity (CC).

Table 1: Proposed efficiency requirements (CSPF) for air conditioners (cooling only)

Proposed minimum energy performance level			
Climate group	Product category		
	CC ≤ 4.5 kW	4.5 kW < CC ≤ 9.5 kW	9.5 kW < CC ≤ 16 kW
Group 1	6.1	5.1	4.5
Group 2	5	4.3	3.8
Group 3	5.3	4.6	4.1
Proposed requirements for high efficiency labelling			
Climate group	Product category		
	CC ≤ 4.5 kW	4.5 kW < CC ≤ 9.5 kW	9.5 kW < CC ≤ 16 kW
Group 1	>= 8	>= 7.6	>= 7.6
Group 2	>= 6.5	>= 6.2	>= 6.2
Group 3	>= 6.7	>= 6.4	>= 6.4

Source: U4E 2019a

Split air conditioners

A single split AC consists of two parts, an outdoor unit and an indoor unit, linked with a refrigerant circuit. The outdoor unit contains the compressor and the condenser where the refrigerant is cooled. The indoor unit comprises of the evaporator, providing cooling to the air that is passing it and then fanned into the room.

Figure 2: Split air conditioner

The capacity range starts with 9,000 British Thermal Units/hour (BTU/h) [2.6 kW] cooling capacity, with the majority of models between 12,000 and 18,000 BTU/h [3.5 – 5 kW] and large models reaching 24,000 BTU/h [7 kW].

Currently employed refrigerants are the HFC blend R410A and the pure HFC R32. Also well suited is the hydrocarbon R290 (propane). Efficient equipment is feasible with all three refrigerants, as the appliance efficiency is largely depending on the design and component selection and only to a small extent on the refrigerant. Inverter type compressors, allowing for high part-load efficiencies exhibit a much higher energy efficiency over a cooling season. Different metrics for energy efficiencies are summarised in the box on metrics for energy efficiency.

From the emissions perspective, the three refrigerants differ greatly. R290 has the lowest GWP and does not require extensive end-of-life-treatment. It is also not regulated under the KA, whereas R410A and R32 are subject to the phase-down schedule.

Both, R32 and R290 are flammable, with different lower flammability levels and burning velocities. Due to its different classification in terms of flammability, charge size restrictions are less stringent for R32 than for R290. Efforts are ongoing to allow for a differentiated safety evaluation and safety measures that go beyond charge size restrictions. The recent update of the International Electrotechnical Commission (IEC) standard 60335-2-40 adopted additional concepts such as enhanced tightness refrigeration system, minimum airflow and maximum releasable charge to determine allowable charge sizes up to 1 kg of flammable refrigerants. This is enough to cover most room AC applications up to 7 kW (24,000 BTU/h).

Market availability is still limited; however, two manufacturers, Godrej from India and Midea from China currently do offer models using R290. Several others have developed R290 models but have not started production. It seems that manufacturers are waiting for a political signal to increase production numbers of such units. The Cooling Technologies database developed by the Environmental Investigation Agency (EIA) and Greenpeace provides an overview of available hydrofluorocarbon-free cooling equipment[3]. As an example, Table 2 shows the performance difference between a popular split AC and Godrej's efficient AC using R290.

Table 2: Comparison of efficient and normal split air conditioner

	Efficient	Normal
Brand	Godrej	AmazonBasics
Model number	AC 1.5T GSC 18 EE 5 GWQG[4]	AB2020INAC021[5]
Cooling capacity	5.3 kW	5.05 kW
Indian Seasonal Energy Efficiency Ratio (ISEER)	5.25	3.98
Energy consumption (kWh/year)	781.42	981.12
Energy class (Indian label scheme)	5 stars	3 stars
Refrigerant	R290	R32

Both ACs are available in India, where the price difference between the efficient and the normal AC is Rs. 3000 (37 Euro, EUR[6]). Using an average electricity price in India of 6.12 Rs/kWh, the payback period of the efficient AC compared to the normal AC is 2.5 years.

Another highly efficient spit AC to mention is Midea's R290 model. It is marketed in Europe, reaching the highest energy class A+++ with a Seasonal Energy Efficiency Ratio (SEER) of 8.5.

Prices for ACs are not always directly proportional to energy efficiency. A market study conducted by the IKI project "Cool Contributions fighting Climate Change" concluded that comfort features such as various control options, air filters and exterior design have a high influence on the final price.

3 https://cooltechnologies.org/

4 https://www.godrej.com/p/appliances/r290-eco-friendly-air-conditioners/godrej-1-5-tr-5-star-r290-refrigerant-inverter-split-ac-gsc-18-ee-5-gwqg

5 https://www.amazon.in/AmazonBasics-Star-Inverter-Split-White/dp/B08J8R76J8/ref=sr_1_1_sspa?keywords=1%2Bstar%2Bair%2Bconditioners&-qid=1654864939&refinements=p_n_feature_twelve_browse-bin%3A2753035031%2Cp_n_feature_eleven_browse-bin%3A2753098031&rnid=2753095031&s=kitchen&sr=1-1-spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyV0VDVzBHUDJUN05SJmVuY3J5cHRlZElkPUEwOTM1OTYwMlZWNk83WFhKTzFFUSZlbmNyeXB0ZWR-BZElkPUEwMjQ4ODYyMUhWTUFFVjlwVVhYMiZ3aWRnZXR0YW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU&th=1

6 On October 5, 2022

Well-trained technicians are required for proper assembly of the refrigerant circuit connecting the two parts of a split AC on-site. Leak-tight installation is a prerequisite to maintaining the initial energy efficiency. Refrigerant recovery of HFC refrigerants needs to be performed in case of repair and at decommissioning. Without proper installation, leaks in the pipework do occur quite often, leading to high average leakage emission rates and higher energy consumption.

Box on metrics for energy efficiency

Energy efficiency ratio (EER) is the ratio between cooling power provided by the appliances and electric power required by the appliance at defined rating conditions. Rating conditions are usually at full load and the EER is defined by a laboratory test.

$$EER = \frac{\text{Cooling power provided}}{\text{Electric power needed}} = \frac{\text{kWthermal}}{\text{kWelectric}}$$

Seasonal coefficients take into account the amount of cooling provided during a defined cooling season and compare it with the calculated energy required to provide this cooling. Several different methods for the calculation are applied in different countries, leading to slightly different metrics and difficulties to compare them to each other.

$$\text{Seasonal coefficient} = \frac{\text{Cooling provided during given time}}{\text{Energy(electricity) needed during given time}} = \frac{\text{kWthermal}}{\text{kWelectric}}$$

The two main standards are the Seasonal Energy Efficiency Ratio (SEER, EN 14825) and the Cooling Season Performance Factor (CSPF, ISO 16538).

SEER and CSPF differ in the applied temperature profile, number and temperature settings for (part load) test points and the inclusion of auxiliary energy consumption, such as stand-by power.

Seasonal coefficients take into account more realistic usage patterns over a cooling season, especially when using climate group specific temperature profiles as recommended by U4E model regulation. Seasonal ratings reflect efficient part load performance of inverter type appliances.

Even if climates do not have specific cooling seasons, but similar conditions during the entire year, inverter type ACs are an advantage, as they react to part-load conditions during the day. This advantage of inverter-type ACs is reflected in seasonal coefficients also for climates with little seasonal variation.

Therefore, it is recommended to use seasonal coefficients for MEPS setting and label classes

Recommendation for further reading:

- United for Efficiency (2019). Energy-efficiency and climate-friendly air conditioners, https://united4efficiency.org/wp-content/uploads/2020/05/U4E_AC_Model-Reg-Supporting-Info_20200227.pdf
- GIZ (2019). Becker, L.; Munzinger, P.; de Graaf, D.: R290 Split Air Conditioners Resource Guide, https://www.green-cooling-initiative.org/fileadmin/Publications/2019_C4_R290_SplitAC_ResourceGuide.pdf

Portable (moveable) air conditioners

Portable ACs are so-called self-contained units, where all refrigerant containing parts are within a corpus. Air ducts can be used to discharge warm air to the outside.

Figure 3: Portable AC

The capacity of portable ACs ranges from 6,000 BTU/hr [1.75 kW] to 10,000 BTU/hr [3 kW]. As no installation work is required on site, the refrigerant circuit is factory sealed and thus emissions during use are very low. R410A and R32 are commonly used, and also R290 can be used under current standards. Inverter and dual inverter technologies are available on portable ACs. The energy efficiency of the dual inverter ACs are higher than normal inverter ACs, it uses twin rotary compressors. The two compression chambers produce a phase difference of 180° compression timing.

The minimum EER requirement for portable ACs is recommended at 3.1 (U4E 2019a).

Table 3: Comparison of efficient and normal portable AC

	Efficient	Normal
Brand	Midea	Klarstein
Model number	Eco Friendly Lite[7]	Pure Blizzard[8]
Cooling capacity	7000 BTU	7000 BTU
EER	3.1	2.6
Energy consumption	0.7 kWh/60min	0.8 kWh/60min
Energy class	A+	A
Refrigerant	R290	R290

7 https://www.midea.com/de/klimatisieren-heizen/mobile-klimageraete/mobiles-klimagerat-eco-friendly-lite

8 https://res.cloudinary.com/chal-tec/image/upload/bbg/10035806/bda/10035806_BDA_DE-EN-ES-FR-IT.pdf

Due to the ban of refrigerants with GWP larger than 150 in portable ACs in the European Union (EU) from 2020 onwards, there are many more manufactures that produce portable ACs with R290, not only for the EU market.

Window air conditioner

A window AC is mounted in windows or through the wall. It is a factory built single unit that contains all components within one casing (Figure 4). The cooling capacity of a window AC ranges from 5,000 BTU/hr [1.46 kW] to 18,000 BTU/hr [5.27kW]. As it is factory built, refrigerant emissions during use are small. They mainly occur, in case of a repair and at end of life. For installation, no specifically skilled RAC technician is required, as there is no handling of refrigerant piping.

Variable speed and fixed speed ACs are available in the market. While it is technically feasible to produce window ACs using natural refrigerants (e.g. R290), the commonly used refrigerants in window ACs are R32 and R410A.

Figure 4: Window air conditioner

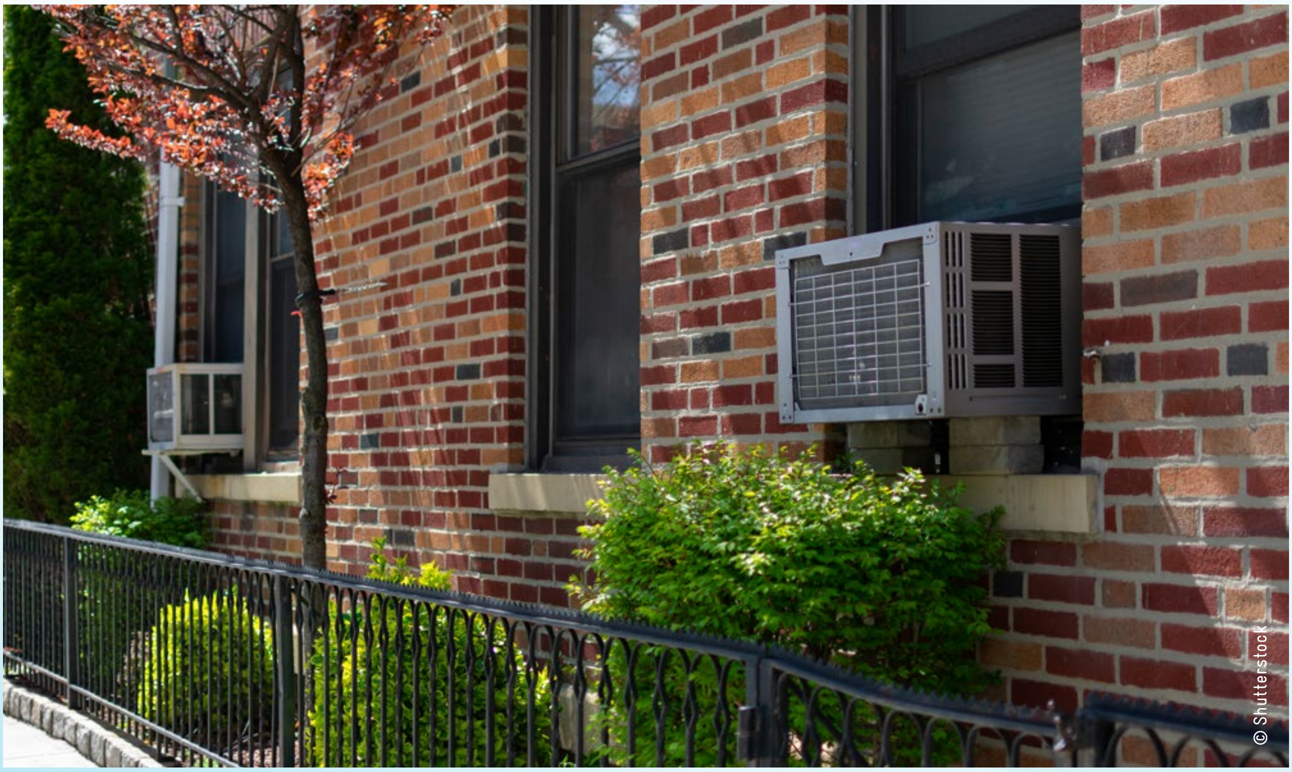


Table 4: Comparison of efficient and normal window AC

	Efficient	Normal
Brand	Voltas	Voltas
Model number	WAC 185V ADA[9]	183 DZA[10]
Cooling capacity	5.05 kW	5.05
ISEER	3.45	2.92
Energy consumption (kWh/year)	1131.82	1338.43
Energy class (Indian label scheme)	5 stars	3 stars
Refrigerant	R32	R32/22

Domestic refrigerators

A large variety of refrigerators for household use is available in the market that differ in size and compressor technology. Refrigerators are broadly classified into refrigerators, refrigerator/freezers and freezers. The reference energy consumption is calculated separately for each compartment and then compared to the tested energy consumption. The proportion of the two results in the energy efficiency index (EEI) or R value. The EEI is tested energy consumption divided by the reference energy consumption multiplied by 100, i.e., lower values indicate higher efficiency. The R is calculated as the reference energy consumption divided by the tested energy consumption, hence higher values indicate higher efficiency.

Table 5: Recommended energy efficiency grading for refrigerators

Grade	Refrigerators, Refrigerator-Freezers , Freezers
High efficiency	R >= 1.50
Medium efficiency	1.25 <= R <1.50
Low efficiency (MEPS)	1.00 <= R < 1.25

Source: U4E 2019b

The standard refrigerant is R600a, the natural refrigerant isobutane, while the insulation foam usually contains pentane. That means in terms of HFC emissions, new refrigerators are not relevant anymore. The remaining issue is the energy consumption that is of particular importance as refrigerators contribute to the base load of electricity grids. Highly efficient refrigerators are commonly available, however, top of class efficient models come with a price premium. The difference in energy consumption between low and highly efficient models is substantial: The example in Table 6 shows the energy consumption is more than halved.

Table 6: Comparison of efficient and normal refrigerators

	Efficient	Normal
Brand	Haier	Grundig
Model number	H3R-330WNA[11]	GSN 10731 XN[12]
EEI (EU rating)	55	124,4
Volume	330 l	375 l
Refrigerant	R600a	R600a
Energy Class (EU)	A	F
Energy (kWh/year)	66	150,20

9 https://www.myvoltas.com/air-conditioners/window-ac/voltas-adjustable-inverter-ac-185v-ada

10 https://www.myvoltas.com/air-conditioners/window-ac/voltas-fixed-speed-window-ac-4011419-183-dza

11 https://www.haier-europe.com/de_DE/one-door/34004913/h3r-330wna/

12 https://www.grundig.com/de-de/haushalt/kuehlen-gefrieren/alle/gsn-10731-xn-1

Commercial refrigeration

Commercial refrigeration refers to non-domestic applications in retail and food service sector, hotels, or restaurants to store or display food items.

Commercial refrigeration usually operates in two distinct temperature levels:

- Medium temperature to store chilled products between 0°C to +8°C
- Low temperature for frozen products between -18°C to -25°C

Commercial refrigeration can be categorised into stand-alone units (also called plug-in units), condensing units and supermarket systems. While natural refrigerant alternatives exist for all three categories, the focus here lies on the mass-produced stand-alone units. Condensing units and supermarket systems depend on the specific store design and are difficult to compare. Nevertheless, commercial display and storage cabinets are also rated individually if they are cooled by a remote condensing unit. In Table 7, U4E's recommended efficiency levels are shown for several product sub-categories. Integral equipment are plug-ins – only requiring an electric plug to function, while remote equipment is connected to a condensing unit or a centralised system.

Table 7: Technical criteria for efficient commercial display and storage cabinets.

<table>
<tr><th colspan="4">Equipment category</th><th>Equipment class mode</th><th>Low efficiency (EEI)</th><th>Intermediate efficiency (EEI)</th><th>High efficiency (EEI)</th></tr>
<tr><td rowspan="8">RDC</td><td rowspan="4">Integral</td><td rowspan="2">Horizontal</td><td>Chiller</td><td>RDC-IHC</td><td>130</td><td>90</td><td>50</td></tr>
<tr><td>Freezer</td><td>RDC-IHF</td><td>130</td><td>90</td><td>50</td></tr>
<tr><td rowspan="2">Vertical</td><td>Chiller</td><td>RDC-IVC</td><td>130</td><td>90</td><td>50</td></tr>
<tr><td>Freezer</td><td>RDC-IVF</td><td>130</td><td>90</td><td>50</td></tr>
<tr><td rowspan="4">Remote</td><td rowspan="2">Horizontal</td><td>Chiller</td><td>RDC-RHC</td><td>130</td><td>90</td><td>50</td></tr>
<tr><td>Freezer</td><td>RDC-RHF</td><td>130</td><td>90</td><td>50</td></tr>
<tr><td rowspan="2">Vertical</td><td>Chiller</td><td>RDC-RVC</td><td>100</td><td>75</td><td>50</td></tr>
<tr><td>Freezer</td><td>RDC-RVF</td><td>130</td><td>90</td><td>50</td></tr>
<tr><td colspan="4">RDC-Beverage Cooler</td><td>RDC-BC</td><td>100</td><td>70</td><td>40</td></tr>
<tr><td colspan="4">RDC-Scooping Cabinet</td><td>RDC-SC</td><td>100</td><td>70</td><td>50</td></tr>
<tr><td colspan="4">RDC-Ice Cream Freezer Cabinet</td><td>RDC-ICF</td><td>100</td><td>70</td><td>50</td></tr>
<tr><td rowspan="4">RSC</td><td rowspan="4">Integral</td><td rowspan="2">Horizontal</td><td>Chiller</td><td>RSC-IHC</td><td>95</td><td>60</td><td>35</td></tr>
<tr><td>Freezer</td><td>RSC-IHF</td><td>95</td><td>70</td><td>50</td></tr>
<tr><td rowspan="2">Vertical</td><td>Chiller</td><td>RSC-IVC</td><td>95</td><td>70</td><td>50</td></tr>
<tr><td>Freezer</td><td>RSC-IVF</td><td>95</td><td>70</td><td>50</td></tr>
<tr><td colspan="4">Refrigerated Vending Machine</td><td>RVM</td><td>100</td><td>70</td><td>50</td></tr>
</table>

RDC: Refrigerated Display Cabinet, RSC: Refrigerated Storage Cabinet

Source: U4E 2021a

Commercial plug-ins (stand-alone unit, integral unit)

Stand-alone refrigerators are similar to domestic refrigerators: the condenser, compressor and evaporator are incorporated in one cabinet. Most of the commercial refrigeration system uses direct expansion vapor compression refrigeration cycle. The stand-alone system usually has one large compartment.

Most used refrigerants are HFCs (R404A, R134a) and hydrocarbons (HC) (R290 and R600a), but also CO_2 can be used. Due to the small charge sizes, HC refrigerants are safe to use without any special safety measures. Apart from the slight adjustment required in the factory to safely handle flammable HC, the capital cost of the HC unit and HFC unit are the same. Even though the energy efficiency is mainly dependent on the components used, the efficiency of the HC unit is better than the HFC system and there is no difference in the design of both systems.

Major refrigerant emission from the stand-alone system occurs at the end-of-life, leakage during the operation is negligible. End-of-life recovery procedure is required for the HFC units compared to HC units.

Figure 5: Stand-alone system

Table 8: Comparison of efficient and normal commercial vertical display plug-ins

	Efficient	Normal
Brand	Jordao cooling systems	Arktic
Model number	FUTURO 2 - 700 P CP CG[13]	233795[14]
Temperature range	-1/+5	2/10
Volume	793	618
Refrigerant	R290	R290
Charge Size	150	120
Energy Class (EU)	A	F
Energy (kWh/year)	1,478	1,694

13 https://www.topten.eu/private/product/view/jordao-cooling-systems-futuro-2-700-p-cp-cg

14 https://manuals.plus/de/Arktis/K%C3%BChlschrank-Anleitung-anzeigen#discarding_environment

3. Steps towards ambitious RAC sector NDC components

This chapters summarises the essential elements and aspects to be considered when integrating the cooling sector in a country's NDC. It establishes success factors and gives an overview of possible mitigation measures that can be considered for both refrigerant and energy-related emissions.

The integration of the cooling sector into a NDC's mitigation target, i.e., refrigerant-related HFC emissions as well as indirect emissions stemming from electricity consumption, is strongly dependent on different factors and prerequisites. They need to be fulfilled to identify and determine ambitious RAC-sector specific mitigation options.

A necessary precondition to consider the cooling sector is a solid data base, such as a detailed RAC sector GHG inventory, ideally at equipment (Tier 2) level, which can serve as evidence base and starting point for the development of cooling sector mitigation strategies and measures. Otherwise, there is no possibility to assess current emissions and the mitigation potential.

Key strategic components and steps for integration of the RAC sector into a NDC include

Step 1: A **solid data base**, ideally in the form of a **detailed RAC sector GHG inventory**;

Step 2: **A comprehensive cooling sector mitigation approach** including **long-term strategies** and **implementation plans** that build on the HFC reduction obligations mandated by the KA and at the same time consider emissions generated by energy use;

Step 3: The **anchoring of the cooling sector in the NDC update process** by highlighting its relevance in terms of mitigation potential and joint decision-making by all key stakeholders to determine the best position of the sector in the respective NDC (GIZ 2021c). This needs to be based on **specific NDC components** developed by cooling sector representatives;

Step 4: The **linkage** of cooling sector related mitigation measures and plans **with other relevant sectors** and targets set for them, especially the building sector and demand side energy efficiency, including the consideration of institutional structures and **coordination with the respective (governmental) actors**.

Step 5: The development of a **tracking and MRV systems for HFC emissions** that is in line with the requirements of both agreements, the MP and the PA.

These elements are described in more detail in the following chapters.

Step 1: RAC sector GHG inventory as precondition

As a precondition for bringing the cooling sector into an NDC, countries need to establish a solid data base for the cooling sector in the form of a RAC sector GHG inventory. The overarching aim of the inventory is to quantify the emissions, i.e., direct and indirect emissions, that are generated by the cooling sector and to obtain a detailed picture of the different emission sources within the sector and outside for the case of electricity-related indirect emissions sources. Following the categorisation of different methodologies in terms of data granularity as determined by the Intergovernmental Panel on Climate Change (IPCC) guidelines, an inventory based on Tier 1 is established by using aggregate data in a top-down approach, e.g., by considering data on chemical sales at the sectoral level in combination with a composite emission factor. In contrast, applying a Tier 2 approach requires more detailed information on the stock of cooling appliances, i.e., the equipment in use. Under both approaches, emissions can be either calculated by choosing an emissions-based approach that considers the annual sales and stock of substances and applies a (composite) emission factor. Or, as a second option, a mass balance approach can be adopted that considers chemical sales (GIZ 2013a).

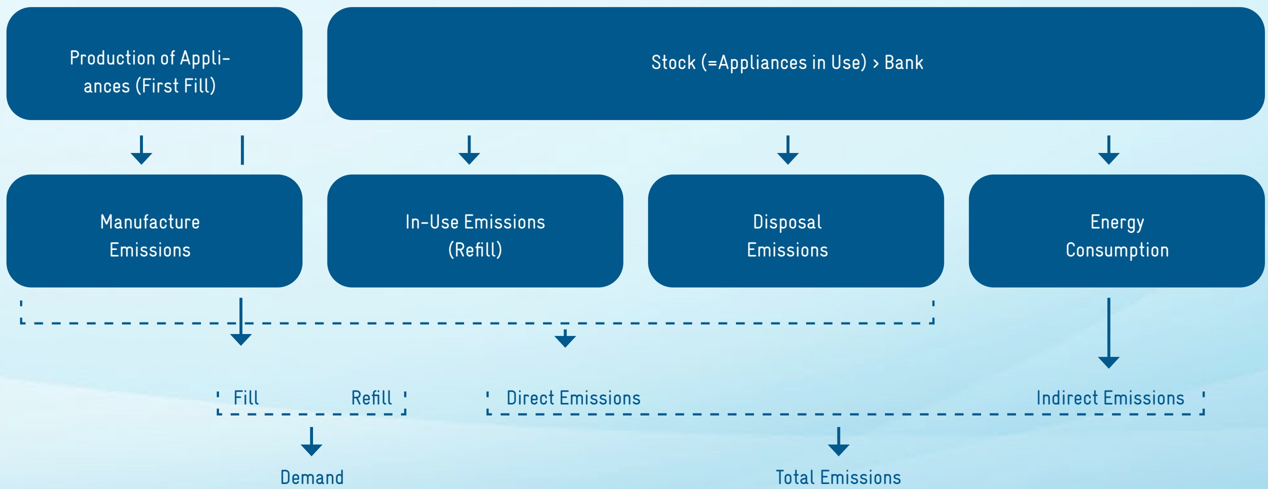
Table 9: Overview of IPCC 2006 Tiers and approaches

	Emission factor approach (a)	Mass-balance approach (b)
Tier 2 (emission estimation at a dis-aggregated level)	Data on chemical sales and usage pattern by sub-application [country-specific or globally/regionally derived] Emission factors by sub-application [country-specific or default]	Data on chemical sales by sub-application [country-specific or globally/regionally derived] Data on historic and current equipment sales adjusted for import/export by sub-application [country-specific or globally/regionally derived]
Tier 1 (emission estimation at an aggregated level)	Data on chemical sales by application [country-specific or globally/regionally derived] Emission factors by application [country specific or (composite) default]	Data on chemical sales by application [country-specific or globally/regionally derived] Data on historic and current equipment sales adjusted for import/export by application [country-specific or globally/regionally derived]

Source: IPCC 2006

The figure below depicts the Tier 2 emission factor approach in more detail. It needs to be highlighted that the schematic overview also includes the indirect emissions from electricity consumption.

Figure 6: Schematic overview of emission factor approach to calculate HFC emissions



Source: GIZ 2013a

Thus, to establish a comprehensive RAC sector GHG inventory based on a Tier 2 emission factor approach, detailed information on the number of currently installed equipment (stock) as well as the respective technical parameters, such as type of refrigerant, initial charge size, annual leakage rates and energy efficiency are needed. Obtaining this data might require significant efforts. Those can be minimised by setting up a sectoral Monitoring, Reporting and Verification (MRV) system that enables continuous and partially automatic update of the parameters (see also annex G for further details). In the RAC sector, a joint approach of an equipment based HFC inventory with a MRV system would help institutionalise the data collection process. In this way, by establishing a data collection routine and flow, it would enable an accurate accounting of HFC emissions and tracking of mitigation efforts, especially of those linked to refrigerants and energy savings. In addition, this joint approach can serve to define and frequently update mitigation strategies in the RAC sector that can be included into national and international climate agendas (GIZ 2021b).

The current inventory can be expanded to include a strategic component by estimating scenarios for emissions driven by future cooling needs. This would be part of the building blocks for NDC integration described below.

However, even in the absence of a detailed national inventory, experiences from existing inventories show that room ACs, such as split ACs, window-type ACs and portable ACs are a large source of emissions projected to raise sharply in the future. In addition, the energy consumption of domestic refrigerators that constitutes a baseload on the electricity grid may not be the application with the highest electricity consumption. But it is considered a low hanging fruit, as highly efficient and climate-friendly refrigerators using R600a are state of the art, supported by ambitious MEPS in many countries. A simultaneous buildup of a database concerning the subsectors that are being targeted by mitigation actions might be a sensible compromise.

Recommendation for further reading:

- GIZ (2013b). Heubes, J.; Papst, I.: NAMAs in the refrigeration, air conditioning and foam sectors. A technical handbook. Module 1. Inventory, https://www.green-cooling-initiative.org/fileadmin/user_upload/giz2014-en-NAMA-Handbook-Module-1_WEB.pdf
- GIZ (2021b). Kotin-Förster, S.; Gloel, J.; Papst, I.; Oppelt, D.: Measurement, Reporting & Verification (MRV) in practice. A comprehensive handbook for the measurement, reporting, and verification of greenhouse gas emissions in the refrigeration and air-conditioning sector, https://www.green-cooling-initiative.org/fileadmin/Publications/GIZ2021_Measurement_Reporting_Verification_MRV_Handbook.pdf

Step 2: Sector specific mitigation strategies and implementation plans as the cornerstone

Cooling sector strategies and implementation plans set the framework for countries' cooling related mitigation measures. Also, they establish a step-by-step process including specific milestones and activities to reach the ultimate mitigation goals for the sector. National cooling strategies or plans can thus be the cornerstone for identifying and quantifying specific targets and measures to be included in the updated NDC.

Countries might choose different approaches and frameworks to identify and determine sector specific mitigation strategies and implementation plans. These can include (but are not limited to) RAC sector roadmaps, long-term cooling strategies and cooling action plans. However, all different approaches have in common that they need to be built on a **solid sector assessment** including quantification of current sectoral emissions (see section above). Based on the detailed assessment of the current emission sources as well as the mitigation potential in different cooling sub-sectors, respectively of technologies that are typically applied in those sub-sectors, mitigation measures can be elaborated considering two crucial key aspects:

- **Mitigation costs** and
- **Mitigation potential** of the envisaged measures.

These significantly influence the choice of the final mitigation actions and targets regarding the current stock of appliances. Not only monetary aspects should be considered in the assessment, but also non-monetary barriers, as for instance the overall availability of alternative, green cooling technologies or specific country priorities. Höglund-Isaksson et al. (2017) identified two factors with the potential to influence abatement costs in the RAC sector. One is the future rate of technological development and the second is the replacement of old HFC-based appliances with more energy efficient alternatives.

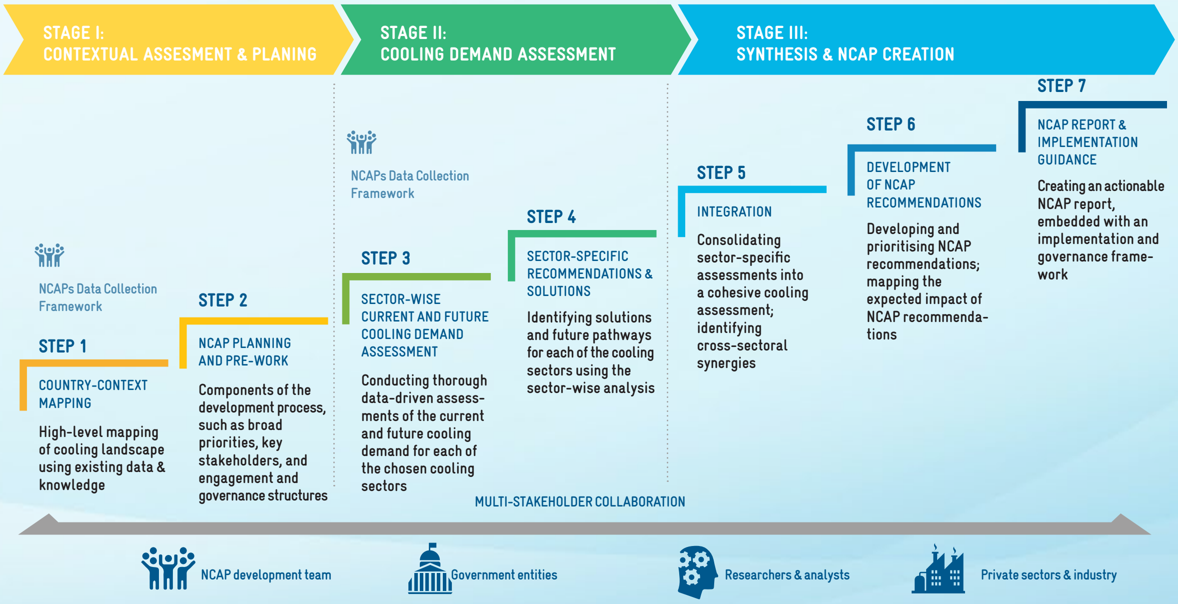
This study reveals that the abatement costs of Art. 5 and non-Art. 5 Parties of the MP is strongly influenced by the sectoral composition of future demand for cooling services. One of the best low-cost options is the replacement of HFCs by natural refrigerants in the industry, transport and commercial sub-sectors. Compliance with the KA would result in estimated marginal abatement costs below 60 EUR/t CO_2eq for the period of 2018-2050, with the exemption of non-Art. 5 countries that already have HFC regulations in place (Höglund-Isaksson et al., 2017). Both aspects thus need to be carefully assessed and used for comparison between different mitigation options before further developing cooling sector related mitigation strategies and plans.

Going beyond the current appliance stock, scenarios for the development of future appliance numbers and emissions during the NDC period need to be developed based on expected cooling need, taking into account economic projections. Ideally, one optimistic and one pessimistic economic scenario would be elaborated.

Key aspects that might influence the selection of the most promising mitigation options comprise the (future) availability of green cooling technology in the country, financial resources that can be mobilised domestically and internationally to implement the mitigation activities, the existence of the required skills base of technicians as well as the country's priorities regarding resources and capacities and cross-sectoral synergies.

There are various guidebooks that describe effective processes for development of and key elements of cooling sector strategies and implementation plans, such as the Cool Coalition's National Cooling Action Plan (NCAP) Methodology (Kumar et al. 2021). It contains detailed guidance on the different steps to be taken to design a National Cooling Action plan that can be adjusted to match a country's specific context and priorities. Figure 7 illustrates the main stages and steps for NCAP development.

Figure 7: Example of key steps for the development of a National Cooling Action Plan

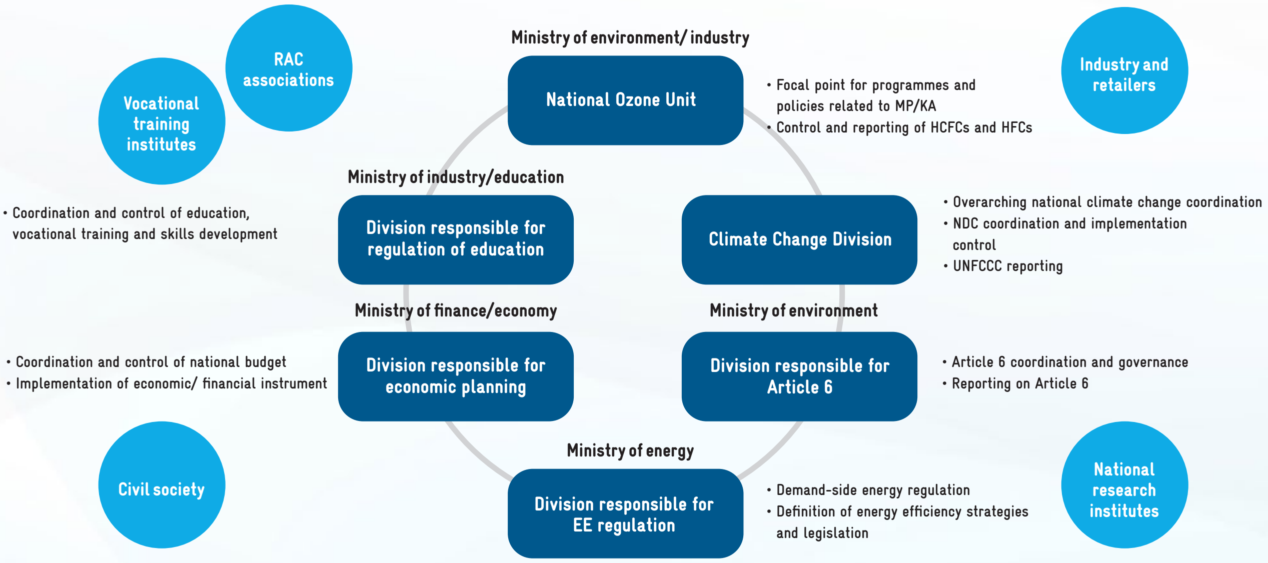


Source: Kumar et al. 2021

Only through a dedicated stakeholder engagement approach the best possible mitigation actions in the context of a NCAP can be identified and selected, as this ensures a view from all possible angles. This means to consider institutional structures and responsibilities and to involve all relevant stakeholders to an appropriate degree and in a timely manner. Such a process enables all barriers to be identified and taken into account as far as possible and synergies and linkages with other sectors and measures to be spotted and planned for.

Key actors to be considered as well as their main responsibilities and impacts are presented in the figure below.

Figure 8: Stakeholder mapping of key actors (in typical distribution of mandates) relevant in the cooling sector



Source: authors

Recommendation for further reading:

- GIZ (2016). Becker C., Usinger, J., Papst I., Heubes, J., Oppelt, D., Röser, F., Munzinger, P., Andres, D., Boos D.: Advancing nationally determined contributions (NDCs) through climate-friendly refrigeration and air conditioning. Guidance for policymakers, https://www.green-cooling-initiative.org/fileadmin/Publications/2016_C4_Advancing_ndcs_climate_friendly_rac.pdf
- Kumar, S.; Sachar, S.; George, G.; Goenka, A. (2021). Holistic methodology for developing a national cooling action plan, Cool Coalition, https://coolcoalition.org/national-cooling-action-plan-methodology/
- K-CEP (2019). Principles for national cooling plans, https://www.k-cep.org/wp-content/uploads/2019/04/Principles-for-National-Cooling-Plans.pdf

Step 3: Designing ambitious mitigation measures for the RAC sector and anchoring them in the NDC update process

If, as described above, a country has a cooling sector strategy or similar, the objectives and measures to be included in the NDC with regard to the RAC sector can be identified and defined relatively straightforwardly on the basis of the strategy.

If that is not the case but a cooling sector inventory exists, it is advisable to specify the NDC mitigation targets and activities for the cooling sector by assessing the marginal abatement costs and mitigation potentials linked to specific cooling sub-sectors and related technologies, as discussed in chapter 2. In such a situation, it may be more difficult to bring the cooling sector into the discussion on the NDC update as a "champion" pushing for its inclusion is necessary. In the absence of such a champion, actors wanting to cover the cooling sector in the NDC may focus on the mitigation options for the RAC sector linked to the most significant sources of emission.

Moreover, if there is a cross-sectoral approach to the NDC update, institutions interested to include the cooling sector may want to take a macro-economic perspective and compare costs and barriers of cooling-related mitigation to other sectors to be included in the NDC. From a national point of view, the ambition level for cooling sector related mitigation activities should be high, if costs and barriers are rather low in comparison to other sectors. In contrast, if costs and barriers are considered to be high, the level of ambition should be set at a lower level.

Generally, as for any sector when determining the cooling sector component of a NDC, the country's socio-economic status and overall climate change ambition play an essential role. Thus, governments striving for a very ambitious climate policy might also opt for higher mitigation targets in the RAC sector, compared to countries with less aspirational climate targets. This strongly relates to the question of covering costs for the mitigation activities and whether they should be borne domestically or whether international funding is needed. And finally, it is crucial to decide which mitigation should be pledged under the unconditional or conditional target. In that context, different sources of finance need to be considered, depending on the marginal abatement costs, barriers to implementation and technical parameters. Domestic financial resources could be used for mitigation measures with lower abatement costs and short payback periods, and thus those measures would be listed under the unconditional NDC target. High-cost options should be reserved for international funding and only be listed under the conditional NDC target. International climate finance to be targeted for those can come from multilateral funds, such as the Green Climate Fund (GCF) or the Global Environment Facility (GEF), or bilateral initiatives, e.g., the International Climate Initiative (IKI) of the German government.

Incorporating cooling in NDC sectors

Based on the mitigation options that have been identified and selected for the NDC integration and the emission sources that are addressed by these measures, it is crucial to anchor the cooling sector in the NDC update process right from the beginning. In concrete terms, this means that it needs to be carefully assessed and decided upon, together with the relevant (sectoral) stakeholders and the entity responsible for the coordination of the NDC update, where exactly to include the cooling sector. Depending on the emission sources and measures, i.e., whether those are tackling refrigerant- or energy related emissions, the cooling sector can be incorporated in

- the energy sector, for energy related emissions;
- the industrial processes and product use (IPPU) sector, for refrigerant related emissions;
- a separate RAC or cooling sector, for both, energy-and refrigerant-related emissions.

If the cooling sector is assigned its own component, it should be ensured that it is nevertheless anchored within the relevant emission source categories. Hence, HFCs must be included in the scope of GHGs covered by the NDC if this is not already the case and the selected measures target the reduction of HFC emissions. ODS such as HCFC emissions can be mentioned, but not counted against the GHG emission baseline as ODS are usually not part of the baseline. An early decision on the anchoring of the cooling sector is vital to safeguard that it is not overlooked in the further process and to ensure linkage with the other sectors and measures.

Step 4: Linkage of cooling sector related mitigation measures and plans with other relevant sectors in the NDC update context

For the successful integration of the cooling sector it is indispensable to engage the relevant sectoral stakeholders that represent the cooling sector, first and foremost the National Ozone Unit (NOU) and the department responsible for energy efficiency. This might be a challenge if processes and coordination of the NDC update process are complex, involving different national stakeholders and multiple donors that support and participate. Very often, large donors overlook the significance of the cooling sector and predominantly focus their assistance on "traditional sectors" such as the energy or forestry sector. Therefore, on the one hand, it is important to emphasise the relevance of the sector from the beginning of the NDC update process (see also chap. 3) and, on the other hand, to clearly elaborate and consider the linkages as well as challenges with other sectors and measures.

Most likely, envisaged mitigation activities in the cooling sector dealing with energy related emissions have synergies or even overlap with mitigation efforts in the energy sector. In most countries, the energy sector is one of the key pillars of the mitigation related climate change action and targets. This includes, for instance, the decarbonisation of the power sector. Therefore, the energy sector occupies a priority position in many national contexts and is more powerful than other, smaller sectors, which in most cases include the cooling sector. It must be noted here that the energy sector probably has the say on energy-related mitigation activities, whereas the cooling sector can be considered to be on the receiving end. Consequently, it is advisable to use the synergies of energy efficiency measures in the RAC sector with energy sector targets and to coordinate them with the responsible actors in the energy sector. In this way, the cooling sector, through the promotion of energy efficiency of RAC appliances, can contribute to achieve energy sector targets by reducing the energy demand. Lastly, it must be kept in mind that an increasing penetration of renewable energy in a country's energy mix will lower the mitigation potential of the indirect cooling sector component. This could pose a challenge for bringing in the cooling sector, especially if the renewable energy targets are overoptimistic. However, pushing the energy efficiency of cooling equipment and thus lowering the electricity consumption, results in higher shares of renewable energy and a faster reduction in energy intensity of the power system.

Step 5: Tracking and MRV of HFC use and emissions

Under both agreements, the KA to the MP and the PA of the UNFCCC, countries are obliged to report on their actions in the cooling sector. Under Article 7, the MP establishes clear requirements for Parties to report on controlled substances. For HFC production and consumption, amounts are expressed in tCO_2eq. In the context of the PA, each Party can develop and follow their own mitigation targets in their NDCs. However, this represents a challenge when it comes to comparing and aggregating country endeavors. Therefore, accounting allows each Party to track their individual progress and understand and compare it with the targets and progress of others, enabling in this way a collective improvement. Article 4 of the Paris Agreement stipulates that Parties shall align their accounting for NDCs based on the so called TACCC principles: Transparency, Accuracy, Completeness, Comparability, Consistency. Moreover, they need to ensure environmental integrity and avoidance of double counting. Article 13 of the PA further introduces the Enhanced Transparency Framework (ETF) which can be considered the backbone of the PA. It provides guidance for the processes for accounting of NDCs. Detailed requirements and guidelines for the accounting and reporting – the so-called modalities, procedures, and guidelines (MPGs) of the ETF - were adopted at COP24 in Katowice in decision 18/CMA.1. In line with the MPGs, all Parties need to report information through biennial transparency reports (BTRs) and national inventory reports (NIRs) (ECBI 2020). The NIRs cover emissions and removals of direct GHGs from the 'Kyoto basket of gases' which comprises the following seven gases: carbon dioxide (CO_2), methane (CH4), nitrous oxide (N2O), perfluorocarbons (PFCs), HFCs, sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3).

Thus, HFCs are subject to reporting requirements under both regimes, the MP and the UNFCCC. These can be informed by a synchronised MRV system that accounts for both, energy-related as well as refrigerant-related emissions of the cooling sector. While GHG inventories entail data of GHG emissions as a one-time endeavour, an MRV system supports the constant monitoring of emissions and provides updated information. In the RAC sector, a joint approach of an equipment based HFC inventory with an MRV system would help institutionalise the data collection process by establishing a data collection routine and flow that would enable an accurate accounting of HFC emissions and tracking of mitigation efforts, especially those linked to refrigerants and energy savings. In addition, this joint approach can serve to identify and define mitigation strategies in the RAC sector that can be included into national and international climate agendas (GIZ 2021b). The benefits of a sectoral MRV system are summarised in the table below.

Table 10: Overview of benefits of an MRV system

Stakeholders	Associated benefits
Importers, retailers, manufacturers, consumers	• Provide relevant information (e.g., GHG calculators) for businesses who report their activity data • Provide market overview (e.g., sales trends, average MEPS, etc.) • Improved knowledge of type of products in markets
Climate department/ UNFCCC focal point	• Inform and comply with several international reporting obligations at once (NDCs (NIR, BTR), Nationally Appropriate Mitigation Action (NAMA), GHG inventories, MRV for climate financing etc.)
National Ozone Unit, Montreal Protocol	• Enhance national capacities (e.g., data collection systems, data quality, etc.) • Monitor the progress of continuous data collection • If applicable: improve granularity of inventory by moving from IPCC Tier 1 to IPCC Tier 2 methodology
National entity responsible for energy sector/ energy efficiency (Energy & Environment Ministries)	• Enhance national reporting • Increase political buy-in for climate issues • Provide coherent data for national policy making (identification and prioritisation of mitigation efforts) • Regular update of label classes and MEPS • Measure effectiveness of policy actions

Source: GIZ 2021b

Specifically, the tracking of HFC consumption and emissions can be done at different levels and through various approaches. As mentioned under Step 1, GHG emissions can be accounted for by using different Tier approaches with an increasing level of granularity from Tier 1 to Tier 3 level. Hence, the higher the level of detail of data used to monitor and report emissions, the higher the ambition of the MRV approach. Involving users in the reporting of HFC use supports and facilitates the data collection process and enables countries to obtain more granular data needed for a Tier 2 approach.

4. Benchmarking of ambition

The following sections present a set of different policy instruments that can be considered to design a comprehensive RAC sector NDC component and assign them a certain level of ambition, depending on the country category, as defined in the next sub-chapter. In addition, a separate benchmarking tool is available as an excel application to facilitate the evaluation of ambition.

4.1. Country categories and corresponding levels of ambition

In order to reflect different country contexts and to identify appropriate measures, including the level of ambition, we define three different country categories based on the typical appliances or sub-sectors found in the national context. Those can be linked to the annual refrigerant consumption. Throughout the guideline, the categories relate to measures addressing direct emissions (HFC use) as well as indirect emissions (appliance efficiency).

- **Category A:** Country that **only imports refrigerants and appliances/equipment with mainly residential and commercial air conditioning, residential refrigeration and few commercial refrigeration.** Those are typically, but not limited to low volume consuming (LVC) countries in the MP context.
- **Category B:** Country that **only imports refrigerants and appliances/equipment with residential and commercial as well as industrial applications for air conditioning and refrigeration.** These countries usually have a higher refrigerant consumption than Category A countries.
- **Category C:** Country that **has equipment manufacture** and **more commercial/ industrial applications.** These countries usually have a higher refrigerant consumption than Category A and B countries.

Table 11: Overview of country categories

Country context	Country Cat A	Country Cat B	Country Cat C
Import vs. manufacturing of equipment			
Equipment manufacturing in country	✗	✗	✓
Key sub-sectors in the country			
Residential and commercial AC and refrigeration	✓	✓	✓
Industrial refrigeration	✗	✓	✓

Source: authors

The difference between Country Category A and B mainly lies in the existence, respectively number of industrial refrigeration equipment, which is expected to hardly exist in Category A countries. At this point, it should be emphasised that this is a simplified representation and only serves to roughly categorise measures. To properly assess the level of ambition of mitigation activities in a country's RAC sector, a comprehensive analysis of the country context, including existing mitigation targets, policies, and plans, is required.

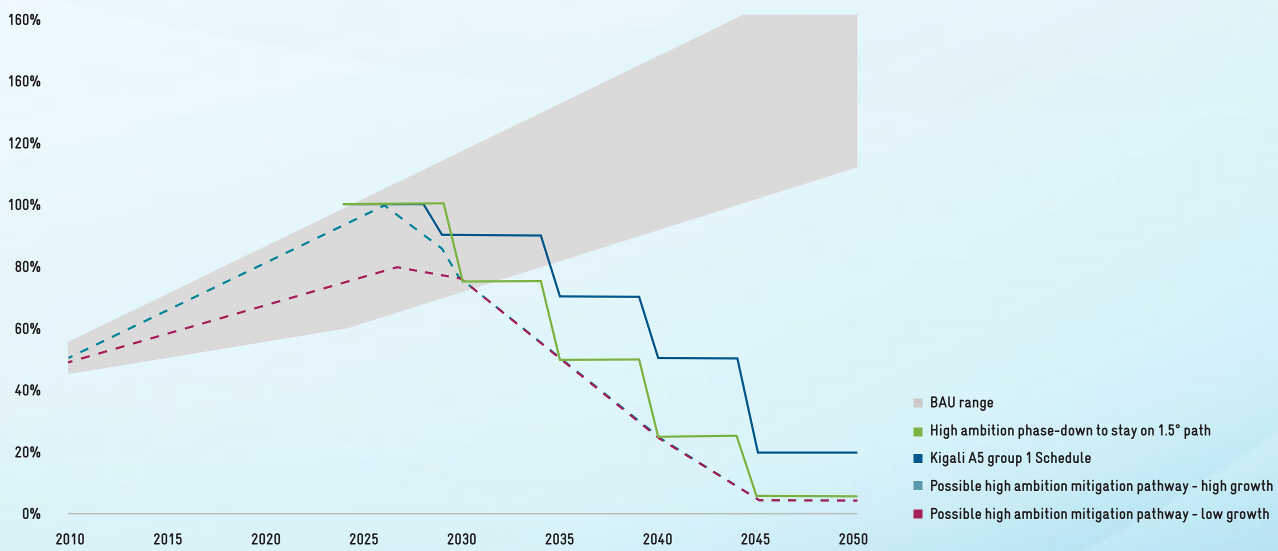
With regard to ambition, a country ideally establishes an overall economy-wide HFC emission reduction target in its NDC which aims at reducing the emissions beyond the effects of the KA.

The KA in its current form falls short to deliver GHG HFC emission reduction required to stay on the 1.5°C pathway. The 1.5°C pathway requires global HFC emission reduction of 75-80% relative to 2010 (Purohit et al. 2022). The same study outlines that current consumption schedules are not sufficient to meet this target and recommends a fast phase-down and a last step-down to 95% reduction as early as possible. As the Montreal Protocol controls consumption, it is proposed to also use this metric when talking about ambitious emission reduction targets. Although there is no simple translation from consumption to emissions, any measure that targets the containment of refrigerants in turn also reduces the consumption as less virgin refrigerant is required.

Limiting consumption means for Art. 5 countries that the option for growth provided by the HCFC part of the consumption baseline up to the freeze year should not be used, or only to a limited extend. The effort required to limit growth up the freeze year depends on the historic HFC consumption and the socio-economic growth up to 2024. National circumstances differ greatly spanning from almost no additional growth projected in the business-as-usual (BAU) scenario to severe difficulties to accomplish the freeze level in 2024. Therefore, the ambition levels for overall consumption reduction targets are provided in qualitative terms, as efforts are required for a certain target is not comparable between countries.

In the short term, we recommend limiting the growth of HFC consumption as much as possible until 2024. The extent of the targeted limitation and the effort required strongly depend on national circumstances. Ideally, the current levels of HFC consumption are frozen, as later reductions can start from a lower level of consumption. This is the basis for the longer-term target that is informed by Purohit et al. (2022) to accelerate the reduction of HFC consumption. The ambitious consumption phase-down should target a reduction of 95% by 2045. This could be achieved by a 25% reduction step every 5 years, starting in 2030 with the first step as illustrated in Figure 9.

Figure 9: Proposed high ambition HFC phase-down schedule



Source: authors

Recommendation for further reading:

- GIZ (2021e). Michaelowa, A.; Laßmann, D.; Espelage, A.; Feige, S.; Moreno, L.: The 'HCFC adder' in the Kigali Amendment baseline calculation. Risks to environmental integrity of the Paris Agreement
- GIZ (2021d). Michaelowa, A.; Laßmann, D.; Espelage, A.; Feige, S.; Moreno, L.: Baseline and monitoring methodologies for HFC mitigation action. MRV standardisation and streamlining as well as accounting of HFC mitigation – including energy efficiency improvement – under the Kigali Amendment and Paris Agreement

4.2. Toolbox of policy instruments to address RAC sector emissions

Governments can choose between different policy instruments to foster mitigation strategies. In relation to the RAC sector, these policy instruments can address refrigerant consumption, and production, as well as efficiency of appliances (GIZ 2021d). Typical policy instruments can be divided into four groups: information instruments, regulatory instruments, economic instruments, and enabling instruments (Grubb et al., 2020). Table 12 illustrates some examples of how the different policy instruments can be applied in the cooling sector.

Table 12: List of possible policy instruments to drive mitigation in the cooling sector

Policy instrument	Refrigerants	Energy efficiency
Regulatory instruments	Overall (economy-wide) declared HFC consumption reduction target	Regulatory instruments to promote higher energy efficiency of equipment
	Regulatory instruments to reduce HFC consumption	Enforcement of energy efficiency regulation
	Regulatory instruments to promote containment and re-use of HFC refrigerants	
	Regulatory instruments to manage end-of-life treatment of refrigerants (and appliances)	
Economic/ financial instruments	Financial instruments to reduce HFC consumption	Financial instruments to support higher energy efficiency of equipment
	Market-related instruments to reduce HFC consumption	
Economic/ financial instruments	Capacity building for technicians	
	Tracking and MRV of HFC consumption and emissions	

Source: authors based on Grubb et al. 2020

Measures to reduce refrigerant related emissions

Regulatory instruments to reduce HFC consumption

According to Grubb et al. 2020, the key consumption-oriented policy instruments that evidence a potential effectiveness and high feasibility are supply chain procurement, carbon-intensive materials charge, and infrastructure improvement. Second-ranking policy instruments include regulatory standards, business emission agreements or allowances, environmental goods and services agreements, and recycling requirements.

Thus, various regulatory instruments can be applied, either as single measure or as a combination of different instruments, to support the reduction of HFC use and the switch to low GWP refrigerants. This applies to both, demand (user) and supply (producer) side. The following table summarises the various instruments and attributes them with the respective emission and thus mitigation potential level.

Table 13: Regulatory instruments to regulate HFC consumption

Policy instrument	Ambition level		
	Category A	Category B	Category C
No regulation to reduce HFC use	Low	Low	Low
Introduction of GWP limit of HFCs for certain appliances/ technologies based on thresholds as defined in current EU F-gas regulation	High	Medium	Medium
Ban of synthetic refrigerants for specific sub-sectors/ appliances, e.g., refrigerators, freezers, plug-in commercial equipment	High	High	High
Green public procurement with GWP limits for refrigerants based on current EU F-gas regulation	Medium	Medium	Medium
Green public procurement to promote the availability of highly efficient equipment using natural refrigerants	High	High	High
Refrigerant assessment on its recyclability, with possible restrictions on blends that are difficult to recycle/reclaim	NA	High	High
Commitment of local manufacturers to change to natural refrigerants	NA	NA	Medium
Regulation/ requirement for local manufacturers to change to natural refrigerants	NA	NA	High

Source: authors

Financial instruments to reduce HFC consumption

There are a number of financial instruments that can effectively reduce the use of refrigerants containing HFCs. There are different ways to incentivise the purchase of green cooling equipment. The main objective of such financial instruments is to bring down the investment costs of green cooling equipment which, in some cases, are still considerably higher, than those of conventional technologies. Even if the investment in climate-friendly cooling equipment pays off financially in the long term due to lower operational costs, it requires upfront funding to reduce the sometimes higher investment costs and the payback periods. Another option to reduce investment in technologies that operate with synthetic refrigerants is to impose taxed or levies, depending on the GWP value.

Table 14 provides an overview of the instruments.

Table 14: Financial instruments to regulate HFC consumption

Policy instrument	Ambition level		
	Category A	Category B	Category C
No financial regulation/ incentives to reduce HFCs and promote natural refrigerants	Low	Low	Low
Levy (e.g., tax, fee) on the use of high GWP HFCs	Medium	Medium	Medium
Financial incentives (e.g., import tax reduction, subsidy) to use natural refrigerants			
<20% of equipment cost	Medium	Medium	Medium
>20% of equipment cost	High	High	High
GWP weighted levy or carbon tax on all HFCs and HFOs (substances as defined in EU F-gas regulation)	High	High	High
Reduction of investment cost via bulk procurement programme	High	High	High

Source: authors

Market-related instruments to reduce HFC consumption

As discussed in section 3, there are different sources of funding for cooling related mitigation measures that might be considered by countries, mainly based on the marginal abatement costs and availability of domestic finance. An effective means to mobilise additional resources for mitigation in the cooling sector are revenues obtained through the sale of emission credits through market mechanisms. These can be established at the national level, through for instance the inclusion of HFCs in (existing) emissions trading schemes (ETS) or the engagement in international carbon markets under Article 6 of the Paris Agreement.

Table 15: Market-related instruments to reduce HFC consumption

Policy instrument	Ambition level		
	Category A	Category B	Category C
No regulation to reduce HFC use/ emissions	Low	Low	Low
Inclusion of cooling sector in national Article 6 strategy/ plans	Medium	Medium	Medium
Inclusion of HFCs in emissions trading system (ETS) for all sectors	High	High	High
Inclusion of cooling sector and HFCs in national voluntary market.	High	High	High
Existence of Art. 6 methodologies for cooling (HFC)-related Art. 6 activities	High	High	High

Source: authors

Capacity building for technicians

Any change in equipment deployment, reduction of refrigerant emissions and preservation of energy efficiency over the equipment lifetime can only happen when technicians know about proper installation and safe handling of all refrigerants. Therefore, technician training is a centre piece of any policy to reduce emission from the RAC sector. The goal is to establish a system for qualification, certification and registration of RAC technicians that is fit to proof that registered technicians are duly qualified to handle all refrigerants safely and maintain appliance efficiency by proper servicing[15].

Table 16: Capacity building for technicians

Policy instrument	Ambition level		
	Category A	Category B	Category C
No skills development in the cooling sector	Low	Low	Low
Introduction of technicians trainings to reduce leakage rates and familiarise with flammable/high pressure/toxic refrigerants	Medium	Medium	Medium
Introduction of qualification, certification and registration (QCR) system including skills development for flammable/high pressure/toxic refrigerants (natural refrigerants)	High	High	High

Source: authors

15 Fit for Green Cooling - Green Cooling Initiative (green-cooling-initiative.org)

Regulatory instruments to promote containment and re-use of HFC refrigerants

While the compliance mechanism of the Montreal Protocol is based on the consumption of controlled substances, emissions are relevant in the climate arena. Containment and re-use of refrigerants has cost benefits, contributes to keep up energy efficiency, and is resource efficient.

Both operators of equipment and service technicians are responsible for leakage prevention. However, short-sighted cost considerations often lead to a neglection of proper service intervals.

Regulations that aim at rule setting for the qualification of technicians performing servicing and leakage checks as well as prescribing checking intervals are very useful and prevent emissions when enough resources are put in for enforcement. Systems that include operator's registries and online documentation of performed leakage checks are most ambitious.

On-site recycling of refrigerants that is directly put back into the same system from where it was taken out reduces the demand for new refrigerants, as well as the amounts that need to be treated. If on-site recycling is not possible, refrigerants need to be collected along good practice guidelines to enable efficient reclaim. As reclaim installations are depending on reasonable amounts of refrigerants, these measures are only suggested for countries in Categories B and C.

Table 17: Regulatory instruments to promote containment and re-use of HFC refrigerants

Policy instrument	Ambition level		
	Category A	Category B	Category C
No regulation to promote recycling and re-use of HFC refrigerants	Low	Low	Low
Regulation to ensure servicing and leakage checks are done by certified technicians	Medium	Medium	Medium
Mandatory on-site recycling of refrigerants for large RAC systems	NA	Medium	Medium
Regulation to ensure regular leakage checks (EU) depending on charge sizes, documented per logbook	High	High	High
Operators' registry for larger systems	High	High	High
Establishment of refrigerant reclaim facilities in combination with mandatory regulation to ensure proper handling	NA	High	High

Source: authors

Regulatory instruments to manage end-of-life treatment of refrigerants (and appliances)

When refrigerants are contaminated beyond reclaim or are banned from use, proper collection and destruction avoids substantial amounts of GHG emissions and prevents toxic break-down products from accumulating in the environment. Setting up collection systems of appliances containing refrigerants (refrigerators, freezers, small AC units) and provide for their environmentally sound treatment is a major task that often requires the involvement of producers and importers of equipment and substances. Highest ambition and perseverance are required to set up and run a successful extended producer responsibility (EPR) scheme.

Recommendation for further reading:

- Climate and Ozone Protection Alliance (COPA):
  https://www.copalliance.org/
- GIZ (2018). Papst, I.: Global banks of ozone depleting substances. A country level estimate
  https://www.international-climate-initiative.com/en/iki-media/publication/global_banks_of_ozone_depleting_substances/
- GIZ (2017). Heubes, J., Gloel, J., Papst, I. : Global roadmap on ODS bank management,
  https://www.international-climate-initiative.com/en/iki-media/publication/global_roadmap_on_ods_bank_management/
- GIZ (2017). Heubes,J.: Guideline to conduct an ODS bank inventory,
  https://www.international-climate-initiative.com/en/iki-media/publication/guideline_to_conduct_an_ods_bank_inventory/
- GIZ (2017). Gloel, J., Heubes, J.: Guideline on policy measures for the management and destruction of ODS,
  https://www.international-climate-initiative.com/en/iki-media/publication/guideline_on_policy_measures_for_the_management_and_destruction_of_ozone_depleting_substances/
- GIZ (2017). v. Heinemann, S., Beckmann, J., Heubes, J.: Guideline to establish a collection system for equipment containing ODS,
  https://www.international-climate-initiative.com/en/iki-media/publication/guideline_to_establish_a_collection_system_for_equipment_containing_ozone_depleting_substances/
- GIZ (2017). Gloel, J.: Guideline for the transboundary movement of ODS waste,
  https://www.international-climate-initiative.com/en/iki-media/publication/guideline_for_the_transboundary_movement_of_ods_waste/

Table 18: Regulatory instruments to manage end-of-life treatment of refrigerants (and appliances)

Policy instrument	Ambition level		
	Category A	Category B	Category C
No regulation of end-of-life treatment	Low	Low	Low
Establishment of refrigerant/waste collection system incl. proper treatment for pilot regions (urban/ metropolitan areas)	Medium	Medium	Medium
Collection points for refrigerants and waste appliances and routines for proper treatment, (e.g., financed by import tax), including reverse logistics (take-back schemes for importing countries)	High	High	High
Sufficient collection and recycling capacity, financed by EPR scheme	High	High	High

Source: authors

Tracking and MRV of HFC consumption and emissions

Table 19 summarises the different measures related to tracking and reporting of HFC use and emissions that can be taken to enhance ambition.

Table 19: Instruments for tracking and MRV of HFC consumption and emissions

Policy instrument	Ambition level		
	Category A	Category B	Category C
No tracking of HFC emissions	Low	Low	Low
Tier 1 emissions reporting	Medium	Medium	Medium
Sub-sector specific indicators defined and tracked	High	High	High
Tier 2 emissions reporting of HFCs	High	High	High
Reporting requirement for refrigerant users		High	High

Source: authors

Measures to reduce energy related emissions

Regulatory instruments to promote higher energy efficiency of equipment

Promoting energy efficient equipment is a constituent in many NDCs, often as overall target that is not broken down to specific applications. For the RAC sector, several appliance types like room ACs and household and commercial refrigerators are predestined to be targeted by minimum energy performance standards and labelling provisions. In essence, the level of ambition is determined by the stringency of MEPS and label. United for Efficiency (U4E), an initiative led by UNEP to bring together key stakeholders engaged in product efficiency, has developed model regulations for the mentioned appliances. They are used as benchmark for ambition levels. Awareness raising and technician training to maintain energy efficiency, as well as green public procurement are supporting policies.

Table 20: Regulatory instruments to promote higher energy efficiency of equipment

Policy instrument	Ambition level		
	Category A	Category B	Category C
No regulation of energy consumption of cooling equipment	Low	Low	Low
Introduce awareness programmes to encourage consumers to choose energy-efficient products and services	Medium	Medium	Medium
Support training and skills development of RAC technicians to ensure proper maintenance of equipment to maintain energy efficiency	Medium	Medium	Medium
Introduction of MEPS that are 10% lower than U4E thresholds	Medium	Medium	Medium
MEPS based on seasonal energy efficiency (SEER) or cooling seasonal performance factor (CSPF)	Medium	Medium	Medium
Commitment of local manufacturers to comply with high EE requirements and change to natural refrigerants	NA	NA	Medium
Ban on import of second-hand appliances	Medium	Medium	Medium
Green public procurement limited to appliances at medium efficiency U4E performance levels	Medium	Medium	Medium
Mandatory energy or eco-label informed by U4E levels, including regular update provision	Medium	Medium	Medium
MEPS at U4E medium efficiency grade by 2025	High	High	High
Green public procurement to promote the availability of highly efficient equipment using natural refrigerants	High	High	High
Regulation/ requirement for local manufacturers to comply with high EE requirements	NA	NA	High

Source: authors

Enforcement of energy efficiency regulation

Enforcement of energy efficiency seeks to ensure compliance with energy-efficiency standards and mainly targets manufacturers and sellers of particular appliances. Respective regulations hold manufacturers and sellers accountable for failing to comply with national or international energy efficiency standards (Department of Energy of the United States, n.d.). Within the RAC sector, the appliances that are more linked to enforcement of energy efficiency regulations are mass products such as domestic and commercial refrigerators and ACs.

Table 21: Regulatory instruments to ensure compliance with energy efficiency regulations

Policy instrument	Ambition level		
	Category A	Category B	Category C
No enforcement of energy efficiency regulation	Low	Low	Low
Ad hoc conformity confirmation (spot/verification testing) of equipment to ensure products' compliance	Medium	Medium	Medium
Regular conformity confirmation (spot/verification testing) of equipment to ensure products' compliance, including levying of penalties in case of non-compliance	High	High	High
Product registration system to implement and monitor the MEPS (incl. EE and refrigerant info of imported appliances) including levying of penalties in case of non-compliance	High	High	High

Source: authors

Financial instruments to support higher energy efficiency of equipment

Financial instruments refer to those instruments that enable the use of resources from the public sector to be used in an efficient manner and to stimulate the participation of the private sector towards specific practices. In the case of the cooling sector, financial instruments shall be designed and integrated appropriately into the life cycle of RAC appliances, preferably with a standardised and shared set of tools for different stakeholders (FIRECE, 2018). Some of the most feasible mechanisms to promote energy efficiency include loans and taxes (see table below).

Table 22: Financial instruments to support higher energy efficiency of equipment

Policy instrument	Ambition level		
	Category A	Category B	Category C
No financial incentives to promote highly energy efficient equipment	Low	Low	Low
Electricity tax			
<20% of electricity price	Medium	Medium	Medium
>20% of electricity price	High	High	Medium
Regular conformity confirmation (spot/verification testing) of equipment to ensure products' compliance, including levying of penalties in case of non-compliance			
Product registration system to implement and monitor the MEPS (incl. EE and refrigerant info of imported appliances) including levying of penalties in case of non-compliance	Medium	Medium	Medium
Regular conformity confirmation (spot/verification testing) of equipment to ensure products' compliance, including levying of penalties in case of non-compliance	High	High	High
Product registration system to implement and monitor the MEPS (incl. EE and refrigerant info of imported appliances) including levying of penalties in case of non-compliance	NA	NA	High

Source: authors

4.3. Introduction of the benchmarking tool

Based on the policy instruments and mitigation options presented in this guideline, a benchmarking tool has been developed. The overall objective is to enable decision-makers to do a self-analysis of the cooling sector-related measures included in the current NDC or to be included in future updated NDCs. In a first step and in line with the categorisation described in Step 3, the excel-based tool helps to identify the respective country category. In a second step, the user can select different policy instruments aiming at the reduction of refrigerant-related or energy-related emissions. Hereby, the tool follows the same logic and structure as presented in the guideline. Based on the respective country category, it displays the level of ambition of each selected measure. The tool does not claim to do an in-depth analysis of RAC sector NDCs, nor can it take into account specific country circumstances. This would require an exhaustive assessment of existing and planned policies, legislation and projects, as well as socio-economic factors, not only for the cooling sector, but also beyond, i.e., in comparison to overall economy-wide emissions and climate targets. Therefore, the ambition level resulting from the selected policy instruments is more an indication of whether the measures are going in the right direction.

5. Technical Annex

I. Policy instruments to address refrigerant related emissions

A. Regulatory instruments to reduce HFC consumption

1. Introduction of GWP limit of HFCs for certain appliances/technologies

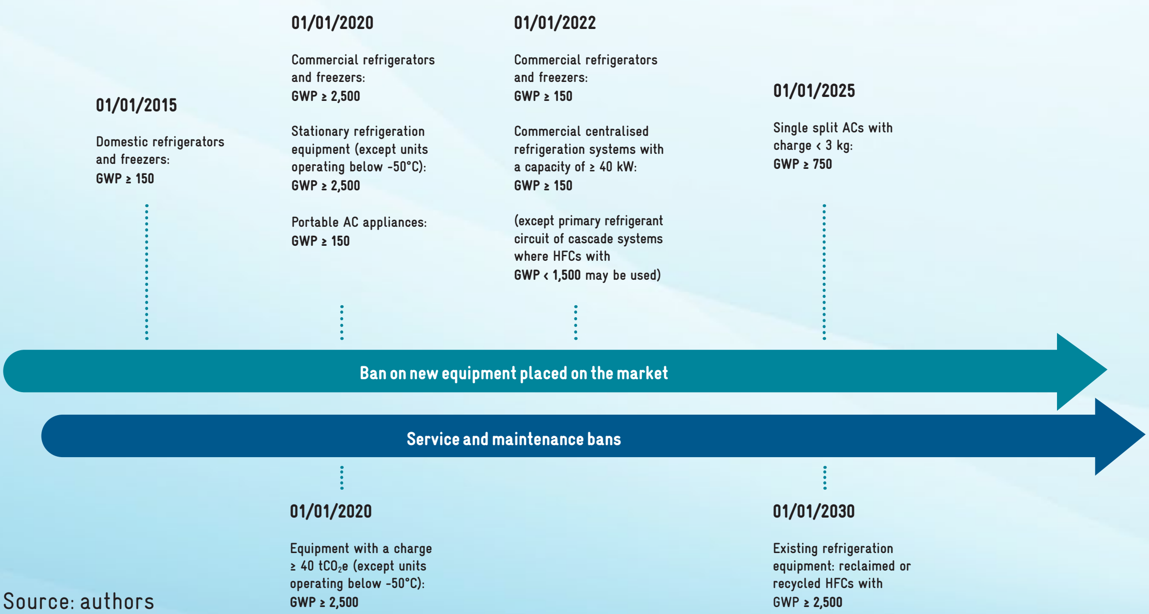
Policy instrument	Ambition level		
	Group A	Group B	Group C
Introduction of GWP limit of HFCs for certain appliances/technologies based on thresholds as defined in current EU F-gas regulation	High	Medium	Medium

Source: authors

Most fluorinated GHG (F-gases) have a greater GWP than other GHGs. Their use is prominent in several types of refrigeration and air conditioning equipment, such as air conditioning, commercial refrigeration and mobile air conditioning. Introducing a GWP limit to HFCs used in most common appliances within the RAC sectors promotes the reduction of the release of F-gases into the atmosphere and, therefore, contributes to the mitigation of global warming (European Environmental Agency 2021).

The Regulation No 517/2014 of the European Parliament and the Council of the European Union, the so-called EU F-gas Regulation that went into effect in 2015, provides a good example of how GWP thresholds can be applied for certain technologies. It has the overarching goal to reduce the EU's F-gas emissions by two-thirds by 2030 compared with 2014 levels which shall be achieved through a quota system for HFCs that is complemented by additional measures to gradually reduce F-gas emissions. Amongst others, the regulation defines restrictions on the placing of products and equipment in the market, based on the GWP value of the F-gases contained in these appliances. An example of the application of this regulation is the restriction to introduce refrigerators and freezers for commercial use in the market that contain HFCs with a GWP higher than 150 from January 2022 (European Parliament and the Council of the European Union, 2014). Figure 10 summarises the current GWP limits for cooling equipment as stipulated by Annex III of the EU F-gas regulation. The regulation is currently being revised. On 5 April 2022, the Commission made a legislative proposal to update the F-gas Regulation.

Figure 10: Overview of GWP limits according to EU F-gas Regulation



Source: authors

Best practice example: Regulation Impact Statement for emission reduction options for synthetic GHGs in Australia

In 2016, the Government of Australia presented the Regulation Impact Statement (RIS), which evaluates options to reduce emissions from HFCs by 85% between 2016 and 2036. HFCs contribute to 2% of Australia's CO_2eq emissions, which account for a total consumption of 7.82 Mt CO_2eq per year. Currently Australia regulates the manufacture, import, export, and domestic end use of HFCs in accordance with the Ozone Protection and Synthetic Greenhouse Gas Management Programme. With the past phase-out of HCFCs, there has been an increase in the use of HFCs in cooling appliances assembled in Asia, Europe, and North America, which are imported to Australia (Department of the Environment and Energy of Australia 2016).

To reduce the use of HFC-based appliances, the RIS has included the participation of various stakeholders and proposed 3 options that require additional policy action. The first one is to include a legislated HFC phase-down based on the reduction of imports of bulk gases. This option would allow a decrease in total amounts of HFCs that may be imported to the country. The second option is the ban of HFC pre-charged equipment. With this option equipment with high GWP would be banned from import and alternatives that make use of refrigerants with a lower GWP would be introduced. The third option is the mandatory control of domestic equipment. This option would rely on mandatory maintenance requirements related to direct (leakage) and indirect (electricity use) emissions, leading to a reduction in the demand for bulk HFC instead of limiting its availability (Department of the Environment and Energy 2016).

2. Ban of synthetic refrigerants for specific sub-sectors/appliances

Policy instrument	Ambition level		
	Group A	Group B	Group C
Ban of synthetic refrigerants for specific sub-sectors/appliances, e.g., refrigerators, freezers, plug-in commercial equipment	NA	High	High

Source: authors

The Montreal Protocol is an example of an effective ban of ODS refrigerants including chlorofluorocarbons (CFCs) and HCFCs. Based on the mandatory phase-out schedule prescribed by the international agreement, CFCs have been banned since 2010 and HCFCs are expected to be banned in non-Article 5 countries (i.e., industrialized countries) and almost completely phased out in Article 5 countries[16] (developing countries and emerging economies, receiving funds to support the phase-out of ODS) by 2030 (GIZ 2014). Further bans of synthetic refrigerants, such as HFCs and hydrofluoroolefines (HFOs), can be implemented to accelerate the decrease of F-gas emissions. Those can be applied specifically on appliances or in specific sub-sectors, where more climate friendly technologies exist that are technically feasible and commercially viable. To apply in-depth bans on new equipment, it is important to evaluate the size of each sub-sector in terms of HFC demand and the availability and feasibility of climate-friendly alternatives. In order to carefully assess the viability of bans for specific technologies or sub-sectors, the following criteria should be taken into account (apart from the overall availability of climate-friendly alternatives):

- **Geographic location:**
  Appropriate technologies for differing ambient temperatures and cooling temperature requirements (depending on the use case, e.g., different temperatures in food retail systems)

  Available skills base of (RAC) technicians
- **Cost effectiveness for different sizes of system:**
  Alternative (natural) refrigerants in some cases are only economically viable above a certain equipment or plant size
- **Overlapping market sectors:**
  Similar types of equipment are used in various sectors and ban applicability is subject to the end user circumstances (for instance chillers can be applied for air conditioning of buildings, but can be also used for industrial applications) (SKM Enviros 2013)

16 The Montreal Protocol defines Article 5 countries as "Any Party that is a developing country and whose annual calculated level of consumption of the controlled substances in Annex A [ODS] is less than 0.3 kilograms per capita […]" (UN 1989). These countries are eligible to receive funding for the implementation of their phase-out measures through the MLF.

Best practice example: US Environmental Protection Agency's Significant New Alternatives Policy programme (SNAP)

The Significant New Alternatives Policy (SNAP) Programme was established by the U.S. Environmental Protection Agency and is directed to evaluate substitutes for ozone-depleting substances and supports the process towards their transition. The programme evaluates and publishes a list of acceptable alternatives that can be used and rovides information open to the public. The main environmental factors considered for this evaluation include ozone depletion potential, flammability, toxicity, and occupational health and safety (GSA Federal Acquisition Service, 2013). Some of the most relevant substitutes are directed to the industrial sector, including adhesives, aerosols, solvents, foam blowing agents, and refrigeration and air conditioning (EPA 2022).

3. Green public procurement

Policy instrument	Ambition level		
	Group A	Group B	Group C
Green public procurement with GWP limits for refrigerants based on current EU F-gas regulation	Medium	Medium	Medium
Green public procurement to promote the availability of highly efficient equipment using natural refrigerants	High	High	High

Source: authors

Green public procurement (GPP) can be used by public authorities to limit acquisition of cooling appliances to certain refrigerant types/efficiency classes. As shown in its first large scale implementation with the front-runner AC programme in Japan, it can lead to rapid spillover to the private sector, given the cost reduction of the appliances due to the captive market (GIZ 2021a). The benefit from sustainable cooling appliances increases when the transition towards low-GWP refrigerants goes along with energy efficiency improvements (GIZ 2021; Shakti Foundation 2017).

An example of typical GPP programmes is the introduction of minimum energy efficiency requirements for specific types of equipment. Technical specifications related to refrigerants can include:

- To specify the type of refrigerant in the system that will be open for bids;
- To specify a maximum GWP level for refrigerants used in AC and refrigeration systems;
- To require that manufacturers take back old cooling equipment at the end-of-life, specifying that the disposal of the equipment shall include the recovery of refrigerants;
- To apply a preferential policy for goods that meet environmental criteria. Bids that meet such criteria would be favored in a certain percentage (Shakti Foundation 2017).

The study on "Green Cooling in Public Procurement", published by GIZ (GIZ 2021a) provides valuable insights and detailed orientation on how GPP specifically for green cooling appliances can be set up, including overcoming typical barriers and challenges. As a starting point, GWP limits for certain cooling equipment under the GPP programme could be oriented towards the requirements contained in the EU F-gas regulation. An even more ambitious approach could require eligible cooling units to meet the condition to use natural refrigerants.

Recommendation for further reading:

- GIZ (2021a). Kahlen, L.; Moie, J.; Munzinger, P.; Teutsch, L.: Green Cooling in Public Procurement. How to advance the procurement of climate-friendly and energy efficient air conditioners in the public sector, https://www.green-cooling-initiative.org/fileadmin/user_upload/GIZ_Proklima_Green_Cooling_in_Public_Procurement_final.pdf
- Shakti Foundation (2017). Promoting low-GWP refrigerants through public procurement, policy brief, https://shaktifoundation.in/wp-content/uploads/2014/02/CEEW-Procuring-Low-GWP-Refrigerants-through-Public-Procurement-5Oct17.pdf

Best practice example: GPP in Costa Rica

Costa Rica is considered one of the frontrunners when it comes to GPP. The country has established a comprehensive legal framework for sustainable public procurement (SPP) which is accompanied by the provision of information materials for (green) procurement and the anchoring of GPP in various institutions through official committees. It was the first country in the Latin American region that has adopted detailed procurement laws that consider sustainability aspects. The GPP manual, that has been published by the government in 2008, contains criteria for different product groups related to their environmental impact, such as energy efficiency in electric appliances or recyclable plastics. Key success factors of the Costa Rican GPP framework are considered to be, amongst others, i) evaluation of the complete lifecycle of a product for the assessment of its negative impact, ii) close collaboration between procurement staff and technical staff within institutions, iii) more creativity in bid evaluation approaches, especially when assigning scores to environmental criteria, and iv) strengthened monitoring and verification processes (GIZ 2021a).

4. Refrigerant assessment on its recyclability, with possible restrictions on blends that are difficult to recycle/reclaim

Policy instrument	Ambition level		
	Group A	Group B	Group C
Refrigerant assessment on its recyclability, with possible restrictions on blends that are difficult to recycle/reclaim	High	High	High

Source: authors

In contrast to the very limited number of HCFCs on the market, there are many more HFCs available. As no universal alternative refrigerant to HCFC-22 was identified, industry has created a long list of refrigerants and their blends. They are often marketed as drop ins to replace HCFC and high GPW HFCs. This can create problems when it comes to recycling and reclaim. Blends may fractionate, meaning that its composition changes as components emit at different speed due to different boiling points. This complicates recycling and it is only advisable to recharge the recovered blend to the system from where it has been taken out. Most often, blends need to be reclaimed, where the components are first separated and then mixed again. New blends with mixtures of R134a, R32 and R1234yf require new separation technologies, as conventional cryogenic distillation is not effective due to very similar substance properties (Pardo et al., 2021). Those alternative separation technologies are currently being researched and it will take time until they are commercially available.

With the increasing number of blends, more recycling cylinders are required, as recovered refrigerants should not be mixed.

Thus, especially for small countries, with limited access to reclaim facilities, it is recommended to evaluate the import of niche-refrigerant blends.

5. Commitment of or regulation for local manufacturers to change to natural refrigerants

Policy instrument	Ambition level		
	Group A	Group B	Group C
Commitment of local manufacturers to change to natural refrigerants			Medium

Source: authors

Especially for countries that not only import cooling equipment but also produce such devices, supply side measures to reduce HFC use and shift towards natural refrigerants can be an effective push to transform the cooling sector. Some of the F-gas regulations currently in place include mandatory leakage checks and bans. In order to avoid these regulations and the uncertainty of F-gases prices in the future, shifting to natural refrigerants is becoming the best alternative not only to enhance energy efficiency, but to gain independence from increasingly strict regulations. However, one of the biggest concerns when handling natural refrigerants is managing the large charges of these refrigerants. Reducing the refrigerant charge sizes by using indirect refrigerating systems is a recommended solution to avoid any safety concerns (Radermacher et al. 2016). A first step can be commitments by producers to use natural refrigerants in the production of appliances that are technically relatively easy to convert. For instance, this could be in the form of private sector alliances that pledge to shift towards green cooling. A good overview of private sector engagement in the cooling sector and best practice examples are provided in the publication "Non-state action towards climate-friendly and energy efficient cooling" (GIZ 2018a). A more stringent way is the regulation for local producers to switch to natural refrigerants for certain cooling equipment types. This could be backed by corresponding financial incentives or support in the form of grants, subsidies or other financial benefits.

Recommendation for further reading:

- GIZ (2018a). Becker, C.; Kurdziel, M.: Non-state action towards climate-friendly and energy efficient cooling. Assessing the potential of major end-use industries, https://www.green-cooling-initiative.org/fileadmin/Publications/2018_Green_Cooling_Initiative_Non-state-action.pdf

B. Financial instruments to reduce HFC consumption

1. Levy on the use of high GWP HFCs

Policy instrument	Ambition level		
	Group A	Group B	Group C
Levy (e.g., tax, fee) on the use of high GWP HFCs	Medium	Medium	Medium

Source: authors

Some of the economic instruments that can be applied efficiently in the RAC sector include levies, such as taxes or fees. These instruments, which have a steering function through the price of the equipment and the refrigerants used, can push the market and demand towards more sustainable, climate-friendly refrigerants by increasing the cost of devices that use high GWP refrigerants. Hence, if the GWP value of the refrigerant that is to be imported and used in cooling equipment (bulk) or contained (pre-charged) in the RAC equipment exceeds a certain threshold (e.g., 1,500), a higher tax is to be paid. Levies can be introduced in a staggered manner. This means that the amount of the levy depends on the respective GWP value of the refrigerant and becomes higher with increasing GWP value. Alternatively, only the use of certain gases can be charged a higher tax.

Of course, such instruments also work the other way round. This means that levies for very climate-friendly appliances that use natural refrigerants, for example, can also be significantly reduced or even waived altogether.

Best practice example: Levies on HFCs in the Republic of Seychelles

In February 2021, the Republic of Seychelles introduced an amendment to the Environmental Protection Act (Act 18 of 20216) which regulates the environmental levies on refrigerant gases and equipment (S.I. 9 of 2021) (Republic of Seychelles, 2021a):

Range of Global Warming Potential (GWP)	Levy (% of the total value of Refrigerant
Gas and Equipment)	0%
Exceeding 99 GWP but not exceeding 1, 999 GWP	5%
Exceeding 1, 999 GWP but not exceeding 2, 999 GWP	8%
Exceeding 2, 999 GWP	10%

Source: Republic of Seychelles (2021a)

At the same time, the government of the Republic of the Seychelles established a VAT exemption for refrigerants with a GWP value below 100 and related equipment (Republic of Seychelles, 2021b).

2. GWP weighted levy or carbon tax

Policy instrument	Ambition level		
	Group A	Group B	Group C
GWP weighted levy or carbon tax on all HFCs and HFOs (substances as defined in EU F-gas regulation)	High	High	High

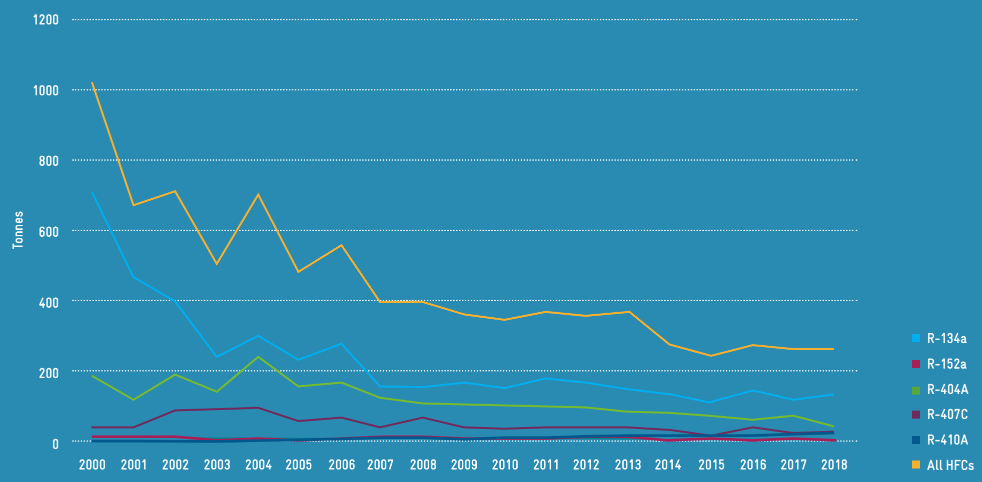
Source: authors

An even greater reduction in HFC use and consequently emissions can be achieved by introducing a GWP-weighted levy or a carbon tax on all HFCs and HFOs that are imported to and used in the country. The resulting levy, for instance in form of a (carbon) tax, reflects the climate impact of the respective refrigerant and is therefore higher for very climate damaging HFC refrigerants. The levy can be designed in a progressive form with periodic increases, as is the case in France, for example. Furthermore, the definition of substances covered by the regulation is ideally based on the gases included in the → EU F-gas regulation (Annex III).

Best practice example: HFC tax in Denmark

In 2000, the government of Denmark adopted an HFC tax which saved approx. 5.3 MtCO_2eq until 2020. The underlying standard regulates the price per ton CO_2eq which was initially set at 150 Danish Krones (DKK) (USD 21.6). As the decline in HFC imports became less and less, the government decided to increase the tax again in 2020. Besides, the persisting tax ceiling of DKK 600 (USD 86.4) has been removed with the revision of the legislation. The tax is complemented by a ban of HFCs in new equipment which was put into effect in 2006 and leads to HFC imports only being made for servicing purposes (Stausholm 2020). The figure below shows the impact of the Danish HFC legislation for the period 2000 – 2018.

Figure 11: Import of HFCs to Denmark 2000-2018



Source: Danish EPA 2019, Stausholm 2020

Best practice example: HFC tax in France

Similar to the tax that has been introduced by the Danish government, France has put a law into force (2019 Finance Bill) that mandates the imposition of an HFC tax starting from 2023, covering bulk refrigerant as well as pre-charged equipment entering the country. Refrigerants that are recycled and brought into the market again are excluded from the tax. The levy follows a stepwise increase:

- 2023: 15 EUR / tCO_2eq
- 2024: 18 EUR / tCO_2eq
- 2025: 22 EUR / tCO_2eq
- 2026: 26 EUR / tCO_2eq
- 2027: 30 EUR / tCO_2eq

In addition, the purchase of HFC-free equipment is incentivised by a tax reduction of up to 40% on the original value of the device. The waiver is applicable to the taxable income of companies (Global Alliance for the Future of Food 2022; Refrigeration World 2022).

3. Financial incentives to use natural refrigerants

Policy instrument	Ambition level		
	Group A	Group B	Group C
Financial incentives (e.g., import tax reduction, subsidy), <20% of equipment cost, to use natural refrigerants	Medium	Medium	Medium
Financial incentives (e.g., import tax reduction, subsidy), >20% of equipment cost, to use natural refrigerants	High	High	High

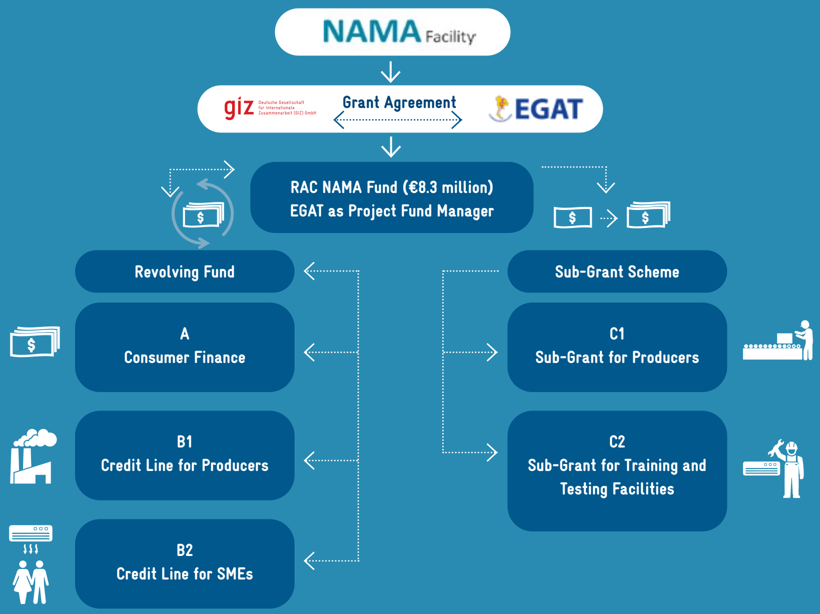
Source: authors

Financial incentives that support the introduction of cooling equipment with low or zero GWP refrigerants can accelerate the uptake of such climate-friendly appliances and induce a shift towards green cooling technologies. There are several ways to provide incentives, such as tax exempts, subsidies or rebate schemes at purchase, investment grants or innovative approaches like on-bill and on-wage financing. Even refunds after purchase or long-term credits (for instance until the gains from lower electricity bills have offset the higher upfront costs) can be an effective means to direct the demand towards green cooling technologies (IGSD & UN Environment 2020). Ultimately, they all aim to reduce the cost of alternatives compared to HFC units, making them more economically attractive to the user, as in many cases technologies based on natural refrigerants are associated with higher upfront costs. Even if these are offset by lower operating costs over the course of the equipment's use, it often takes a push to stimulate demand, as users usually do not have the corresponding awareness and are deterred by the higher initial costs. Depending on the share of the equipment cost that is covered by the financial incentive scheme, such a measure can be considered medium (<20% of equipment cost) or high (>20% of equipment cost) level ambition.

Best practice example: Thailand RAC NAMA

With support of the NAMA Facility, Thailand implemented the Thailand Refrigeration and Air Conditioning Nationally Appropriate Mitigation Action (RAC NAMA) in the period 2016-2021. Part of the activities covered by the NAMA was the establishment of the RAC NAMA Fund which aims to promote the market introduction of green cooling technologies with financial instruments designed for various target beneficiaries in the cooling sector. This includes local cooling equipment producers, residential consumers and commercial end-users (small and medium-sized businesses, SME) and training institutions and testing facilities. The ultimate goal is to encourage the adoption of green commercial refrigerators, ACs and chillers and to promote investment in these technologies. In total, the RAC NAMA Fund disbursed EUR 8.3 million, divided into two components: revolving fund (EUR 5.3 million) and a grant scheme (EUR 3 million). The fund was operated by the Electricity Generating Authority of Thailand (EGAT). EGAT will build upon these successes and utilise the experience and knowledge gained from the implementation of the RAC NAMA Fund to manage the new Cooling Innovation Fund (CIF), resulting from the remaining budget of the RAC NAMA Fund, to further promote sustainable innovation and market transformation to climate-friendly and energy efficient cooling technologies using natural refrigerants (Thailand RAC NAMA n.d.).

Figure 12: Structure of Thailand RAC NAMA Fund



Source: Thailand RAC NAMA n.d.

4. Reduction of investment cost via bulk procurement programme

Policy instrument	Ambition level		
	Group A	Group B	Group C
Reduction of investment cost via bulk procurement programme	High	High	High

Source: authors

Bulk procurement programmes are a variant of GPPs. Such programmes aggregate demand and due to the larger demand batches often lead to cost reductions in production. Such concepts have been used for instance in India to accelerate diffusion of LED lamps very successfully. One crucial aspect when designing the bulk procurement is the critical size to establish an effective tender. It should reflect payback periods and take into account sector specific needs and consumer demand which is ideally based on information obtained through a detailed market survey. In this way, excessive product procurement, incorrect estimation of transport needs and savings in storage requirements that may not have been included in the planning process can be avoided (IGSD & UN Environment, 2020). Moreover, it is advisable to centralise the procurement processes through a central procurement entity (GIZ 2021a).

Recommendation for further reading:

- IGSD & UN Environment (2020). Buyers Club Handbook. January 2020 Update, http://www.igsd.org/wp-content/uploads/2020/07/Buyers-Club-Handbook-Jan2020.pdf
- GIZ (2021a). Kahlen, L.; Moie, J.; Munzinger, P.; Teutsch, L.: Green Cooling in Public Procurement. How to advance the procurement of climate-friendly and energy efficient air conditioners in the public sector, https://www.green-cooling-initiative.org/fileadmin/user_upload/GIZ_Proklima_Green_Cooling_in_Public_Procurement_final.pdf

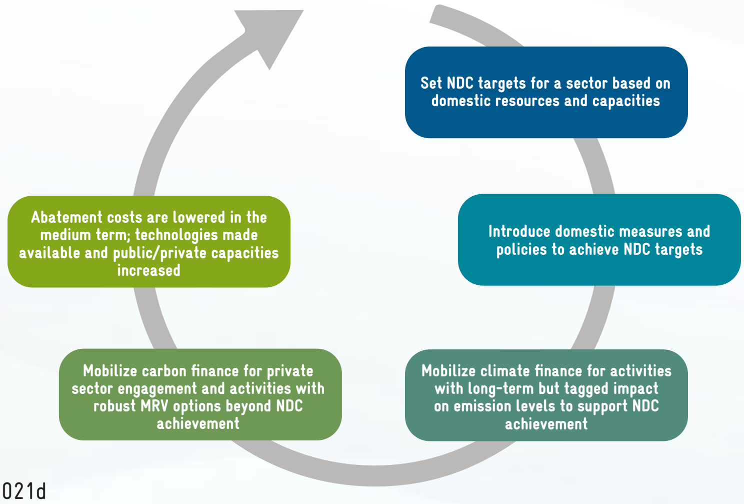
Best practice example: Bulk procurement of room ACs in India

In 2017, the government of India via the ESCO Energy Efficiency Services Limited (EESL) initiated a bulk procurement of 100,000 energy efficient split ACs for private (residential) and public institutions. The overall goal was to accelerate the market transformation towards highly efficient AC equipment by increasing the demand through aggregate purchases. Ultimately, this would not only stimulate the demand, but would also lead to a drop in equipment costs. Unfortunately, there was no restriction on the GWP of refrigerants used in the equipment to be purchased. The tender resulted in the supply of 60,000 units using R410a refrigerant and 40,000 units using R290 (propane). The latter was supplied by the Indian manufacturer Godrej. Without aggregating the demand, the purchase of these units would have been associated with significantly higher costs. Although the specification of the refrigerants for the tender leaves room for improvement, the procurement has proven helpful for several institutions to procure highly efficient air conditioning systems with lower life cycle costs (GIZ 2021a).

C. Market-related instruments to reduce HFC consumption

Market-related instruments can be linked and complemented by international and national climate finance, as illustrated by the graph below.

Figure 13: Division of labour between different funding sources in the context of the NDC cycle



Source: GIZ 2021d

International market-based instruments can help to set incentives in the next NDC cycle through limited length of crediting periods and sharing of the mitigation outcomes with the buyer country. In the short term, activity-based carbon finance can be used to stimulate private sector engagement beyond the unconditional NDC achievement. In the longer term, market-based interventions could be upscaled to programmatic or sector-level approaches. This would require further and innovative development of the underlying methodological approaches to quantify the mitigation outcomes that can be used for crediting.

There are basically two options under Article 6 to enter into market-based mechanisms:

- **Bilateral or multilateral approaches under Article 6.2:** Cooperative approaches are anchored in Article 6.2 and can adopt very different forms of market-based cooperation, such as international trading of parts of the countries' emission budgets defined in the NDCs, linking ETS and transferring credits from a baseline-and-credit mechanism. Thus, Article 6.2 provides a high degree of flexibility to Parties to adapt their cooperation to national circumstances in order to align it with their NDC achievement. The common element of these different approaches is that they lead to a transfer of "internationally transferred mitigation outcomes" (ITMOs). Mitigation outcomes must be "real, verified and additional" and must not lead to higher global emissions. They are assigned to the country (host) and year (vintage) in which they occur (GIZ 2021d). Article 6.2 activities can help to mobilise carbon revenues in the short term, through implementation of pilot activities. Since countries currently are in the process of establishing their Article 6 governance and institutional structures and processes, such pioneering measures could lead to higher transaction costs.

- **Article 6.4 mechanism:**
The mechanism enshrined in Article 6.4 of the PA, the so-called Art. 6.4 mechanism (A6.4M), will credit Article 6.4 Emission Reductions (A6.4ERs) by activities authorised by host countries according to approved methodologies. The A6.4M is known as the successor to the Clean Development Mechanism (CDM) established by the Kyoto Protocol. It will leverage funds for adaptation and aims to deliver Overall Mitigation in Global Emissions (OMGE) through the cancellation of a certain share of issued A6.4ERs. The Supervisory Body (SB), an entity under the authority of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA), has the responsibility to oversee the mechanism. It will approve eligible baseline and monitoring methodologies as well as methodological tools such as additionality tests. Activities will be registered upon validation by a designated operational entity (DOE) as well as approval by the host country (Michaelowa et al. 2021b). Article 6.4 activities could be chosen by countries for long-term mitigation actions in the cooling sector to obtain additional funding through both, revenues from ITMOs and results-based finance.

Principles and criteria for Article 6 activities in the cooling sector, differentiated between Art. 6.2 and 6.4

- Minimum criteria under the Article 6.2 guidance:
  - The activity needs to apply a **robust methodology** that is in line with IPCC guidance. It must also be applied to guarantee…
    - That the activity is additional. This relates to **financial** and **regulatory additionality**, i.e., the activity is not mandated by law and not financially viable without the carbon revenue.
    - That the activity contributes to **NDC achievement** and does not lead to an increase in emissions. Thus, it needs to generate **credible and real emission reductions** that are measured against a stringent baseline that goes below BAU.
  - It has to be demonstrated through a robust assessment that the activity will have **no negative environmental, economic, and social impacts**. This includes respect of human rights, rights of indigenous peoples, local communities, and gender equality.
  - Parties need to ensure **robust accounting** and **avoidance of double counting**, through application of the Article 6.2 guidance.

- Minimum criteria under Article 6.4 mechanism:
  - The activity needs to contribute to the **host Party's NDC** and **long-term low greenhouse gas emission development strategies (LT-LEDS)** and equitable sharing of mitigation outcomes.
  - The activity must be consistent with the **national SD objectives** and follows the A6.4M methodological requirements in this regard.
  - It requires the application of a **methodology that is approved by the A6.4M**, including **regulatory and financial additionality testing** and a **stringent baseline setting approach** which considers:
    - Benchmarks derived from an assessment of best available technologies (BAT)
    - Performance benchmarks derived from technologies deployed in similar circumstances
    - Emission trends and projections adjusted downwards
  - It has to be demonstrated through a robust assessment that the activity will have **no negative environmental, economic, and social impacts**. This includes respect of human rights, rights of indigenous peoples, local communities, and gender equality.

Recommendation for further reading:

- GIZ (2021e). Michaelowa, A., Laßmann, D., Espelage, Q., Feige, S., Moreno, L.: The 'HCFC adder' in the Kigali Amendment baseline calculation. Risks to environmental integrity of the Paris Agreement, https://www.green-cooling-initiative.org/news-media/publications/publication-detail/2021/12/17/the-hcfc-adder-in-the-kigali-amendment-baseline-calculation
- GIZ (2021d). Michaelowa, A., Laßmann, D., Espelage, Q., Feige, S., Moreno, L.: Baseline and monitoring methodologies for HFC mitigation action. MRV standardisation and streamlining as well as accounting of HFC mitigation – including energy efficiency improvement – under the Kigali Amendment and Paris Agreement, https://www.green-cooling-initiative.org/news-media/publications/publication-detail/2021/12/17/baseline-and-monitoring-methodologies-for-hfc-mitigation-action

1. Inclusion of the cooling sector in national Article 6 strategy/plans

Policy instrument	Ambition level		
	Group A	Group B	Group C
Inclusion of cooling sector in national Article 6 strategy/plans	Medium	Medium	Medium

Source: authors

After the guidance and requirements for Article 6 activities was finalized and adopted at COP26 in Glasgow, countries are now gradually starting to develop Article 6 strategies and plans. The formulation of a country's Article 6 strategy should be consistent with its NDC and its NDC implementation plan. Therefore, the country's NDC should be the reference point when decision-makers initiate their work on the Article 6 strategy. This will ensure that the Article 6 strategy has maximum effectiveness, synergies with existing strategies and overall political consistency. If countries decide to embark on Article 6 activities in the cooling sector, the envisaged measures should be part of the Article 6 strategy. By integrating those activities and thus clearly indicating priorities related to the RAC sector, countries can attract and target potential buyers of mitigation outcomes and facilitate the matchmaking between project developers, financiers and policy makers.

Prerequisites to design an Article 6 strategy are:

- Assessment of the overall mitigation potential and projected mitigation until the target year by (sub-) sectors and technologies;
- Categorisation of mitigation activities according to their funding needs, i.e., financing possible through domestic resources (unconditional target) or need for international funding (conditional target);
- Identification of mitigation activities under the conditional target that already received international climate finance and of those that are in the pipeline to receive international climate finance in the future;
- Current status of achieving full compliance with the accounting and reporting requirements under the UNFCCC, especially regarding the ETF starting in 2024 (Espelage et al. 2022).

Recommendation for further reading:

- Espelage, A., Weldner, K., Censkowsky, P., Michaelowa, A., Hoch, S., Singh, A., Wawrzynowicz, I., Emana, Nsikan, N., Sfeir, J., Greiner, S. (2022). Blueprint for Article 6 Readiness in member countries of the West African Alliance, Perspectives Climate Group/ Climate Focus, https://www.perspectives.cc/public/fileadmin/user_upload/Blueprint_FINAL.pdf

2. Inclusion of HFCs in emissions trading system (ETS) for all sectors

Policy instrument	Ambition level		
	Group A	Group B	Group C
Inclusion of HFCs in emissions trading system (ETS) for all sectors	High	High	High

Source: authors

Another option to tackle HFC use is through the inclusion of HFCs in (existing) emissions trading systems (ETS). These comprise market instruments that seek to reduce GHG emissions by providing economic incentives and aim at promoting GHG emission reductions where they are cheapest to achieve. Most ETS that are currently operating at national or regional levels are based on a so called "cap-and-trade" system. The cap, which is set by the government, determines the maximum amount of GHG emissions that can be emitted by the sectors included in the ETS. Typically, those are the energy and industry sectors.

There are different ways to set the cap ranging from an absolute emissions reduction target (so called "mass-based" cap) to a relative emissions reduction target (IEA 2020). By integrating HFCs in such a cap-and-trade system, where members are allocated CO_2 allowances that determine the amount of emissions they are allowed to emit, HFCs emissions get a limit. If these are exceeded by individual members, they have to buy additional allowances. The EU ETS for example, that has been established in 2005, covers all large installations for electricity generation and heating, large industrial installations such as steelworks, refineries, cement works and, since 2012, aircraft operators (BMUV 2022).

Recommendation for further reading:

- IEA (2020). Implementing Effective Emissions Trading Systems: Lessons from international experiences, https://iea.blob.core.windows.net/assets/2551e81a-a401-43a4-bebd-a52e5a8fc853/Implementing_Effective_Emissions_Trading_Systems.pdf

3. Inclusion of cooling sector and HFCs in national voluntary market

Policy instrument	Ambition level		
	Group A	Group B	Group C
Inclusion of cooling sector and HFCs in national voluntary market	High	High	High

Source: authors

Similar to including HFCs in an (existing) ETS, countries can integrate the cooling sector and more specifically HFCs into their national voluntary markets. Voluntary carbon markets allow emitters to compensate for their unavoidable emissions by acquiring carbon credits from projects that remove or reduce GHG emissions. There are different ways for companies to engage in voluntary carbon markets: they can participate either individually or as part of an industry-wide scheme. An example for such a scheme is the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which was established by the aviation sector to offset its GHG emissions. Several countries have developed national and sub-national baseline-and-credit systems for domestic voluntary purposes, e.g., Costa Rica, Peru, and Thailand. Voluntary carbon markets can offer complementary project types and methodological approaches compared to (international) carbon markets that are used for compliance purposes. However, environmental integrity and robust and transparent accounting are principles that should be also followed by voluntary carbon markets (Ahonen et al. 2021).

4. Existence of Art. 6 methodologies for cooling (HFC)-related Art. 6 activities

Policy instrument	Ambition level		
	Group A	Group B	Group C
Existence of Art. 6 methodologies for cooling (HFC)-related Art. 6 activities	High	High	High

Source: authors

A further step to initiate market-based activities in the cooling sector under Article 6 is the development of respective methodologies. Those are the backbone of any Article 6-related initiative and a prerequisite to enter market-based cooperation. Article 6 methodologies need to adhere to the principles as stipulated by the guidance for Article 6.2 and Article 6.4 (see also text box under section → C Market-related instruments to reduce HFC consumption) and ensure environmental integrity, robust accounting, and avoidance of double counting. Besides, they must safeguard the additionality of Article 6 activities, the contribution to sustainable development in the host country, as well as contribution to the host Party's NDC and LT-LEDS. Existing methodologies that have been developed under the CDM or voluntary standards are not sufficiently addressing and fulfilling all these requirements. Therefore, more comprehensive and innovative methodologies that specifically target HFC-related Article 6 activities need to be elaborated.

D. Regulatory instruments to promote containment and re-use of HFC refrigerants

1. Mandatory on-site recycling of refrigerants

Policy instrument	Ambition level		
	Group A	Group B	Group C
Mandatory on-site recycling of refrigerants	Medium	Medium	Medium

Source: authors

On-site recycling means to use the very same refrigerant that was recovered from a system prior a repair to charge the system from which it has been taken out after the repair. Ideally, the refrigerant is cleaned using basic filters that remove water, oil, and particles.

This practice helps to reduce refrigerant amounts that require collection and treatment and is as such, cost- and resource-efficient. It requires the RAC technician to be trained and equipped with the right tools.

2. Regulation to ensure that refrigerant handling, installations, servicing, and leakage checks are carried out by certified technicians

Policy instrument	Ambition level		
	Group A	Group B	Group C
Regulation to ensure that refrigerant handling, installations, servicing, and leakage checks are carried out by certified technicians	Medium	Medium	Medium

Source: authors

The occurrence of refrigerant emissions comes down to the skill and awareness of the individual RAC technician. Hand in hand with proper training (→ Chapter E), a regulation is needed to set the required skills that a technician needs to have to perform certain tasks at RAC equipment. For example, in the EU, the required skill level increases if systems are getting larger and activities require to break the refrigerant circuit.

3. Establishment of refrigerant reclaim facilities in combination with mandatory regulation to ensure proper handling

Policy instrument	Ambition level		
	Group A	Group B	Group C
Establishment of refrigerant reclaim facilities in combination with mandatory regulation to ensure proper handling	NA	High	High

Source: authors

This measure is relevant for countries where the amount of refrigerants that is banked in equipment points to the potential of refrigerant recovery being large enough to operate a reclaim facility, that is country group B and C. Refrigerant reclaim entails proper cleaning of refrigerants and the separation of blends in their component refrigerants. The final product is tested and needs to adhere to a specified quality standard, which is "as good as new". The quality of the recovered refrigerants has a direct impact on the efficiency of the reclaim process. Refrigerants need to be recovered separated by specification, i.e., separate collection cylinders for R134a, R410A, etc. The cylinders need to be cleaned before use to avoid contamination and also the equipment used for recovery needs to be cleaned between uses.

That leads to the requirement to ensure proper handling of recovered refrigerant to enable its reclaim, along with testing facilities to check on the quality delivered. Such provisions are best linked to financial incentives for returned refrigerants in a quality that allows reclaim.

4. Regulation to ensure regular leakage checks (EU) depending on charge sizes, documented per logbook

Policy instrument	Ambition level		
	Group A	Group B	Group C
Regulation to ensure regular leakage checks (EU) depending on charge sizes, documented per logbook	High	High	High

Source: authors

Leakage checks by trained technicians are key to prevent refrigerant emissions during operation. Especially at large installations, they can prevent high amounts of emissions and also help to keep original energy efficiency levels, as lower refrigerant charges also cause higher energy consumption. If leaks are detected, the leak has to be repaired within a prescribed timeframe. It is recommended to use a tiered approach, setting shorter checking cycles for larger installations.

To aid the implementation, mandatory record keeping by operators is required. In its basic form, this can be done as a paper logbook kept with the equipment. Several countries have adopted online-logbook systems were checking interval can be monitored automatically. This requires high initial effort, but enables the monitoring of the market, and provides useful data for GHG reporting and HFC phase-down.

An example for detailed requirements on leakage checks is the EU F-gas regulation No. 517/2014. Article 4 defines the compulsory leak checks of F-gas containing equipment based on their charge. Equipment containing quantities of 5 t CO_2eq or more (or 10 t CO_2eq or more, if hermetically sealed) are subject to regular leak tests. Sectors covered are: stationary refrigeration and air conditioning, heat pumps (RAC&HP), stationary fire protection equipment, refrigeration units on trucks and trailers, electrical switchgears and organic Rankine cycles (ORC). Specified leak test intervals depending on charge sizes are summarised in Table 23.

The installation of leak detection systems is obligatory for equipment containing 500 t CO_2eq or more for stationary RAC&HP, stationary fire protection equipment and for electrical switchgears and ORCs installed after 1 January 2017. The leakage detection system is to be checked for proper functioning every 12 months, for electrical switchgears, every 6 years.

Table 23: Leak test intervals depending on their charge, required for stationary RAC&HP, stationary fire protection equipment, refrigeration units on trucks (of mass > 3 t) and trailers, electrical switchgears not being exempt and organic Rankine cycles

Required test interval	No test	24 months	12 months	6 months	3 months
Without installed leak detection system	< 5 t CO_2eq (or < 10 t CO_2eq, if hermetically sealed)		5 t CO_2eq or more, but less than 50 t CO_2eq	50 t CO_2eq or more, but less than 500 t CO_2eq	500 t CO_2eq or more
With leak detection system	< 5 t CO_2eq (or < 10 t CO_2eq, if hermetically sealed)	5 t CO_2eq or more, but less than 50 t CO_2eq	50 t CO_2eq or more, but less than 500 t CO_2eq	500 t CO_2eq or more	

Standard leak checking requirements are defined in Implementing Regulation (EC) No 1516/2007 for stationary RAC&HP equipment. The requirements comprise the check of equipment records and a systematic check of system parts that are prone to leakages. Specifically listed are joints, valves including stem, seals including those on replaceable driers and filters, parts of the system subject to vibration and connections to safety or operational devices. A direct or indirect measuring method for leak checking shall be applied.

In case a leak was found and repaired, a leakage test with oxygen free nitrogen or other suitable pressure testing and drying gas shall be carried out prior to recharging the system with F-gases.

In case of a leak, the operator is responsible to get the leak repaired as soon as possible and carry out a leakage test within one month to test whether the repair was successful. Newly installed equipment must be checked for leakage immediately after it has been put into service.

Only certified technicians are allowed to perform leak tests. Depending on the method applied and the charge size, different levels of certification are necessary as defined in the relevant implementing regulations.

The operators of equipment that is subject to regular leak testing are obliged to keep the test records for each piece of equipment. Those test records must contain the information specified in Article 6.1 (as reproduced in the list below) and have to be kept by the operator and the technician (undertakings) for at least five years if there is no central database where those data are stored. The records are to be made available on request to the competent national authority.

Required information of the test records:

- the quantity and type of fluorinated greenhouse gases installed
- the quantities of fluorinated greenhouse gases added during installation, maintenance, or servicing or due to leakage
- whether the quantities of installed fluorinated greenhouse gases have been recycled or reclaimed, including the name and address of the recycling or reclamation facility and, where applicable, the certificate number
- the quantity of fluorinated greenhouse gases recovered
- the identity of the undertaking which installed, serviced, maintained and where applicable repaired or decommissioned the equipment, including, where applicable, the number of its certificate
- the dates and results of the leakage checks carried out under Article 4(1) to (3)
- if the equipment was decommissioned, the measures taken to recover and dispose of the fluorinated greenhouse gases

5. Operators' registry for larger systems, including regulation against end-of-life release

Policy instrument	Ambition level		
	Group A	Group B	Group C
Operators' registry for larger systems, including regulation against end-of-life release	NA	High	High

Source: authors

To keep track of refrigerant use, an obligatory operators' registry is a high ambition measure. As Group A countries do not have so many large installations the effort to set up a registry is often deemed unproportionally to the benefit. Such registry systems require high effort to be set up but are a valuable means to keep track of activities performed on the RAC equipment and account for the refrigerant usage. Repeated refill might call for questions on system tightness as well as no records of recovered refrigerants at decommissioning are a reason for further investigation.

Best practice example: Poland

For tracking refrigerant related leakage emissions, Poland has established an electronic database. The electronic database includes a central register of operators running appliances containing F-gas. The reporting to the database is mandatory for all equipment operators with equipment containing more than 5 tons of CO_2eq F-gases. The operators must track F-gas handling activities including installations, maintenance/servicing, repair, decommissioning, leakage checking, leakage repairs, leakage detections, the type of leakage detection systems and refrigerant recovery. For each type of equipment, one logbook must be maintained. Environmental inspectors will carry out spot checks on the proper regular compilation of the logbooks and the related reporting. The data used in the database serves as a data input for the national inventory on emissions of fluorinated GHGs under Article 4 of the UNFCCC (UNEP, Legislative, and Policy Options to Control Hydrofluorocarbons).

E. Capacity building for technicians

Since the first time that mechanised cooling was invented in the 18th century, there have been continuous changes and improvements in the methods of cooling based on increased scientific knowhow and skills. The global movement in the 1980s to protect the ozone layer from destruction caused by the release of CFCs led to the adoption of the Montreal Protocol (MP) in 1989. The urgent need to phase-out ODS like CFCs in RAC equipment led to fast paced developments in the industry towards alternative refrigerants. New refrigerants seen as replacements to existing ODS refrigerants required new skills and know-how which was supported primarily under the MP regime through activities designed for skilling of technicians. The RAC industry has made tremendous developments since the 1980s as the global demand for cooling has been increasing manifolds and is expected to keep rising as our climate becomes warmer. The number and types of refrigerants available have also increased exponentially. The cooling equipment designs have changed based on the cooling requirements and added to these is the need to address GWP emissions resulting directly from refrigerant release/leaks and indirectly through energy consumption. With all these developments, the technicians handling the equipment, installing, repairing and maintaining it, are required to have knowledge and skills to meet these ever-changing requirements. Refrigerants have differing characteristics of toxicity, flammability, high working pressure, and varied GWP values, all requiring to be handled appropriately to ensure safety and protection of the environment. Systems are getting more complicated both electronically and in the features they contain and tasks they perform. The successful functioning of these cooling equipment needs suitably skilled technicians who are the backbone of the cooling industry across the globe. The RAC technicians must be able to install, service, repair and maintain a wide range of RAC equipment. Capacity building and skilling of these RAC technicians is a prerequisite for a safe and efficient working of the cooling sector overtime.

The emphasis on skilling of RAC technicians has taken centre stage as part of a holistic approach to the RAC sector. A skilled RAC technician base available in a country has multiple advantages. Well trained technicians are a huge benefit for the RAC industry by ensuring the equipment is well maintained overtime and thus contributing to improved brand value. For the consumers, trained technicians provide safety and reduces costs. For the government/country GHG emissions are reduced when RAC equipment is well maintained. For the RAC technicians themselves, being better skilled increases their safety as well as leads to improved incomes associated with enhanced skills.

The following section provides a list of characteristics that support countries to determine their overall status with respect to the capacity building initiatives for RAC technicians that are ongoing in the country as well as provide a benchmark to what a country can aim towards for skilling of its RAC technicians. Ideally, countries would include all these features; however, it is likely that a combination of characteristics are to be adopted by a country rather than all. The country would then be best placed to decide how to weight the existing status and what additional measures can be adopted overtime to have a truly progressive and ambitious path to achieve the desired goals in the RAC sector.

Actions funded under the HCFC Phase-out Management Plans (HPMPs) of the MP and under the Kigali Implementation Plans (KIPs) are considered as low ambition, as they do not require extra effort and are usually not designed to formalise RAC technician training.

All 197 countries of the UN have ratified the MP. Integral to the MP and its funding mechanism for developing countries, the MLF, is the need for training of RAC technicians. The concept of "incremental cost" in phasing-out ODS, is the fundamental eligibility criteria for funding under the MLF. That means that funding is provided covering the extra cost that is induced from using alternative substances. Thus, the objective of these trainings, conducted under the auspices of the MLF, is primarily to prepare the working technician base in a country, to deal specifically with the phasing-out of ODS refrigerants as mandated under the MP and its amendments. All countries have undertaken such trainings since the time they have ratified the MP. However, the starting point is very divers. Some countries may not have been able to formalise the RAC technician capacity building. This could be due to political strife, armed conflict, or instability that prevents concerted efforts towards establishing a capacity building regime that is stable and continuous. Instead, training is an ad hoc exercise done to meet project objectives. Such ad hoc training usually has the following characteristics:

- Might include a Train the Trainer (TOT) approach, where trainers are provided appropriate training in compliance with the MLF requirements;
- These trainers then conduct national training for mostly already working technicians (duration ranging from 2-5 days);
- The content of these trainings would be limited to the requirements of phasing-out ODS and the alternatives that could be utilised as replacement;
- The course content is not formally incorporated into the official curriculum of local institutes that might teach RAC courses as a standalone subject or as part of an electrical course. Trainings are therefore conducted so as to meet specific milestones (number of technicians trained) within approved projects under the MLF;
- "Learning on the job" is the main engine driving skill development in the RAC sector as formal training is not mandated or required.

1. Introduction of technicians' training

Policy instrument	Ambition level		
	Group A	Group B	Group C
Introduction of technicians' trainings to reduce leakage rates and familiarise with flammable/high pressure/toxic refrigerants	Medium	Medium	Medium

Source: authors

There is general acceptance that the MP through the MLF has encouraged increased capacity building of RAC technicians in all countries. However, the form of these RAC trainings varies from county to country based on efforts made by the countries to specifically address the needs of the domestic RAC industry and to a certain degree align with the global trends in the RAC sector. The approach adopted to capacity building follows a systematic approach that is guided by existing frameworks and structures that already exist related to skills and capacity building for technical fields. It is expected that the majority of developing countries have several elements that characterize a systematic approach in place:

- TOTs are more comprehensive, larger in scope and are covering aspects that go beyond immediate requirements of MLF relating to simple phasing-out ODS. TOTs extend to local industry needs and incorporates global cues on future developments expected or ongoing in the RAC sector.
- Existence of a formal curriculum development procedure in place. It may have a systematic timeframe for update and review of the curriculum or be dependent on demand.
- Some effort is made to update the existing RAC curriculum in local training institutes to include the relevant identified components especially related to "Best practice Training" in RAC servicing and maintenance. These "Best practice Trainings" would include topics such as methods of leak testing, using nitrogen for flushing, recovery, reuse and recycling of refrigerants and basic information on natural refrigerants like hydrocarbons, CO_2 and ammonia and their applications are incorporated into the training course.
- Short courses for working technicians spanning 2-5 days would be conducted under the MLF projects and "certificate of participation" awarded to all participants.
- There is a framework for some form of interaction between the RAC industry and the NOU to ensure a collaborative approach to capacity building of technicians. This could be the existence of a RAC association, or a steering committee especially established to address the activities conducted under the MLF.
- Adoption of international standards like ISO 5149 – Refrigerating systems and heat pumps – Safety and Environmental requirements. However, the implementation and enforcement of these standards is not mandatory.

2. Introduction of a national system for qualification, certification and registration (QCR)

Policy instrument	Ambition level		
	Group A	Group B	Group C
Introduction of qualification, certification and registration (QCR) system including skills development for flammable/high pressure/toxic refrigerants (natural refrigerants)	High	High	High

Source: authors

As of now, around 130 countries have already ratified the KA demonstrating that they are committed to opt for climate friendly refrigerants. Countries that already have in place some framework conditions (established regime for standards and norms) can more easily and effectively move towards establishing a capacity building framework that is recognised as "state of the art" for skilling of manpower in the country. The value of a well thought out and properly executed training, has wide ranging benefits for the RAC industry as well as for the environment as indicated in the beginning of this chapter.

The European standard EN 13313:2010 "Refrigerating systems and Heat pumps – Competence of Personnel" is one of the foremost standards that provides a guideline on how capacity building and skill testing of RAC technicians need to be developed by countries in order to reduce refrigerant leakages, maintain safety and minimise environmental impacts. The standard sets out associated competency profiles and establishes procedures for assessing the competence of persons who carry out work related to installation, maintenance, servicing and operation of RAC systems. GIZ Proklima, Germany's programme to provide support to countries to advance their RAC sector transformation, has been a frontrunner in championing the use of natural refrigerants and high energy efficiency in the RAC sector through the concept of "Green Cooling". To support this effort, GIZ Proklima has developed a comprehensive Qualification, Certification and Registration (QCR) scheme to address the capacity needs of the RAC sector called "Fit for Green Cooling".[17]

The QCR scheme refers specifically to the following:

- **Qualification** refers to training of personnel that is based on providing specific competencies in line with the tasks expected to be completed and the personnel's respective level of qualification. Proper qualification will ensure that the environmental and health related risks are minimised, energy efficiency is increased and a future oriented workforce is created.

- **Certification** is the means by which the acquired knowledge can be measured. All persons who demonstrate their practical (skills) and theoretical (knowledge) competence by being successfully assessed by an approved Certifying Body would receive a certificate of competence.

- **Registration** is the formal record maintained by a central authority of all RAC technicians and their acquired certification status.

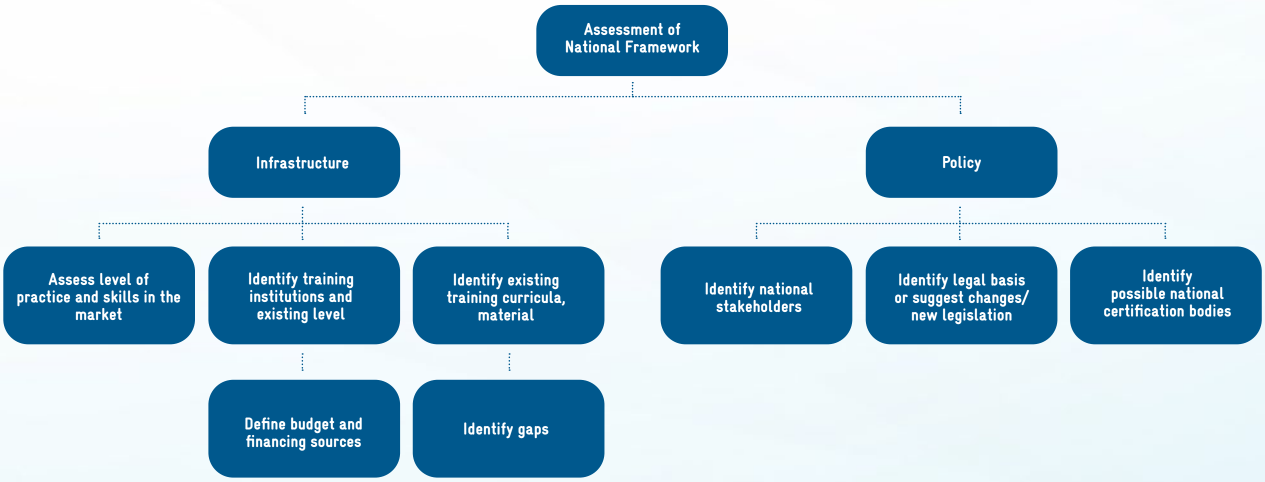
17 https://www.green-cooling-initiative.org/green-cooling/fit-for-green-cooling

The "Fit for Green Cooling" scheme is designed based on the provisions of the EN13313 – 2010, EN 378, ISO 5159, EN50110, ISO 13585 as well as European F-gas regulations and a slew of standards from industry bodies like ASHRAE, AHRI etc.

For a country to embark on a QCR scheme, it will require to establish the appropriate framework conditions. Even though QCR has established steps, it provides flexibility to countries to adapt the components of the QCR to their existing national capacity building frameworks.

- At the on-start, a thorough assessment of the current status related to existing infrastructure, policy/regulations, curricula for the training of RAC technicians would be required as shown in Figure 14.

Figure 14: Assesment for establishing a QCR scheme



Source: authors

- Following the identification of the gaps, the next step would be to address the gaps and establish the appropriate basis to implement the QCR scheme successfully. This would include ensuring suitable infrastructure for training institutions to conduct suitable hands-on training, updating curricula, TOT to ensure their ability to conduct the trainings as per the new curriculum. For example, GIZ Proklima has developed 14 extensively detailed training modules that capture the details of all necessary components of the refrigeration, air conditioning and heat pump (RACHP) curriculum. It includes the detailed content of the topics to be taught, teaching aids for the trainers in line with the content (i.e., Power Points, handouts etc.), as well as the assessment criteria that need to be evaluated to determine competency and knowledge gained.

- The certification component of the QCR scheme will require that a suitable qualification framework is developed and agreed on with the responsible authorities in the country. The qualification framework lays out the different levels of competencies, the prerequisite requirements to be met to be eligible for a specific qualification level, and the authorities responsible for competency testing. Below is an example of Kenya's Qualification Framework for technical education which is also applied to the RACHP courses in the country.

- The technicians that achieve certification through the competency assessments will be registered with their details at a central authority that maintains the registry of names. An associated accreditation system would be established which would ideally be in a form of a licensing scheme for each and every person working in the RACHP space based on their competency level.

- The QCR scheme can only be successful if there is an inbuilt procedure in place that includes the provision of a periodic review/revision of the qualifications offered under the QCR scheme.

- To ensure that capacity building remains dynamic and up to date, the QCR scheme must also include the requirement of RAC technician license renewal after a specific number of years. Four to five years is considered ideal as a duration of validity for the RAC technician license. This ensures that the technicians on the ground are always up to date with the developments taking place in this fast-changing sector.

Country case: Kenya

The Kenya National Qualification Framework (KNQF) has been adopted with the vision to establish a single harmonised system for the development, assessment and award of qualification. It includes all educational and training sectors with its different forms of learning. The KNQF establishes criteria across qualifications that relate to accreditation, quality assurance and examination systems and is aligned to national standards and international best practice. The KNQF levels consist of detailed level descriptions which are based on knowledge, skills and competencies.

A Kenyan student has two paths to acquire qualification - academic or vocational. The first 2 levels in the KNQF relate to basic education, Level 3- 6 refer to the vocational or the technical and vocational training and education (TVET) system while Level 7 and higher relate to university qualification.

Kenya National Qualification Framework[18]

KNQF Level	General and Further Education an Training Sub-Framework		Notional hours (minimum)
10	Doctorate Degree		3600 after KNQA level 9
9	Master's degree		2400 after KNQA level 7
8	Post-Graduate Diploma Professional Bachelor's Degree	Professional Master Craft Person	1200 after KNQA level 7 or 6000 after KNQA level 2
7	Bachelors's Degree	Master Crafts Person -I or Management Professional	4800 after KNQA level 2 or 2400 after KNQA level 6
6	National Diploma	Master Crafts Person -II or Management Professional	2400 after KNQA level 2 or 1200 after KNQA level 5
5	Craft Certificate National Certificate National Vocational Certificate -IV	Professional Certificate or Master Craft Person III	1200 after KNQA level 2 or 600 after KNQA level 4
4	National Vocational Certificate -III/Artisan Certificate	National Skills Certificate -I GTT-I	600 after KNQA level 2 or 300 after KNQA level 3
3	National Vocational Certificate -II	National Skills Certificate -II GTT-II	300 after KNQA level 2
2	Secondary Certificate National Vocational Certificate -I	National Skills Certificate -III / Government Trade Test GTT-III	Primary Education level 1
1	Primary Certificate	Basic Skills/Skills for Life	Birth Certificate

The KNQF is viewed as an important step as it also establishes standards for recognition of qualifications acquired within Kenya and outside. Facilitating the comparison between different levels and types of qualifications, enables employers to clearly benchmark the level of competency of a prospective employee. A standardized system of qualification supports the increased mobility of students and workers.

The Kenya Qualification Authority (KNQA) has been set up primarily to operationalse the KNQF and ensure its adherence. As part of its mandate KNQA is responsible for accrediting all institutions and their curriculums in accordance to the KNQF, among other tasks. Overall, the KNQF can be seen as a promising step towards building confidence in Kenyan qualifications.

Vocational training to become a RAC technician can be started after the completion of the 10th school year, through the National Vocational Certificate 1 and progressively move to higher qualifications. While the Vocational Training certificates are for long term courses, the National Skills Certification are essentially aligned to assessments that are conducted at designated institutions at specific times of the year. Testing of prior learning, which is especially relevant to the RAC sector, is assessed under the Government Trade Tests (I – III) which entitles the successfully graduating technician to receive a National Skills Certificate. There are currently three accredited qualification bodies relevant

18 https://www.knqa.go.ke/index.php/about-the-qualification-framework/

to the RAC sector: the Curriculum Development Assessment and Certificate and Council (CDACC/TVET), the National Industrial Training Authority (NITA) and Kenya National Examination Council (KNEC). The curricula of these RAC qualification bodies are currently being upgraded for standardization across the different bodies. After the upgrade of the RAC curriculum, the new curriculum will require registration under the KNQA to enable the roll out of the courses in line with the KNQF levels. Appropriate teaching aids and assessment criteria are to be provided to institutions and trainers who are appropriately skilled to conduct the upgraded curriculum. The time frame for the updated curriculum to be operational is mid 2023/early 2024, when Kenya would be conducting state of the art RAC training courses across institutions in the country.

F. Regulatory instruments to manage end-of-life treatment of refrigerants (and appliances)

The set-up of sufficient collection infrastructure for waste equipment (domestic refrigerators and freezers, room ACs and commercial stand-alone equipment such as island freezers, bottle coolers, etc.) as well as used refrigerants for reclamation or destruction is a large venture for all countries. As both are important, but require different partners and logistics, the measures are separated for the two types of waste.

The roadmap for ODS and HFC bank management offers detailed guidance and details four core processes that need to be worked on:

1) Regulations
2) Sustainable financing
3) Collection infrastructure
4) Destruction/Reclamation

In the following, the recommended measures are outlined in terms of their coverage. For details regarding their implementation, the reader is referred to the roadmap and guidelines on ODS banks.

Recommendation for further reading:

- Climate and Ozone Protection Alliance (COPA), https://www.copalliance.org/
- GIZ (2018). Papst, I.: Global banks of ozone depleting substances. A country level estimate, https://www.green-cooling-initiative.org/fileadmin/Publications/2018_Global_banks_of_ozone_depleting_substances.pdf
- GIZ (2017). Heubes, J., Gloel, J., Papst, I.: Global roadmap on ODS bank management, https://www.green-cooling-initiative.org/fileadmin/Publications/2017_Global_roadmap_on_ODS_bank_management.pdf
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- GIZ (2017). v. Heinemann, S., Beckmann, J., Heubes, J.: Guideline to establish a collection system for equipment containing ODS, https://www.green-cooling-initiative.org/fileadmin/Publications/2017_Guideline_to_establish_a_collection_system_for_equipment_containing_ODS.pdf
- GIZ (2017). Gloel, J.: Guideline for the transboundary movement of ODS waste, https://www.green-cooling-initiative.org/fileadmin/Publications/2017_Guideline_for_the_transboundary_movement_of_ODS_waste.pdf

1. Establishment of refrigerant collection system incl. proper treatment for pilot regions (urban/metropole areas)

Policy instrument	Ambition level		
	Group A	Group B	Group C
Establishment of refrigerant collection system incl. proper treatment for pilot regions (urban/metropole areas)	Medium	Medium	Medium

Source: authors

Apart from financial resources it is often the network density of collection centers that poses a challenge. Therefore, the suggested medium ambition measure is to pilot a metropole region, where the activity density is high and collection amounts are maximised. At the same time, organisational structures can be tested for a later roll-out.

2. Establishment of waste appliance collection system incl. proper treatment for pilot regions (urban/metropole areas)

Policy instrument	Ambition level		
	Group A	Group B	Group C
Establishment of waste appliance collection system incl. proper treatment for pilot regions (urban/metropole areas)	Medium	Medium	Medium

Source: authors

The collection of old refrigeration appliances is often in the responsibility of the municipalities as part of collection activities on Waste electric and electronic equipment (WEEE). Old refrigeration appliances are one category of WEEE and require precautions to prevent HFC emissions. One challenge is to collect the appliances with intact refrigeration cycle, so the HFC can be recovered at the collection center. This often requires the inclusion of the informal sector to prevent waste pickers from taking out the compressor as scrap metal, but to deliver the whole refrigerator to collection centers. The set up can again be tested in a metropole region before a larger roll-out.

3. Collection points for refrigerants and routines for proper treatment, including reverse logistics (take-back schemes for importing countries)

Policy instrument	Ambition level		
	Group A	Group B	Group C
Collection points for refrigerants and routines for proper treatment, including reverse logistics (take-back schemes for importing countries)	High	High	High

Source: authors

The logistics that are set up for the distribution of refrigerants, from importer to wholesaler to end-user is an important building block to also collect the refrigerant from end-user to wholesaler to exporter (or reclaimer/destructor). On the basis of a respective regulation, the gas container logistic is best put on those that have already experience with it and who do have already a functioning distribution network.

Ultimately, a sustainable financing scheme needs to be established. The most logical approach is the polluter pays principle. For refrigerant importing countries, a meaningful approach is to put an import tax on HFCs. Using a GWP-weighted approach has an additional guidance function for the market. The import tax could also form a part of the rebate scheme to incentivise recovery, where a fraction of the paid tax is returned upon delivery of used refrigerant to designated collection points. Further information on financial instruments can be found in section → B Financial instruments to reduce HFC consumption.

This regulatory approach is taken by several European countries. Sufficient testing capacities are required when implemented as rebate scheme.

4. Collection points for waste appliances and routines for proper treatment

Policy instrument	Ambition level		
	Group A	Group B	Group C
Collection points for waste appliances and routines for proper treatment	High	High	High

Source: authors

The recycling of WEEE is a necessity to move towards a circular economy. HFC-containing appliances are just one category of WEEE but require special treatment to prevent the refrigerant and foam blowing agents from emitting. Fully integrated and automated recycling plants for refrigerators, where shredding of the corpus happens in a closed system and is integrated with HFC recovery, are often out of reach. However, proper refrigerant recovery is less resource intensive and is the important first step, regardless of the treatment of the refrigerator corpus. Manual dismantling of the refrigerator corpus cannot be recommended unconditionally but has environmental benefits if done by properly trained and equipped staff.

5. Sufficient collection and recycling capacity, financed by EPR scheme

Policy instrument	Ambition level		
	Group A	Group B	Group C
Sufficient collection and recycling capacity, financed by EPR scheme	NA	NA	High

Source: authors

The management of end-of-life refrigerants and waste refrigeration appliances with full capacity and fully financed is certainly highly ambitious. However, given the large environmental benefits of such action, it is imperative to pursue this goal. EPR for equipment manufacturers as well as gas producers are important buildings blocks for such a system.

G Tracking and MRV of HFC consumption and emissions

1. Tier 1 emissions reporting of HFCs

Policy instrument	Ambition level		
	Group A	Group B	Group C
Tier 1 emissions reporting of HFCs	Medium	Medium	Medium

Source: authors

A MRV system enables countries to strengthen their information basis to track their mitigation actions for national planning, implementation, and coordination. If not yet included in a country's monitoring and reporting efforts, a Tier 1 level approach could be a starting point to track and report HFC emissions. As already mentioned under Step 5, a Tier 1 methodology follows a top-down approach looking at the RAC sector as a whole with no further disaggregation into different sub-sectors. Key parameter is the bulk consumption of refrigerants at the national level, combined with a default emission factor. It therefore provides little insight into the specific characteristics of the cooling sector and no further data on sub-application distribution of equipment.

2. Tier 2 emissions reporting of HFCs

Policy instrument	Ambition level		
	Group A	Group B	Group C
Tier 2 emissions reporting of HFCs	High	High	High

Source: authors

The Tier 2 approach goes into more detail when calculating emissions. In the cooling sector, this approach often implies to quantify the installed equipment (stock) using HFCs to derive demand and emissions. By counting stock appliances per sub-sector and assessing the respective refrigerant use, default emission factors can be adjusted to country-specific values. Hence, it provides more accurate and detailed information on the actual RAC sector characteristics found in the national context and therefore allows for a targeted approach to tackle most relevant sub-sectors in terms of HFC emissions. A continuous monitoring scheme could make use of different approaches to track key parameters for distinct sub-applications. For instance, mass or standardised products such as domestic refrigerators, room ACs or commercial stand-alone units, can be monitored by counting sales via a product database and estimation of the stock through the use of statistical data. For custom-made products, e.g., industrial centralized systems or chillers, the stock can be estimated in a similar way via a statistical approach or counted via an operator registration system (GIZ 2021b).

Table 24: Overview on standardised and custom-made applications

Standardised products (preferably in product registration database)	Custom-made products (preferably via operator registration)
Commercial and stand-alone units (e.g., bottle coolers, ice-cream cabinets)	Commercial condensing units (e.g., cold rooms) Centralised supermarket systems
Refrigerators and freezers	Industrial integral systems Industrial condensing units Industrial centralised systems
Refrigerated trucks	Refrigerated trucks
ACs in cars	ACs in larger vehicles
Self-contained (portable) ACs (Single) split ACs	Ducted ACs Rooftop (packaged) systems Multi-split and variable refrigerant flow (VRF) systems Chiller

Source: GIZ 2021b

Recommendation for further reading:

- GIZ (2021b). Kotin-Förster, S., Gloel, J., Papst, I., Oppelt D.: Measurement, Reporting & Verification (MRV) in Practice, https://www.green-cooling-initiative.org/fileadmin/Publications/GIZ2021_Measurement_Reporting_Verification_MRV_Handbook.pdf

3. Sub-sector specific indicators defined and tracked

Policy instrument	Ambition level		
	Group A	Group B	Group C
Sub-sector specific indicators defined and tracked	High	High	High

Source: authors

Obtaining more granular data on HFC uses and emissions can be achieved by defining and tracking sub-sector specific indicators. For example, product databases as mentioned in the previous sub-chapter, can be used to request further information on appliance specific parameters, such as refrigerant used, initial refrigerant charge, cooling capacity, lifetime, price, etc. It has the advantage that energy-side characteristics can also be queried, such as the energy efficiency ratio or the SEER. This would require a mandatory registration for manufacturers and importers of the appliances that are intended for sale in the country. Upon initial registration, the number of units sold needs to be reported annually. Other crucial factors, such as emission factors during manufacturing/first fill of appliances, servicing and end-of-life can be obtained by involving relevant stakeholders including representatives from the NOU, from the Association of RAC technicians, and equipment manufacturers among others (GIZ 2021b).

Best practice example: South Korea

In South Korea, importers and manufacturers are obliged to annually report on sales units. The database thereby combines information on the manufacturer, the model name, the cooling capacity, the seasonal efficiency and the refrigerant as well as RAC sales (Ministry of Knowledge Economy 2011).

4. Reporting requirement for refrigerant users

Policy instrument	Ambition level		
	Group A	Group B	Group C
Reporting requirement for refrigerant users	High	High	High

Source: authors

Especially the tracking of sub-sector and equipment specific use of HFC refrigerants poses a challenge. One solution to overcome this barrier is to adopt reporting requirements for refrigerant users, e.g., through mandatory tracking and recording of each use of HFC refrigerants (e.g., import, export or manufacturing). This should include detailed information on the refrigerant type, quantity and purpose of use. The most sophisticated and efficient approach is to have an electronic system where data is automatically processed and reported. This approach allows to have a bottom-up approach to track HFC use which can be cross-checked and validated through monitoring of HFC imports at the aggregate level.

Best practice example: Slovakia

Certified companies are listed in an online registry according to their category of activity (stationary and mobile AC, refrigeration, solvents, SF6, etc.). The system offers electronic logging, reporting and data processing. Data are reported on www.szchkt.org, www.cochkt.sk, where data is summarised and statistics are generated according to the need of IPCC 2006 (Area n.d.).

II. Policy instruments to address energy related emissions

There is a lot of material available on the promotion of appliance energy efficiency in general and on efficient cooling equipment in particular. We especially reference to the model regulation and background documents elaborated by U4E, who published information on several refrigeration appliances: Domestic refrigerators and freezers, room ACs and commercial stand-alone appliances. The model regulations include MEPS level setting as well as proposals for label categories and could be applied on a national level with little adjustments.

We restrict ourselves to describing the measures, please consult the provided links for further information.

A. Regulatory instruments to promote higher energy efficiency of equipment

Extensive work has been done by U4E on this issue. Thus, the interested reader is referred to their reports.

Recommendation for further reading:

- United for Efficiency (2019). Model Regulation Guidelines, Energy-Efficient and Climate Friendly Air Conditioners, https://united4efficiency.org/wp-content/uploads/2021/11/U4E_AC_Model-Regulation_EN_2021-11-08.pdf
- United for Efficiency (2019). Supporting Information on the Model Regulation Guidelines for Energy-Efficient and Climate-Friendly Air Conditioners, https://united4efficiency.org/wp-content/uploads/2020/05/U4E_AC_Model-Reg-Supporting-Info_20200227.pdf
- United for Efficiency (2019). Model Regulation Guidelines for Energy-Efficient and Climate Friendly Refrigerating Appliances, https://united4efficiency.org/wp-content/uploads/2019/11/U4E_Refrigerators_Model-Regulation_20191029.pdf
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- United for Efficiency (2021). Model Regulation Guidelines for Energy-Efficient and Climate-Friendly Commercial Refrigeration Equipment, https://united4efficiency.org/wp-content/uploads/2021/11/U4E_CommercialRefrig_ModelRegulation_20211109.pdf
- United for Efficiency (2021). Supporting Information on the Model Regulation Guidelines for Energy-Efficient and Climate-Friendly Commercial Refrigeration Equipment, https://united4efficiency.org/wp-content/uploads/2021/11/U4E_CommercialRefrig_Supporting-Info_20211109.pdf

1. Introduce awareness programmes to encourage consumers to choose energy-efficient products and services

Policy instrument	Ambition level		
	Group A	Group B	Group C
Introduce awareness programmes to encourage consumers to choose energy-efficient products and services	Medium	Medium	Medium

Source: authors

As consumers are those who take the investment decision, they need to be aware of their choices and the consequences. Most required are life cycle cost assessments comparing investment cost with operating cost, e.g., as web-based information source. Also, staff at shops that sell appliances need to be aware of the issue to offer qualified guidance to customers.

2. Support training and skills development of RAC technicians to ensure proper maintenance of equipment to maintain energy efficiency

Policy instrument	Ambition level		
	Group A	Group B	Group C
Support training and skills development of RAC technicians to ensure proper maintenance of equipment to maintain energy efficiency	Medium	Medium	Medium

Source: authors

This measure links to the QCR concept described in above and puts specific emphasis on maintenance for energy efficiency. Activities include regular filter cleaning as well as ensuring proper refrigerant charges by regular checks and can also encompass advice for efficient temperature setting and system control.

3. Introduction of MEPS that are at least 10% lower than U4E thresholds

Policy instrument	Ambition level		
	Group A	Group B	Group C
Introduction of MEPS that are at least 10% lower than U4E thresholds	Medium	Medium	Medium

Source: authors

It is acknowledged that the proposed MEPS threshold by U4E, although well justified with the trends for minimum performance standards within the appliance exporting countries, is very ambitious for many countries. Therefore, the medium ambition measure is proposed to target a MEPS level somewhat lower than the one proposed by U4E. However, this should only be seen as an intermediate target on the way to adopt highly ambitious MEPS.

4. MEPS based on seasonal energy efficiency (SEER or CSPF) for AC appliances

Policy instrument	Ambition level		
	Group A	Group B	Group C
MEPS based on seasonal energy efficiency (SEER or CSPF) or AC appliances	Medium	Medium	Medium

Source: authors

The issue with the choice of the metric for the MEPS is the consideration of part-load performance. Traditionally, AC appliances only had an on/off switch, making it either run at full speed or being switched off. The introduction of inverter type technology enables the compressor to modulate the compressor speed to the actual cooling needs thereby avoiding frequent energy-intensive on/off cycles. However, as long as MEPS are determined using only the energy efficiency at a defined maximum ambient temperature, the efficient inverter type ACs are penalised. U4E's model regulation propose using ISO 16358 as reference for testing and calculation of the CSPF.

5. Commitment of local manufacturers to comply with high EE requirements and change to natural refrigerants

Policy instrument	Ambition level		
	Group A	Group B	Group C
Commitment of local manufacturers to comply with high EE requirements and change to natural refrigerants	NA	NA	Medium

Source: authors

For countries in Group C that have national manufacturing capacities of refrigeration and AC appliances, it is important to ensure that those manufacturers can compete with rising requirements regarding energy efficiency, and also adapt to the HFC phase-down as early as possible. As changes in the design and subsequently in the manufacturing process are time-consuming, including both energy efficiency and switch to natural refrigerants at the same time is advisable.

6. Ban on import of second-hand appliances

Policy instrument	Ambition level		
	Group A	Group B	Group C
Ban on import of second-hand appliances	Medium	Medium	Medium

Source: authors

As second-hand equipment is usually not efficient, it is not advisable to allow its import. In addition, the declaration as second-hand items is often misused to import electronic waste. Banning the import of second-hand equipment makes it consequently easier to stop import of electronic waste.

7. Green public procurement limited to appliances at medium efficiency U4E performance levels

Policy instrument	Ambition level		
	Group A	Group B	Group C
Green public procurement limited to appliances at medium efficiency U4E performance levels	Medium	Medium	Medium

Source: authors

Green public procurement is often referred to as a pull-measure to stimulate the market to provide highly efficient appliances. As public procurement often requires larger quantities of equipment, it can also help to bring down per unit costs. U4E has published several sustainable public procurements guides[19] and supporting spread-sheets to be used as further guidance.

8. Mandatory energy or eco-label informed by U4E levels, including regular update provision

Policy instrument	Ambition level		
	Group A	Group B	Group C
Mandatory energy or eco-label informed by U4E levels, including regular update provision	Medium	Medium	Medium

Source: authors

19 https://united4efficiency.org/resources/green-public-procurement-technical-guidelines-and-specifications-for-energy-efficient-refrigeration-appliances/, https://united4efficiency.org/resources/green-public-procurement-technical-guidelines-and-specifications-for-energy-efficient-air-conditioners/

Enabling informed consumer choices is best implemented by mandatory labelling. To keep up with technical development, the label categories need to be revised in regular intervals. When newly introducing a label scheme, it is advisable to define label classes even above current best available technology to provide space for the market to develop, as this was done with the recent EU energy label revision.

For energy labels to be effective, they need to be ambitious to show the difference between low and high efficiency appliances. Therefore, the efficiency classes as recommended by U4E are used as guidance for ambitious design of energy classes.

9. MEPS at U4E medium efficiency grade by 2025

Policy instrument	Ambition level		
	Group A	Group B	Group C
MEPS at U4E medium efficiency grade by 2025	High	High	High

Source: authors

As energy efficiency improves over time, it is important that MEPS follow this development. Ideally, a laddered approach sets future MEPS levels already today, so the market has time for transition. As high ambition, the current medium level can be set as minimum in future strengthening steps, i.e., in 2025.

10. Green public procurement to promote the availability of highly efficient equipment using natural refrigerants

Policy instrument	Ambition level		
	Group A	Group B	Group C
Green public procurement to promote the availability of highly efficient equipment using natural refrigerants	High	High	High

Source: authors

In addition to the medium ambition measure on energy efficiency, this high ambition measure also requires the refrigerant to be a natural one, i.e., R290, R600a, R744, R717, etc. As availability in some equipment categories is still a challenge, this is considered as high ambition.

11. Regulation/requirement for local manufacturers to comply with high EE requirements

Policy instrument	Ambition level		
	Group A	Group B	Group C
Regulation/requirement for local manufacturers to comply with high EE requirements	NA	NA	High

Source: authors

For countries that have national manufacturers of appliances, it is important to enable them to keep up with international developments and comply with strengthening requirements. To promote national manufacturing to not only keep up, but to offer high-efficiency equipment is considered highly ambitious. This could also be an economic advantage, potentially opening export markets for highly efficiency appliances.

B. Enforcement of energy efficiency regulation

1. Conformity confirmation of equipment

Policy instrument	Ambition level		
	Group A	Group B	Group C
Ad hoc conformity confirmation (spot/verification testing) of equipment to ensure products' compliance	Medium	Medium	Medium
Regular conformity confirmation (spot/verification testing) of equipment to ensure products' compliance, including levying of penalties in case of non-compliance	High	High	High

Source: authors

Conformity confirmation of equipment refers to steps that shall be followed by suppliers and other relevant stakeholders to ensure that products adhere to energy efficiency requirements before being placed in the market. These requirements must be specified for each regulated product and should be included in a valid legislation. A clear and feasible conformity confirmation procedure includes instructions to suppliers and provides clear and practical requirements. The implementation of unrealistic or unreasonable requirements increases the risk of non-compliance even when market stakeholders aim to follow the relevant legislation (U4E 2021b).

Within the procedure for conformity confirmation, some additional processes such as conformity verification can be undertaken to verify that products already placed on the market conform to the most relevant regulatory requirements. This process is useful to avoid that some suppliers introduce products that are not in order with such requirements, ultimately ensuring the intended impact of the energy efficiency regulations. The steps related to the conformity verification include documentation inspection, visual inspections, in-store and online inspections, verification testing, costs of verification activities, and risk screening (U4E 2021b).

Documentation inspection is directed to the review of documents in a product registration system (refer to Annex II.B.2). In the case that a product registration system is not in place, the party placing the product shall provide the documentation, such as a model identification code and brand, a list of equivalent products, technical characteristics including energy consumption, energy performance test reports, details of the refrigerant and blowing agent, among others, to a Market Surveillance Authority (MSA).

The visual inspection performed by the MSA is meant to check if the product is consistent with regulation requirements and to determine whether a further verification assessment is required. This can occur in the case that the product reveals defectiveness or technical mismatches.

In-store and online store inspections are meant to check that energy labels are displayed in a proper manner at selling points and to check that the information of the products is accurate with the label category.

The verification testing is a crucial step to determine a product´s compliance and must be varied out by an impartial laboratory operating under contract. This step allows to identify products that have a risk of non-compliance. Cost of verification activities relates to the actions that the MSA can implement to ensure that verification testing is carried on along with the provision of the costs related to it. U4E revealed the laboratory and operational costs of carrying out the verification testing for domestic refrigerators:

Table 25: Laboratory and operational costs of verification testing for domestic refrigerators

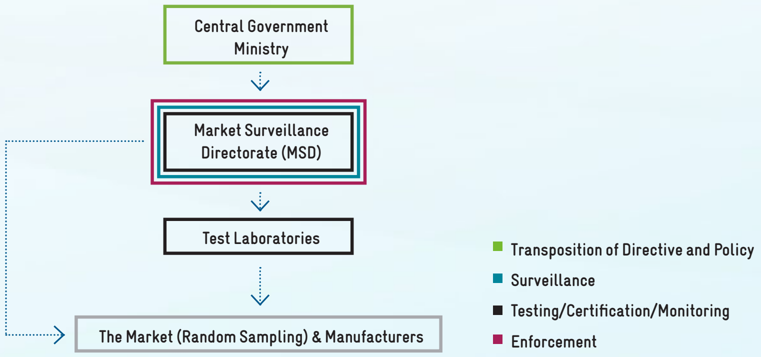
Expensive Category	Low Estimate (USD)	High Estimate (USD)	Description
Capital Costs			
Refrigerator-specific equipment	$252,000	$602,000	Test chamber for multiple units, air handling system, chiller, control and measurement equipment, test loads and conditioning, software.
Generic equipment (usually pre-owned)	$3,000	$5,000	Voltage stabilizer, ambient temperature controls, meters and sensors.
Accreditation	$5,000		To ISO 17025
Inter-laboratory trials	$5,000		For calibrating proficiency
Operational Costs			
Staffing	2		Minimum number of trained technicians
Space	$50m^2$		Minimum space requirements
Equipment calibration and maintenance	$2,000		Estimated annual costs
Capacity building, staff training, laboratory re-accreditation, re-certification	$2,000		Estimated annual costs

Source: U4E 2021b

Risk screening refers to supporting strategies that allow the verification actions and processes to achieve the maximum compliance under the budget available for such purposes. One action within this step is to target and test products that have a higher risk of non-compliance rather than testing all products to be released in the market (U4E 2021b).

An example of the implementation and enforcement of MEPS is demonstrated by study on energy efficiency regulation for energy-consuming equipment in Europe developed by Navigant Consulting Europe. According to the study, the average institutional arrangement for energy labelling and Eco-design Directives is as follows (Waide et al. 2021):

Figure 15: Typical Institutional Arrangement for MV&E Activities under the Energy Labelling and Ecodesign Directives



Source: Waide et al. 2021

Key barriers to improving compliance by Member States in the application of these strategies are inadequate funding and capacity of the institutions responsible for carrying out monitoring, verification, and enforcement activities; weak penalties for non-compliance; lack of transparency related to compliance activities; and lack of awareness among consumers (which is accepted by manufacturers and retailers since this would reduce the possibility of them being “shamed” publicly (Waide et al. 2021).

2. Product registration system to implement and monitor the MEPS

Policy instrument	Ambition level		
	Group A	Group B	Group C
Product registration system to implement and monitor the MEPS (incl. EE and refrigerant info of imported appliances) including levying of penalties in case of non-compliance	High	High	High

Source: authors

As explained under section I.G. Tracking and MRV of HFC use and emissions, product registration system serve to track the import and sale of cooling equipment (mainly mass products such as domestic refrigerators, room ACs and commercial cooling equipment). The requirement to indicate EER and SEER supports the monitoring of energy efficiency performance of the equipment which is brought to the market and helps to implement and enforce existing energy efficiency regulations (MEPS). In case of non-compliance with the MEPS, it is recommendable to levy penalties in order to strengthen enforcement.

C. Financial instruments to support higher energy efficiency of equipment

1. Electricity tax

Policy instrument	Ambition level		
	Group A	Group B	Group C
Electricity tax <20% of electricity price	Medium	Medium	Medium
Electricity tax >20% of electricity price	High	High	High

Source: authors

Electricity taxes are a steering instrument that helps to manage demand. The higher the tax, the greater the incentive to switch to energy-efficient appliances. This is of course applicable to a wide range of electrical appliances. But especially in countries where space cooling accounts for a large part of the monthly or annual electricity bill, such a tax can be an effective tool to reduce electricity consumption through more efficient appliances. Depending on the level of tax compared to the electricity price, the measure can be classified as medium (<20% of electricity price) or high ambition (>20% of electricity price).

2. Financial incentive (e.g., rebates, loans, on-bill financing schemes, new for old exchange programmes, etc.)

Policy instrument	Ambition level		
	Group A	Group B	Group C
Financial incentive (e.g., rebates, loans, on-bill financing schemes, new for old exchange programmes, etc.), <20% of equipment cost, to promote the purchase of highly efficient RAC equipment	Medium	Medium	Medium
Financial incentive (e.g., rebates, loans, on-bill financing schemes, new for old exchange programmes, etc.), >20% of equipment cost, to promote the purchase of highly efficient RAC equipment	High	High	High

Source: authors

Another option to encourage or accelerate the switch to energy-efficient appliances is to offer financial incentives, such as subsidies or loans with more favourable conditions (e.g., very low interest rates). Such measures help to overcome the cost barrier that exists in most cases of highly energy-efficient RAC equipment. By providing financial incentives that lower the price of the appliance, up-front investment cost and consequently payback periods can be significantly reduced. There are a variety of ways to design such financial incentives. These include, but are not limited to:

- Subsidies
- Rebates
- Loans
- On-bill or on-wage financing schemes
- New for old exchange programmes

The higher the financial support, the more ambitious the mitigation measure may be.

3. Subsidy of R&D programme to develop higher-performance technology solutions

Policy instrument	Ambition level		
	Group A	Group B	Group C
Subsidy of R&D programme to develop higher-performance technology solutions, <50% of costs	Medium	Medium	Medium
Subsidy of R&D programme to develop higher-performance technology solutions, >50% of costs	High	High	High

Source: authors

In order to support the transition to more energy-efficient appliances also from the supply side, there is the possibility to promote manufacturers through financial support of targeted R&D programmes. Subsidies that are directed at such programmes which aim at developing higher-performance technology solutions can vary, depending on the targeted sub-sector respectively equipment. If more than half of the R&D costs are financially supported, the measure is considered to be highly ambitious.

III. The cooling sector in the international context

Regarding emission reductions generated by the two regimes, the KA and the PA, there are two important methodological aspects to consider. First of all, the KA establishes an HFC reduction pathway based on national baselines and with an ultimate reduction target of HFC consumption and production between 80-85%, depending on whether the country is an Article 5 Party or a non-Article 5 Party. Table 26 presents the phase-down schedule for Article 5 countries.

Table 26: Overview of KA HFC phase-down schedule for Groups 1 and 2 of Art. 5 Parties

	Art. 5 Group 1[20]	Art. 5 Group 2[21]
Baseline years	2020 – 2022	2024-2026
Baseline calculation	Average production and consumption of HFCs in 2020-2022 + 65% of HCFC baseline	Average production and consumption of HFCs in 2024-2026 + 65% of HCFC baseline
Freeze year	2024	2028
Reduction Step 1	2029 – 10%	2032 – 10%
Reduction Step 2	2035 – 30%	2037 – 20%
Reduction Step 3	2040 – 50%	2042 – 30%
Reduction Step 4	2045 – 80%	2047 – 85%

Source: GIZ 2021

For an Art. 5 Party, the first HFC reduction step of 10% will take place in 2029, followed by a reduction of 30% in 2035, 50% in 2040, and 80% in 2045. The initial step is important to consider because this is the point where actual emission reductions start to manifest. The baseline against which the reduction will be measured consists of two components (GIZ 2021e):

1. The **average HFC consumption (and production)** over the period of three years, as shown in Table 26.
2. The **HCFC component**: an equivalent of 65% of the HCFC production and consumption baseline, established based on 2009-2010 levels.

The HCFC component can have a significant impact on the HFC baseline compared to realistic business as usual (BAU) HFC consumption and emission levels. The reason behind this is that several countries managed to achieve greater HCFC reductions than the 65% that was mandated by the HCFC phase-out schedule and therefore expected for 2020.

Thus, the use of the HCFC component probably affects the baseline of some of those countries that achieved accelerated HCFC reductions in the past. For them, it would be crucial to adjust and calculate a baseline that is based on a realistic BAU emissions pathway, in the case that the KA pathway leads to overestimations in the baseline which is commonly referred to as 'hot air' if countries claim fictitious emission reductions (GIZ 2021e).

Moreover, it is relevant to understand the difference between the accounting approaches between the KA to the MP and the PA. The KA considers exclusively levels of production and consumption of HFCs ignoring the point in time when the emission actually occurs. This means, under the KA countries account for **potential emissions** based on the GWP value of the relevant refrigerant. Under the PA, countries report HFC emissions considering the life cycle of cooling appliances and emission factors that relate to refrigerant leakages over time during operation of the equipment and at the point of disposal. Therefore, the emissions reported under the PA are considered as **actual emissions**.

20 Article 5 countries, Group 1: most Article 5 countries, except for the Parties being part of Group 2 (see below)

21 Article 5 countries, Group 2: Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, UAE

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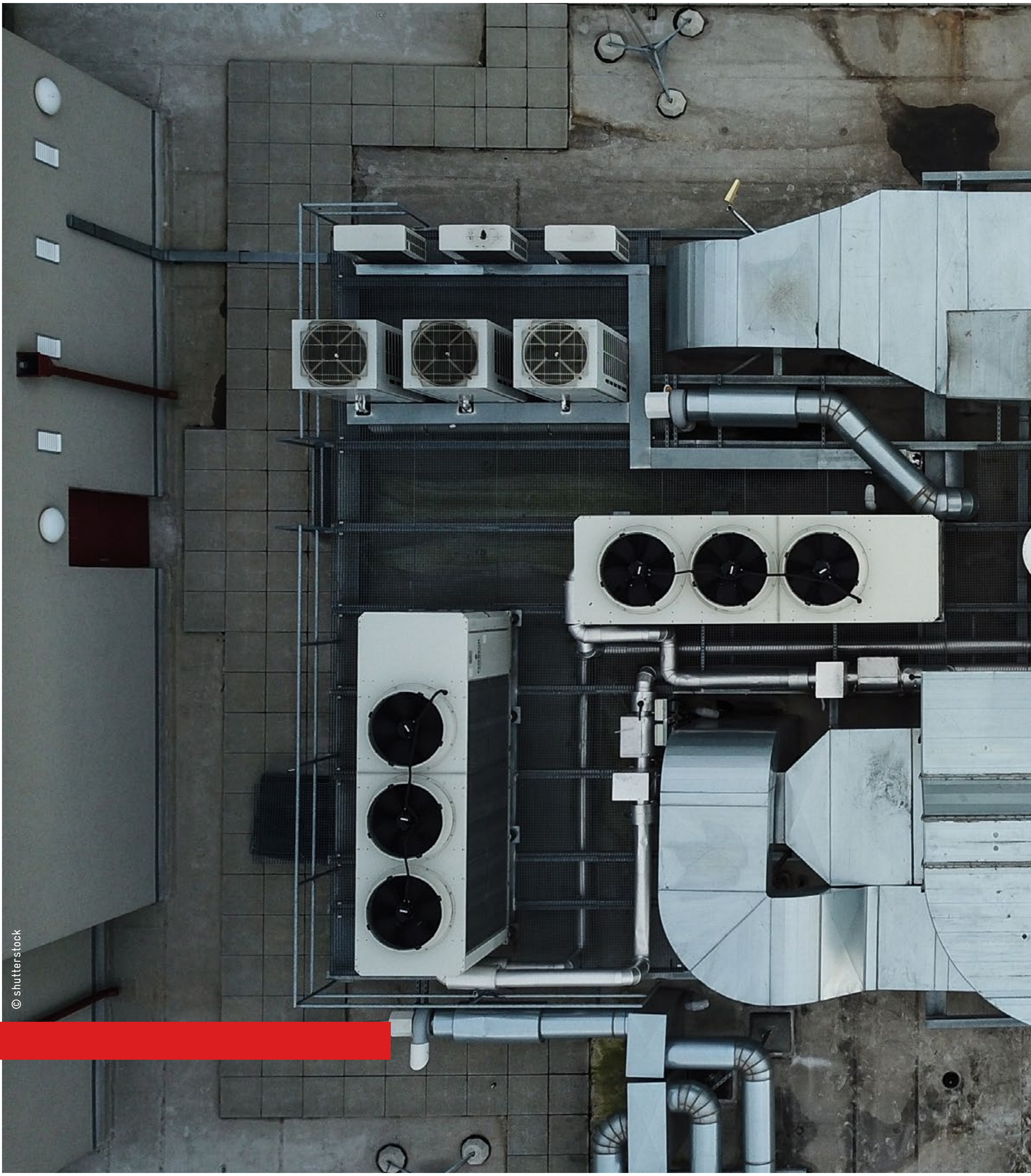

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