Green Cooling in supermarkets

Best available technology and financing options, with a special focus on Kenya

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LIST OF ABBREVIATIONS

AE	Accredited Entity
CAPEX	Capital Expenditures
CDM	Clean Development Mechanism
CDP	Carbon Disclosure Project
CER	Certified Emission Reduction
CGF	Consumer Goods Forum
CO2	Carbon dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CFC	Chlorofluorocarbons
ETS	Emission Trading Scheme
FQD	Fuel Quality Directive
GCF	Green Climate Fund
GHG	Greenhouse gas
GIZ	German Corporation for International Cooperation
GRI	Global Reporting Initiative
GWP	Global warming potential
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
IEA	International Energy Agency
ITMO	Internationally Transferred Mitigation Outcome
KA	Kigali Amendment
MEPS	Minimum Energy Performance Standard
MP	Montreal Protocol
NDC	Nationally determined contribution
ODP	Ozone depletion potential
ODS	Ozone depleting substance
PA	Paris Agreement
PSF	Private Sector Facility
RAC	Refrigerant and air-conditioning
RETRAK	Retail Trade Association of Kenya
SBTI	Science Based Targets initiative
SDG	Sustainable Development Goal
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

UNIDO	United Nations Industrial Development Organisation
USD	US Dollar
VCM	Voluntary Carbon Market

1. INTRODUCTION & OBJECTIVE

The cooling sector is a key contributor to global greenhouse gas (GHG) emissions through the use of climate-damaging refrigerants as well as its electricity consumption. The sector's GHG emissions are expected to grow significantly under business-as-usual scenarios, reaching 13% of global emissions by 2030 (GIZ 2019c). This is compounded by a massive expected increase of emissions of hydrofluorocarbons (HFCs) which are strong GHGs.

Since the signing of the Montreal Protocol (MP) in 1987, a global agreement to phase-down substances depleting the ozone layer, achievements have been made and the ozone layer has made a significant recovery. However, 30 years since the historic agreement, it has become clear that HFCs – the substance used to replace chlorofluorocarbons (CFCs) for refrigeration – have solved one problem but exacerbated another potentially even more significant one. HFCs have been discovered to have a significant global warming potential (GWP), with a much higher potential than carbon dioxide (CO2).

The signing of the Kigali Amendment (KA), coupled with action at EU level, as well as the fact that HFCs are listed as one of the GHG under the Paris Agreement (PA), has helped to highlight the environmental and climate impact of HFCs and has demonstrated that regulatory pressure will continue to grow on operators globally to shift to natural refrigerants. The PA, along with the HCFC phase-out under the Montreal Protocol and its HFC phase-down as envisioned by the KA, all drive the global need to move towards climate-friendly and energy-efficient refrigeration appliances.

Companies depending on cooling services for their operation (e.g. food retail companies and supermarkets) will sooner or later have to convert their systems accordingly, using natural, low-GWP alternatives. The technological choice of today has a significant influence on current and future GHG emissions. While this may present a challenge for food retailers, these businesses have a great opportunity to prepare for a more sustainable approach overall.

Refrigeration solutions with natural refrigerants usually require less maintenance, have higher energy efficiency and a smaller carbon footprint. They not only benefit the environment, but also save costs for businesses.

Retail sales in developing countries have increased by more than 350% between 2003 and 2018 and now represent more than half of total global retail sales (GIZ 2018c). The food retail sector is a fast-growing sector in most African countries. Cooling systems typically account for about 40-60% of the total energy consumption in a supermarket (GIZ 2018c). To promote climate- and ozone-friendly cooling products and devices in supermarkets, demonstration projects and first-of-its kind commercial applications are needed. However, to date only few initiatives driven by non-state actors exist in Africa in the context of Green Cooling solutions[1].

It is important for retail companies to understand which technical options exist and how this complies with future legislative changes. Such companies need to know the benefits and potential challenges/risks for applying these new technical solutions and what risk mitigation options and potential additional financing opportunities may exist or arise in the future. A compelling business case for retail companies can only be made if the energy, environmental and climate related benefits are combined with an economically feasible approach for installing and operating the new Green Cooling systems.

The objective of this paper is to raise awareness among supermarket chains active in Africa about the political obligations related to climate change and ozone depletion that will increasingly affect the cooling sector.[2]

1 In this publication, we often use the term "Green Cooling". It covers all cooling solutions that use natural refrigerants (such as propane or CO2) and are highly energy-efficient.

2 According to GIZ (GIZ 2018c), food retail stores can be grouped into minimarkets (or convenience stores), supermarkets, and hypermarkets with corresponding floor sizes of approximately less than 200 m², 200 to 2000 m², and above 2000 m². Stores of all three categories offer a variety of food products, parts of which must be stored chilled or frozen, and additional ranges of household products.

This paper will further describe potential technical opportunities that already exist in the context of Green Cooling and discuss initial ideas on how such solutions may receive additional support and finance, and how activities in this regard may be integrated in broader sustainability reporting, which is already delivered by most larger retail companies anyway.

» Chapter 2 sets the overall context and provides background information on why commercial refrigeration actors (including supermarkets), as part of the Refrigeration and Air Conditioning (RAC) Sector, need to prepare for applying Green Cooling solutions.

» Chapter 3 describes elements for the business case from a rather technical perspective (incl. technical options available.

» Chapter 4 outlines current barriers and potential additional financing opportunities for Green Cooling.

» In Chapter 5 (Conclusion) key information from the Chapters 2 to 4 is summarized and concluding key considerations are provided.

2. THE IMPORTANCE OF CONVERTING COMMERCIAL REFRIGERATION TO GREEN COOLING

This Chapter provides an overview of current trends in the RAC sector in terms of growth rates and emissions (Section 2.1) and gives a short overview of the contribution of the commercial sector and specifically supermarkets (Section 2.2) to sector emissions. Furthermore, a summary of key international policy frameworks is presented, focusing on their impacts on the cooling sector at global, national and sectoral level (Section 2.3). In this context, it will be shown how Green Cooling can contribute to an overall more sustainable path for businesses (Section 2.4).

2.1 THE REFRIGERATION AND AIR CONDITIONING SECTOR: GROWING DEMAND AND CURRENT CHALLENGES

Space cooling and refrigeration, be it storage of food or medicines or air conditioning of hospitals and schools, is a crucial element to achieve or maintain adequate human living standards and should therefore be considered a basic need. Driven by economic growth, a growing global population and demographic changes as well as changing lifestyles, the RAC sector has globally experienced a steady increase in the last decades which is projected to continue over the next years (GIZ 2016). While markets in developing countries grow at rates of 0-4% per year, developing countries record growth rates of 7-15% on average. As a result, developing countries are expected to account for about 80% of the entire RAC market (number of appliances) in 2030 (GIZ 2018). However, at the same time, the use of RAC equipment is a main driver for global GHG emissions which have a severe impact on the climate. Those are estimated to contribute to around 13% of the global total GHG emissions in 2030 (GIZ 2019).

Main subsectors contributing to GHG emissions caused by the RAC sector are unitary air conditioning, such as air conditioners for residential and commercial use, chillers, mobile air conditioning, domestic refrigeration, and commercial, industrial and transport refrigeration. Although air conditioning represents the largest sub-sector in terms of GHG emissions with a share of approx. one third of total RAC sector emissions (3,830 MtCO2e in 2016) at the global level, commercial refrigeration, which includes supermarket equipment, also significantly contributes to the sectors emissions by accounting for around 12% (474 MtCO2e) of total RAC emissions (GIZ 2018). In Kenya for example, according to Nordea, 'the entry of international players in Africa's retail market space, the increasing purchasing power of a growing middle class, a robust macroeconomic growth, and affordable retail space attributed to a proliferation of shopping malls in the last five years and, among other factors has led to continued expansion of the retail sector' (Nordea 2020). It can be expected that supermarkets will experience a similar growth and that the demand for fresh products and frozen convenience food will increase in a similar way, which requires better cooling and refrigeration services in supermarkets.

GHG emissions from cooling appliances can be divided into direct emissions stemming from the use of refrigerants and indirect emissions originating from electricity consumption. In most countries, the electricity production is mainly based on fossil fuel combustion resulting in large amounts of CO2 emissions, which represents approx. two thirds of total RAC emissions (GCI 2020). Regarding direct emissions from the use of refrigerants, most cooling appliances are operated with fluorinated gases, especially HCFCs and HFCs. These are potent GHG with a GWP that is, in some cases, more than 1,000 times higher than that of CO2. In line with the general growth of the RAC market, HFC emissions in particular are increasing at a rate of 8% per year and are projected to account for 7-15% of global GHG emissions by 2050 (UNEP 2020). This is because countries are obliged by the MP to phase-out HCFCs with the target for developing countries to have them completely replaced by 2030.[1] Since HFCs are also harmful GHG, Parties to the MP agreed to reduce these gases as well and to phase-down their production and consumption. The KA to the MP, adopted in 2016, regulates the according phase-down schedule for developed and developing countries. It is expected that compliance will reduce global warming by 0.4°C by 2100 (compared to baseline, EC 2019). Further information on political implications can be found in chapter 2.3 of this white paper.

1 Developed countries will completely phase-out HCFCs until 2020.

The International Energy Agency (IEA) estimates that a combined approach comprising energy efficiency measures with the transition to low-GWP refrigerants could mitigate GHG emissions by up to 210-460 GtCO2e. This is in the same range as four to eight years of total global annual GHG emissions based on 2018 levels (IEA 2020).

In the African context, the size of the cooling sector and the corresponding GHG emissions differ widely across countries. According to the database provided by the Green Cooling Initiative, GHG emissions from the RAC sector in Kenya were at 7.01 MtCO2e in 2016 translating into 146 kgCO2e per capita, whereas for instance in Ghana, per capita emissions were estimated at 229 kgCO2e (0.559 MtCO2e in total) and for Seychelles at 1,140 kgCO2e (0.107 MtCO2e) in 2016 (GCI 2020). Of course, the use of RAC equipment also strongly depends on various factors such as country's climatic conditions, electrification rate, economic development and standards of living.

2.2 THE ROLE OF COMMERCIAL REFRIGERATION WITH A SPECIAL FOCUS ON SUPERMARKETS

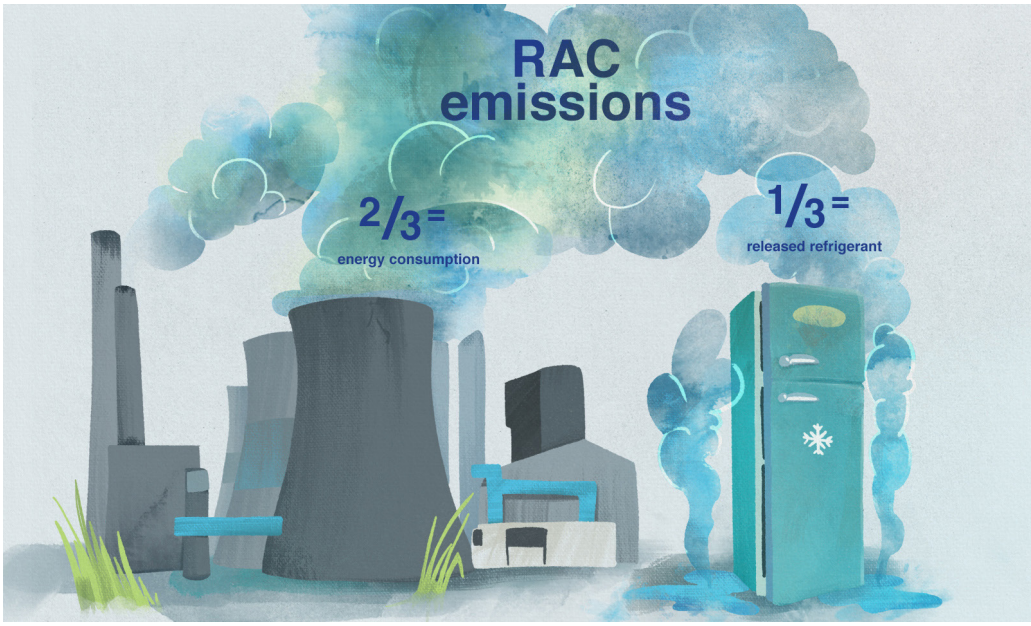
The commercial refrigeration sector, which includes for example cooling systems for supermarkets as well as cold stores, has a projected worldwide annual growth of 3.3%. In 2020, approximately 90.6 million appliances were in use in commercial refrigeration, and this number is projected to increase to 122 million appliances in 2050.

The commercial refrigeration sector contributes 7.2% of the total GHG Mitigation Saving Potential of the RAC Sector (annually until 2050; Proklima 2019).

Supermarkets are typically operated through larger chains. In more developed countries, these chains then also own, operate or control the selection of the RAC appliances. In less developed countries, stand-alone appliances are often directly owned by and operated through product brands like Coca-Cola or Unilever (GIZ 2018c).

Supermarkets play an important role in providing fresh or frozen goods to the consumer. Furthermore, a functioning cooling chain is also important for reasons of food hygiene. While freezing is becoming more and more important in Europe and in the USA, chilling is an essential aspect in supermarkets in Africa. Due to hygiene requirements such as in meat processing, cooling is almost indispensable. Legal requirements for the temperatures of meat, fish, dairy products, and fruit and vegetables underpin these requirements.

The transport routes for fresh goods have also increased in recent years. For example, goods are offered in supermarkets which, without appropriate cooling, would already have spoiled on arrival at the sales outlets. Without appropriate cooling, an extensive range of fresh products as offered in supermarkets would be unthinkable. For these reasons, temperature-controlled logistics from producer to consumer will become more and more important.



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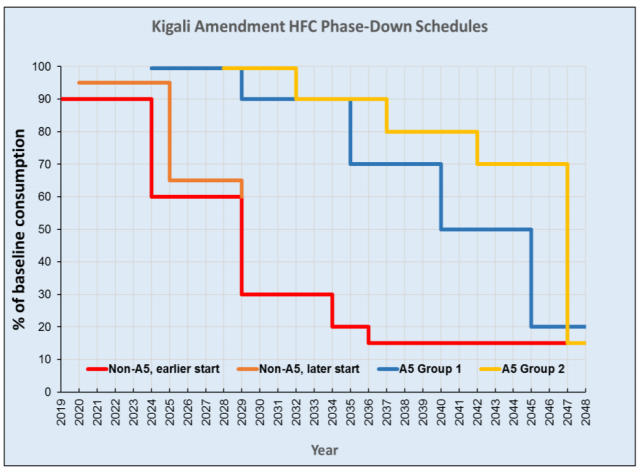
2.3 POLITICAL IMPLICATIONS: TACKLING EMISSIONS FROM THE RAC SECTOR ON A GLOBAL SCALE

As briefly touched upon in section 2.1, HFCs are mainly used to replace HCFCs in RAC equipment. HCFCs in turn are ozone depleting substances (ODS) and were introduced as a substitute for the heavily ozone-damaging CFCs in cooling equipment. Both HCFCs and HFCs are to be completely phased-out at the global level by 2030 at the latest (UNEP 2020).

HFC emissions will be internationally controlled by the KA which entered into force in January 2019. According to the rules set out in the KA, most Parties belonging to the Article 5 Group (developing countries including all African Countries) must freeze their HFC production and consumption in 2024, followed by a first reduction step of 10% in 2029. The reduction will be measured against a baseline which is set based on the average HFC production and consumption during a three-year period (2020-22 for most developing countries) . In addition, a proportion of the original HCFC baseline (65%) needs to be added in order to obtain the Kigali HFC baseline (UNEP 2017). The following figure illustrates the HFC phase-down schedules for developing (Article 5) and developed (Non-Article 5) countries.



However, the KA is not the only multilateral agreement addressing HFC emissions. The PA under the United Nations Framework Convention on Climate Change (UNFCCC) sets out a global and legally binding framework that addresses all major GHG, including HFC, with the overall goal to limit global warming to well below 2°C and to make efforts to limit it to 1.5°C. Parties to the UNFCCC are required to set and communicate their national post-2020 climate targets by developing Nationally Determined Contributions (NDCs). These are revised every five years with the aim to raise their ambition, taking into account the country's national circumstances and capabilities. The pledges included in the NDCs vary across countries and range from absolute economy-wide emission reduction targets to sectoral targets to specific measures to reduce emissions. They do not only include climate change mitigation aspects, but also deal with the question of how countries can and will adapt to the negative impacts of climate change. Here too, the cooling sector can play an important role, e.g. through the establishment of cold chains in the health or food sector.

Thus, HFCs are covered by both the KA and the PA. Currently, countries are in the process of revising and updating their NDCs. The first round of national climate targets submitted to the UNFCCC by 2015 in the run-up to the adoption of the PA showed that many countries did not consider the RAC sector and its mitigation potential in their national climate targets. Only half of the NDCs included HFCs in the list of GHG to be tackled by emission reduction activities, but the vast majority did not mention any specific mitigation actions in the cooling sector (GIZ 2016). However, since the RAC sector gained relevance in the last years and countries recognised the importance of addressing emissions of the cooling sector, more and more countries integrate it into their national climate strategy and their updated NDCs. Among others, Kenya, Ghana and Namibia are currently considering to further strengthen the relevance of the RAC sector in their NDCs.

The clear trend to reduce GHG emissions in the RAC sector through climate action and corresponding policy instruments will have implications for the commercial refrigeration sector, including cooling services for the retail market (e.g. supermarkets). This may lead to new regulations such as, for instance, a ban on high-GWP refrigerants or the introduction of Minimum Energy Performance Standards (MEPS) for certain technical appliances (e.g. air conditioners, refrigerators). As an example, the EU F-gas regulation includes a ban of HFCs with a GWP above 150, from 2022 onwards, for refrigerators and freezers for commercial use and multipack centralised refrigeration

for commercial use with a rated capacity of 40kW and above (Table 6, Regulation (EU) No 517/2014). Other countries (e.g. Spain) implement incentives to reduce the use of high-GWP refrigerants (HFCs) and to encourage the shift to non-fluorinated refrigerants, such as a staggered taxation system with tax exempts or reductions for using low-GWP gases (GIZ 2018b).

2.4 THE RELEVANCE OF NON-FINANCIAL (SUSTAINABILITY) REPORTING

Businesses may not yet be directly exposed to the implications of international treaties like the Paris Agreement or the Kigali Amendment when it comes to mitigating emissions. However, with growing pressure for companies to address social and environmental concerns, most larger companies will, sooner or later, deem sustainability reporting inevitable. In light of reducing GHG emissions, two aspects are key in sustainability reporting for businesses like supermarket companies: one, outlining current trends and existing initiatives for non-financial reporting; and two, discussing potential advantages of applying such reporting standards.

Investors and financial institutions often require a stronger focus on sustainability, climate-related risks and disclosure of environmental performance, as they have become key drivers of investors' decision-making. Furthermore, stakeholders, shareholders and customers demand higher transparency and accountability from businesses towards contributing to the United Nations Sustainable Development Goals[1] (SDGs) (UN 2020), which helps determine improvements in practices and operations. Integrating and working towards SDGs for businesses goes far beyond plain greenwashing. Instead, it is a means for companies to become sustainable themselves.

But how can a company transparently and comprehensibly demonstrate the aspects in which it operates along the principles of sustainability and social responsibility? There are several initiatives and standards seeking to systematise corporate sustainability aspects and encouraging companies to make their results public. This is referred to as "non-financial reporting". Non-financial reporting is a means of communicating with internal and external stakeholders about the company's engagement with and response to the three pillars of sustainability (economic, environmental, and social). This comprises the largest economic, environmental, and social impacts of a business such as economic performance, assessment of emissions, employee and community engagement, and further relevant issues.

The increased need of consumers, investors, businesses and policy makers for sustainable solutions has led to a growing demand for climate-friendly cooling technologies. But who decides which technology will be installed? Typical decision makers concerning the use of RAC equipment of supermarket chains are technical directors, technology and innovation/sustainability managers or sales managers. In developed countries, consumer good companies are already being critically monitored by consumers and environmental NGOs regarding their climate and environmental footprint.

Publicly listed companies are even urged to transparently report and lower their carbon footprint. Adopting these technological developments and presenting the contributions achieved by the retail market and its businesses as part of their non-financial reporting has a strong potential to improve relations with stakeholders and would promote competitive advantages (e.g. in terms of overall business performance, client base, accessing funding).

1 SDGs are adopted by all United Nations Member States in 2015 aiming to achieve environmental, social, and economic integrity goals and targets by 2030 (UN 2020). In line with this, African Union Agenda 2063 has been introduced to build a more prosperous Africa in 50 years (UN Women 2017). In Kenya, the SDG Forum is a membership platform that provides space for organisations to engage with national and subnational governments, citizens, private sector, media, academia and development partners to implement, monitor and report on SDGs and the Agenda 2030 (SDGs Kenya Forum 2020).

EXAMPLE 1: PICK N PAY, SOUTH AFRICA

South African based supermarket "Pick n Pay" reports their aligning efforts with SDGs and other collaborative initiatives in their annual non-financial report. In relevance to the paper, the supermarket committed to a natural refrigerants project carried out under the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU) (PnP 2019). They commissioned CO2 transcritical refrigeration systems which go along with their plan for improving energy efficiency and reducing GHG emissions and thus contribute to SDGs.

2.5 POLITICAL IMPLICATIONS: TACKLING EMISSIONS FROM THE RAC SECTOR ON A GLOBAL SCALE

There exist various standards for non-financial reporting, most of which are voluntary. This paper takes a closer look at three of the most common initiatives: the Global Reporting Initiative (GRI), the Science-based target initiative (SBTi) and the Carbon Disclosure Project (CDP).

Companies worldwide, for instance, follow Global Reporting Initiative (GRI) standards, the world's first globally accepted standard for sustainability reporting, to enhance the practices of sustainability reporting and promote involvement in dialogue with investors, policymakers and civil society (GRI 2020). GRI ensures transparency and responsibility for impacts of the private and public organisations and generates consistency and credibility in sustainability reporting. The standards are designed based on the sector-specific requirements and are classified into economic, environmental and social material topics.

Many internationally recognised supermarket brands with presence in Africa already communicate corporate environmental, social, and economic contributions through the compliance to the GRI and the commitment to the SDGs, Science-based targets initiative (SBTi), and Carbon Disclosure Project (CDP). Companies apply these initiatives and frameworks to also put forward corporate benefits of using Green Cooling technology and their subsequent impacts on the environment and society.

The GRI as a starting point provides a framework for companies to report on their sustainability performance, while SBTi, and CDP manifest a company's sustainability commitment through solid methodology and analysis.

GRI is often used in collaboration with CDP in the field of climate change and water disclosure. CDP enables access to GHG emissions data for investors by facilitating the analysis of companies and investor portfolios to carbon risk (GSSB and CDP, 2018). It supports companies, cities, states, and regions to measure and manage their risks and opportunities on climate change, water security, and deforestation. The alignment of GRI and CDP helps improve consistency and comparability of environmental data and efficiency to corporate reporting allowing companies to seize the opportunity of synergies between these initiatives.

SBTi guides companies in defining their GHG emission reduction targets aligned with current climate science of limiting global warming to well-below 2°C above pre-industrial levels and pursuing efforts to limit warming to 1.5°C, hence meeting the goals of the Paris Agreement (SBTi, 2020). It ensures that companies consider the most recent emissions scenarios, partner organisation policies, and GHG accounting practices and develop sector-specific pathways where businesses from all sectors and of all sizes can enter the initiative on a voluntary basis. By taking part in SBTi, companies enhance their competitive advantage in the transition to a low-carbon economy. SBTi is already becoming part of the annual non-financial reporting practice of companies including some of the global supermarket brands.

EXAMPLE 2: WALMART INC., USA

Remark: The example is on sustainability reporting rather than on Green Cooling.

Walmart Inc., an American multinational retail cooperation, reports on their annual progress in sustainability including economic, environmental, and social contributions in compliance with GRI standards. The company has introduced "Project Gigaton", involving suppliers in setting targets to reducing emissions in defined areas namely energy use, sustainable agriculture, waste, deforestation, packaging and product use (Walmart Inc. 2019). The project has been implemented in collaboration with different frameworks, including CDP, to connect suppliers to measurement methodologies, guidance and practical tools to facilitate the reduction in the emissions. Improving the performance of the refrigeration systems is part of Walmart's target of reducing GHG emissions in their operations.

In current fluctuating political scenarios and rising adverse consequences of climate change, businesses need to build resilience, adaptability, and capacity for growth. This requires a long-term sustainable approach to conform to the shifts in policy, investor and society priorities that promote smarter and cleaner products and services such as Green Cooling technologies. Many NDCs promote corporate compliance and thus create incentives for investors to seek to identify companies that are well-positioned for the future and focus on de-carbonisation actions.

Businesses are not only pushed to be more responsible for their actions but also to ensure the sustainability of their value chain. This creates more opportunities for sustainable collaborations and innovation and building competencies, especially in terms of technological development and green practices. In consequence, they enhance the reputation and enable cost savings and financial well-being in the long run due to increased efficiency, better investor and customer relations, and resilience to climate-related risks.

EXAMPLE 3: CARREFOUR S.A., FRANCE

Carrefour S.A., a French multinational corporation specialised in retail, has evaluated the Group's GHG emissions and aligned its strategy to the 2°C scenario to reduce CO2 emissions (Scope 1+2) worldwide by 40% by 2025 and 70% by 2050 (Carrefour 2019). The company's target of reducing refrigerant-related GHG emissions by 40% by 2025 and commitment of phasing out HFC refrigeration units and phasing in natural (CO2) refrigerant systems by 2030 in Europe is part of the above-mentioned objective.

3. BUSINESS CASE: GREEN COOLING OPPORTUNITIES FOR SUPERMARKETS

The previous chapter illustrated the importance of sustainability issues for positive business development. What opportunities exist in the commercial refrigeration sector to become more sustainable? This chapter provides an overview of the best available Green Cooling technologies for supermarket applications, including benefits, risks, cost advantages and case studies.

3.1 BEST AVAILABLE GREEN COOLING TECHNOLOGIES

In this paper, the term Green Cooling refers to the use of natural refrigerants with low GWP in combination with high energy efficiency. Unlike conventional refrigerants, natural refrigerants are non-synthetic and occur naturally. Examples of natural refrigerants are ammonia, carbon dioxide, hydrocarbons, water and air, which have no ODP and no or very low GWP.

Natural refrigerants have been used in a wide variety of refrigeration applications for more than a hundred years. We are not talking about "new" refrigerants" and "new" systems. Of course, the technology around natural refrigerants has evolved and improved in recent years, and there are modern systems with natural refrigerants.

Natural refrigerants offer the possibility to design and operate refrigeration systems in a sustainable way. The low GWP and high efficiency of natural refrigerants allow us to follow the challenges posed by restrictions on the entire sector regarding the environmental impact of refrigeration systems.

Natural refrigerants - GWP for supermarket applications:		
Ammonia	R717	GWP 0
Carbon dioxide	R744	GWP 1
Hydrocarbons	R290, R600, R1290	GWP 3-6

However, these challenges can be addressed in system design and overcome through existing standards and regulations as well as qualified training for technicians. In this way, they can be installed and operated safely. While natural refrigerants have many advantages in terms of environmental friendliness and efficiency, some of them also have disadvantages such as high flammability, toxicity or higher required system pressure.

Just a few years ago, the use of natural refrigerants in supermarkets was almost non-existent. Today, natural refrigerants can be considered a standard solution in many supermarkets, especially in Europe.

The figures below show how natural refrigerants are expected to develop in Germany and reveal a clear trend towards increasing use of natural refrigerants. Accordingly, by 2030, many discounters will only use natural refrigerants in their refrigeration systems.

A study conducted by Shecco shows a remarkable number of installations of R744 transcritical systems worldwide. Since the first transcritical systems were installed in the early 2000s, there have been over 29,000 installations in Europe alone and over 220 systems in South Africa in the last 10 years.

sub-sector	refrigerant	market penetration rates in new products and equipment [%]				
		2015	2018	2020	2025	2030
Stand-alone units	R404A	19	10	0	0	0
	R407C	75	0	0	0	0
	R134a	6	40	25	0	0
	R455A/R454C	0	0	15	15	15
	R290	0	50	60	85	85

sub-sector	Refrigerant	market penetration rates in new products and equipment [%]				
		2015	2018	2020	2025	2030
centralised systems Discounter	R134a	80	30	5	0	0
	R290	4	22	32	38	40
	R744 (CO_2) transcritical	12	40	55	55	60
	Below 40 kW: R410A	4	8	8	7	0

TABLE 1: MARKET PENETRATION RATES IN COMMERCIAL REFRIGERATION IN GERMANY (SOURCE: DIANA THALHEIM, GERMAN ENVIRONMENT AGENCY, 2019)

Environmental impact and costs for commercial refrigeration

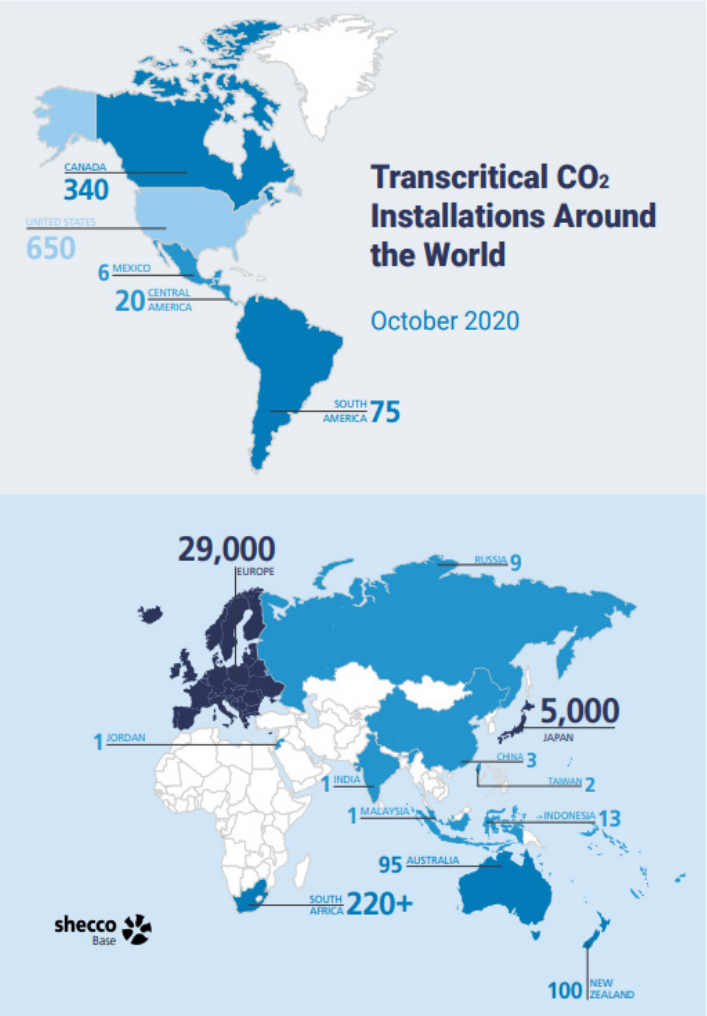
There are two main factors influencing the operating costs and environmental impact of commercial refrigeration: energy use, and the refrigerant used. According to rough estimates, two thirds of the refrigeration sector's emissions trace back to energy consumption, often referred to as indirect emissions, and one third to released refrigerants, or direct emissions (Green Cooling Initiative, 2015). The two are briefly discussed below.

Indirect emissions: electricity demand

The electricity demand for refrigeration systems in supermarkets depends on which additional energy consumers (e.g. oven or air conditioning) are used. According to a rough estimate, the energy consumption is about 60% of the total energy consumption of a supermarket.

According to the study Energy Management in Retail by EHI, a scientific institute of the retail industry, the energy consumption of the refrigeration system in a supermarket is about 48% of the total consumption. For the study, 31,800 supermarkets and data from 61 supermarket chains in Germany, Austria and Switzerland were evaluated. It is interesting to note that old supermarket installations have a potential of 37% to reduce energy consumption compared to new ones and that all supermarket chains are working on the issue of lighting and refrigeration with a focus on efficiency.

FIGURE 1: TRANSCRITICAL CO2 INSTALLATIONS AROUND THE WORLD (SOURCE: ACCELERATE SPECIAL ISSUE #111)



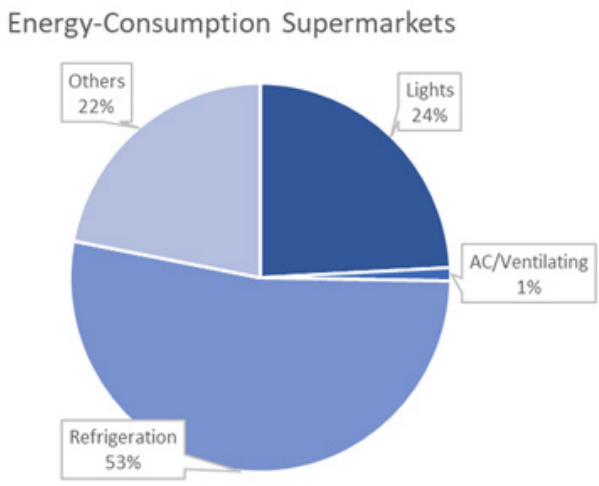


FIGURE 2: ENERGY CONSUMPTION IN SUPERMARKETS (SOURCE: EHI, ENERGY MANAGEMENT IN RETAIL 2020)

Most of these figures solely focus on German/Austrian and Swiss supermarkets. The situation will be different in African supermarkets, especially considering the demand for air conditioning. The supply of ready-to-eat hot meals, which are sold more often in African supermarkets, also has an impact on energy consumption.

One of the easiest ways to reduce energy consumption is to establish a functioning cold chain. This ensures that products are delivered to supermarkets at the right temperatures, which also has a positive effect on product quality. Glass doors on cabinets and covers on freezers minimise temperature loss and thus also the energy consumption of the entire system. Glass doors can reduce energy consumption by up to 50%.

Direct emissions: Released synthetic refrigerants

As mentioned earlier, the second factor that determines the environmental impact and operating costs of commercial refrigeration is the refrigerant used. System leaks, where the refrigerant used escapes into the environment, have an impact on the environment. These leaks occur and are inherent in the system. Refrigeration systems, and especially supermarket refrigeration systems, have a large number of connections in the piping system that can leak.

These leakages can be reduced to a certain minimum (e.g. by design or quality of the components and materials used), but cannot be avoided. Therefore, the use of low GWP refrigerants reduces the environmental impact of leakage. In addition, the refrigerant that has leaked from the system must of course be replaced. As natural refrigerants are usually much cheaper than the conventional, synthetic refrigerants, this also has an impact on the operating costs. Although the upfront investment costs for new, climate-friendly systems may be higher (see below), the long-term operating costs are lower due to lower leakage-related costs, low maintenance costs and, most importantly, low energy consumption (Greenpeace, n.d.).

Investment costs

In addition to the operating costs of such a system, the investment costs also play a role. Determining the exact investment costs is complex and often cannot be answered unequivocally due to the large number of variables. Almost every supermarket chain has different requirements that need to be met. Investment costs should also be considered in terms of the lifetime of a system. It makes a big difference whether a supermarket is renovated every seven years or rebuilt after 25 years.

The initial investment costs for refrigeration systems using natural refrigerants are often higher than the initial investment costs for conventional systems. This is due to the special requirements of natural refrigerants as well as their lower availability (no economies of scale yet). However, the operating costs of systems using natural refrigerants can often be significantly lower, as already described, due to the high energy efficiency and lower costs of natural refrigerants. The holistic consideration of all system costs, from installation to operation to disposal, shows that refrigeration systems with natural refrigerants have the lowest lifetime costs. Therefore, over the lifetime of the system, natural refrigerants may still be the cheaper option, apart from also being more environmentally friendly (Proklima, 2008).

FIGURE 3: MINIMISING ENERGY CONSUMPTION AND INCREASING PRODUCT QUALITY WITH GLASS DOORS IN SUPERMARKETS (SOURCE: COLRUYT SUPERMARKETS, BELGIUM)

3.2 POSSIBLE SUPERMARKET SYSTEMS WITH GREEN COOLING TECHNOLOGY

After explaining the advantages of climate-friendly technology, this article presents three possible systems for supermarkets. The following three systems are a selection from an enormous number of variants that already exist on the market for Green Cooling technologies. The systems listed below can be seen as examples that show the possibilities for implementing environmentally friendly and efficient systems. They shall give an idea of how systems can be both environmentally friendly and economical, and how they offer maximum product quality of chilled and frozen products.

The following characteristics were taken into account when selecting the systems to be presented:

- Systems were deliberately chosen with natural refrigerants whose GWP is a maximum of 6 in order to keep the effects of system leakage low from the outset.
- All systems are available from different manufacturers or suppliers.

TABLE 2: OVERVIEW OF THE REFRIGERATION SYSTEMS PRESENTED

	Decentralised system	Centralised secondary system	R744 transcritical
Refrigerant type	R290 (propane) R744 (carbon dioxide)	R290 (propane) R717 (ammonia)	R744 (CO2)
Availability	Off the shelf; available in most countries of the world.	Off the shelf; available in most countries of the world.	Off the shelf; available in most countries of the world.
Installation difficulty (low - medium - high)	Low effort. Simple system with small refrigeration circuits and one water circuit.	Medium effort with knowledge of secondary systems.	Medium to high effort.
Maintenance difficulty (low - medium - high)	Little effort. Cooling units regulate themselves.	Low to medium effort.	Medium to high effort in terms of technician training.
ISO/ASHRAE classification of the refrigerant	A3	A3 for R290 and B2L for R717	A1
Potential to reduce the charge of the refrigerant	approx. 80%	approx. 90%	Due to the high volumetric cooling capacity (5 to 8 times higher than R22), the use of R744 also leads to a reduction in the filling quantity compared to HFCs.

3.2.1 DECENTRALISED SYSTEM WITH A SECONDARY WATER CIRCUIT

The main idea of using this system is to reduce the amount of refrigerant. With these systems, a reduction of > 80% is possible compared to conventional systems. The refrigeration system is divided into small circuits and thus the refrigerant charge can be reduced to a minimum.

Small refrigeration units are installed in the shelves and cabinets and a water or glycol circuit system takes the heat from the supermarket. These shelves or cabinets function almost like household refrigerators connected to a water/glycol system.

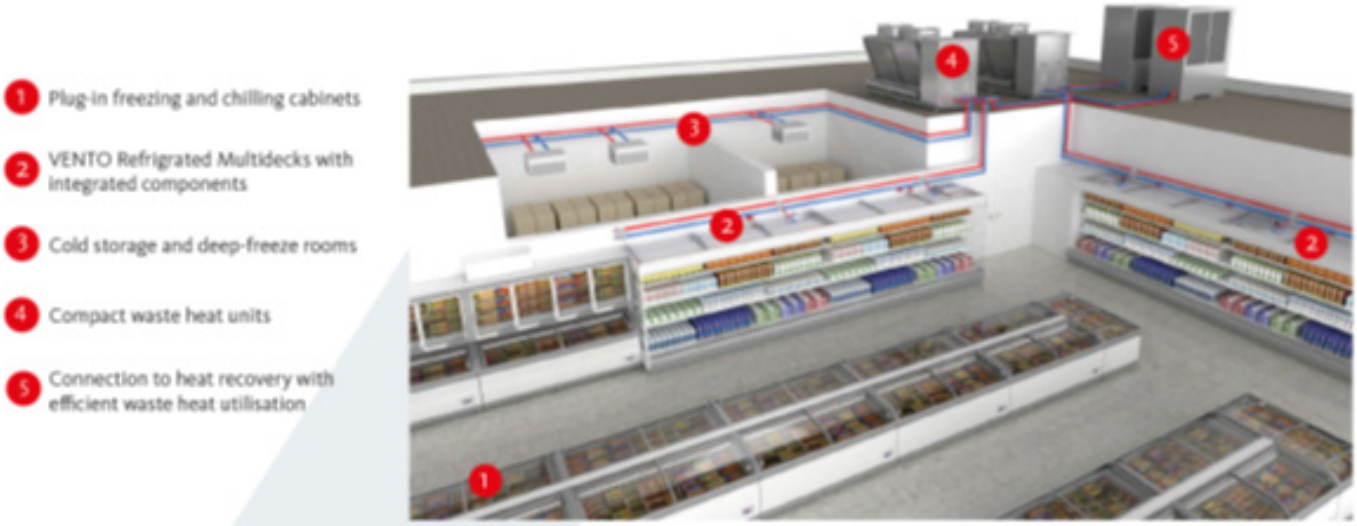


FIGURE 4: MODEL STRUCTURE OF A DECENTRALISED SYSTEM (SOURCE: AHT AUSTRIA)

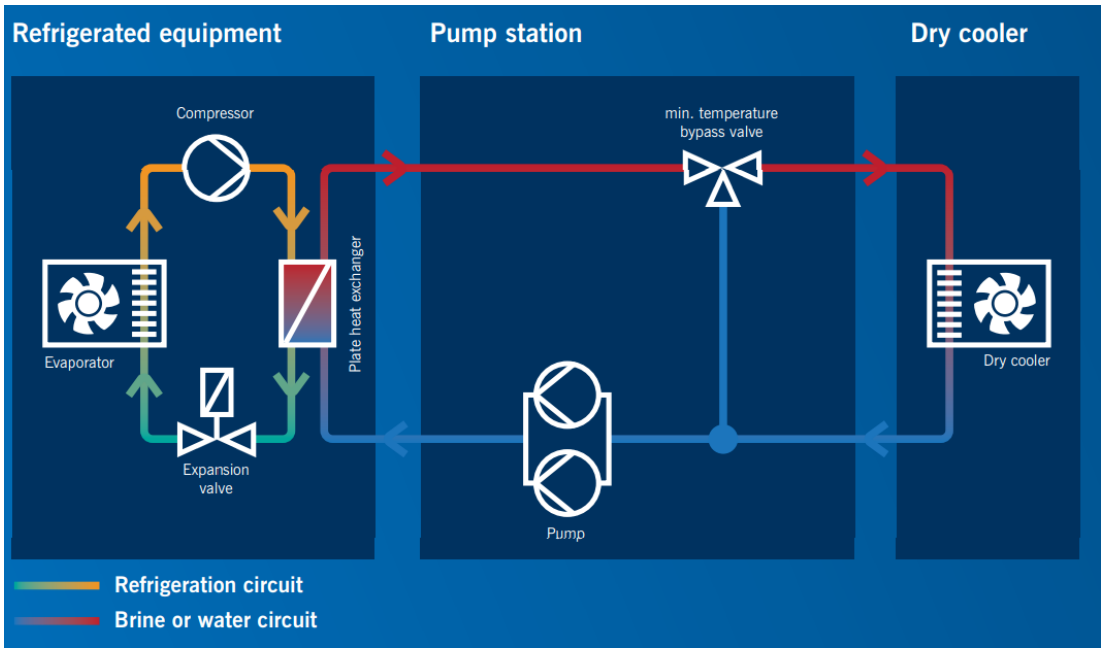


FIGURE 5: COOLING CIRCUIT (SOURCE: BASETEC)

Advantages of decentralised systems with a secondary water circuit

Standardised systems.

Simple cooling circuits.

Easy to install.

Easy maintenance and servicing.

Almost a plug-and-play system.

R290 has no ODP.

R290 has a low GWP = 3.

R290 is cheap and available.

R290 is chemically stable.

R290 has excellent thermodynamic properties.

Highly efficient and powerful.

R290 is safe to use if the correct protocols are followed.

Reduced refrigerant charge.

3.2.2 CENTRALISED SECONDARY COOLING SYSTEMS

Refrigeration systems can leak and lose refrigerant to the environment. This loss of refrigerant causes higher energy consumption, temperature problems with the chilled or frozen products, and service costs.

One possibility is to reduce the filling quantity in the system to a minimum by designing a secondary system. The use of a secondary system offers the possibility to realise a small cooling circuit, resulting in a lower filling quantity. Typically, the cooling circuit is located only in the machine room or in a rack mounted on the roof. A glycol/brine circuit (secondary system) is used to cool the cabinets, shelves or room. These liquids usually have a freezing point below 0° C to achieve the required temperature in a cold room or rack.

As the refrigerant is not in public areas, natural refrigerants such as hydrocarbons or ammonia can be used, which are classified as A3 or A2L and are therefore flammable and/or toxic.

In these systems, the refrigerant charge can also be reduced by up to 90% compared to a common F-gas system where the refrigerant is located throughout the refrigeration system. Secondary systems have a long history in industrial refrigeration, e.g. in the meat or dairy industry.

In Europe, these systems are on the rise after the F-gas regulation and phase down and are also being used more and more in smaller applications. In combination with R744 (CO2) cascades for lower temperatures, they form standardised systems with high energy efficiency values.

Secondary refrigeration system for chilled products and an R744 cascade system for frozen products. The R290 chiller is a free-standing roof-mounted system. A glycol circulates in the freezer cabinets and shelves. R744 is used for the freezers.

FIGURE 7: CENTRALISED SECONDARY COOLING SYSTEM

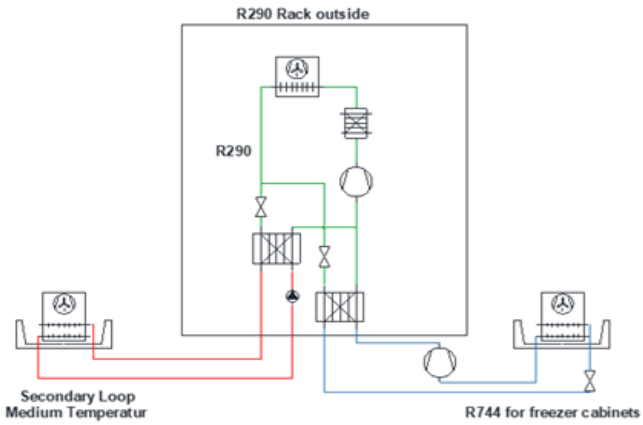


FIGURE 6: EXAMPLES OF ROOF-MOUNTED R290 CHILLERS (SOURCE: KWN AND THERMOFIN)

According to the safety standards in Europe, it is possible, for example: R290 racks located outdoors and having higher amounts of R290 in the system.

Example: Secondary Cooling Systems in South Africa

In South Africa, two supermarkets were converted from R22 systems to R717/CO2 cascade systems. The aim was to show that Green Cooling systems were a viable alternative to HFC systems and that supermarket chains in Africa could also rely on natural refrigerants.

These supermarkets were also monitored with a focus on energy savings. The two projects following Case Study-2 showed energy savings between 13% and 21% compared to the previously installed R22 systems.

Taking into account the higher investment costs, the return on investment would be about seven years. Supermarket facilities of this size run for about 25 years, illustrating that even higher investment costs can be very acceptable.

Advantages of centralised secondary cooling systems

R290 has no odp.

R290 has a low gwp = 3.

Standardised systems such as r290 or r717 chillers.

R290 is cheap and available.

R290 is chemically stable.

R290 has excellent thermodynamic properties.

Highly efficient and powerful

R290 is safe to use if the correct protocols are followed.

Easy-to-install, ready-assembled chillers.

Reduced refrigerant charge.

Secondary loops with brine/glycol are easy to handle.

Possibility of using hydrocarbons and ammonia.

3.2.3 R744 TRANSCRITICAL

Refrigeration systems with the refrigerant R744 are already seen as a standard system in the supermarket sector in Europe. Various manufacturers offer industrially manufactured racks and the days of pilot projects or test systems are long over. The system concepts are used differently depending on the manufacturer, contractor, or the operator's requirements.

The higher system pressures compared to conventional systems with F-gases are mastered. Transcritical means that R744 does not condense above 31° C. At this point, the efficiency drop of the system is much higher than in HFC systems, where the efficiency also drops at higher ambient temperatures.

At condensing temperatures < 31° C, R744 is quite competitive with HFC systems in terms of efficiency. Efficiency comparisons are not straightforward and it should be borne in mind that refrigeration systems are not operated at maximum load and maximum condensing temperature throughout the year.

Due to the high volumetric cooling capacity of this refrigerant, the system components such as compressors or pipelines are many times smaller than in conventional systems. Due to a very high compression index for R744, heat recovery is another important advantage.

In the early days of transcritical R744 systems, there was a misconception of the energy efficiency of these systems. Because R744 has certain properties when it comes to higher temperatures, a higher energy consumption of these systems was believed to be at play.

Today, improvements in design and components, as well as experience in operating these systems, have shown that transcritical R744 systems can be operated very efficiently and with lower energy consumption than commonly built F-gas systems.

FIGURE 8: R744 TRANSCRITICAL SYSTEM (SOURCE: KWN)

Advantages of R744 transcritical systems

R744 has no ODP.

Low GWP = 1.

Chemically stable, non-toxic.

R744 is cheap and widely available.

R744 transcritical systems are already on the market and have proven themselves.

R744 is neither toxic nor flammable.

Reduced refrigerant charge, due to the higher volumetric cooling capacity compared to HFCs.

The high volumetric cooling capacity reduces the diameter of the piping and the size of the components.

4. IDENTIFYING BARRIERS AND LEVERAGING FINANCE FOR ACTIONS ON GREEN COOLING IN SUPERMARKETS

As shown in the previous section, technical solutions to reduce HFCs in cooling appliances of supermarkets are available and often make economic sense, as they result in energy savings (between 20-40%) and have payback periods of typically below five years and in some cases even below two years (GIZ 2018c). However, in most African countries various barriers exist that prevent supermarkets and supermarket chains in switching to that technology. These barriers pose higher risks for investors and for accessing required finance.

4.1 TYPES OF BARRIERS FOR GREEN COOLING IN SUPERMARKETS

The situation in each country may look very different when it comes to these barriers. In some cases, certain barriers may be specifically strong, and others may be already (partly) removed. Some retail companies may also be able to retrofit their cooling equipment despite certain existing barriers, due to their global activities (e.g. global players like Walmart, Carrefour, etc.), their access to financial sources, and their stakeholder engagement (e.g. extensive involvement in sustainability reporting).

It is expected that most African-based food retail companies face most of the barriers listed below. Multinational companies operating supermarkets in Africa may have different approaches for ordering technical equipment and accessing financing options, but they face similar local barriers. That is arguably one of the reasons why, to date, there are only very few Green Cooling projects in Africa. There are several barriers exerting influence to a varying extent. While some were selected from practice, they differ across countries and operators. The following list provides a selective overview.

Barrier 1: Awareness among supermarket owners and customers

The adoption of Green Cooling requires broad awareness among different stakeholders. These include not only national governments and local authorities, but also suppliers and manufacturers, as well as commercial and industrial end-users. Supermarket operators along with private consumers can help drive the market uptake with knowledge of the economic and environmental benefits of Green Cooling.

Barrier 2: Comparable data on life-cycle costs

Operators are often risk-averse. With their existing systems delivering expected results, they often make decisions based on investment costs, because data on running costs is very hard to get or uncertain. The energy consumption as part of the running costs depends on a bulk of factors (e.g. ambient temperature, cold chain, design on the cabinets, staff behaviour, etc.). This makes it difficult for supermarkets chains lacking experts or an internal department to evaluate energy consumption.

Barrier 3: Suitable financing options

At the national level, it is important that African countries develop integrated investment strategies that adequately combine and/or complement support activities to reduce HFC emissions with effective energy efficiency measures. It is furthermore essential that within an integrated RAC sector strategy different funding sources and actors (domestic and international) are identified to match the diverse financing needs according to their mandates. Subsidies, for example, help operators to invest in new systems with possibly higher investment costs, which therefore reduces the financial risk for operators. These subsidies also demonstrate the impact of their investment on the environment.

Barrier 4: Availability of Green Cooling technology

The most fundamental requirement is to ensure the availability of new technologies. They usually face a "chicken-and-egg problem": if there is not enough demand for Green Cooling technologies, the market does not offer them sufficiently. If the market does not offer them sufficiently, these technologies have no chance of being upscaled and made available more cheaply on a mass scale. This again makes them seem less attractive to buyers.

In most African countries, there is an actual or at least perceived non-availability of natural refrigerant solutions due to a lack of information, shortage of knowledge exchange, and uncoordinated initiatives. This non-availability includes not only the refrigerants or foam, but also the access to components for cooling systems optimised for toxic, flammable or high-pressure substances (shecco, 2013).

Barrier 5: Training technicians and securing adequate maintenance

Contractors tend to install systems they know. Refrigeration systems are usually no standard systems and almost every plant is different. Contractors reduce their risks when they repeat installing the same kind of refrigeration system like R22 systems. In addition, training personnel in the use of new technologies is costly. And changing to other systems such as natural refrigerants means investing in new equipment. Without external pressure from customers or political authorities, there is no incentive to be trained on new refrigeration systems.

Barrier 6: Standards & Regulations

Standards and regulations play a very important role in changing to environmentally friendly systems. Whether it is the Eco Design Directive, the F-Gas Regulation in the EU or other regulations, they are big drivers towards changing systems to become more efficient and environmentally friendly.

The F-Gas regulation and the phase down of synthetic refrigerants with high GWP make conventional refrigeration systems more expensive. Operators grow weary of continuous changes in refrigerants, from R22 to R134a or R404A, R449 or R507. Natural refrigerants do not involve big changes, phase-downs, or complex standards and regulations. It is possible to switch from conventional refrigerants to natural ones in one single step; there is no need for synthetic intermediate solutions. Investing in natural refrigerants is calculable compared to synthetics. Standards help contractors and operators in their decisions.

4.2 LEVERAGING FINANCE

Removing such barriers is usually not in the hands of one supermarket chain but requires a rather cooperative approach. There are various ways for Governments and non-state actors (incl. privately owned retail companies) to receive support for overcoming such barriers and enable innovation. Applying Green Cooling technologies and achieving the benefits related to this (i.e. achieving the GHG mitigation targets of the Government/sector, reducing the use of HFCs, applying and running a more sustainable technology in the supermarkets) is attractive for various stakeholder groups, including the retail sector as a whole, supermarket managers (e.g. technical directors, sustainability managers), Governments, investors, as well as environmental and development organisations. The Government and the sector as a whole, e.g. represented by an association or a number of key players in a country or region, should ideally engage and closely cooperate with each other to achieve a significant shift towards Green Cooling.

Larger supermarket chains and especially companies that are globally and regionally active are certainly aware of direct financing opportunities (beyond equity) for financing channels and funding sources for innovative and sustainable technologies and business approaches. For example, the Kenyan based supermarket chain Naivas Limited has received USD 10 million from various funds (incl. International Finance Corporation) for activities not related to Green Cooling (DEG 2020). These funding sources are very diverse and largely depend on the purpose of the fund (e.g. innovation funds, technological funds, sustainability funds) as well as on the type and the overall constitution of a company (e.g. legal status, financial situation of the company, geographical location, etc.). Such direct access opportunities are not part of this paper.

The following sections explore possible financing options linked to the national and global climate policy context described earlier. These options are likely to increase in the future and could possibly make an additional and sometimes decisive contribution to breaking down barriers and promoting important technical innovations in the direction of higher sustainability, like Green Cooling technologies in supermarkets.

4.2.1 Profiting from domestic public support

For complying with the targets set under international treaties (e.g. KA, PA) and for achieving nationally set objectives (e.g. National Development Plan, National Climate Strategies), governments are eager to remove barriers for enabling sectoral reforms and necessary investments.

Regulatory interventions (e.g. setting of standards or limits like MEPS) are typically used in cases where the implementation of the mitigation option would be viable but other barriers, such as information asymmetries, prevent the scaled-up uptake of such a technology. Furthermore, governments can provide support through targeted subsidies, or financing support – for example, certain low-carbon investments may have higher capital requirements and may therefore require dedicated provision of funds by public finance institutions, such as development banks. Such financial instruments can take various forms, such as provision of (re-payable) grants, concessional loans, or guarantees, as well as equity investments from public sources (Kempa and Moslener, 2017).

The two main approaches to deliver support through subsidies are to either increase the revenue of the project, or to reduce its cost of implementation. Governments can remove existing subsidies for carbon-intensive technologies (e.g. existing HFC-based refrigerants) in order to reduce their cost advantage over low-carbon alternatives. To reduce costs of mitigation activities, governments can also incentivise the private sector through granting tax exemptions or accelerating depreciation. Both lead to a lower tax burden of private sector projects or the respective investments and therefore result in improved financial viability/bankability.

4.2.2 Accessing international climate finance

According to UNFCCC, 'Climate finance' refers to local, national or transnational financing—drawn from public, private and alternative sources of financing - that seeks to support mitigation and adaptation actions that will address climate change (UNFCCC 2020).

For achieving the obligations under the PA, both for climate mitigation and adaptation, various funding opportunities exist for governments and national, sectoral and private stakeholders. The national targets for mitigation and adaption are defined in the NDCs of each country. There is an unconditional target and a conditional target, the latter under the condition that international support is received. Besides bilateral support mechanisms (between two countries) and specific multilateral funding options for mitigation and/or adaptation (e.g. through multilateral climate funds), there are also multiple other funding options that can contribute to achieving the NDCs.

Arguably the most prominent climate fund is the Green Climate Fund (GCF), established by the UNFCCC to support global climate action through promoting a low-emission and climate-resilient transition in developing countries. GCF serves the PA, supporting developing countries in reaching their NDCs. The Fund seeks to engage across public and private sectors to unlock high impact and paradigm-shifting climate investments.

GCF offers a range of flexible financial instruments, enabling it to respond to specific investment contexts and market barriers. Any GCF funding is channelled through so-called Accredited Entities (AEs). For accessing GCF support, private companies need either to partner with an existing AE or apply to become an AE themselves.

GCF has set up the Private Sector Facility (PSF) to specifically fund and mobilise private sector actors, including institutional investors, and leverage GCF's funds to encourage corporates to co-invest (GCF, 2019). The PSF offers long-term funding through various instruments (incl. debt, grants, guarantees, equity) and can even structure in concessionality, if needed. The objective is to minimise investment risks, drive systemic transformation, scale small projects and bundle them into larger portfolios and to support capacity building.

Bottom-up activities initiated and executed by relevant end-user industries – "non-state actors" – that go beyond current regulatory and policy requirements set by national governments, are central for achieving a shift towards Green Cooling technologies and for tapping the GHG mitigation potential and related sustainability benefits in the RAC sector. "Non-state" action can be led by single actors, such as supermarket companies, or include several actors within and across the sector, in a non-state collaborative initiative or alliance (e.g. associations). For example, the Retail Trade Association of Kenya (RETRAK) is the voice of the retail industry with the main objective being to provide retailers with a central representative body to put across their agenda and retail trade concerns to government agencies, parliament and other bodies for their benefit (RETRAK 2020).

Relevant networks and initiatives in the HFC space for refrigeration include the Consumer Goods Forum (CGF), a relevant network in the supermarket sector encouraging all actors to shift to HFC-free alternatives, or 'Refrigerants, Naturally!', a relevant platform for the supermarket sector as it demonstrates the technical and economic feasibility of natural refrigerants in commercial refrigeration.

Initiatives or alliances can also include other stakeholders, for example non-governmental organisations, but also international and regional organisations like United Nations Development Programme (UNDP), United Nations Industrial Development Organisation (UNIDO), the German Development Agency (GIZ) and others that often assume a coordinating role. The vast majority of climate mitigation activities funded through the GCF and other climate funding sources on the ground are effectively based on "non-state" actions, regulated and mandated by governments but implemented by non-governmental entities.

In particular, the access to long-tenor debt financing and the overall efficiency of the functioning of the finance sector are core drivers of investments in mitigation projects (e.g. in energy efficiency) (Haas and Kempa, 2019). All these imperfections on financial markets are likely to be more predominant in developing economies, where the financial sector is typically less developed, which might further deter access to finance. Therefore, a combined approach with public finance used, e.g. for removing barriers and establishing necessary framework conditions including financing mechanisms or incentive schemes, and private finance being used for applying such instruments (e.g. obtaining low interest loans) is a typical set-up for international climate finance projects.

However, while this approach is often considered best suited to transform a sector or sub-sector, there are potential drawbacks as well. A good preparation with close stakeholder engagement and awareness of individual needs and risks are essential for designing an internationally funded project. Moreover, during implementation and operation, different targets of the government (e.g. achieving the mitigation targets under the NDCs) and the private sector (operating a sustainable supermarket and growing the business with lean procedures and administrative efforts) need to be aligned.

Where such 'blending' of resources (international climate funding, domestic public funding, private investments) exists, it is important to specify the conditions under which financial support to mitigation activities can be counted as climate finance in the context of the PA. To avoid double counting of GHG mitigation achieved and claimed (e.g. under the NDCs), it must be ensured that the mitigation is allocated pro rata to the respective financing sources.

4.2.3 Carbon Markets and Carbon Finance

International carbon markets can play a key role in reducing global GHG emissions cost-effectively. Carbon markets emerge when market-based instruments take hold and trading of carbon emission certificates begins. Market-based instruments put a price on GHG emissions (e.g. €/tCO2e), thus promoting efficient climate change mitigation. The number of emissions trading systems around the world is increasing. Besides the EU emissions trading system (EU ETS), national or sub-national systems are already operating or under development in Canada, China, Japan, New Zealand, South Korea, Switzerland and the United States. Other demand emerges from international emission reduction schemes like the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) or the EU's Fuel Quality Directive (FQD).

The PA provides for a robust and ambitious basis for the use of international markets and reinforces international targets, transparency and the accountability of Parties. Recognising the importance of international carbon markets, the PA (under Article 6) allows Parties to use international trading of emission allowances to help achieve emission reduction targets. Mitigation options covered by the conditional NDC target and fulfilling additionality criteria are eligible for market mechanisms under the PA and international climate finance. It should be noted that the detailed rule book for market mechanisms under the PA has not been finalised. However, a number of pilot initiatives already exist that provide funding for mitigation actions (Greiner et al., 2020).

While the price level achieved for internationally transferred mitigation outcomes (ITMO), the term for emission reduction units under Article 6, will be the key driver for private sector engagement in market mechanisms, several other parameters like the level of transaction costs, the degree of government interference and the scope of eligible activities will be relevant. Balancing the delicate trade-off between private sector costs and assurance of environmental integrity is vital if new market mechanisms are to trigger private sector participation in climate change mitigation and adaptation activities at a larger scale.

Due to the necessity to account for transfers of mitigation outcomes in the context of NDC implementation, (host) government institutions will play a greater role than has been the case under the Clean Development Mechanisms (CDM). The CDM is one of the Flexible Mechanisms defined in the Kyoto Protocol that provides for emissions reduction projects which generate Certified Emission Reduction units (CERs) which may be traded in emissions trading schemes. The interaction between private and public sector actors is just one of many factors that private sector participants will consider when evaluating the overall attractiveness of participating in Article 6 transactions (Michaelowa, 2019).

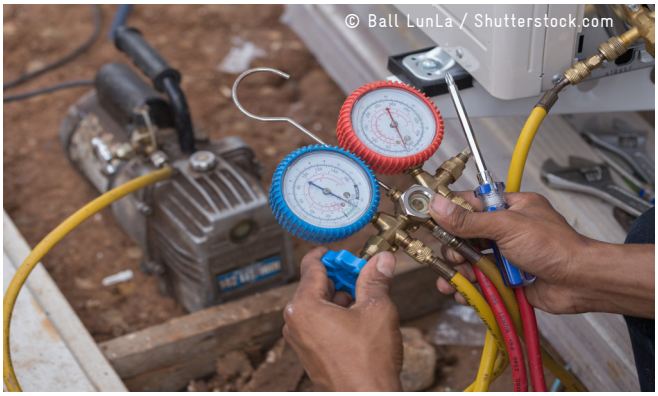
For financing activities like implementing Green Cooling technologies, carbon markets and the provision of additional finance for GHG emission reductions can be an effective mechanism for the private sector. In contrast to upfront financing, such results-based finance is an approach where a financier disburses funds to a recipient upon the achievement of a pre-agreed climate mitigation outcome. For this type of carbon finance, payments need to be made ex-post for climate mitigation achieved, and once other predefined and reported results have been fulfilled and independently verified (Benitez et al., 2017). While such results-based financing approaches can be a powerful tool to support operational expenses once projects are up and running, they do not enable project developers to close financing gaps associated with upfront capital expenditures (CAPEX).

In addition to compliance markets for carbon with legal requirements, voluntary demand for carbon credits currently also exists, driven mostly by corporate social responsibility considerations of buyers (Hermwille and Kreibich, 2016). One of the dominant voluntary carbon market (VCM) standards today is the Verra/Verified Carbon Standard (VCS) followed by the Gold Standard. The latter is considered the premium VCM standard due to its strong emphasis on local stakeholder involvement and the creation of sustainable development benefits. Though depending on the type of VCM and the buyers' interest of emission certificates, those voluntary offsets delivering high social and environmental co-benefits are the more attractive ones.

4.2.4 Blending of financing sources

Blending of market mechanisms (carbon finance) and climate finance can be useful to mobilise higher cost measures and overcome investment barriers that remain even in the presence of a carbon price signal, e.g. limited access to finance. Additional support through (upfront) climate finance can be critical to get activities off the ground. Thus, climate finance is important to flank market mechanisms until investment barriers disappear.

When designing support programmes and engaging both public and private actors, it will be crucial to create incentives for the private sector (i.e. supermarkets) that help foster private investments and the deployment, installation and operation of technology. At the same time, environmental integrity and monitoring of achievements made (e.g. GHG emission reductions) must be ensured.



5. CONCLUSION

Providing cooling services based on refrigerants containing HCFC or HFC cause severe damage to the ozone layer as well as the climate. For supermarkets, cooling and refrigeration are essential services. In many African countries, the number of supermarkets is growing rapidly and so is the demand for cooling (especially for food products). If no countermeasures are implemented, there will be significant negative implications for the ozone layer and the climate.

Global treaties, namely the MP and the PA, include measures to avoid or reduce negative impacts of using HCFC and HFC for cooling services. Governments are already obliged to phase out HCFCs and phase down HFCs under the MP/KA and each country must develop concrete plans (NDCs) to reduce its national GHG emissions as a contribution to the targets set under the PA. As a result, countries introduce new legislations and will increase reporting requirements.

The necessity to reduce GHG emissions also affects the RAC sector. Accelerating climate action and corresponding policy instruments will have implications for the commercial refrigeration sector, including cooling services for the retail market (e.g. supermarkets). Companies depending on cooling services for their operation (e.g. food retail companies and supermarkets) will sooner or later have to convert their systems accordingly, using natural, low-GWP alternatives.

Alternative technical solutions, so-called "Green Cooling" technologies applying natural refrigerants are already available and, in many cases, economically beneficial. The three systems explained in this paper (decentralised R290 system with a secondary water loop; centralised secondary system; R744 transcritical) are a selection of Green Cooling technologies from an enormous number of variations already available on the market. These technologies provide great opportunities for supermarket companies. Refrigeration solutions with natural refrigerants usually require less maintenance, have higher energy efficiency and a smaller carbon footprint. Additional financing opportunities already exist due to the national and global climate policy context described earlier.

These options are likely to further increase in the future and could possibly make an additional and sometimes decisive contribution to breaking down existing or remaining barriers and promoting important technical innovations in the direction of higher sustainability, like Green Cooling technologies in supermarkets.

When new supermarkets are built or existing supermarkets retrofit cooling equipment, awareness of existing and upcoming obligations and available technical and financial opportunities is important. Investment decisions of today will have implications for GHG emissions in the next decade. Supermarkets can play an important role in helping to reduce the use of HCFCs and HFCs and in preparing for a more sustainable business performance altogether.

While the consequences of the MP and PA may not be clear to all stakeholders yet, many internationally recognised supermarket brands with a presence in Africa already communicate corporate environmental, social, and economic contributions through certain compliance standards like GRI or SBTi. Integrating achievements from Green Cooling actions into such reporting would enhance the reputation and enable cost savings and financial well-being in the long run due to increased efficiency, better investor and customer relations, and resilience to climate-related risks.

The public sector and the RAC sector as a whole, e.g. represented by an association or a number of key players in a country or region, should ideally engage and closely cooperate with each other to achieve a significant shift towards Green Cooling.

Adopting Green Cooling technological developments and presenting the contributions achieved by the retail market and its businesses as part of their non-financial reporting not only has a strong potential to improve relations with stakeholders. It would also promote competitive advantages in terms of overall business performance, a more content client base and accessing additional funding sources.

When planning a supermarket refrigeration system, several requirements must be considered, including investment costs, operating costs, safety aspects, product quality, service & maintenance. Green Cooling technologies with natural refrigerants are available and competitive compared to other systems considering all aspects.

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