Cool Up
Upscaling Sustainable Cooling

COOLING SECTOR STATUS REPORT JORDAN:

Analysis of the current market structure, trends, and insights on the refrigeration and air conditioning sector

March 2022

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Table of Contents

Figures

Tables

Acronyms

AB	Arab Bank
AC	Air conditioning
BSRIA	Building Services Research and Information Association
CAGR	Compound annual growth rate
CBJ	Central Bank of Jordan
CFC	Chlorofluorocarbons
CLASP	Collaborative Labelling and Appliance Standards Program
CO_2	Carbon dioxide
COP	Coefficient of performance
DC	District cooling
EBRD	European Bank for Reconstruction and Development
EE	Energy efficiency
EER	Energy efficiency ratio
EUR	Euro
GAM	Great Amman Municipality
GCI	Green Cooling Initiative
GDP	Gross domestic product
GHG	Greenhouse gas
GWP	Global warming potential
HAMCO	Household Appliances Manufacturing Company
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
IEA	International Energy Agency
IKI	International Climate Initiative
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
JAB	Jordan Ahli Bank
JCS	Jordan Catering Supplies
JD	Jordan Dollar
JLGC	Jordan Loan Guarantee Corporation
JREEEF	Jordan Renewable Energy & Energy Efficiency Fund
kW	Kilowatt
m^2	Metres squared

MEMR	Ministry of Energy and Mineral Resources
MENA	Middle East and North Africa
MEP	Mechanical, engineering, and plumbing
MEPS	Minimum Energy Performance Standards
MP	Montreal Protocol
MT	Metric ton
MW	Megawatt
NDC	Nationally Determined Contributions
NEEAP	National Energy Efficiency Action Plan
NOU	National Ozone Unit
ODS	Ozone-depleting substance(s)
PHC	Privatization Holding Company
PTAC	Packaged terminal air conditioning (unit)
R1234ze	HFO-1234ze (unsaturated HFC, hydrofluoroolefin)
R134a	HFC-123a (tetrafluoroethane)
R22	HCFC-22 (chlorodifluoromethan)
R290	HC-290, Propane (hydrocarbon)
R32	HFC-32 (difluoromethane)
R404A	Mixture composed of HFCs: R143a (trifluoroethane), R125 (pentafluoroethane), R134a (tetrafluoroethane)
R407C	Mixture composed of HFCs: R32 (difluoromethane), R125 (pentafluoroethane), and 1,1,1,2-tetrafluoroethane
R410A	Mixture composed of HFCs: R32 (difluoromethane) and R125 (pentafluoroethan)
R600a	HC-600a, Isobutane (hydrocarbon)
R717	NH3-717, Ammonia (natural refrigerant)
R718	Water (natural refrigerant)
R744	Carbon dioxide
RAC	Refrigeration and air conditioning
RCREEE	Regional Center for Renewable Energy and Energy Policy
RE	Renewable Energy
RTOC	Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee
R&D	Research and development
SME	Small and Micro Enterprises
UAC	Unitary Air Conditioning
UK	United Kingdom
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
US	United States
VRF	Variable refrigerant flow
W	Watt

1. Introduction

With energy demand expected to increase 50% by 2040,[1] Middle East and North Africa (MENA) countries are facing a range of climate-change related challenges. The region's energy challenges include rapidly growing populations, urbanisation, and a heavily strained energy infrastructure. Cooling in air conditioning (AC)-equipped households already represents a major source of energy consumption in the region. The use of cooling is expected to grow further since, with an improved standard of living, more households are using air conditioning (AC) systems. There is large potential for energy saving as many of the space cooling and refrigeration systems in use have a low energy efficiency. An additional climate impact from cooling comes from the refrigerants still used in many of today's air conditioners and refrigerators. Such refrigerants with a high global warming potential are 2,000 times more potent for the climate (direct greenhouse gas emissions) than carbon dioxide and natural refrigerant alternatives. Without further policy intervention, direct and indirect emissions from cooling and refrigeration may rise 90% above 2017 levels by 2050, creating a vicious feedback loop.

1.1. The Cool Up programme

The Cool Up programme promotes accelerated technological change and early implementation of the Kigali Amendment to the Montreal Protocol and Paris Agreement in Egypt, Jordan, Lebanon, and Türkiye. The programme focuses on enabling natural refrigerants and energy efficient solutions to mitigate the effects of rising cooling demand. The Cool Up approach is based on four pillars: reducing cooling demand, phasing down hydrofluorocarbons (HFCs), replacing and recycling inefficient equipment and refrigerants, and training and raising awareness.

The programme's cross-segment approach focuses on the residential and commercial AC (air conditioning) sector and on the commercial refrigeration sector.

The programme aims to develop lasting institutional capacity and increase the deployment of sustainable cooling technologies in the market. To enable a cooling market transformation towards sustainable cooling technologies, the Cool Up programme will:

- Enhance cross-sectoral dialogue between national actors to build ownership to support long-term impact.
- Develop policy actions to create a supportive regulatory environment.
- Develop financial mechanisms and funding structures to enable the cooling market transition.
- Support the commercial deployment and dissemination of existing and emerging technologies with natural refrigerants.
- Provide resources for capacity development on sustainable cooling in the four partner countries.

In Middle East and North Africa (MENA) countries, cooling constitutes a major source of energy consumption; it produces indirect greenhouse gas (GHG) emissions and contributes to ozone depletion and global warming. The Cool Up programme seeks to address this challenge in its partner countries by mitigating the adverse impacts of refrigerants through promoting accelerated technological change and facilitating early implementation of the Kigali Amendment and Paris Agreement.

The programme is divided into three pillars:

- Policy and regulation
- Technology and markets
- Financing and business models

[1] British Patrol, "BP Energy Outlook 2018 Edition"

1.2. Aim and scope of this report

This cooling sector status report is the first in a series of reports that will be produced by the Cool Up programme. It aims to provide an overview of the cooling sector, laying the foundation for further work to be used within the programme and to facilitate informed decision makers for all public and private sector stakeholders.

In the partner countries—Egypt, Jordan, Lebanon, and Türkiye—detailed cooling market studies, which are needed to understand the status quo and transform the AC and cooling market sustainably, are hardly available.

This cooling sector status report presents a compilation of the limited data available on the focus sectors,[2] specifically AC in residential and non-residential buildings and commercial refrigeration in non-residential buildings. While this report focuses on those sectors, for completeness, it briefly summarises the current policy landscape and outlines several types of policies and regulations (e.g. international protocols, national strategies, laws and standards, and code policy) as well as the finance landscape. The Cool Up programme will be detailing these programme components further in separate reports.

The report is structured as follows:

- Chapter 2 provides a brief country overview, followed by high level summaries of the policy and the financial sectors.
- Chapter 3 gives an overview about the measures that were used to guide Cool Up's activities including clarity in definitions, data scope, and limitations of the study.
- Chapter 4 summarises the main findings of this report.
- Chapters 6 and 7 focus on the sector status of the AC and the commercial refrigeration markets, presenting data on the building stock and market potential, market characteristics, and developments.
- Chapter 8 discusses typical refrigerants used in the country.
- Chapter 4 provides insights on the relevance of natural refrigerants, the importance of maintenance, and key factors that impact a purchase decision.

1.3. Kigali Amendment

Most cooling systems rely on refrigerants with high global warming potential (GWP), leading to high direct emissions from the refrigerant circuit. Adopted in 1987, the Montreal Protocol phases down consumption and production of ozone-depleting substances (ODS)—most notably hydrochlorofluorocarbons (HCFCs)—in a stepwise manner, with different timelines for developed and developing countries (referred as Article 5 countries). Recognising the threat of fluorinated gases, specifically HFCs, to global climate change, in 2016, the international community decided in Kigali (Rwanda) on an amendment to the Montreal Protocol. Jordan has become the first country in the Middle East to ratify the Kigali Amendment to phase down HFCs. The Kigali Amendment entered into force on 1 January 2019 and implements a global HFC phase-down to reduce HFC production and consumption by more than 80% over the next 30 years.

For the Cool Up partner countries—Egypt, Jordan, Lebanon, Türkiye[3]—the same HFC phase-down schedules apply under the Kigali Amendment (see Table 1).

The baseline is determined as the country's average consumption of HFCs for 2020,2021, and 2022 plus 65% of the baseline for HCFCs.

[2] This report is not a part of national government reporting work under the Montreal Protocol; it does not present an official baseline report and it is not part of an HFC inventory.

[3] These countries are considered developing (Article 5) countries under the Montreal Protocol. Article 5 countries follow different phase-out schedules than industrialized countries.

Table 1 Schedule of phase-down of HFC consumption in Cool Up partner countries

Steps	Reduction schedule
1	Freeze 100% of the baseline for 2024-2028
2	Phase down by 10% of the baseline for 2029-2034
3	Phase down by 30% of the baseline for 2035-2039
4	Phase down by 50% of the baseline for 2040-2044
5	Phase down by 80% of the baseline for 2045

The upcoming years represent numerous opportunities and challenges for cooling sector conversions and the introduction of sustainable and future-proof alternatives to ODS and HFCs.

In many countries in past years, HCFC replacement led to the introduction of HFCs in major cooling applications. However, with the reduction schedule for HFCs in the Kigali Amendment, HFCs no longer represent a sustainable alternative to ODS. Enabling the uptake of sustainable alternatives, such as natural refrigerants, prevents a switch from HCFCs to HFCs and from HFCs to environment friendly low GWP alternatives. This direct replacement early in the transition process is called leap frogging and creates opportunities for emissions reductions, energy savings, and investments in future-proof technology.

In the last decade, natural refrigerants and climate-friendly measures (referred as not-in-kind technologies[4]) have been researched extensively. Examples of such not-in-kind technologies are being commercially introduced worldwide (e.g. passive cooling of buildings). Additionally, technical solutions to boost system efficiency have been identified and established for applications relying on natural refrigerants.

[4] Systems that do not rely on a vapor compression cycle using a gaseous refrigerant.

2. Overview

2.1. Setting the scene

Jordan's climate varies between Mediterranean and desert and is generally very arid. There are approximately 1113 cooling degree days in Jordan a year[5]. Energy consumption and power demand in the country has steadily increased due to economic and population growth. With these increases, Jordan is facing rising energy demand, particularly in the residential sector. Lighting, cooling, and heating represent the largest share of energy consumption in the country, and the residential sector accounts for about half of electricity consumption in Jordan. More than 60% of energy consumed in households is used for heating and cooling.

2.2. Macroeconomic overview

Jordan has a GDP of EUR[6] 39.5 billion or EUR per capita of 3,854 in 2020 Given the scarce availability of water, oil, and other natural resources, the government heavily relies on imports to meet its energy needs. In 2017, more than 94% of Jordan's energy use was imported—mainly natural gas.[7] The government subsidises energy prices to ensure affordable energy prices to Jordanians.

2.2.1. Electricity consumption

The residential sector accounts for 21% of final energy consumption.[8] As of 2020, the residential building sector in Jordan is the single largest electricity consumer in Jordan, with 49% of the country's total electricity consumption. The non-residential building sector accounts for more than 10% of total electricity consumption.[9] On average, more than 60% of energy consumed in households was used for space heating and cooling.[10] The demand on AC has increased due to the rise in peak summer temperatures and inefficient natural ventilation in buildings.[11]

Electricity demand has been increasing about 4.3% per year, on average, since 2018.[12] Energy demand and electricity demand were forecast to grow by 3.5% and 4%, respectively, in 2020.[13] Based on the results of the Electricity Demand Forecast Study for 2020-2040, the peak load is expected to increase by 3% in 2019 and 2.9% annually. [14]

[5] Source: https://xp20.ashrae.org/standard169/169_2013_a_20201012.pdf

[6] All data given in USD in the original source has been converted to USD. 1 USD has been converted to 0.90 EUR, based on European Central Bank, "Euro foreign exchange reference rates"

[7] Ministry of Energy and Mineral Resources, "Energy 2020 - Facts & Figures"; The World Bank, "Energy imports, net (% of energy use)"

[8] Ministry of Energy and Mineral Resources, "Energy 2015 - Facts and Figures"

[9] Based on:
Ministry of Energy and Mineral Resources, "Energy 2020 - Facts & Figures";
International Energy Agency, "Key stats for Jordan 1990-2016";
National Energy Research Center, "Personal communication with Eng. M. Tawalbeh"

[10] Al-Hinti and Al-Sallami, "Potentials and Barriers of Energy Saving in Jordan's Residential Sector through Thermal Insulation"

[11] Jordan Green Building Council, "Developing an Energy Benchmark for Residential Appartements in Amman"

[12] Ministry of Energy and Mineral Resources MEMR, "Energy Brochure 2019"; National Electric Power Company, "Annual Report 2019"

[13] Ministry of Energy and Mineral Resources, "Energy 2020 - Facts & Figures"

[14] Based on:
Ministry of Energy and Mineral Resources, "Energy 2020 - Facts & Figures";
Ministry of Energy and Mineral Resources, "Energy 2015 - Facts and Figures";
International Energy Agency, "Key stats for Jordan 1990-2016";
National Energy Research Center, "Personal communication with Eng. M. Tawaleh"

Energy demand growth is primarily driven by the following:

- Steep growth in population, mainly from an influx of refugees—from 5 million in 2000 to 9.9 million in 2016[15]
- Economic development (average GDP growth of 3% per year between 2008 and 2018)[16]
- Increased living standards[17]

Resulting economic challenges lie in persistently high poverty rates, unemployment and underemployment, budget and current account deficits, and government debt.[18]

Jordan's increasing energy needs make it vulnerable to international price volatility.[19] The cost of energy subsidies consumed nationally represent 10% of Jordan's GDP (2018).[20]

2.2.2. RAC sector emissions

The share of direct emissions in the sector's overall emissions is in the range of 15% to 40% according to different studies.[21] There is lack of country-specific studies on specific refrigeration and air conditioning (RAC) sector emissions.

The Green Cooling Initiative (GCI)[22] has developed an online model that provides RAC sector-specific data on installed technologies, sales, and emissions (and saving potential). The model allocates about 40% of the total (i.e. direct and indirect) emissions of the RAC sector to the AC and commercial refrigeration subsector, of which about 29% of the emissions stemmed from commercial and residential AC systems and 14% stemmed from commercial refrigeration systems (see **Figure 1**). The GCI model allocates 6% of the emissions to chillers (industrial and commercial subsectors). The remaining emissions are allocated to other RAC subsectors (mobile AC-passenger cars, transport refrigeration-trucks, and domestic and industrial refrigeration).[23]

[15] International Energy Agency, "Key stats for Jordan 1990-2016". The population growth is driven mainly by influx of refugees (2 million Palestinians, 2.5 million Syrians, in addition to 700,000 South Asians low-wage workers.

[16] International Monetary Fund, "World Economic Outlook Database"

[17] Sahawneh, "Energy Policy Country Report Jordan"

[18] CIA World Factbook, "Jordan Economy Profile 2018"

[19] CIA World Factbook; Jordan has secured several contracts for liquefied natural gas and is exploring nuclear power generation, exploitation of abundant oil shale reserves, and renewable technologies, as well as the import of Israeli offshore gas

[20] Ministry of Energy and Mineral Resources MEMR, "Energy Brochure 2019"

[21] See, for example:

National Ozone Unit Lebanon, "Guidance for Integrating Efficient Cooling in National Policies in Lebanon"

Egypt Environment Agency Affairs, "National Ozone Unit Activities"

Campbell, Kalanki, and Sachar, "Solving the Global Cooling Challenge"

Own calculations based on:

Build_ME, "Towards a Low-Carbon Building Sector in the MENA Region"

United States Environmental Protection Agency, "Stationary Refrigeration Leak Repair Requirements"

California Air Resources Board, "Potential Impact of the Kigali Amendment on California HFC Emissions"

United States Environmental Protection Agency, "Stationary Refrigeration Leak Repair Requirements"

[22] Green Cooling Initiative, "Global greenhouse gases emissions from the RAC Sector"

[23] Based on: Green Cooling Initiative

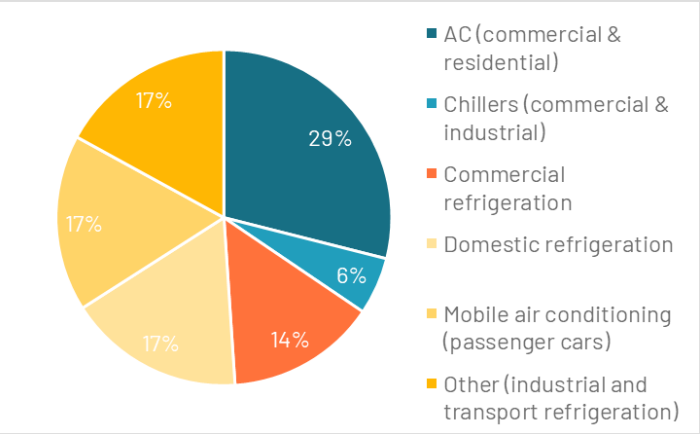

Figure 1 RAC sector emissions Jordan (2016)

2.3. Policy landscape

Jordan has been a party to the Montreal Protocol (MP) since 1989 and has has ratified the five subsequent amendments made under the MP, including the recent Kigali Amendment in October 2019. Jordan has progressed on its commitments relevant to the Montreal Protocol and Kigali Amendment through the implementation of several relevant programs, laws, and other policy instruments such as codes and standards. The policy instruments governing the RAC and building sector in Jordan were analysed to identify the key strengths and shortcomings towards phasing down HFCs, using natural refrigerants and reducing cooling demand. The regulatory analysis covers the four categories of policy instruments that hierarchically include the following categories: a) International Protocols and commitments, b) National Plans and Strategies, c) Laws and bylaws relevant to the RAC and building sector, and d) Standards and codes.

The regulatory analysis shows that Jordan has successfully implemented ongoing projects to phase out HCFCs, including through controlling imports of ODS through licensed importers and monitoring ODS-consuming and converted enterprises. Jordan has also started implementing a plan to phase down HFCs through the recently approved instructions. Though new instructions for phasing down HFC consumption are in place, HFCs are not yet controlled substances and are not monitored by Jordanian customs. As a result, importers are not obliged to register or obtain a license to import nor to report the quantities of imported HFCs to the NOU.

Sustainable cooling still needs to be reflected and streamlined across the different Jordan national strategies. The government has published an updated NDC (2021) and has raised Jordan's mitigation ambition to 31% reduction of emissions by 2030 compared to business as usual for base year 2012. The updated NDC includes a measure targeting reduction of HFCs consumption aligned with the national commitments to comply with the Kigali Amendment. For instance, the Ministry of Energy and Mineral Resources is planning to prepare the Third NEEAP which is supposed to compile key measures that are relevant to energy efficiency and related national priorities. However, Jordan has not developed a National Cooling Plan to integrate cooling aspects in Jordan's overall climate strategies.

Most of the existing laws are -to a large extent- well enforced and implemented, however there is room for improvement. For example, the Waste Management Framework Law No.16 of 2020 and the forthcoming Electrical and Electronic Waste Management all could contribute to improving the end-of-life management of the RAC appliances but a recovery and waste management scheme for phased-out refrigerants still needs to be elaborated. There is room for improvement to further develop codes and standards which govern the waste management of ODS and HFC as well as safety requirements and the certification of technicians and updating procedures for MEPS. There are several well-elaborated MEPS and labels for most RAC appliances of residential use but not for commercial RAC appliances.

Although Jordan has a National Ozone Committee, that serves as an advisory body to provide guidance to NOU to prepare the national ODS phase-out regulations, it lacks awareness of the linkages between F-gases regulations, energy efficiency standards of the RAC sub-sectors and the building codes. This lack of

awareness is identified as a key gap that hinders the coordination and mainstreaming of the cooling relevant issues across national regulations and policies. There is also a need for awareness raising around other sustainable cooling topics, especially the link between Kigali Amendment commitments and energy efficiency measures, as well as the enforcement of the building codes to reduce the cooling demand.

Based on the analysis of the policy instruments and experts interviews with several stakeholders in Jordan, some key policy recommendations have been derived to support the preparation of policy frameworks that guide the transition towards sustainable cooling and utilization of natural refrigerants. There is a detailed report with full analysis and policy recommendations available on the Cool Up website.

2.4. Finance landscape

Jordan has weathered the COVID-19 shock better than most countries[24]. The Banking sector in Jordan is quite robust, and relevant indicators such as the capital adequacy ratio of 19% are well above the prudential requirements of 12%. Banks have comfortable liquidity, with an average ratio of 138.1%, well over the regulatory minimum of 100%. Commercial banks finance both the public and private sectors, and there are 24 banks in the country, some of which have been in existence for more than 50 years.

CBJ data indicated that the total assets of the banking sector increased from EUR 72.46 billion[25] in 2019 to EUR 77.06 billion in 2020 (by 6.3%). This rise may be attributed to Government's introduction of policies with subsidised lending rates to the private sector, and more SMEs accessed the utilisation of the financing resources during the pandemic. The private sector deposits increased marginally mainly due to rise in spending during the pandemic. Commercial banks increased their borrowings from the CBJ during the year 2020 to fulfil the increasing demand for private lending. Overall, the country's financial sector demonstrated resilience to changing financing climate. Banks adapted to the Government's policies to address the economic requirements resulting from COVID-19 while still maintaining enough liquidity.

Most commercial banks assist solar PV electricity generation (renewable energy – (RE) generation) and EE projects as a part of their lending or as a sustainability initiative. Financial institutions are strong in Jordan, and with the policy push from the Government and CBJ, they expanded their portfolios within the EE and RE sectors. Reputed commercial banks such as Arab Bank (AB) and Jordan Ahli Bank (JAB), have sustainability approaches, commitments, disclosure, and adequate reporting. The Jordan Renewable Energy & Energy Efficiency Fund (JREEEF) invests in various renewable energy and energy-efficient technologies. JREEEF signed an agreement with the number of local commercial banks to provide finance at the subsidised rates of interest. In addition, Jordan Loan Guarantee Corporation (JLGC) provides guarantees to SMEs through participating commercial banks. JLGC also offers export credit guarantees and guarantees to loans offered for Renewable Energy projects.

[24] Jordan's Economic Update, April 2022 – The World Bank

[25] All currencies not given in Euro were converted to EUR using the exchange rate of the European Central Bank on 05 July.

3. Methodology

The first step in developing the cooling sector status report was establishing an understanding of the status of the refrigeration and AC (RAC) sector. The following set of measures were used to guide programme activities to maintain clarity in definitions, data scope, and limitations of the study.

3.1. Definitions

The programme uses the following definitions:

- Sustainable cooling is affordable and safe cooling that satisfies user needs with lowest possible impacts on the environment. Specifically, this implies the absence of environmentally harmful refrigerants (like fluorinated gases), a low energy demand (including a high efficiency), and at least readiness for a fully renewable energy supply.
- Direct greenhouse gas (GHG) emissions are related to refrigerant losses on each appliance (refrigerant leakage, operational and at disposal after end of life).
- Indirect GHG emissions are those related to the generation of the electricity used for cooling.
- RAC sector:
  - Refrigeration: Domestic, commercial, industrial, and transport refrigeration
  - AC: Residential and commercial AC manufacturing (including chiller)
  - Servicing sector for RAC
- Air conditioning (often referred to as AC, A/C, or air con) is the process of removing heat and moisture from the interior. It is used in domestic and commercial environments.
- The commercial refrigeration scope includes stationary systems used to store and display food and beverages in retail (supermarkets, shops) and food service (restaurants, hotels) but not for processes. The United Nations Environment Programme (UNEP) defines commercial refrigeration systems as systems that usually include standalone, condensing, or centralised units that mostly do not exceed a capacity of 200 kW and keep temperatures between -25°C and 8°C.[26]
- Commercial refrigeration cold storage includes commercial-scale cold storage rooms, which are usually equipped with condensing or centralised units and have capacities of up to 200 kW. These applications serve as storage for food and beverage products and differ from industrial-scale cold storage, which is used for the processing and storage of food and beverages or in the manufacturing process of petrochemicals, chemicals, and pharmaceuticals. Such systems can range in size from 5 MW to 30 MW.[27]
- Synthetic refrigerants are substances of anthropogenic origin (they do not occur naturally). These include HCFCs and HFCs, among others.
- Natural refrigerants are non-synthetic refrigerants that can be found in nature.
- Energy efficiency ratio (EER) W/W measures the energy efficiency of cooling devices in watts (W). A higher EER rating corresponds to higher energy efficiency.
- Residential building sector consists of single and multifamily buildings.
- Non-residential building sector includes public and private offices, education, health and social, hotel and restaurant, wholesale and retail trade, and other buildings (e.g. sports facilities). Industrial, agricultural and fishery buildings and warehouses are not included.

[26] Definition based on United Nations Environment Programme, "Presession Documents: Workshop on Hydrofluorocarbon Management"

[27] United Nations Environment Programme, "2018 Report of the Refrigeration, Air Conditiong and Heat Pumps Technical Options Committee"

3.2. Building segments and equipment types in scope of the Cool Up programme

AC sector

- Building segments: Focuses on residential buildings that cover single-family and multifamily buildings and on non-residential buildings, i.e. on public and private offices, education, health and social, hotel and restaurant, wholesale and retail trade, and other buildings (e.g. sports facilities).
- Equipment types (AC systems): Although there are many different technologies installed in the market, they can be clustered into the following key technology segments, which are used to depict the market characteristics.[28] AC systems can generally be divided into central and decentral systems.
  - Ducted air conditioning provides cooling (or heating) through a system of ducts. The central unit consists of a compressor, condenser, and an air handling unit, normally located in the attic or basement. Cool (or hot) air is distributed through a series of ducts and vents to the building. These systems are also called central air conditioning systems, which can be broadly segregated into two types, i.e., split central air conditioners (duct split) and packaged central air conditioners.[29]
  - Splits units: Single split systems consist of an indoor and an outdoor unit and provide AC for one indoor zone.
  - Multi-split and variable refrigerant flow (VRF) systems: Multi-split systems consist of one outdoor and several indoor units. VRF systems are sophisticated multi-split systems. Several outdoor units can support many indoor units (up to 64), and the indoor units can be regulated individually.
  - Packaged units (e.g. rooftop): All components are enclosed in a single box. Packaged units are typically located outside (rooftop, terrace) and provide cooling by delivering conditioned air to one or more indoor zones.
  - Chillers: Central cold generation units as part of a central AC system, which can be categorised into three groups:
    1. Compression water-cooled chillers
    2. Compression air-cooled chillers
    3. Sorption (absorption or adsorption) chillers

    - Chillers are connected to distribution water or delivery systems (fan coil units or air handling units).

[28] Primary sources for these definitions are:
United Nations Environment Programme (UNEP) Ozone Secretariat, "FACT SHEET 7 Small Self Contained Air Conditioning"
United Nations Environment Programme (UNEP) Ozone Secretariat, "FACT SHEET 8 Small Split Air Conditioning"
United Nations Environment Programme (UNEP) Ozone Secretariat, "FACT SHEET 9 Large Air-Conditioning (air-to-air)" United Nations Environment Programme (UNEP) Ozone Secretariat, "FACT SHEET 10 Water chillers for air conditioning"
United Nations Environment Programme, "2018 Report of the Refrigeration, Air Conditiong and Heat Pumps Technical Options Committee"

[29] CIELO, "Ducted vs. Ductless Air Conditioning Systems"

Commercial refrigeration sector

Cool Up focuses on the commercial refrigeration sector. Domestic and industrial refrigeration are not included in the Cool Up programme scope.

- Building segments: Focuses on corner stores, restaurants, supermarkets, and hotels, including areas for cold storage.
- Equipment types (commercial refrigeration systems): Covers the three main types of equipment:[30] standalone equipment, condensing units, and centralised systems (for supermarkets). The different equipment types are used in different building segments:
  - Most medium to large supermarkets prefer to use centralised systems because they are usually more energy efficient than condensing units and plug-in cabinets. The size of the sales area of supermarkets that use a centralised refrigeration system range from 400 m^2 to up to 20,000 m^2.
  - Condensing units are commonly used in medium and small stores and can often be found in fast food outlets, restaurants, bars, and convenience stores. In comparison to a centralised system, they allow fewer cabinets to be connected to the system, take up less space, and are usually easier to install.
  - Standalone refrigeration systems are typically self-contained systems such as ice cream freezers, display cases, and vending machines. They are often referred to as plug-in units because they are closed systems, which do not require extensive installation.

3.3. Data collection approach

The data for this report was collected from various primary and secondary sources.

- **Primary data** was gathered through expert interviews and field visits. Around 15 interviews were executed per partner country. The interviews were conducted with a diverse set of experts representing manufacturers; assemblers; wholesalers; architects; mechanical, electrical, plumbing (MEP) consultants; and project developers. Field visits were completed in some countries.
- **Secondary data** was obtained from a diverse set of publications covering statistical sources and national documents (e.g. the National Cooling Plan Lebanon[31] or HFC inventory in Jordan from United Nations Industrial Development Organization (UNIDO)[32]), market research companies (e.g. Building Services Research and Information Association (BSRIA) for Türkiye and Egypt),[33] a literature review, and regional information such as the Collaborative Labelling and Appliance Standards Program (CLASP)[34] or the Regional Center for Renewable Energy and Energy Policy (RCREEE).[35]

This data approach had limitations, such as partial lack of systematic approaches for data collection (e.g. data on HFC consumption, data basis for installed technologies, especially in the commercial refrigeration sector), difficulty accessing official data, missing background information to available data, and high ranges of data for the same point between different sources. Due the data situation in the mentioned RAC subsectors, this report acknowledges data gaps and data from different sources that results in discrepancies. To reduce the limitations, the Cool Up programme utilised various approaches such as analysis of different data sources, cross valuation, reliability analysis, and use of expert opinions.

Several strategies were used to handle the data limitations. If no country-specific values were available, data gaps were closed by using information from global studies such as those from the Intergovernmental

[30] United Nations Environment Programme (UNEP) Ozone Secretariat, "FACT SHEET 4 Commercial Refrigeration"
[31] National Ozone Unit Lebanon, "Guidance for Integrating Efficient Cooling in National Policies in Lebanon"
[32] United Nations Industrial Development Organization, "HFC Inventory of Jordan"
[33] The Building Services Research & Information Association, "Split Systems 2018"
[34] Klinckenberg and Smith, "Scoping Study for Commercial Refrigeration Equipment"
Waide, van der Sluis, and Michineau, "CLASP Commercial refrigeration equipment: mapping and benchmarking"
[35] Regional Center for Renewable Energy and Energy Efficiency, "Field survey results for AC market in Egypt"

Panel on Climate Change (IPCC),[36] International Energy Agency (IEA),[37] Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee (RTOC), Rocky Mountain Institute,[38] and CLASP,[39] as well as by using data from a global model developed by the Green Cooling Initiative (GCI)[40] and by using knowledge from expert interviews.

The global model developed by GCI[41] estimates data on installed equipment in the stock and sales data and provides projections for AC systems (also chiller AC) and commercial refrigeration systems; other RAC subsectors are also covered. Due to the global model approach, the country-specific values are afflicted with a different grade of uncertainty.

The observed lack of comprehensive data for current trends on the RAC market in the partner countries highlights the need for further assessments and a systematic data collection.

Key data parameters will be monitored throughout the programme duration and will be reflected in updates of programme activities and recommendations.

[36] Intergovernmental Panel on Climate Change, "Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change"

[37] International Energy Agency, "The Future of Cooling - Opportunities for energy efficient air conditioning"

[38] Campbell, Kalanki, and Sachar, "Solving the Global Cooling Challenge"

[39] Waide, van der Sluis, and Michineau, "CLASP Commercial refrigeration equipment: mapping and benchmarking"

[40] Green Cooling Initiative, "Global greenhouse gases emissions from the RAC Sector". The model estimates data on installed equipment in the stock (as well as sales figures) for AC cooling equipment and for the commercial refrigeration sector.

[41] Green Cooling Initiative

4. Summary of key findings and recommendations

Several companies are manufacturing different types of air conditioning (AC) under different brand names in Jordan. Of the AC systems on the market in Jordan, 50% are produced by local manufacturing companies. However, the country still relies on imports from outside countries to meet the growing demand. Jordan has more than 400 workshops that provide maintenance and services to the refrigeration and air conditioning (RAC) sector.

The demand for RAC units across Jordan is growing and that trend is expected to continue. AC market drivers include increasing affordability (gross domestic product growth), rising population, new construction activities, climate change, increasing electricity prices, the introduction of new technical regulations, and the availability of new technologies. The demand for different AC technologies is driven by installations in new buildings, new installations in existing buildings (to increase the share of air conditioned rooms), and the replacement of defective AC systems. In the new construction sector, around 60% of new apartments and 80% of new single-family buildings, between 70% and 75% of new offices and supermarkets, and 90% and 95% of new healthcare and new hotel buildings install AC systems. In existing residential buildings, there is substantial growth potential for the cooling market, as about 80% of the residential floor area and about 50% of the non-residential floor area is not yet air conditioned. While the AC market in Jordan already grew by 1.5% between 2017 and 2020, the AC market is expected to experience a compound annual growth rate (CAGR) of about 6% between 2021 and 2027.

Currently installed equipment and new units installed have a lower efficiency than the best available technology, so there is a large potential for energy savings. AC systems installed in the building stock have an energy efficiency ratio (EER) or a coefficient of performance (COP) in the range of 2.5-4.5 (existing buildings) and an average of about 3.5.

The commercial refrigeration sector is dominated by local manufacturers for condensing and centralised systems. Commercial standalone refrigeration systems are locally manufactured and imported. The main suppliers of standalone systems to supermarkets and quick service and casual restaurants are the Jordanian and international food and beverage industries.

Jordan currently imports all refrigerants. The main refrigerant used in the AC sector is R410A, followed by R134a. The refrigeration sector mainly uses R134a, R404A, and R407C. Servicing equipment mostly employs R22 for the old units and R134a, R407C, R410A, R600a, and R717 for the newly installed units. Natural refrigerants are available in Jordan, though their uptake has been limited. Government is promoting the transition to natural refrigerants in RAC applications by mobilising the required support from international agencies for the private sector to facilitate the shift to new technologies.

The overall market for cooling equipment in Jordan is expected to continue to grow. This strong market growth requires introducing sustainable cooling technologies and natural refrigerants early on as a direct replacement to prevent potential lock-in effects to harmful refrigerants. Perceived key challenges to the uptake of natural refrigerants include safety issues and the associated costs.

Cool Up presents a unique opportunity to build on the regulatory framework currently in place, Jordan's well-established manufacturing sector, and commercial banks, which provide green finance to scale-up sustainable cooling technologies and the use of natural refrigerants. It is imperative that Cool Up raises awareness of the potential and opportunities around natural refrigerants and improving energy efficiency; the programme must also address concerns about safety and upfront investment costs.

5. Air conditioning market

- The overall market for cooling equipment is expected to continue to grow.
- The national AC market is dominated by local manufacturers and imported products.
- There is large potential for energy savings—installed equipment and new units installed have lower efficiency than the best available technology.
- The main market drivers in the residential building sector are economic growth (affordability), extreme weather conditions (ad hoc decision to buy an AC system), and new construction activities. In the non-residential building sector, 70%–95% of all new non-residential buildings install AC systems.
- Split systems (ductless) are the main system type in the overall market (installed and sold each year); in larger non-residential buildings, chillers are the main technology, and district cooling (DC) has been implemented in Abdali.

5.1. Building stock and market potential

In Jordan, residential buildings make up the majority (79%) of the total building floor area (315 million m^2). Of this residential floor area, 65% is single-family housing, while the rest is floor area in apartments in multifamily housing. The highest share in non-residential floor area is office buildings (39%), educational buildings (19%), and wholesale and retail buildings (14%) (see **Figure 2**).

The annual new construction rate in the residential sector was about 1.5% in 2017-2019. [42]

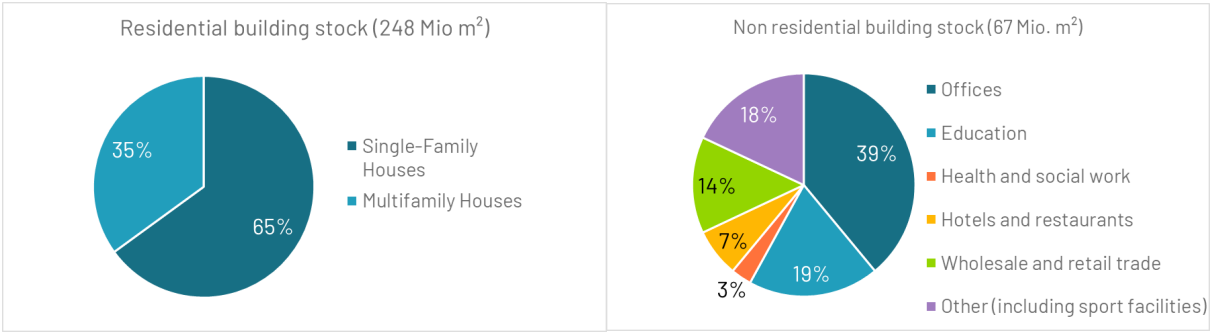

Figure 2 Building stock in Jordan in 2020 [43]

In the residential sector, about 55% of the housing units have an AC system installed (sum of the shares illustrated in light blue and yellow in **Figure 3**). [44] [45] In the housing units with an installed AC system, about 35%of the rooms or floor area is air conditioned. [46] This means that about 20% of the total residential floor area or rooms are air conditioned (share illustrated in yellow in **Figure 3**) [47] and 80% of the floor area is not air conditioned (sum of the shares illustrated in light and dark blue in **Figure 3**).

The picture is different in the non-residential building sector. About 75% of buildings were equipped with at least one AC system. In these non-residential buildings with an installed AC system, about 68% of the floor area is air conditioned. [48] This means that about 51% of the total commercial floor area is air conditioned and the other half of the floor area is not air conditioned.

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[42] Calculated on the basis of:
Jordan Strategy Forum, "The Construction & Housing Sector in Jordan"
Guidehouse, "Guidehouse Global Building Stock Model"
Department of Statistics Jordan, "Main results of the general census of population and housing 2015"

[43] Guidehouse, "Guidehouse Global Building Stock Model"

[44] Expert Interviews

[45] Department of Statistics Jordan, "Main results of the general census of population and housing 2015"

[46] Expert Interviews

[47] About 55% of housing units have an AC system installed; in these housing units about 36% of the rooms or floor area is conditioned. By multiplying these numbers, the share of the total conditioned floor area can be estimated (55%*36% = 20%).

[48] Expert Interviews

A potential growth area for cooling equipment sales is floor area in existing buildings that is not yet air conditioned.

According to scientific approaches, the maximum penetration of AC systems in the building stock is determined by a maximum climate-based market saturation and the availability in the market depending on average household income.[49] In this context, the penetration rate of cooling equipment is defined as the share of residential housing units and non-residential buildings with at least one AC system installed.

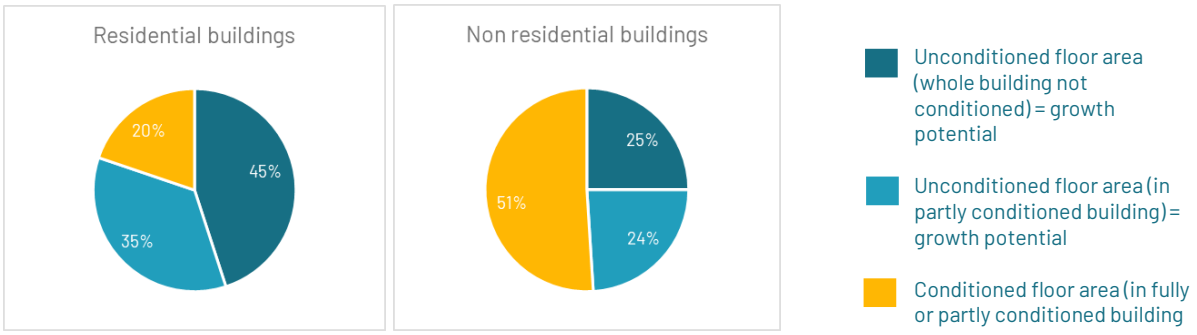

Figure 3 Share of unconditioned floor area (=growth potential) in residential and non-residential buildings

The new construction sector is also a key potential growth area for sales that is not reflected in this illustration.

The overall market is expected to grow in the future.

5.2. Market characteristics and developments

In Jordan, several companies are manufacturing different types of AC appliances under different brand names. The major brands sold in the country—including the imported equipment—are Petra Engineering Industries Com., Middle East Electric Industries Com Ltd., Abu Haltam Group for investments, National Refrigeration Com, National Integrated Industrial Complex, Zahran and Partners, Ramco Air Conditioning, Panasonic, Daikin, Carrier, Trane, Samsung, Gree, LG, Daewoo, and Akai. [50]

Jordan has more than 400 workshops that provide maintenance and services to the RAC sector.[51]

Of the AC systems put on the market in Jordan, 50% are produced by local manufacturing companies, mainly Petra Engineering.[52] The country still relies on imports from outside countries to meet the growing demand.

5.2.1. Predominant technologies

Although many different technologies are installed in the market, they can be clustered into the following technology segments, which are used to depict the market characteristics further:

- Single split systems
- Multi-split and VRF systems
- Packaged terminal AC (PTAC) (e.g. rooftop) systems
- AC chillers

For definitions of each segment, see Chapter 3.2.

The single split system is the predominant AC system type installed in the current building stock in Jordan. Most of the split systems are ductless. Specifically, the single split system is the predominant system in the residential, office, and retail building segments. Chillers are the predominant technology in larger non-

[49] McNeil et al., Bottom-Up Energy Analysis System - Methodology and Results
[50] United Nations Industrial Development Organization, "HFC Inventory of Jordan"
[51] United Nations Industrial Development Organization
[52] Interview with Petra Engineering Industrial Co.

residential buildings such as shopping malls, large hotels, and healthcare buildings. VRF systems have a low share in the existing building stock, but their current sales are increasing. Packaged systems (e.g. rooftop) have major market share in the retail building segment and are also installed in hotels and the office and healthcare building segments.

Table 2 provides an overview of the most relevant technologies in the existing building stock per building segment.

Table 2 Overview of AC systems installed in existing buildings in each building segment [53]

Predominant installed AC technology – large share*	Second predominant installed AC technology – small share*	Third predominant installed AC technology – very small share*	Neglected share*

	Single split ductless	Single split ducted	AC chiller	Packaged (e.g. rooftop)	Multi-split, VRF	
Single-family						
Multifamily						
Hotel						
Office						
Retail (including supermarkets)						
Healthcare						

* Market share refers to the share in the respective building segment and **not** to the whole market.

Table 3 provides an overview of the most relevant technologies in the new construction sector by building segment.

Single split systems are mainly sold to the residential sector. But these system types are also sold to non-residential sector, especially to office buildings and small hotels, to supermarkets and stores. Central systems are typically sold to retail, office, and healthcare buildings. Chillers are typically sold to big hotels, big hospitals, and shopping malls. VRF are sold to residential buildings (single-family buildings), retail and office buildings.[54]

Table 3 Overview of AC systems installed in newly constructed buildings in each building segment [55]

Predominant AC technology – large market share*	Second predominant AC technology – small market share*	Third predominant AC technology – very small market share*	Neglectable market share*

	Single split ductless	Single split ducted	AC chiller	Packaged (e.g. rooftop)	Multi-split, VRF	
Single-family						
Multifamily						
Hotel						
Office						
Retail (including supermarkets)						
Healthcare						

* Market share refers to the share in the respective building segment and **not** to the whole market.

[53] Expert Interviews
[54] Expert Interviews
[55] Expert Interviews

AC systems installed in the building stock have an energy efficiency ratio (EER W/W) in the range of 2.5-4.5 (existing buildings), with the majority having an efficiency significantly below the best available efficiency range.[56]

Table 4 provides an overview of the efficiency range of the technologies currently installed in the stock, of new equipment, and of the best available technology.

Table 4 Efficiency of different AC systems[57]

System type	Efficiency range in the stock (EER 35/27)*	Efficiency installed in new buildings	Best available efficiency	
			National	International
Single split systems (small)	2.5-4.5	3.5	4.5	6.5
VRFs/Multi-splits	3.0-4.5	4.0	5.0	5.0 / 4.4
Chillers	3.0-4.5	3.0-5.0	5.0	3.9-6.1**
Central ducted (e.g. rooftop)	2.5-4.0	3.0	4.0	4.3

* According to EN 14511
** EER 7/12°C//30/35°C according to EN 14511, EER only of the chiller not the whole AC system, for whole systems it will be significantly lower depending on type of distribution and transfer system ("air only," "air + water," or just "water")

Typical AC systems (excluding chillers) are replaced every 7-10 years.[58]

District cooling

Jordan has one DC project, built in 2016, which produces 31,000 tons of cooling capacity and running all year around. It provides cooling to 18 buildings (residential, commercial, hotels, malls, etc.) with a total floor area of 300,000 m^2; the system is located in Abdali, Amman. The cooling system includes eight compressors using R717 (ammonia). This refrigeration plant allows 37% emissions reductions compared to several individual cooling systems.

The DC-heating plant is designed to make a significant reduction in greenhouse gas emissions of about 15,000 tonnes per year due to the use of efficient chillers using R717 (ammonia refrigerant). The project is designed to save 40% in energy consumption by significantly reducing peak electrical demand, which lowers the cost of heating and cooling for end users. The total project cost exceeds EUR 95 million, including a loan of EUR 27 million by EBRD.[59]

The Jordan District Energy company supplies chilled water as part of the provided services by the district heating and cooling plant for the Abdali Complex; the system supplies chilled water to the refrigeration system in the C-Town Abdali Mall used for the water cooled condenser, which is a unique project installed by Abdin Industries. The system consists of two refrigeration racks and two freezing racks that use direct current inverter technology rather than the traditionally used alternating current inverters.

Observation of the system's performance and Hypermarket electricity bills indicate savings up to 60%. The system is also stable–the temperatures of the cabinets have been steadily maintained since the activation of the system. On top of this, the system is centrally monitored and controlled by the maintenance staff; it also remotely monitored by Abdin Industries.

[56] Expert Interviews
[57] Expert Interviews
[58] CLASP, "Environmentally Harmful Dumping of Inefficient and Obsolete Air Conditioners in Africa"
[59] European Bank for Reconstruction and Development, "Abdali District Heating and Cooling"

Figure 4 C-Town Rack System

Figure 5 C-Town Abdali Hypermarket

Chilled Water System with heat recovery unit for Central Slaughterhouse of Great Amman Municipality (GAM).

Replacing the existing old chiller with a new efficient chiller with an integrated heat recovery system is currently under implementation at Central GAM's Slaughterhouse that can deliver both chilled water and hot water that are needed simultaneously in the process. A high COP of about 6.0 can be reached by a chiller with a heat recovery unit.

5.2.2. Market trends and drivers

AC for residential and commercial applications has become popular in Jordan due to the increase in economic development, population, and the harsh climatic condition in recent years.

The demand for different AC technologies is driven by installations in new buildings, new installations in existing buildings (to increase the share of air conditioned rooms), and the replacement of dysfunctional AC systems. The potential area for sales growth in existing buildings is explained in Chapter 5.1.

The main sales drivers in the existing residential building segment are increasing affordability (GDP growth), growing population, and climate change (increase in temperature in summer, including temporal heat waves, and decrease in temperature in winter compared to average figures). These factors drive sales growth due to first-time installations in existing buildings.[60]

The new construction sector is another significant market for the increase in AC system sales in the residential and the commercial sectors. Between 60% (apartments) and 80% (single-family buildings) are equipped with AC systems. The new construction sector is a key driver for sales growth in the non-residential building segment, which has a more saturated market in the existing building segment compared to the residential sector. Between 70%-75% (office, supermarket) and 90%-95% (healthcare and hotel) of new non-residential buildings install AC systems.[61]

Other factors influencing sales are increasing electricity prices, the availability of new technologies such as inverters, the introduction of new technical regulations for eco-design, economic growth, the COVID-19 pandemic, new projects addressing efficient cooling systems, and new construction. For the replacement of old systems, the demand is mainly driven by the change in electricity prices, awareness about energy savings, and level of income. Most users in the residential sector replace their ACs only when the system reaches end of life.[62]

On a technology level, the trend is to use a ductless split unit with a full inverter. For chillers, a new technology is available for use: Turbo Core Compressors, which are expected to be more energy efficient and are still under R&D stage.[63] **Table 5** summarises the impact of these drivers and the trends they create on a technology level.

Table 5 Trends in the AC sector and their impact on AC sales

Technology	Main applications in the future	Market drivers	Emerging trends	Estimated impact on sales
Single split (ductless) Single split (ducted)	Residential (majority)	Enforcement of new technical regulations related to AC (energy labelling and eco-design in 2014) through use of inverter technology New projects and the Royal initiative related to school heating programmes using ACs and solar PV systems. Commercial installations driven by new construction, economic growth, and COVID-19 changes.	New refrigerants utilised, R32	↑
Multi-splits			Not popular due to higher initial cost; single splits dominate the market.	↓
VRF	Residential single-family, hotels	Growth in the leisure and tourism sector (new-built hotels) New constructed single-family houses	Become popular with mechanical, electrical, plumbing (MEP) consultants and for new single-family housing and hotels	↑

[60] Expert Interviews
[61] Expert Interviews
[62] Expert Interviews
[63] Expert Interviews

Technology	Main applications in the future	Market drivers	Emerging trends	Estimated impact on sales
Packaged (rooftop)	Healthcare, Hotels, and offices	Decline of investment in the retail sector	Still decreasing investment in the retail sector due to COVID-19	↓
Chillers	Large buildings; hotels and hospitals	New construction of hotels and hospitals New technology has been introduced for chillers using inverters	It became popular for hotel owners and hospitals, especially due to inverter technology	↑
DC	Retail	One project, Abdali DC project, was built and is in operation.	No new planned projects	↓

5.2.3. Market size and structure

The GCI model estimates the number of units installed in Jordan's building stock to be about 285,000 AC systems.[64] The model seems to underestimate the number of installed AC systems considering the number of households and non-residential buildings, the share of buildings with at least one AC system installed, the share of floor space that is conditioned (see Chapter 5.1), and the available import and export data for the number of systems (see this chapter).[65]

According to the *Observatory of Economic Complexity*, in 2019, Jordan exported EUR 81 million worth of AC systems and imported EUR 63 million worth of AC systems.[66] Most of the total imported equipment comes pre-charged with refrigerants and the rest requires a top-up.[67] The main countries of destination (export) are Saudi Arabia, the US, Kuwait, and Qatar. The main countries of origin (import) are China, Belgium, Germany, and Thailand (see **Figure 6**).

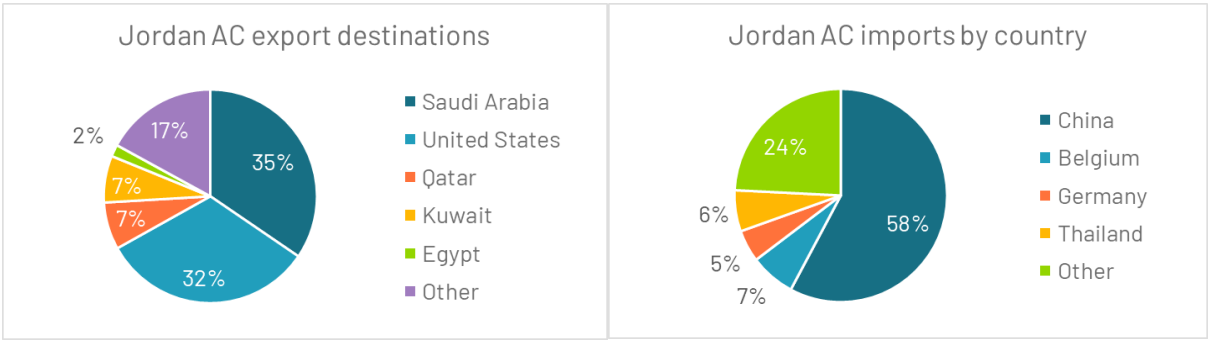

Figure 6 Import and export of AC systems (2019)[68]

In 2016, the hydrofluorocarbon (HFC) inventory of Jordan[69] estimated the total number of imported AC systems to be 332,000, exported AC systems to be 34,000, and AC systems that have been manufactured locally to be about 150,000 systems.[70] Considering the number of households,[71] the penetration rate and

[64] Numbers based on: Green Cooling Initiative, "Global greenhouse gases emissions from the RAC Sector"; the number for chillers contains the commercial and industrial sectors.
[65] Build_ME, "Towards a Low-Carbon Building Sector in the MENA Region"
[66] Observatory of Economic Complexity, "Trade Data"
[67] Observatory of Economic Complexity
[68] Observatory of Economic Complexity
[69] HFC Inventory in Jordan, UNIDO,2015
[70] HFC Inventory in Jordan, UNIDO,2015
[71] Build_ME, "Towards a Low-Carbon Building Sector in the MENA Region"

typical replacement rate,[72] and the share of air conditioned rooms per household,[73] these figures seem to be overestimated.[74] Based on the analysis in Jordan, the AC system market in Jordan (residential and non-residential sector) is estimated to be in the range of 90,000-110,000 sales.[75]

The AC market is strongly dominated by single split systems, which represent about 80% of the market (mainly ductless) in monetary terms. Other technologies such as chillers and central units (packaged and VRF systems) have a minor share in the market. **Figure 7** illustrates the shares of the different AC systems in the market in 2016 in monetary terms (sales volume in USD). In terms of the number of systems, the share of single split systems is still higher, and the share of systems is much lower (due to the higher price per unit for a chiller compared to a single split system).

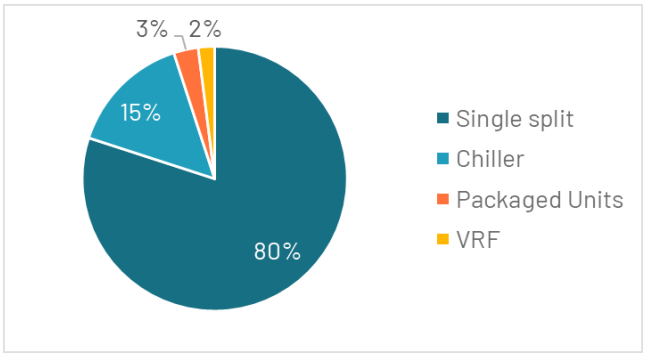

Figure 7 AC market volume overview by technology in monetary terms (share in sales volume in EUR, 2016)

While the Jordan AC market already grew by 1.5% between 2017 and 2020, the AC market is expected to experience a compound annual growth rate (CAGR) of about 6% between 2021 and 2027. Most of the market growth can be attributed to the room AC market, including the single split system market (mainly ductless, with inverted technology). The fastest growth rate is expected to take place in the AC chillers and the VRF systems market. In contrast, the market for packaged systems (e.g. rooftops) will stay stable or even shrink.[76] [77]

[72] Build_ME, Expert Interviews

[73] Expert Interviews

[74] An explanation may be found in differences in accounting and coding. The number may also reflect part of AC systems.

[75] Estimated considering the number of households, penetration rate, replacement rate, and new installations. For the commercial sector, it is assumed that the share in terms of number of systems is about 20% based on experience in the Lebanon market (National Ozone Unit Lebanon, "Guidance for Integrating Efficient Cooling in National Policies in Lebanon")

[76] 6Wresearch, "Jordan Air Conditioner (AC) Market (2021-2027)"

[77] United Nations Industrial Development Organization, "HFC Inventory of Jordan"

6. Commercial refrigeration market

- Supermarkets dominate the commercial refrigeration sector in Jordan; other large market segments are hotels and restaurants.
- The main technologies are standalone systems (65%) and condensing units (30%).
- Population growth, increasing electricity prices, the introduction of new technologies, economic growth, the COVID-19 pandemic, and new construction activities are the main drivers for new installations.
- Food and beverage providers are the main suppliers of standalone refrigeration systems to supermarkets and quick service and casual restaurants.
- The Jordanian commercial condensing and centralised refrigeration sector is dominated by local manufactures; commercial standalone refrigeration systems are locally manufactured and imported.

6.1. Market segments and predominant technologies

The predominant technology clusters for commercial refrigeration are commercial standalone systems, condensing units, and centralised systems (for definitions, see Chapter 3.2).

Standalone refrigeration systems such as chest freezers are mainly used for small refrigeration applications (typically small and medium sized freezers) in small supermarkets. Often free of charge, standalone reach-in refrigerators and freezers are provided by food and beverage industries. Quick service restaurants depend mainly on standalone products. [78]

Condensing units are typically installed in medium and large supermarkets and hypermarkets. They are predominantly used in large restaurants, hotels, and restaurants that have a central kitchen supporting their branches and large restaurants. They are also popular in relatively small cold stores due to lower upfront costs. [79]

Centralised plants are popular in large cold storage due to higher efficiency compared to condensing refrigeration systems. [80]

The typical capacity size (electrical rated power) of a commercial standalone system is 260 W–1,200 W. The capacity size of the condensing and centralised systems depends on the size requested by the customer, which is typically higher than the standalone types.[81] The typical capacity size of a condensing system is in the range of 2 kW-20 kW and of a centralised system is 40 kW-200 kW.[82]

Table 6 provides insights into typical systems and their technical design including application type and typical size range in the Jordan commercial refrigeration market.[83]

[78] Expert Interviews
[79] Expert Interviews
[80] Expert Interviews
[81] Desktop research and Expert Interviews
[82] United Nations Environment Programme (UNEP) Ozone Secretariat, "FACT SHEET 4 Commercial Refrigeration"
[83] Field visits of the project team between September 2021 and January 2022, photos taken by the project team

Table 6 Typical refrigerators in the Jordanian commercial refrigeration market

System	Image	Technical design	Used in	Typical Size range[84] Volume (Litre) Electric rated power (W)
Chest freezer (standalone system)		Self-contained Air cooled Built-in condensing unit	Small, medium, and large supermarkets	300-500 litre 260 W-500 W
Reach-in refrigerator or freezer (standalone system)		Self-contained Built-in condensing unit	Small, medium, and large supermarkets and hypermarkets, restaurants	360-1,750 litre 500 W-950 W
Reach-in freezer (condensing unit)		Remote condensing unit	Medium and large supermarkets	As per customer request according to available space
Reach-in refrigerator (condensing unit)		Remote condensing	Large and medium supermarkets	As per customer request according to available space
Display refrigerator cabinets (standalone system)		Self-contained Built-in condensing unit	Medium and large supermarkets, hypermarkets, and restaurants	As per customer request according to available space

[84] Desktop search and collected technical data during field visit.

System	Image	Technical design	Used in	Typical Size range[84] Volume (Litre) Electric rated power (W)
Centralised reach-in refrigerator		Centralised rack system	Hypermarkets	As per customer request according to available space
Condensing or centralised combined reach in open and closed freezer cabinet		Remote condensing unit or rack system	Large supermarkets and hypermarkets	As per customer request according to available space
Cold rooms		Centralised (rack system) or condensing system	Restaurants, hotels, and hypermarkets	As per customer request according to available space

Table 7 provides an overview of the building segment (use cases) and typical refrigeration systems used.

Table 7 Commercial refrigeration segments in Jordan[85]

Building type (market segment)	Typical refrigeration systems, including number of units
Small-sized supermarket (up to 50 m^2)[86]	▶ 2-4 standalone reach-in refrigerators (some are provided by food and beverage industries) ▶ 1-2 standalone chest freezers
Medium-sized supermarket (51 m^2 to 99 m^2)	▶ 5-8 standalone reach-in refrigerators and standalone reach-in freezers (some are provided by food and beverage industries) ▶ 3-5 standalone chest freezers ▶ Up to 2 condensing reach-in refrigerators
Large-sized supermarket (100 m^2-250m^2)	▶ More than 8 standalone reach-in refrigerators and standalone reach-in freezers (some are provided by food and beverage industries) ▶ 3-5 standalone chest freezers (some are provided by food industries) ▶ Up to 2 condensing refrigerators and freezers ▶ Up to 3 standalone display refrigerator cabinets ▶ Up to 2 condensing combined reach-in open and closed freezer cabinets

[85] Expert Interviews and Field visits of the project team between September 2021 and January 2022

[86] In some countries, this segment is referred to as corner store.

Building type (market segment)	Typical refrigeration systems, including number of units
Hypermarket	▶ Standalone refrigerators and freezers (some are provided by food and beverage industries) ▶ Standalone display refrigerators ▶ Condensing reach-in refrigerators and cold rooms ▶ Centralised systems (provides cold rooms dedicated for refrigerating and freezing food and display refrigerators and freezers) ▶ Number of systems is large and varies according to hypermarket size
Quick service restaurant (door-to-door only) such as pies, pastries, etc.	▶ Standalone refrigerators and freezers (some refrigerators are provided by food and beverage industries) ▶ Standalone display refrigerator (less in number than the ones used in other types of restaurants)
Casual restaurants (seated and door-to-door), up to 80 seats	Standalone types of freezers and refrigerators are used: ▶ Up to 3 standalone refrigerators for beverages (provided by beverage industries) ▶ Standalone refrigerators and freezers ▶ Standalone display refrigeration
Large restaurants (seated), more than 80 seats	▶ Up to 6 standalone refrigerators for beverages (some are provided by beverage industries) ▶ Up to 6 standalone display refrigeration units ▶ Up to 3 standalone freezers ▶ Condensing (cold rooms) (for more than 250 seats)
Three-star hotels	▶ Few standalone refrigerators and freezers
Four-star hotels	▶ Up to 30 standalone refrigerators and freezers ▶ Few condensing units (cold rooms)
Five-star hotels	▶ More than 10 standalone refrigerators and freezers ▶ Few condensing units ▶ Cold rooms (more than 10 condensing type; the numbers increase as the hotel capacity increases)

6.2. Market trends and drivers

Due to the growing population and commercial sector expansion, the demand for commercial refrigeration in Jordan is expected to continue to increase.

The demand for new installations of different commercial refrigeration systems depends on the following key drivers: population growth, increase in electricity prices, introduction of new technologies, economic growth, COVID-19 pandemic, and new construction activities. The energy efficiency programme that was launched with incentives (purchase premium) for commercial refrigeration units is another key driver.[87]

The replacement segment is driven by the change in electricity prices, increasing awareness of energy savings, and economic feasibility.

In supermarkets, the new installation and replacement (mainly) of standalone systems is driven by the plans of suppliers and manufacturers in the food and beverage industries that provide these systems, which are mainly dedicated to their own products.[88] [89]

[87] Expert Interviews

[88] Field visits of the project team between September 2021 and January 2022

[89] Expert interviews with the food industry

Table 8 summarises the emerging trends for different building types and market segments.[90]

Table 8 Emerging trends for different building types and market segments

Building type (market segment)	Main refrigeration system types used	Emerging trends
Case 1: small-sized supermarkets	Chest refrigerator and freezer	Most supermarkets now install few larger appliances instead of several smaller ones
	Standalone reach-in refrigerator	Most popular in big and small cities, and their numbers increase every year due to population growth and urbanisation rate increase
	Standalone chest freezer	
Case 2: medium-sized supermarkets	Top 1 standalone reach-in refrigerator and reach-in freezer	Most popular in big cities
	Top 2 condensing reach-in refrigerator (rack system)	
	Top 3 standalone chest freezers	
Case 3: large-sized supermarkets	Top 1 standalone reach-in refrigerator and reach in freezer	Most popular in big and small cities, and their numbers increase every year due to population growth and urbanisation rate increase
	Top 2 standalone chest freezer	
	Top 3 condensing or centralised reach-in refrigerator (rack system)	Only found in big cities
	Top 4 standalone display refrigerator cabinet	
	Top 5 condensing combined reach-in open and closed freezer cabinet	

6.3. Market size and structure

The GCI model estimates the total number of commercial refrigeration systems installed in Jordan to be about 94,800 (units).[91]

In Jordan, the number of commercial refrigeration systems sold was projected to be about 7,430 units in 2020.[92] These are mainly standalone systems (also referred to self-contained plug-in systems) and condensing units, mainly used in supermarkets (hypermarkets, large, medium, and small), restaurants, and hotels.[93] In 2021, experts estimate a share of about 65% for commercial standalone systems, a share of about 30% for condensing units ,and a share of about 5% for centralised systems in the market (referring to the number of systems).[94]

The condensing and centralised systems market is mainly dominated by local manufacturers, which are representing major local brands. Around 85% of the commercial refrigeration condensing and centralised refrigeration systems are locally manufactured; they are designed according to customer request, noting that the compressors are imported from major international manufacturers such as Copeland, Bitzer, and

[90] Field visits of the project team between September 2021 and January 2022

[91] Data derived from the GCI model (Green Cooling Initiative, "Global greenhouse gases emissions from the RAC Sector"). The model calculates the number of systems in use via an indicator (number of system per capita: 0.0114).

[92] Green Cooling Initiative

[93] Expert Interviews

[94] Expert Interviews

Danfoss.[95] The manufacturer assembles the compressor with the other components, which are locally manufactured for the refrigeration system.

Abdin Industries, Mohammed Tahseen Baalbaki Company, and others are the main local manufacturers. Jordan has around 29 companies manufacturing different types and models of domestic, commercial, and industrial refrigerators (see **Table 9**).[96]

Table 9 Main local refrigeration manufacturing companies[97]

No.	Company name
1	Abdin Industries
2	Mohammad Abu Haltam Group for Investments
3	AlHafez Group for Investment & Trade (National Electric)
4	Privatization Holding Company – PHC
5	Exeed Electronics
6	Household Appliances Manufacturing Company (HAMCO)
7	Jordan Catering Supplies (JCS)
8	Naim Dahdal & Sons Co
9	Palestine Raja Duweik & Partner Co
10	Murad and Muath Hassouna Company
11	Manaa for Restaurants Equipment
12	Afaneh Refrigerators Factory
13	Mohammed Tahseen Baalbaki & Partners Company
14	Awar Trading Company

[95] Based on:
Expert Interviews
United Nations Industrial Development Organization, "HFC Inventory of Jordan"
[96] United Nations Industrial Development Organization
[97] United Nations Industrial Development Organization

7. The refrigerant market

- All refrigerants are imported to Jordan.
- R22 (hydrochlorofluorocarbon, or HCFC) is the main refrigerant in existing cooling equipment and is substituted by HFCs (mainly R410A).
- The barriers that hinder the uptake of natural refrigerants (perceived by the end user) are safety issues and related costs; these need to be addressed.

7.1. The current refrigerant market

Jordan does not produce refrigerants, so all the refrigerants are imported for domestic use.[98] In 2020, about 800 metric tons (MT) of refrigerants were imported, mostly from India, the UK, China, the US, Italy, and Singapore.[99] This imported quantity includes all the types of refrigerants used for manufacturing and services purposes in different RAC applications.

R22 is among the most used refrigerants in existing cooling appliances; it is also still available for servicing purposes.[100]

Different high global warming potential (GWP) blends have been introduced as alternatives to ozone-depleting substances (ODS) on the Jordanian market. The consumption has increased from about 1,307 MT in 2012 to 1,532 MT in 2015, representing a CAGR of about 17% over that period. Based on the projected annual growth rates in demand forecasted for ODS alternatives until 2030, the consumption of these substances is estimated to reach about 7,638 MT in 2030. For synthetic refrigerants, the entire sector is expected to be covered by HFCs in the future.[101]

In 2020, the total consumption of the refrigeration manufacturing and service sectors was about 690 MT; about 40% was consumed in the servicing sector. The National Ozone Unit (NOU) has records of the imported refrigerants broken down by manufacturing (including refrigeration, aerosol, foam, solvent, and firefighting) and quantities used to service existing equipment. The quantities shown for manufacturing are further broken down into AC and "Other." The records are not indicative of the quantities of bulk refrigerants used for manufacturing in commercial refrigeration.

The main refrigerant used in the AC manufacturing sector was R410A, followed by R134a. The refrigeration sector[102] mainly used R134a, R404A, and R407C. The servicing sector mainly used R134a.

Table 10 summarises the quantities of HFC refrigerants used in RAC applications in 2020.

Table 10 Quantities of HFC refrigerants used in RAC applications in 2020

Substance	Manufacturing (MT)			Servicing (MT)
	Other	AC	Total	
R 32				2.6
R 134a	246	81	327	136
R 404A	60	0	60	18
R 407A	5.5	4.5	10	0
R 407C	29	0	29	8
R 410A	0	89	89	21
R 507A	3	0	0	0

[98] Expert Interviews
[99] National Ozone Unit Jordan, Jordan Customs, "Trade data for the RAC market"
[100] Expert Interviews
[101] United Nations Industrial Development Organization, "HFC Inventory of Jordan"
[102] Including domestic, commercial, and industrial refrigeration, industrial chillers, and transport refrigeration.

The AC industry, which was strongly depending on R22 as the dominant refrigerant for new AC units before 2016, started to shift into using HFCs as ODS alternatives to comply with the national HCFC phase-out plan. According to Petra Engineering's records, the consumption of R22 was 130 MT, 8 MT of R134a, 2.9 MT of R407C, and 2.3 MT R410A in 2009. The company gradually shifted to using HFCs from 2010 to 2016, where the consumption reached 17.7 MT of R22 (only 13% of the 2009 level mentioned previously), 40 MT kg of R134a, 72 MT of R407C, and 28 MT of R410A in 2015. In 2018, the company started the conversion to manufacture rooftop AC units up to 400 kW with low GWP refrigerants using R290, R32, and Hydrofluoroolefin (HFO). [103]

R717 (ammonia) is mainly used for DC of the Abdali Business Complex in Amman using air-cooled chillers. Small quantities of R717 are being used in two servicing workshops for assembly and first fill of newly imported refrigeration equipment. [104]

Most commercial refrigeration systems are manufactured in Jordan and include refrigerants such as R404A and R134a. Commercial refrigeration equipment, which has previously been manufactured with R12 (CFC), is now manufactured with R134a due to the country's HCFC phase-out targets. Additionally, R404A is increasingly being used for low temperature commercial refrigeration equipment. R134a is predominantly used for smaller medium to low temperature systems, while R404A can be primarily found in larger systems. [105]

Servicing equipment mostly employs R22 for the old units and R134a, R407C, R410A, R600a, and R717 for the newly installed units. [106]

7.2. Availability of low GWP and natural refrigerants

7.2.1. Availability of low GWP refrigerant cooling systems

The Jordanian government is committed to the Montreal Protocol (MP) and its amendments. Since 2016, the national regulation [107] has been set up to prohibit import and re-export of HCFCs as bulk refrigerants or any refrigeration and AC systems charged with these substances. The regulation also prohibits the production of new units of RAC equipment using ODS under the control of MP. As a result of the mentioned provisions, all of the imported bulk refrigerants (except the quantities for servicing) and the RAC units for household and commercial uses include HFCs, low GWP, and natural refrigerants.

For a long time, Jordan's RAC market consisted of the imported RAC units and the locally manufactured units. With the diverse brands available on the market, the low GWP substances are expected to be available in the locally manufactured and imported units. For instance, R32 has been used in AC units for several years at Petra.

7.2.2. Availability of natural GWP refrigerant cooling systems

Through the NOU, the government is promoting the transition to natural refrigerants in RAC applications by mobilising the required support from the international agencies for the private sector to facilitate the shift to new technologies.

A demonstration project funded by a Climate and Clean Air Coalition to introduce a new clean cooling technology in a supermarket using CO_2 is a pioneering experience to the Middle Eastern food retail sector. The conversion from HFCs to R290 in a facility manufacturing large commercial unitary rooftop AC units of up to 400 kW at Petra since 2018 (with the support of UNIDO) is also a success story of shifting smoothly to natural refrigerants in the domestic market.

[103] Expert Interviews

[104] Expert Interviews

[105] Expert Interviews, United Nations Industrial Development Organization, "HFC Inventory of Jordan"

[106] United Nations Industrial Development Organization

[107] http://moenv.gov.jo/ebv4.0/root_storage/ar/eb_list_page/ministry_info_english.pdf, Article 32 of the instructions.

Commercial plug-in refrigeration systems have been produced domestically using R290 since 2018.

At a large project carried out in Al Abdali, a DC system deploying a state-of-the-art cooling and heating plant using R717 condensers and chilled water is demonstrating that significant reductions in the peak electricity demand are possible when moving to natural refrigerants. Further, R600 is available in domestic refrigerators according to observations from field visits to retail market.

8. Further cooling sector insights

8.1. Most relevant natural refrigerants

With no or only negligible GWP, natural refrigerants are a sustainable and future-proof option in compression cooling. Further advantages of natural refrigerants are their low and stable costs, high efficiency,[108] and availability. However, some challenges associated with the handling of natural refrigerants exist—e.g. the flammability of hydrocarbons (e.g. R290, propane). Potential safety concerns must be addressed by certain measures related to RAC systems. For example, setting requirements for systems exceeding a certain capacity to place the flammable gas in a machinery room, permit access only for trained technicians, and for ventilation and leak detection. The qualification and skills of technical personnel to install, repair, service, and maintain RAC equipment and systems are of key relevance, especially for natural refrigerants. Based on their chemical and physical properties, additional technical know-how and practical experience is needed to handle natural refrigerants safely. The existing experience of RAC technicians in developing countries primarily includes handling HCFCs and HFCs but not, or to a limited extent, natural refrigerants.

Due to the lack of regulation, the motivation to transition to natural refrigerants is low in conventional HFC industries. Additionally, the sales volumes of the limited number of RAC systems relying on natural refrigerants available on the markets are low.

Table 11 summarises the main application areas and key characteristics of the most relevant natural refrigerants.

Table 11 Key characteristics of the most relevant natural refrigerants[109, 110]

Refrigerant	GWP (100 yrs)	Main areas of application	Advantages	Challenges
R290 (Propane)	3	▶ Room AC units (monoblock and split units) ▶ Small chillers ▶ Plug-in commercial refrigeration	▶ High efficiency ▶ No significant cost upcharge ▶ Available	▶ Highly flammable (=>charge limits)
R600a (Isobutane)	3	▶ Standalone refrigerators	▶ High energy efficiency ▶ Common technology	▶ Highly flammable (but due to low charges and good sealing of main applications not a major issue)
R717 (Ammonia)	0	▶ Chillers ▶ Central refrigeration systems	▶ Excellent efficiency for low temperature applications (well below 0°C) ▶ Easy to operate and maintain ▶ Low operating pressure	▶ Toxic (but low risk, as it can be smelled far before reaching critical concentration) ▶ Corrosive to copper, brass, and bronze ▶ Highly flammable (=>charge limits)
R744 (Carbon dioxide)	1	▶ Supermarket refrigeration ▶ Combined systems (heating and cooling)	▶ Not flammable ▶ High temperature fluid for heat recovery ▶ Non-toxic ▶ Low maintenance systems ▶ Non-corrosive	▶ Requires more complex systems due to high discharge pressures ▶ Very low critical temperature (31 °C)

[108] Specifically, propane (R290) and ammonia (R717) have better thermal properties than conventional refrigerants.

[109] Azar and Nosbers, "Implications of natural refrigerants for cooling technologies – Converting from HFCs/HCFCs to natural refrigerants"

[110] Intergovernmental Panel on Climate Change, "Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change"

8.2. High leakage rates and poor maintenance

- Improving maintenance is important to reduce leakage rates and improve energy efficiency in the future.
- Current leakage rates are rather high in the commercial refrigeration sector (up to annual 20%-40% in condensing units and centralised systems).
- Absence of end-of-life management of refrigerants typically results in 100% release of the refrigerant into the atmosphere during disposal.
- There is high demand for raising awareness and building capacity for those involved in the disposal process of refrigerants.
- There is demand for installing monitoring and evaluation mechanisms and needed facilities to ensure safe disposal of the refrigerants.

Regular maintenance is an important factor for reducing direct emissions from RAC equipment. Poor maintenance results in high(er) refrigerant leakage rates and a lower equipment efficiency. The typical maintenance practice in the RAC sector is a regular (mostly annual) service for filter replacement, electrical check-ups, regular cleaning, and refrigerant charge checking. Especially for smaller AC systems, the typical maintenance not on an annual basis; rather, it is on an ad hoc basis, typically caused by a technical malfunction of the system itself. During maintenance, often the complete refrigerant charge is released into the atmosphere, and the system needs to be completely recharged (exception are large systems, which may have a liquid receiver).[111]

One key challenge is building the capacity of cooling service technicians and other market participants such as AC installers, service companies and repair technicians to address leakage, improving maintenance skills.[112]

Supermarket owners stress that no regular or professional maintenance is typically performed on commercial refrigeration systems; it depends on the sales company's maintenance and replacement plans. The most performed maintenance measure for systems is to clean the condensing units, which depends on the climate (dusty or not) and is typically completed annually as part of the after sales support provided by the manufacturer.[113]

According to interviews in the partner countries, the annual leakage rates in the different countries are between 5% and 10% for AC systems; for chillers (system), it is about 15%-20% and 20%-40%for large commercial refrigeration systems (standalone systems have low leakage rates in most cases).[114] Available studies provide values in the same order of magnitude.[115] The demand for RAC servicing on a national level can be estimated to be around 40%-60%of the whole subsector (AC and commercial refrigeration) consumption.[116]

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[111] Expert Interviews

[112] National Ozone Unit Lebanon, "Guidance for Integrating Efficient Cooling in National Policies in Lebanon"

[113] Expert Interviews

[114] Expert Interviews

[115] See for example:

National Ozone Unit Lebanon, "Guidance for Integrating Efficient Cooling in National Policies in Lebanon"

CLASP, "Environmentally Harmful Dumping of Inefficient and Obsolete Air Conditioners in Africa"

United Nations Environment Programme, "Presession Documents: Workshop on Hydrofluorocarbon Management" For AC systems, the UNEP factsheets with its global scope consider the typical leakage rates 1%-6 %; for commercial refrigeration systems and for standalone equipment to be 5%-20%; for the condensing unit and centralized systems to be in the same order of magnitude.

Intergovernmental Panel on Climate Change, "Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change"

National Ozone Unit Lebanon, "Guidance for Integrating Efficient Cooling in National Policies in Lebanon"

[116] Assumption based on:

Government of Turkey, "Turkish Greenhouse Gas Inventory 1990 - 2019"

United Nations Industrial Development Organization, "HFC Inventory of Jordan"

United Nations Environment Programme, "Presession Documents: Workshop on Hydrofluorocarbon Management"

At the end of their technical lifetime, RAC systems are usually disassembled to reuse some parts or components as spare parts for other systems. Refrigerants are not disposed properly; instead, they are released without any precautions. This absence of end-of-life (waste) management legislation results in high refrigerant emissions into the atmosphere at the disposal stage, which can, depending on the annual leakage rate, easily add up to a multiple of the initial charge amount.[117]

Key challenges to improving end-of-life management are the lack of:

- Awareness of those involved in the disposal process of refrigerants on safety measures.
- Monitoring and evaluation mechanisms.
- Needed facilities and resources that ensure the safe disposal of the refrigerants.

Major challenges for safe disposal include the lack of:

- Storage space for used refrigerants.
- Proper equipment for refrigerant treatment among technicians.
- Limited awareness of the public on matters related to dangers of the unsafe disposal of old equipment (highlighting the importance of proper maintenance)
- Awareness among installers and technicians.
- Mandatory regulations for safe disposal.[118]

8.3. Key factors for purchase decision

- The upfront investment cost is a key driver for the purchase decision of a certain AC system type.
- Homeowners in existing buildings often make purchase decisions based on consultations with installers or other trusted persons.
- In new homes, the views of architects and MEP consultants impact the type installed AC systems.
- In larger non-residential buildings, international standards impact the type of AC systems installed.
- Related to commercial refrigeration, many brands provide their own refrigeration system for the distribution of their products in supermarkets (mainly standalone systems).

8.3.1. Air conditioning sector

Most interviewed market actors consider cost, especially the upfront investment cost, to be the main criterion affecting purchase decisions for AC and commercial refrigeration systems. Other factors influencing the purchase decision include the reliability and ease of maintenance and, for AC systems specifically, personal recommendations (from installers or sellers).[119]

Because the type of actor taking certain purchase decisions may differ depending on the type of building, relevant characteristics are further discussed as follows.

For existing residential buildings with homeowners, the owners usually decide which AC system to buy, often based on consultations with installers or other trusted persons. In new homes, views of architects, MEP consultants, and building standards that need to be followed impact the purchase decision, although the ultimate decision is taken by the homeowner.[120]

In existing rental homes, property owners usually decide about new AC installations for furnished apartments. While the apartment owners are faced with the investment cost, they do not directly benefit from the installation, so their ability to charge the cost from the tenants is a key factor in the decision to install new AC. For new, large rental apartment blocks, this decision can be influenced by planners,

[117] Expert Interviews
[118] Expert Interviews
[119] Expert Interviews
[120] Expert Interviews

architects, or consultants. Depending on the market, the ability to recuperate investment via rent plays a significant role.[121]

In existing non-residential buildings, purchase decisions for new AC systems are made by the company or business using the building based on recommendations from the contracted MEP consultants or following the country standards of the large companies. In new buildings, architects, planners, or consultants decide what system will be installed.[122]

In large supermarkets, restaurants, or hotels, decisions about which AC systems to buy can be predetermined by existing (sometimes international) standards of the parent company depending on recommendations from contracted MEP consultants. In small independent supermarkets, restaurants, hotels, or corner stores, these decisions are made by the store owner directly, sometimes based on advice from sellers, installers, or MEP consultants.[123]

8.3.2. Commercial refrigeration sector

Large brands often provide their equipment to stores and supermarkets and mainly follow their own guidelines and standards for each store's size and needs. These new installations and replacements are mainly standalone systems and depend on the plans and preferences of suppliers and manufacturers in the food and beverage industries that provide these systems, which are mainly dedicated to their own products.

In large supermarkets, restaurants, or hotels, purchase decisions can be predetermined by existing (sometimes international) standards of the parent company depending on recommendations from contracted MEP consultants. In small independent supermarkets, restaurants, hotels, or corner stores, these decisions are made by the store owner directly, sometimes based on advice from sellers, installers, or consultants influenced by factors such as cost, size, reliability, brand name, and ease of maintenance.[124]

[121] Expert Interviews
[122] Expert Interviews
[123] Expert Interviews
[124] Expert Interviews

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