# Environmentally Harmful Dumping of Inefficient and Obsolete Air Conditioners in Africa

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CLASP

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# List of Acronyms

| | |
|---|---|
| AMU | Arab Maghreb Union |
| BSRIA | Building Services Research and Information Association |
| CAGR | compound annual growth rate |
| CFC | chlorofluorocarbon |
| COMESA | Common Market for Eastern and Southern Africa |
| CSPF | cooling seasonal performance factor |
| ECOWAS | Economic Community of West African States |
| EER | energy efficiency ratio |
| GHG | greenhouse gas |
| GWh | Gigawatt hour |
| GWP | Global warming potential |
| HCFC | hydrochlorofluorocarbon |
| HFC | hydrofluorocarbon |
| IGSD | Institute for Governance and Sustainable Development |
| ISO | International Organization for Standardization |
| JRAIA | Japan Refrigeration and Air Conditioning Industry Association |
| JV | joint venture |
| kg | kilogram |
| kW | kilowatt |
| kWh | kilowatt hour |
| MEPS | minimum energy performance standard |
| MP | Montreal Protocol |
| MT CO2e | megatonnes (million metric tonnes) of carbon dioxide equivalent |
| ODS | ozone depleting substance |
| PAMS | CLASP's Policy Analysis Modeling System |
| RAC | room air conditioner |
| SADC | Southern African Development Community |
| SEER | seasonal energy efficiency ratio |
| T&D | transmission and distribution |
| U4E | United for Efficiency |
| UAE | United Arab Emirates |
| UEC | unit energy consumption |
| US | United States |
| W | watt |

# Foreword

Energy is essential to health and economic productivity. Inefficient and obsolete air conditioners and refrigerators divert energy from more productive uses while degrading the environment. Ozone-depleting and greenhouse gas emissions, as well as other pollutants, from these technologies foul the air causing health, agricultural, ecological and cultural impacts. This report explores the market conditions in Africa where global suppliers dump inefficient equipment using obsolete refrigerants. Many air conditioners and components sold into Africa are too inefficient to be allowed for sale in their countries of manufacture.

CLASP prepared this report using available market research and data collected by Building Services Research and Information Association (BSRIA) and other respected sources. The authors welcome corrections and new data to strengthen the findings.

### Statement on the COVID-19 Pandemic

The research and analysis featured in this report was conducted prior to the global COVID-19 pandemic. Industry, consumers, and regulators have been and will continue to be affected by the profound social and economic impacts of the pandemic. Changes in manufacturing and purchasing patterns will likely occur as a result of major disruptions in the global supply chain and a depression of the global economy; however, the overall trend of environmentally harmful dumping of inefficient and obsolete room air conditioners in Africa will continue without intervention. The findings of this report remain relevant for policymakers in the region and include measures that governments can take to respond to the economic crisis. This report includes a case study of such actions in Morocco.

# Executive Summary

The demand for air conditioners that provide thermal comfort and sustain health is steadily growing across the African continent as consumers seek to improve their quality of life in the face of urbanization and rising global temperatures. From 2005 to 2019, Africa's market for new split room air conditioners (RACs) grew by an estimated 14%, cumulatively.[1] Although a few African countries assemble RACs from imported parts for domestic and regional markets, most African countries rely exclusively on imported products manufactured in other countries. As manufacturing and industrialized economies place increasingly stringent minimum energy performance standards (MEPS) and refrigerant global warming potential (GWP) limits on RACs sold domestically, importing African countries risk becoming even greater dumping grounds for inefficient, environmentally harmful products using obsolete refrigerants that no longer have a viable domestic market in their places of origin and soon worldwide. Weak or non-existent MEPS and the lack of proactive anti-environmental dumping policies in many African countries have facilitated environmentally harmful dumping of inefficient, high-GWP[2] air conditioner products into African markets.

IGSD defined environmentally harmful dumping (henceforth, "environmental dumping") as "the practice of exporting products to another country or territory that: 1) Contain hazardous substances; 2) Have environmental performance lower than is in the interest of consumers or that is contrary to the interests of the local and global commons, or; 3) Can undermine the ability of the importing country to fulfill international environmental treaty commitments."[3]

CLASP conducted a wide-ranging review of relevant markets and trading practices in African countries to determine where environmental dumping of inefficient, high-GWP RACs is occurring and to identify the factors creating a favorable environment for such practices. CLASP analyzed available market data collected by Building Services Research and Information Association (BSRIA)[4] for products sold in 2018, conducted desk research into the policy landscape in Africa, and interviewed policymakers in the region. This report presents our assessment of the split RAC market for four regions and 10 focus countries: North Africa (Algeria, Egypt, Morocco, and Tunisia), West Africa (Ghana and Nigeria), East Africa (Ethiopia, Kenya, and Tanzania), and Southern Africa (South Africa).

CLASP and IGSD welcome additional data including more detailed information on products sales, point of manufacture, energy efficiency, and refrigerant, and also welcome suggestions on how to smoothly transition from obsolete to next-generation RAC technology.

The remainder of this Executive Summary presents our major findings on the extent and impact of the environmental dumping of RACs in Africa.

### Market evidence of environmental dumping of low efficiency RACs into African markets

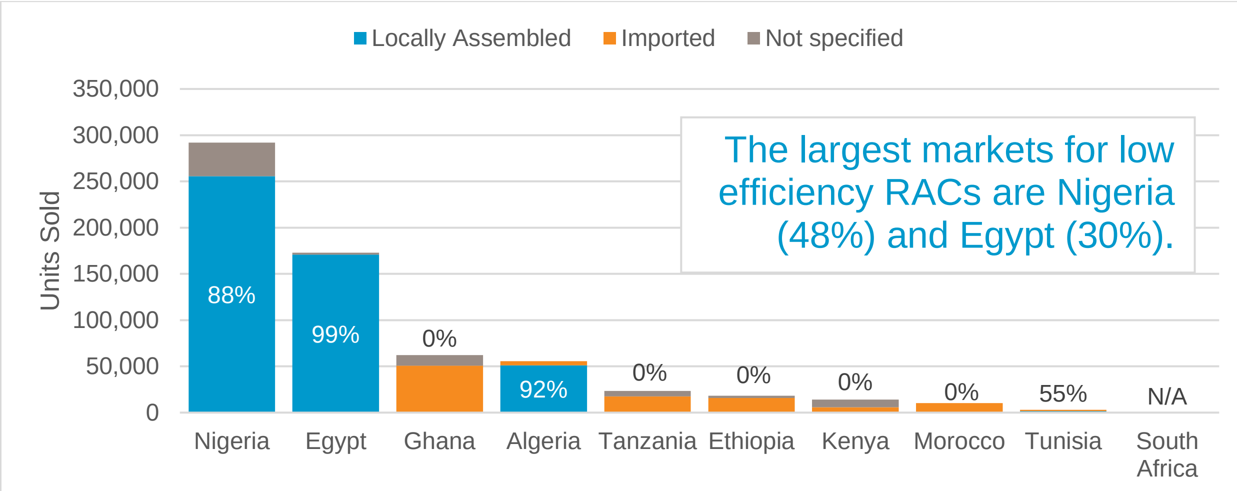
- RACs with energy efficiency ratios (EERs) less than 3.0 W/W (henceforth "low efficiency" RACs) make up 35% of the overall RAC sales in the ten focus countries. The market size for these low efficiency units is about 650,000 units annually. Most RAC manufacturing economies like China, South Korea, Japan, and the US have minimum energy performance standards (MEPS) above 3.0 W/W, meaning such products could not be sold in the countries where they are manufactured.
- At least 50% of the imported low efficiency units are imported from China, with Korea (3.9%), the US (3.2%) and Japan (1.7%) accounting for the other major non-African sources of low efficiency

[1] Euromonitor 2019. For most countries on the African continent, Euromonitor does not have reported sales from trade sources, and instead models approximate market size using national statistics (population, number of households, etc.).
[2] Throughout the report, CLASP will refer to the GWP of refrigerants. To align with Montreal Protocol tracking, CLASP uses IPCC AR4 100-year GWP values. https://www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf
[3] Andersen, Stephen O., Ferris, R., Picolotti, R., Zaelke, D., Carvalho, S., Gonzalez, M. (2018). Defining the legal and policy framework to stop the dumping of environmentally harmful products. Duke Environmental Law & Policy Forum: Vol. XXIX:1. http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1356&context=delpf
[4] Building Services Research and Information Association (BSRIA) is a market research firm.

AC equipment. These fractions could be higher since information on the source country was not available for 39% of the imported low efficiency dataset.[5]

- Non-African local subsidiaries or joint ventures with African companies in Egypt and Nigeria assemble the majority (80%) of low-efficiency RACs sold in the ten focus countries,[6] as discussed later.

*Figure 1: Low efficiency RACs sold in 10 African countries with locally manufactured share indicated*

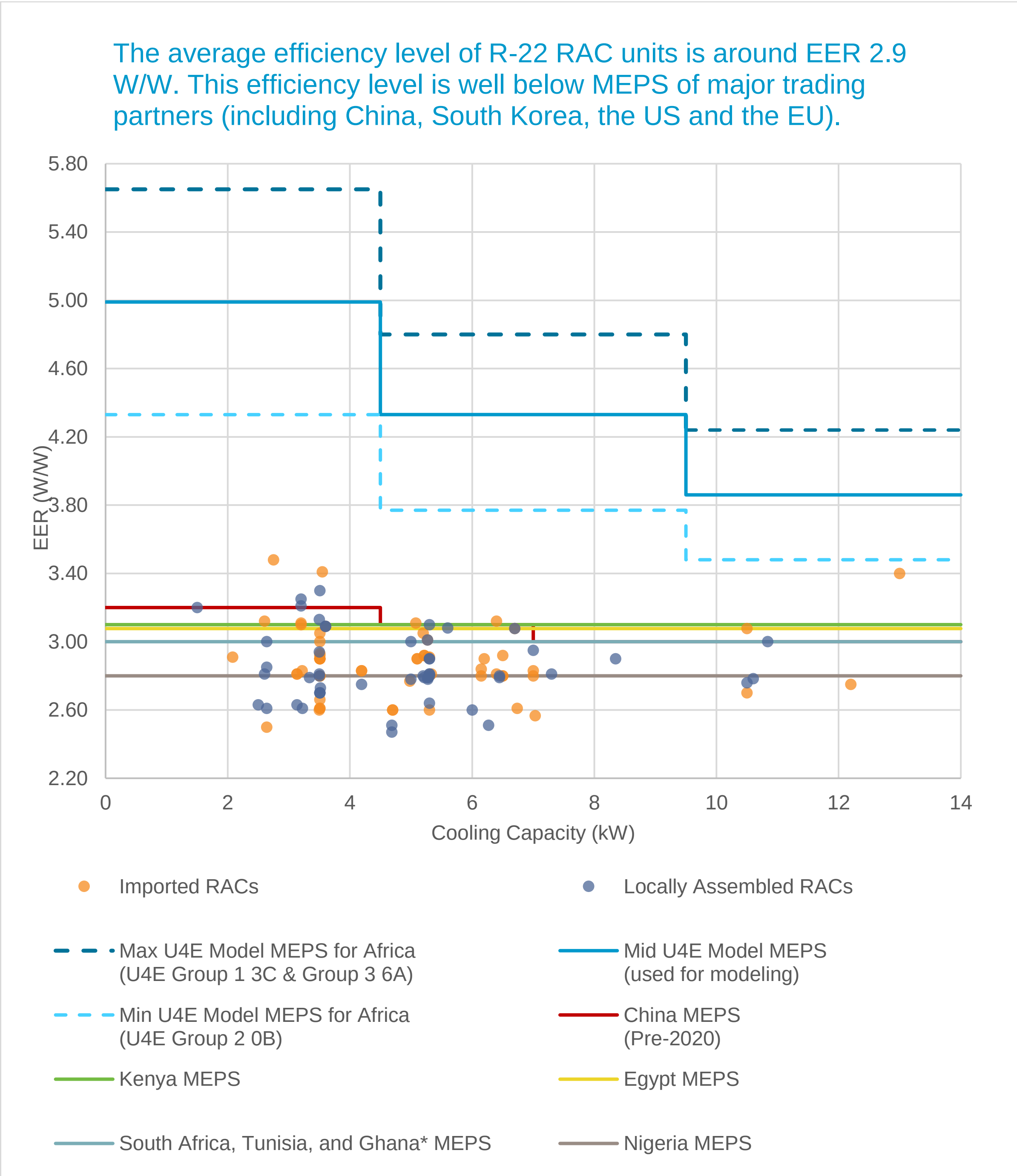



## Market evidence of environmental dumping of high-GWP RACs into African markets

- R-22[7] is an obsolete ozone-depleting greenhouse gas (GHG) in the final stage of phase out under the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol) while R-410A[8] is an obsolete ozone-safe GHG that will soon be phased down under the Kigali Amendment to the Montreal Protocol.
- RACs containing R-22 still account for 47% of overall sales in the ten African focus countries,[9] with a market size of about 800,000 units. Most of the remainder of overall sales in the ten countries use R-410A, with a very small percentage of lower GWP R-32[10] RACs sold exclusively in South Africa.
- A large portion of R-22 units are assembled locally (82%), half of which come from joint ventures between local Egyptian or Nigerian assemblers and international Asian companies.
- China is the largest source of imported R-22 RACs (57%), followed by Egypt (11%), the US (3%), Nigeria (1.6%), and South Korea (0.6%). This share of imports from each country could be even larger - country of origin was not available for 27% of the imported R-22 RAC models in the BSRIA dataset.[11]

[5] Based on analysis of BSRIA 2018 RAC sales data. See Methodology section for further details.
[6] Based on analysis of BSRIA 2018 RAC sales data. See Methodology section for further details.
[7] R-22, a hydrochlorofluorocarbon (HCFC) refrigerant with a GWP of 1,810 over a 100-year time horizon (IPCC AR4), is scheduled to be phased out globally in accordance with the Montreal Protocol.
[8] R-410A, a hydrofluorocarbon (HFC) refrigerant blend with a GWP of 2,088 over a 100-year time horizon (IPCC AR4) is scheduled to be phased down under the Kigali Amendment to the Montreal Protocol.
[9] Based on BSRIA sales weighted data for 10 countries. R-410A RACs accounted for 49% of sales, R-32 RACs accounted for 1% of sales, and refrigerant type was not available for the remaining 3%.
[10] R-32 is a low-GWP hydrofluorocarbon (HFC) refrigerant blend with a GWP of 675 over a 100-year time horizon (IPCC AR4).
[11] Based on analysis of BSRIA 2018 RAC sales data. See Methodology section for further details.

*Figure 2: R-22 RACs in Africa compared to MEPS (N=114, V=789,778)[12]*




*Ghana recently committed to raising the MEPS for RACs from 2.80 W/W to 3.0 W/W

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[12] MEPS levels in the chart are reported in EER. For the max, mid, and min U4E model MEPS, the levels were converted from ISO CSPF to EER using the formula EER = CSPF / 1.062 in accordance with ISO Testing Standard 16358-1:2013. https://www.iea.org/policies/6832-minimum-energy-performance-standards-and-labelling-for-air-conditioners-with-cooling-capacity-71kw

### Identifying the sources of obsolete RACs and RAC components

While there is local assembly of air conditioners in some African countries, particularly Algeria, Egypt, Nigeria, and Tunisia, most African economies import their RACs from major RAC manufacturing economies such as China, South Korea, the US, and Japan. According to Comtrade import statistics, in 2018, China supplied approximately 80% of the RACs imported by the 10 focus countries, followed by Thailand (6%), Turkey (3%), and South Korea (2%).[13] As well, China supplies 71% of the compressors used in refrigeration equipment imported by the focus countries. Other major sources for compressors include Thailand (7%), Germany (3%), France (2%) and Spain (2%).[14]

African countries with significant local assembly of cooling products typically have national requirements and policies that provide incentives for national assembly (i.e., lower import duties for components, domestic content requirements) or bans on the import of assembled units.

A large portion of new, low efficiency RACs using obsolete refrigerants are imported into Africa from major non-African manufacturing countries. However, this research uncovered that there are other major sources for obsolete technology in Africa. Specifically, locally assembled RACs, produced by joint ventures (JVs) between local African companies and large non-African manufacturing companies, produce a significant amount of the low efficiency products utilizing R-22 and R-410A refrigerants. Often, the products produced by these joint ventures are less efficient than those produced by the non-African joint venture member companies for their own domestic markets.

This research identified that environmental dumping of obsolete space cooling technology is occurring in Africa, and the four main sources of environmental dumping are:

- Non-African companies exporting low efficiency RACs containing obsolete refrigerant technologies (at least 26% of the low efficiency RAC market in the focus countries).
- Local subsidiaries of non-African companies assembling RACs in Africa, using imported components for products that are too inefficient to be sold in the domestic market of the non-African companies. These products are sold under the branding of the non-African company (at least 6% of the low efficiency RAC market).
- Joint ventures between smaller African assemblers and large, non-African RAC manufacturers assembling low efficiency RACs that would not be marketable in the home territories of the non-Africa joint venture partner (at least 23% of the low efficiency RAC market). These joint ventures sometimes sell products under the internationally recognized brand names of the non-African JV partners, but also sometimes sell products under brand names unique to the African market.[15]
- Wholly independent African RAC assemblers, not part of a joint venture, importing components[16] for and assembling low efficiency RACs (at least 18% of the low efficiency RAC market). Consider also that African RAC assemblers are hampered in supplying superior products because they compete against low prices of products that are indistinguishable in appearance.

[13] BSRIA's data set is more detailed, but covers a smaller sample size than Comtrade, thus why CLASP references the overall RAC imports/exports shares calculated from Comtrade's data.

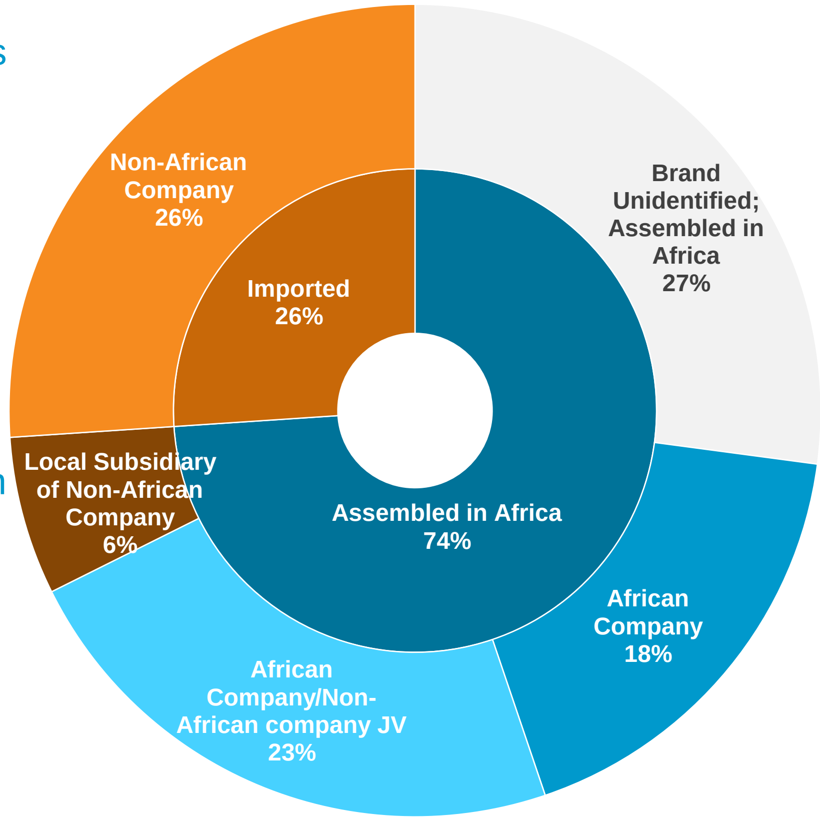
[14] U.N. Comtrade statistics for 2018 for the 10 focus countries. HS code 841510 is used for all RACs and HS code 841430 is used for compressors. See Methodology section for further details.

[15] For example, the Miraco Carrier joint venture in Egypt assembles Carrier, Midea, and Toshiba branded products. In Nigeria, the Haier Thermocool joint venture brands their products as Haier Thermocool.

[16] China is the major manufacturer and exporter of key RAC components, in particular compressors. See Nicholson, Scott R, and Charles W Booten. 2019. "Mapping the Supply Chain for Room Air Conditioning Compressors." https://doi.org/10.2172/1524770

*Figure 3: Origins of low efficiency RACs sold in 10 African countries (N=651,273)*

The majority (74%) of the low efficiency units are assembled in Africa, primarily in Egypt and Nigeria. These RACs are assembled either by local African companies, local subsidiaries of non-African companies, or joint ventures between an African company and one or more non-African companies.




### Impacts of environmental dumping of inefficient, high-GWP RACs

The prevalence of low efficiency RACs puts extra strain on governments' and consumers' budgets. Customers pay higher electricity bills and countries pay more for electricity generation facilities, imported fuel, and electricity transmission and distribution infrastructure. Transitioning to high efficiency RACs can reduce the burden not only on consumers, but also on governments - for example, a World Bank study on northern Africa's RAC market estimated the per AC unit avoided capacity investment cost could reach an average of $234 in 2030.[17] This money could be saved by setting and strengthening MEPS and by prohibiting RACs with HCFC and high-GWP (R-410A) refrigerants as is done in developed countries.

Environmental dumping of air conditioning products with obsolete R-22 and R-410A increases the future demand for these damaging refrigerants at a time when they will be expensive or unavailable in some markets, creating incentive for illegal chemical manufacture and trade.

Some African countries have implemented energy performance standards and bans on secondhand ("used") equipment, to prevent the influx of low efficiency, obsolete refrigeration and air conditioning appliances into their markets. However, numerous countries in Africa have not implemented any form of anti-environmental dumping policy for new products and therefore import products that would be prohibited in the countries where the products were manufactured.

[17] 2030 savings in 2014 dollars. See: Khalfallah, Ezzedine; Missaoui, Rafik; El Khamlichi, Samira; Ben Hassine, Hassen. 2016. *Energy-efficient air conditioning : a case study of the Maghreb : Opportunities for a more efficient market (English)*. Middle East And North Africa (MENA) Energy Series. Washington, D.C. : World Bank Group. p. 57. http://documents.worldbank.org/curated/en/754361472471984998/Opportunities-for-a-more-efficient-market

CLASP modeled the potential impact of four policy alternatives to demonstrate the additional GHG emissions that result from environmental dumping of RACs in Africa. Each unit contributes to GHG emissions in two ways: indirect GHG emissions result from the fossil fuel electricity used to power the RACs over their life cycle, and direct GHG emissions result from leakage and refilling of high-GWP refrigerants over the RAC life cycle, and end-of-life venting if not properly captured, recycled, or destroyed. The four scenarios we modeled are:

- **Base Case (No Efficiency Policy + Unregulated Refrigerant Market):** A business-as-usual scenario that assumes that the RAC market continues to grow at a constant rate annually through 2030, and that the current market shares of R-22, R-410A, and R-32 RACs gradually change in accordance with Montreal Protocol (MP) phase-out schedules for R-22 and phase-down schedules for R-410A. No additional energy efficiency policies or refrigerant requirements are assumed.
- **Policy Scenario 1 (U4E MEPS[18] + Unregulated Refrigerant Market)**: A scenario in which the countries in each region adopt RAC energy efficiency standards equivalent to the U4E Model MEPS in 2022. There are no requirements for the GWP of refrigerants used in this scenario.
- **Policy Scenario 2 (U4E MEPS + U4E Refrigerant Regulation):** A scenario in which the countries in each region adopt RAC energy efficiency standards equivalent to the U4E Model MEPS in 2022 and require the use of refrigerants with GWP ≤ 750 in 2022. For the purpose of modeling, this scenario assumes that all RACs on the market from 2022 onwards use R-32 refrigerant, which has a GWP of 675.
- **Policy Scenario 3 (U4E MEPS + BAT Refrigerant Policy)**: A scenario in which the countries in each region adopt RAC energy efficiency standards equivalent to the U4E Model MEPS in 2022 and require the use of best-available-technology (BAT) refrigerants with GWP < 150 in 2022. For the purpose of modeling, this scenario assumes that all RACs on the market from 2022 onwards use R-290 refrigerant. Recent research estimates that R-290 has a GWP of <1;[19] however, without a more specific value and to keep estimated impacts conservative, CLASP assumes a 100-yr GWP of 1 for the R-290 refrigerant in this scenario.[20]

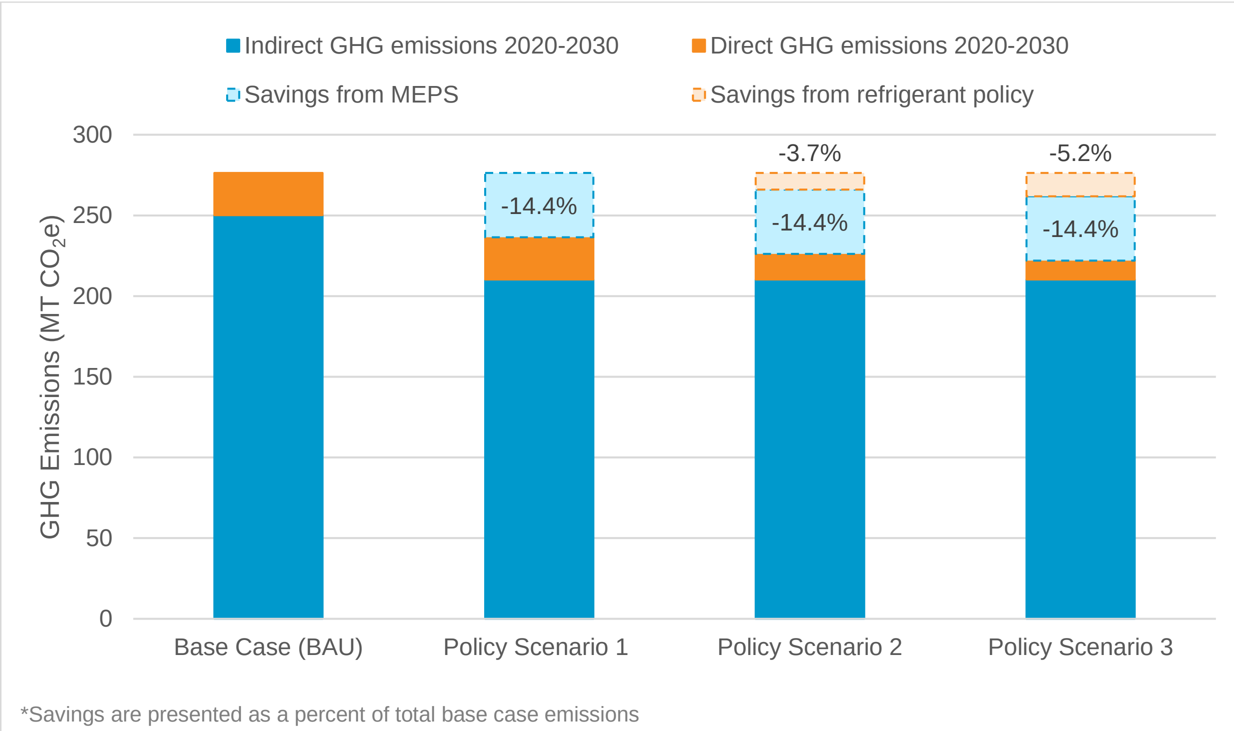
Adopting U4E Model MEPS in 2022 could reduce cumulative 2022-2030 GHG emissions in the four regions by **40 megatonnes (MT) of $CO_2$e**. Simultaneously adopting the U4E guidance to disallow refrigerants with GWPs greater than 750 could avoid an additional **10 to 15 MT $CO_2$e** through 2030, depending on the level of ambition.

[18] In September 2019, United for Efficiency (U4E) published model energy performance standards and labeling guidance to assist governments in developing and emerging economies in establishing or strengthening their regulations. These guidelines present an opportunity for African countries to harmonize around ambitious and achievable MEPS and refrigerant requirements. https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners/

[19] See Appendix A in WMO (World Meteorological Organization), Scientific Assessment of Ozone Depletion: 2018, Global Ozone Research and Monitoring Project – Report No. 58, 588 pp., Geneva, Switzerland, 2018. https://www.esrl.noaa.gov/csd/assessments/ozone/2018/

[20] Some of the African countries studied are (high ambient temperature) HAT countries, which implies a high load scenario – based on current IEC (International Electrotechnical Commission) safety standards, A3 refrigerants can be used for up to 7 kW units only.

*Figure 4: Cumulative 2020-2030 GHG emissions from RACs in Southern Africa under four scenarios*




## Tools for policymakers to prevent environmental dumping of RACs

African policymakers can take action to halt environmental RAC dumping and set in motion a transition to highly-efficient, low-GWP RACs. Measures like energy efficiency policies and energy efficiency-minded trade policy can work together to support African countries in achieving development and climate objectives while limiting emissions from the cooling sector. African consumers will also benefit by having access to high-quality, high-efficiency, affordable products.

Drawing from IGSD's anti-environmental dumping "toolkit", described in "Defining the legal and Policy Framework to Stop the Dumping of Environmentally Harmful Products," these actions include:

1. **Ratify the Kigali Amendment to the Montreal Protocol and adopt implementing policies.** Ratifying and implementing the Kigali amendment, for those African countries that have not already done so, demonstrates a commitment to pursuing a low-GWP path for cooling technologies. R-22 RACs are still highly prevalent in Africa, however as African countries prepare to phase out R-22 under the Montreal Protocol, in the absence of other policies, R-410A RACS are expected to flood the market, especially as other countries adopt early HFC phasedown strategies. Ratifying and implementing the Kigali Amendment will convey the message to local and non-African RAC manufacturers and exporters that the African market for RACs will require alternative refrigerants. Manufacturers may be more encouraged to bring R-32 and R-290 products into the African market more quickly.
2. **Design and implement MEPS & labeling policies consistent with major AC-exporting countries.** Currently, the MEPS for RACs in the few African countries with MEPS tend to be low in comparison to the MEPS in place in the countries that manufacture RACs and RAC components. Implementing MEPS at levels comparable to MEPS in RAC source countries can prevent the environmental dumping of inefficient products and provide substantial GHG emissions savings over time. Adopting U4E's model regulations for RACs may offer African countries a means to prevent the environmental dumping of inefficient RACs, as these guidelines present an opportunity to harmonize around ambitious and achievable MEPS and refrigerant requirements.

3. **Strengthen institutional arrangements.** Institutional arrangements, including how administrative responsibilities for energy efficiency and refrigerants are allocated within a particular government, are critical for efforts to minimize dumping of cooling equipment and components. This includes efforts to combat fraud in MEPS certifications, labeling and product performance claims. Similarly, coordination between authorities responsible for implementing energy efficiency and Montreal Protocol policies, including energy and customs authorities, is essential. Political support is critical for allied responses of champions within agencies and departments to combat anti-dumping.
4. **Revise tariffs on RACs to ensure compatibility with energy efficiency goals.** Trade policies can support or hinder energy efficiency policies. High import tariffs, like those protecting local RAC manufacturers in Egypt and Algeria from foreign competition, may perversely prevent newer technologies from entering the market and decrease the level of ambition from local assemblers and joint ventures. Similarly, high tariffs may drive the creation of black markets for unregulated or secondhand products, as observed in Tunisia. Preferential tariffs should be carefully evaluated to ensure that they do not perversely incentivize the assembly and sale of low efficiency products and should be coupled with robust MEPS.
5. **Ban the import of secondhand, including refurbished, and inefficient RACs and widely publicize and enforce the ban.** Bans on secondhand products, if properly enforced and publicized as in Ghana, can eliminate one official channel for out-of-date or unregulated products. Bans can specify financial penalties for everyone and every enterprise involved in the illegal supply chain.
6. **Organize bulk purchase and buyers' clubs:** Bulk purchases and buyers' clubs help to aggregate demand and purchase high efficiency and low GWP RACs at affordable prices. This type of program can be designed to target replacement of older and inefficient RAC equipment that contains high-GWP refrigerants. Replacement programs are a tool that governments can deploy to respond to economic downturn, as they create jobs in the service sector and benefit consumers by reducing electricity bills.
7. **Properly recycle and dispose of obsolete room ACs:** Policies to regulate the disposal of obsolete air conditioning and refrigeration equipment can help to reduce the environmental impacts of high-GWP refrigerants, by avoiding end-of-life leakage and preventing refurbishing and redeployment of used equipment in the secondhand market.[21]
8. **Elevate solutions to regional level.** Countries will be most successful in addressing environmental dumping when working together regionally to adopt and implement these recommendations (including harmonization around U4E model regulations). Absent regional coordination, if one country adopts policies to avoid environmental dumping, but a neighboring country does not, the neighboring country not only risks greater environmental dumping in its market, but also risks becoming a conduit for continued dumping into its neighbor due to the porous nature of many borders.
9. **Engage local groups profiting under current system by trading in obsolete equipment to be part of the solution.** For example, Ghana's Energy Commission brought together those involved in trading used cooling products to form an Association with elected leaders to facilitate agreement on a transition plan. For new equipment manufactured or assembled in Africa, identify financial incentives to allow local assemblers to modernize their equipment, organize buyers clubs and trainings so as to empower and engage local groups in the transition towards assemble more efficient RACs and Refrigerants.

[21] In regions without existing infrastructure for disposal, refrigerant can be collected and destroyed in local cement kilns and old equipment can be recycled for parts and materials.

## Directions for Future Research by CLASP, IGSD, and Cooperating Partners

**On-the-ground market research to gather information on the informal, and sometimes illegal, secondhand product market**. This report is based on available market research and data by BSRIA and other respected sources. One of the main challenges in conducting the research was the lack of available data on secondhand air conditioner markets in Africa. In countries without specific bans on the import and sale of secondhand (or used) RACs there are not standard systems in place for tracking the sales of these products, this additional on-the-ground market research can fill that gap.

**Research in the supply chain of the air conditioning components market**. There is a significant amount of assembly of inefficient air conditioners using obsolete refrigerants in Africa, despite that many of the major non-African manufacturers associated with assembling, or providing the components for assembly of, these products have access to better components. Future environmental dumping research should examine the forces behind the environmental dumping via these mechanisms.

**Research on tools for African markets to leapfrog from R-22 RACs to R-32, R-290 RACs or other refrigerant blends with GWP under 750.** This report identifies that African countries moving away from R-22 are transitioning mostly to R-410A equipment. This trend exists despite similar efficiency levels and prices for R-410A and R-32 RACs. Further research can determine why this trend exists and identify tools available to policymakers to leapfrog AC market to other refrigerant blends with GWP under 750.

**Research on illegal trade of ozone depleting substances into Africa.** Currently, assessing the extent of illegal trade from Asian into Africa of ODSs and products using ODSs is made difficult by a lack of data and reporting on such trade. However, there appears to be some data and reports on such trade between Asian countries.

**Research on the scale of non-compliance with MEPS in Africa.** There is little information on the extent of compliance issues in Africa countries were MEPS have been implemented. Further study is needed to determine the scale of non-compliant activities such as false/counterfeit labeling, false statements of compliance with MEPS by local assemblers, suppliers and manufacturers, and false product performance claims.

# 1. Introduction

In 2018, the global market for new room air conditioners (RACs) amounted to nearly 161 million units, approximately 2.8 million of which were sold in African markets.[22] While some African regions, such as North Africa, have seen rapid growth in sales of space cooling equipment,[23] as whole the African market is growing slowly, but steadily, averaging around 5% annual growth since 2016.[24] As African economies mature and temperatures rise, the demand for thermal comfort will continue to grow. National and international RAC manufacturers are poised to meet this demand with a variety of cooling products. While there is local assembly of air conditioners in some African countries, particularly Algeria, Egypt, Nigeria, and Tunisia, most African countries import their RACs from major manufacturing economies. China supplies approximately 80% of the RACs imported by the ten focus countries in this report, followed by Thailand (6%), Turkey (3%), and South Korea (2%). As well, China supplies 71% of the compressors used in refrigeration equipment, including RACs, imported by African countries. Other major sources for compressors include Thailand (7%), Germany (3%), France (2%) and Spain (2%).[25]

Energy efficiency policies such as MEPS and energy labeling, when properly implemented, monitored, and enforced, can be used to limit the sale of products with low efficiency levels.[26] In cooling products like RACs, refrigerant requirements can be used to restrict the sale of products containing ozone depleting substances (ODSs) or refrigerants with high-global warming potential (GWP). Many refrigerant requirements align with HCFC phase-out and HFC phase-down schedules under the 1987 Montreal Protocol and the more recent 2016 Kigali Amendment. Energy efficiency and refrigerant policies can work together with trade policy to reduce environmental dumping of inefficient products in developing and emerging economies and to promote market transformation to highly efficient RACs with low-GWP refrigerants.[27] Defining and implementing appropriate policies will be critical to halting the environmental dumping of inefficient RACs in Africa, and ensuring that as the demand for cooling technology grows, consumers benefit from access to high quality RACs that do not come with outsized environmental impacts.

While more than 60 countries have implemented energy efficiency policies,[28] such as minimum energy performance standards (MEPS) and labeling, to regulate and improve the energy performance of the RACs sold on their markets, only nine countries in Africa have adopted such policies.[29] The two largest RAC manufacturing countries, China and Thailand, have established and enforce MEPS for RACs sold in their respective countries. In 2019, China published more stringent MEPS effective in 2020. The upcoming MEPS are more stringent and will begin a transition to a technology neutral policy that holds variable-speed (also known as inverter) and fixed-speed RACs to equivalent energy performance standards.[30] Some African countries have implemented energy performance standards and other policies, such as bans on secondhand equipment, to prevent the influx of low efficiency RACs into their markets. Many others have not implemented any form of energy performance standard and therefore import products that would be prohibited in their countries of manufacture.

[22] Euromonitor 2020

23 For instance, a recent World Bank study on the Maghreb region in Africa found that for the period 2000-2013, the number of installed ACs grew by about 48% annually. Khalfallah, Ezzedine; Missaoui, Rafik; El Khamlichi, Samira; Ben Hassine, Hassen. 2016. Energy-efficient air conditioning : a case study of the Maghreb : Opportunities for a more efficient market (English). Middle East and North Africa (MENA) Energy Series. Washington, D.C. : World Bank Group. p. xix. http://documents.worldbank.org/curated/en/754361472471984998/Opportunities-for-a-more-efficient-market

[24] Euromonitor 2020

[25] Statistics drawn from U.N. Comtrade import and export data for 2018 for the 10 focus countries in this report. HS code 841510 is used for all RACs and HS code 841430 is used for compressors. See Methodology section for further details.

[26] See Andersen, S.O. et al. (2018), at pp. 29-30.

[27] CLASP. 2019. *The Role of Trade Policy and Energy Efficiency Policy to Promote Highly Efficient Air Conditioner Markets.* https://clasp.ngo/publications/the-role-of-trade-policy-and-energy-efficiency-policy-to-promote-highly-efficient-air-conditioner-markets

[28] CLASP 2018

[29] The nine African countries with MEPS and/or labeling for room ACs are Algeria, Egypt, Ghana, Kenya, Namibia, Nigeria, Rwanda (to be implemented as part of NCAP), South Africa, Tunisia, and Uganda.

[30] The full standard is available in Chinese here: http://openstd.samr.gov.cn/bzgk/gb/newGbInfo?hcno=BC04CDC71AD8C36B62C0FF4AE58F633C

In September 2019, United for Efficiency (U4E) published model energy performance standards and labeling guidance to assist governments of developing and emerging economies in designing ambitious energy efficiency policy.[31] These guidelines present an opportunity for African countries to harmonize around ambitious and achievable MEPS and refrigerant requirements. Adopting U4E's model regulations for RACs may offer African countries a means to prevent the environmental dumping of inefficient RACs.

This report provides insight into national and regional markets for RACs in Africa and offers initial estimates on the environmental impacts of dumping of low efficiency, high-GWP RACs in Africa. This report aims to document where and how environmental dumping is occurring, to quantify the impact of environmental dumping by modelling the environmental benefits of different policy scenarios, and to provide recommendations on how policymakers can prevent the most environmentally and economically damaging low efficiency, high-GWP RAC products from entering their markets.

## 1.1 Project Background

In 2018, the Institute for Governance & Sustainable Development (IGSD) defined environmental dumping as the practice of exporting products to another country or territory that: 1) contain hazardous substances, 2) have environmental performance lower than is in the interest of the local and global consumers or that is contrary to the interests of the local or global commons, or 3) can undermine the ability of the importing country to fulfill international environmental treaty.[32] In the case of RAC equipment, this includes:

- Export of technology that cannot legally be sold in the country of export as a consequence of failure to meet environmental, safety, energy efficiency, or other product standards.
- Export of technology that is unusable in the country of export because refrigerants are no longer available because of national regulation or phase-out and phase-down control schedules under the Montreal Protocol.

*Environmentally Harmful Dumping of Inefficient and Obsolete Air Conditioners in Africa* is the result of a yearlong study conducted by CLASP on behalf of IGSD. The goal of the study was to assess the extent and impacts of environmental dumping of inefficient room air conditioners (RACs) and identify the underlying factors enabling dumping (i.e. lack of minimum energy performance standards, unfavorable trade agreements, etc.).

CLASP conducted a wide-ranging review of RAC trading and manufacturing practices in Africa, to determine where environmental dumping of inefficient equipment is taking place, and to identify factors that create a favorable environment for such practices. CLASP used market data collected by Building Services Research and Information Association (BSRIA), imports and exports data from the UN International Trade Statistics Database (Comtrade), and the findings of on-the-ground surveys and interviews with policymakers in African countries to develop RAC Market Profiles for ten African countries.

Using the country-level information, this report seeks to identify market and trade trends at the regional level and evaluates the environmental impact of the proliferation of low efficiency, high-global warming potential (GWP) RACs by quantifying potential future greenhouse gas (GHG) emissions from the use and disposal of RACs in North, West, East, and Southern Africa.

## 1.2 Geographical Scope

CLASP assessed the size and characteristics of RAC markets in ten African countries: Algeria, Egypt, Ethiopia, Ghana, Kenya, Morocco, Nigeria, South Africa, Tanzania and Tunisia. Combined, the ten focus countries account for just under 96% of the room AC market in Africa.[33] Based on analysis of these ten

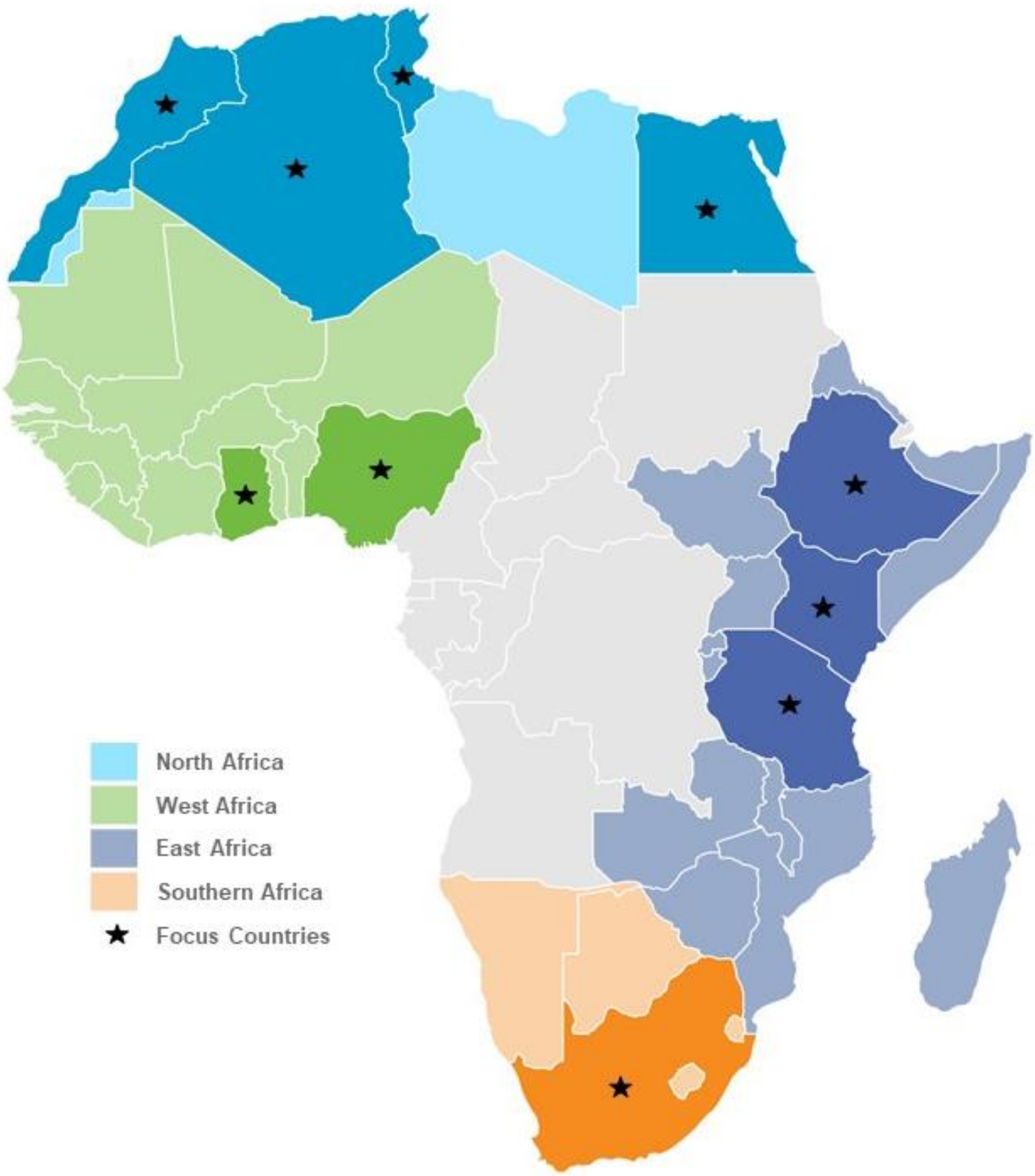
[31] U4E. 2019. "Model Regulation Guidelines for Energy-Efficient and Climate-Friendly Air Conditioners." https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners/

[32] Andersen, Stephen O., Ferris, R., Picolotti, R., Zaelke, D., Carvalho, S., Gonzalez, M. (2018). *Defining the legal and policy framework to stop the dumping of environmentally harmful products.* Duke Environmental Law & Policy Forum: Vol. XXIX:1. http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1356&context=delpf.

[33] Analysis of Euromonitor 2019 air conditioner retail volume data.

focus countries, which represent four regions in Africa, CLASP developed an analytical baseline for the room air conditioner markets in North Africa, West Africa, East Africa, and Southern Africa.

*Figure 5: Map of regions and focus countries*[34]




## 1.3 Product Coverage

This report assesses split RACs which are the most popular room air conditioners in the 10 focus countries

[34] The boundaries contained in this map are indicative and do not indicate any position by the authors of this report on the status of any disputed territory.

# 2. Approach & Methodology

## 2.1 Data Sources

### Market size and product characteristics

To assess the size and product characteristics of the RAC markets in the region, CLASP relied on four sources of data:

1. **BSRIA** market research on the Africa RAC market and energy efficiency analysis – This market research collected primary data in 2018-2019 from importers, manufacturers, distributors and contractors and was the primary information source on RAC sales projected to 2023 and model-level data on the energy efficiency and refrigerants contained in RACs in the 10 focus countries.
2. The **Japan Refrigeration and Air Conditioning Industry Association (JRAIA)** World Air Conditioner Demand report – This report was used as a source of secondary data on the RAC sales. The data was available for eight (8) of the 10 focus countries.
3. **Euromonitor** – Euromonitor provides actual and modeled market size estimates for all countries in Africa. Market size estimates data from 2013 - 2018 were used to estimate annual sales in the 10 focus countries, as well as to estimate regional market sizes for CLASP's impacts analysis.
4. **CLASP Kenya** - Primary data on popular brands, efficiency levels and refrigerants was collected in 2018 for CLASP's *Kenya Room Air Conditioner Market Assessment & Policy Options Analysis.*[35] We compared this data against the data collected by BSRIA and included some of the data in our analysis.

### National and regional trade flows

To assess international trade flows for fully assembled RACs as well as key product components, CLASP analyzed data from the UN International Trade Statistics Database (Comtrade) for RAC units, compressors, and three refrigerants imported to or manufactured in Africa: R-22, R-410A, and R-32. Import, export, reimport, and reexport data for the years 2014-2018 was analyzed for the following HS codes:[36]

- **RACs:** *HS 841510 – Air conditioning machines; comprising a motor-driven fan and elements for changing the temperature and humidity, window or wall types, self-contained*
- **Compressors:** There is no individual HS code exclusively for compressors used in RACs. This report includes import and export data for *HS 841430 – Compressors; of a kind used in refrigerating equipment.* Thus, compressor trade data from Comtrade encompasses all reported import or export of compressors or use in refrigeration equipment (RACs, refrigerators, chillers, etc.), and does not exclusively document import/export of compressors used in RAC assembly.
- **R-22:** As one of the five most popular hydrochlorofluorocarbons (HCFCs), R-22, also known as HCFC-22 has been assigned an individual HS code: *HS 290371 – Halogenated derivatives of acyclic hydrocarbons containing two or more different halogens; chlorodifluoromethane.*[37] Thus, R-22 data from Comtrade encompasses all reported import or export of each refrigerant for any purpose and does not reflect import or export of each refrigerant exclusively for use in RACs. R-22 has a 100-year global warming potential of 1,810.[38]

[35] CLASP. 2019. *Kenya Room Air Conditioner Market Assessment & Policy Options Analysis.* https://clasp.ngo/publications/kenya-rac-market-assessment-and-policy-options-analysis-2019
[36] The Harmonized System is an international nomenclature for the classification of products. It allows participating countries to classify traded goods on a common basis for customs purposes. At the international level, the Harmonized System (HS) for classifying goods is a six-digit code system. https://unstats.un.org/unsd/tradekb/Knowledgebase/50018/Harmonized-Commodity-Description-and-Coding-Systems-HS
[37] UNEP. "HS Nomenclature (HS Codes) for HCFCs and Certain Other Ozone Depleting Substances." OzonAction Fact Sheet. Post-Kigali Update. http://www.unep.fr/ozonaction/information/mmcfiles/7784-e-HSCodes_Factsheet_post_kigali_update.pdf
[38] To align with Montreal Protocol tracking, CLASP uses IPCC AR4 100-year GWP values. https://www.ipcc.ch/report/ar4/wg1/

- **R-32:** Currently there is no individual HS code for difluoroethane, a refrigerant that is not ozone depleting and has a global warming potential of 675,[39] also known as HFC-32. Until the 2022 code update, this organic compound is currently covered along with other HFCs by a single HS code: *HS 290339 – Fluorinated, brominated or iodinated derivatives of acyclic hydrocarbons; other than ethylene dibromide (ISO) (1,2-dibromoethane).*[40] This report includes data on import and export HFCs under this HS code. In August 2019, the World Customs Organization (WCO) recommended an interim approach for identifying specific HFCs by adding additional digits to the existing HS codes;[41] however, this approach was not in use by the countries covered in this report when data was collected. Thus, HFC import/export data from Comtrade encompasses all reported import or export of HFCs for any purpose and does not reflect import or export of each refrigerant exclusively for use in RACs.
- **Mixtures containing HFCs (including R-410A):** Currently, there is no individual HS code for the refrigerant R-410A, a refrigerant mixture of difluoromethane (HFC-32) and pentafluoroethane (HFC-125). Though R-410A is not ozone depleting, the refrigerant has a high global warming potential of 2,088.[42] All mixtures containing HFCs are currently covered by a single HS code: *HS 382478 – Mixtures containing halogenated derivatives of methane, ethane or propane; containing perfluorocarbons (PFCs) or hydrofluorocarbons (HFCs), but not containing chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs).*[43] This report includes data on import and export of HFC mixtures under this HS code, including R-410A. As previously mentioned, the WCO's approach for identifying HFCs, including R-410A, by amending the national HS Codes with additional digits was not in use when this report was developed. Thus, HFC mixture import/export data from Comtrade encompasses all reported import or export of the chemical mixtures any purpose and does not reflect import or export of each refrigerant exclusively for use in RACs. There is currently no coding to differentiate R-410A from the other mixtures containing HFCs imported/exported under this HS code.

### Defining "Low Efficiency"

For the purposes of this report, we define a "low efficiency" air conditioner as one which does not meet a minimum threshold of EER 3.0 W/W. We selected this threshold because it is below the minimum energy performance standards (MEPS) for most countries that export either parts for assembly or complete RACs into African countries e.g. China, South Korea and Japan.

## 2.2 Impacts Evaluations

CLASP conducted an impacts evaluation for four African regions covered by this study. The impacts evaluations focus on two sources of GHG emissions: direct emissions from leakage and servicing over the life of the equipment and the end-of-life disposal of the refrigerants used in RACs; and indirect emissions from generating the electricity consumed by RACs. To conduct these analyses at the regional level, CLASP assumed that regional markets matched those of the countries for which CLASP had data, and aggregated country-level market data by region. CLASP recognizes that RAC market characteristics vary from country to country, thus the findings of our regional impacts evaluations are not precise estimates. We welcome additional information and corrections. Additionally, as market data was not collected for any Central African countries, CLASP did not conduct analysis for Central Africa.

[39] To align with Montreal Protocol tracking, CLASP uses IPCC AR4 100-year GWP values. https://www.ipcc.ch/report/ar4/wg1/
[40] UNEP. "HS Nomenclature (HS Codes) for HCFCs and Certain Other Ozone Depleting Substances." OzonAction Fact Sheet. Post-Kigali Update. http://www.unep.fr/ozonaction/information/mmcfiles/7784-e-HSCodes_Factsheet_post_kigali_update.pdf
[41] UNEP. "HS Codes for HFCs, Advice for Countries in Advance of the 2022 HS Code Update". OzonAction Policy Brief. https://wedocs.unep.org/bitstream/handle/20.500.11822/29244/8052HS_Codes_Brief.pdf?sequence=1&isAllowed=y
[42] To align with Montreal Protocol tracking, CLASP uses IPCC AR4 100-year GWP values. https://www.ipcc.ch/report/ar4/wg1/
[43] UNEP. "HS Nomenclature (HS Codes) for HCFCs and Certain Other Ozone Depleting Substances." OzonAction Fact Sheet. Post-Kigali Update. http://www.unep.fr/ozonaction/information/mmcfiles/7784-e-HSCodes_Factsheet_post_kigali_update.pdf

For all four regions CLASP modeled GHG emissions under four policy scenarios designed to demonstrate the GHG emissions savings that can be achieved by eliminating environmental dumping of low efficiency, high GWP RACs continue. The four scenarios are:

- **Base Case (No Efficiency Policy + Unregulated Refrigerant Market):** A business-as-usual scenario that assumes that the RAC market continues to grow at a constant compound annual growth rate annually through 2030, and that the current market share of R-22, R-410A, and R-32 RACs gradually changes in accordance with Montreal Protocol (MP) phase-out schedules for R-22 and phase-down schedule for R-410A. No additional energy efficiency policies or refrigerant requirements are assumed in this scenario. The refrigerant distributions assumed for each region are detailed in Sections 6-9.
- **Policy Scenario 1 (U4E MEPS + Unregulated Refrigerant Market)**: A scenario in which the countries in each region adopt RAC energy efficiency standards equivalent to the U4E Model MEPS in 2022. There are no requirements for the GWP of refrigerants used in RACs in this scenario.
- **Policy Scenario 2 (U4E MEPS + U4E Refrigerant Regulation):** A scenario in which the countries in each region adopt RAC energy efficiency standards equivalent to the U4E Model MEPS in 2022 and require the use of refrigerants with GWP ≤ 750 in 2022. For the purpose of modeling, this scenario assumes that all RACs on the market from 2022 onwards use R-32 refrigerant, which has a GWP of 675.
- **Policy Scenario 3 (U4E MEPS + BAT Refrigerant Policy)**: A scenario in which the countries in each region adopt RAC energy efficiency standards equivalent to the U4E Model MEPS in 2022 and require the use of best-available-technology (BAT) refrigerants with GWP < 150 in 2022. For the purpose of modeling, this scenario assumes that all RACs on the market from 2022 onwards use R-290 refrigerant. Recent research estimates the R-290 has a GWP of <1;[44] however, without a more specific value and to keep estimated impacts conservative, CLASP assumes a 100-yr GWP of 1 for the R-290 refrigerant in this scenario.

### Calculating Indirect Emissions

To calculate indirect emissions from RAC usage, CLASP used the Policy Analysis Modelling System (PAMS), developed by CLASP and Lawrence Berkeley National Laboratory to help policymakers assess the costs and benefits of standards and labeling (S&L) programs.[45] PAMS is an easy-to-use tool that helps policymakers assess the benefits of S&L programs and identify cost-effective targets for MEPS levels. It is an Excel workbook designed to give first-order policy impacts projections with minimal preparatory research on the part of local policymakers. The model can also be used to perform robust technical analysis to support the development of MEPS, by customizing the tool with any country-specific data that is available.

In this analysis, CLASP used the BSRIA market data to customize the tool with relevant data for North, East, West and Southern Africa, and evaluated the GHG emissions impacts at the regional level for the selected policy scenarios.

In September 2019, United for Efficiency (U4E) published model energy performance standards and labeling guidance to assist governments in developing and emerging economies. These guidelines present an opportunity for global harmonization around ambitious and achievable MEPS and refrigerant requirements. CLASP elected to design this report's energy efficiency scenario around the RAC MEPS outlined in U4E's "Model Regulation Guidelines for Energy-Efficient and Climate-Friendly Air Conditioners." Since this study aimed to address the impacts of environmental dumping of inefficient products that cannot be sold in their country of manufacture, we chose to evaluate scenarios in which all products must meet the U4E Model MEPS.

[44] See Appendix A in WMO (World Meteorological Organization), Scientific Assessment of Ozone Depletion: 2018, Global Ozone Research and Monitoring Project – Report No. 58, 588 pp., Geneva, Switzerland, 2018. https://www.esrl.noaa.gov/csd/assessments/ozone/2018/

[45] The Policy Analysis Modelling System (PAMS) is available online at https://clasp.ngo/tools/policy-analysis-modeling-system

The U4E Model MEPS for RACs use the cooling seasonal performance factor (CSPF) metric for measuring energy efficiency. This allows for a technology neutral approach wherein inverter and fixed speed RACs are held to the same standards. Because RACs sold in Africa primarily report efficiency using EER, rather than a seasonal performance metric like CSPF or Seasonal Energy Efficiency Ratio (SEER),[46] CLASP approximated the relative levels of the U4E Model MEPS for EER models and used these in our analysis (**Table 1**).

*Table 1: U4E Model MEPS for RACs[47]*

| | Cooling Capacity | Minimum U4E MEPS for Africa[48] (CSPF) | Maximum U4E MEPS for Africa[49] (CSPF) | Group 3 MEPS (CSPF) | Group 3 MEPS used in model (EER)[50] |
|---|---|---|---|---|---|
| **Split, Cooling only (CSPF)** | CC ≤ 4.5 kW | 4.60 | 6.00 | 5.30 | 4.99 |
| | 4.5 kW < CC ≤ 9.5 kW | 4.00 | 5.10 | 4.60 | 4.33 |
| | 9.5 kW < CC ≤ 16.0 kW | 3.70 | 4.50 | 4.10 | 3.86 |

U4E provides model MEPS for all countries based on seventeen distinct climate zones. There are variety of climate zones represented in Africa. Due to the variety of climate zones represented in Africa and because CLASP modeled policy impacts at a regional level, we used the MEPS recommended for Group 3 countries for modeling our MEPS scenario, as these values approximate the middle of the range of MEPS recommended for African countries.

## Calculating Direct Emissions

To calculate direct GHG emissions due to leakage and subsequent servicing refills as well as the end-of-life disposal of refrigerants, CLASP used the following formula[51] for calculating direct emissions:

$$GWPdirect = GWP \times m \times L_{annual} \times n + GWP \times m \times (1 - \alpha_{recovery})$$

GWP = Global Warming Potential of the refrigerant
m = refrigerant charge
$L_{annual}$ = leakage rate per annum
n = operating life
$\alpha_{recovery}$ = recycling factor from 0 to 1

**Table 2** summarizes those elements of this formula that are held constant throughout the analyses conducted for the four African regions.

[46] Notably, SEER is used in China, the largest manufacturer of RACs and RAC components.
[47] See Table 5 in U4E Model Regulations. U4E. 2019. Model Regulation Guidelines for Energy Efficiency and Climate Friendly Air Conditioners. https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners/
[48] See Tables 1, 11, and 19 in the U4E Model Regulations. The lowest MEPS recommended for any African countries apply to those categorized into climate group 2 0B (extremely hot-dry): Algeria, Burkina Faso, Chad, Djibouti, Egypt, Eritrea, Ghana, Kenya, Mauritania, Niger, Senegal, South Sudan, and Sudan.
[49] See Tables 1, 11, and 19 in the U4E Model Regulations. The highest MEPS recommended for any African countries apply to those categorized into climate group 1 3C (warm marine) – Kenya, Morocco, and South Africa – and climate group Group 3 6A (cold humid) – South Africa.
[50] Calculated as EER = CSPF / 1.062 in accordance with ISO Testing Standard 16358-1:2013. https://www.iea.org/policies/6832-minimum-energy-performance-standards-and-labelling-for-air-conditioners-with-cooling-capacity-71kw
[51] Khare, A., Carreño, A.M. *Maximizing Climate Benefits through Energy Efficiency and Refrigerant Regulations for Air Conditioners: A case from India*. Energy Efficiency in Domestic Appliances and Lighting (EEDAL).

*Table 2: Leakage rate, operating life, and recycling factor assumptions*

| | Assumption | Source and Justification |
|---|---|---|
| **Leakage rate per annum ($L_{annual}$)** | 10% | CLASP did not have access to specific information on average operational leakage rates in the African countries. To approximate the leakage rates, CLASP researched similar markets and settled on a conservative 10% leakage rate.[52] |
| **Operating Life (n)** | 7 years | Average RAC operating lifetime estimates were available. CLASP assumed an average lifetime of 7 years based on survey findings from Nigeria and the findings of an in-depth RAC market assessment recently conducted in Kenya.[53] |
| **Recycling factor ($\alpha_{recovery}$)** | 0 | Based on the little information around recycling of RACs in Africa, CLASP assumed a recycling factor of 0. |

Complete and detailed methodology for the direct and indirect impacts analyses for North, East, West, and Southern Africa are provided in Sections 6-9.

[52] In a 2015 report on the Indian RAC market, the operational leakage rates for split RAC units was estimated at between 5-15%. Chaturvedi et al. 2015. *India's Long Term Hydrofluorocarbon Emissions: A detailed cross sectoral analysis within an integrated assessment modeling framework.* Council on Energy, Environment & Water and International Institute for Applied Systems Analysis http://ceew.in/pdf/ceew-indias-long-term-hydrofluorocarbon-emissions-29-may-15.pdf

[53] CLASP. 2019. *Kenya RAC Market Assessment and Policy Options Analysis.* https://clasp.ngo/publications/kenya-rac-market-assessment-and-policy-options-analysis-2019

# 3. The Case of Low Efficiency RACs in Africa

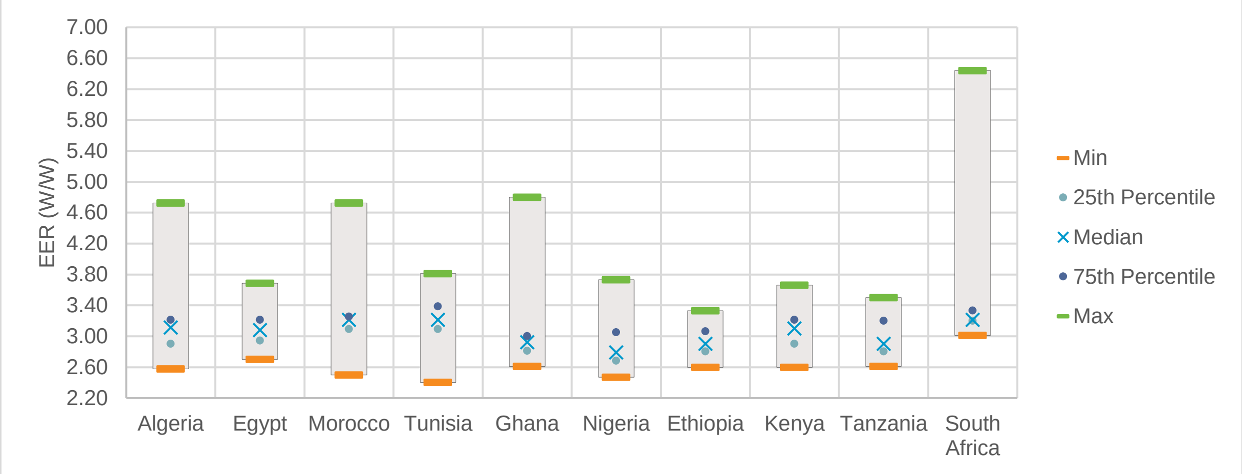
## 3.1 Main Findings

- RACs with efficiencies of less than EER 3.0 W/W make up 35% of the overall RAC sales in the ten African focus countries.[54] The market size for these low efficiency units was about 650,000 units in 2018.
- The largest markets for these low efficiency RACs are Nigeria (48%) and Egypt (30%).
- Non-African local subsidiaries, joint ventures between non-African companies and local companies in Egypt and Nigeria, and local African assemblers who import RAC components assemble the majority (80%) of the low efficiency units on the market.
- At least 50% of the imported low efficiency units are imported from China, with Korea (3.9%), the US (3.2%) and Japan (1.7%) accounting for the other major non-African sources of low efficiency AC equipment. These fractions could be higher since information on the source country was not available for 39% of the imported low efficiency dataset.

## 3.2 Market Based Evidence

Based on RAC market data collected by BSRIA and Kenyan market data previously collected by CLASP,[55] CLASP analyzed the market share of low efficiency units with energy efficiency ratios of less than EER 3.0 W/W in the selected ten African countries. Efficiency levels for RACs ranged from as low as 2.40 W/W to as high as 6.44 W/W;[56] however, the sales-weighted median efficiency across the ten countries averaged 3.04 W/W.

*Figure 6: Range of RAC efficiency levels in 10 African countries (N=495, V=1,634,255)*

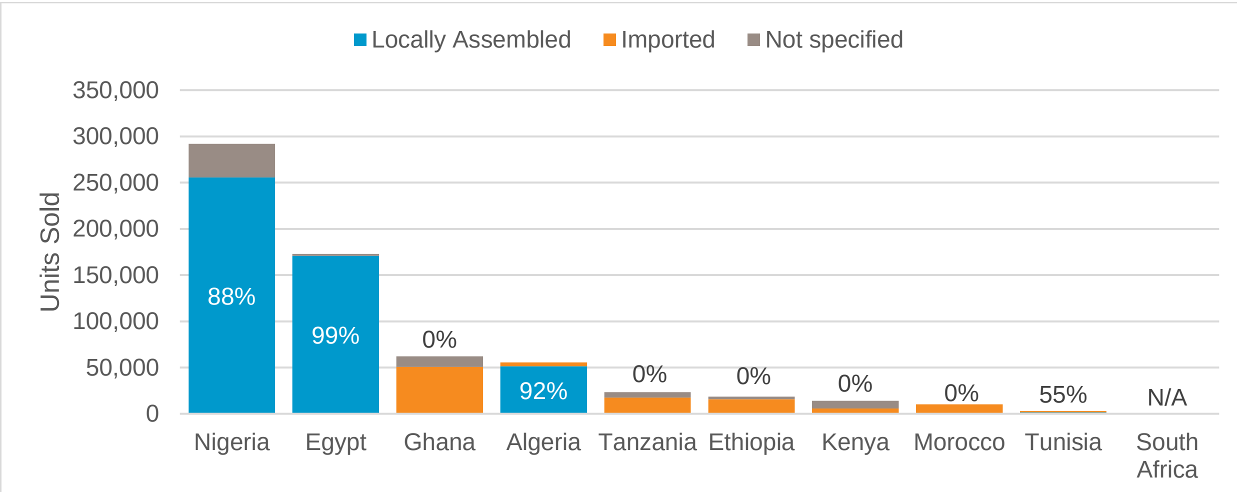



The EER 3.0 W/W threshold was selected because this is below the MEPS for most countries that export either parts for assembly or complete RACs into these African countries e.g. China, South Korea and Japan. These low efficiency units were present in all ten countries. Across the 10 countries, manufacturers and importers reported selling just under 652,000 units with efficiencies below 3.0W/W. Almost all the low efficiency RACs sold in countries with local RAC assembly plants - Algeria, Egypt, Tunisia and Nigeria –

[54] Based on BSRIA sales weighted data for 10 countries. RACs with EERs of between 3.0 – 3.5 W/W make up 47% of the market while other higher efficiency units take up the rest of the market.
[55] CLASP. 2019. *Kenya Room Air Conditioner Market Assessment and Policy Options Analysis.* https://clasp.ngo/publications/kenya-rac-market-assessment-and-policy-options-analysis-2019
[56] A few outliers with higher efficiency levels (>6.40 W/W) were found for South Africa; however, the validity of these models energy efficiency information could not be confirmed, thus the two models, which represent less than 7,000 units sold, are excluded.

were locally assembled (**Figure 7**). Most – 64% – of the low efficiency units were sold in Nigeria and Egypt, while Ghana, Tanzania, Ethiopia, Kenya, and Morocco imported all their low efficiency units. South Africa did not import any low efficiency units in 2018.

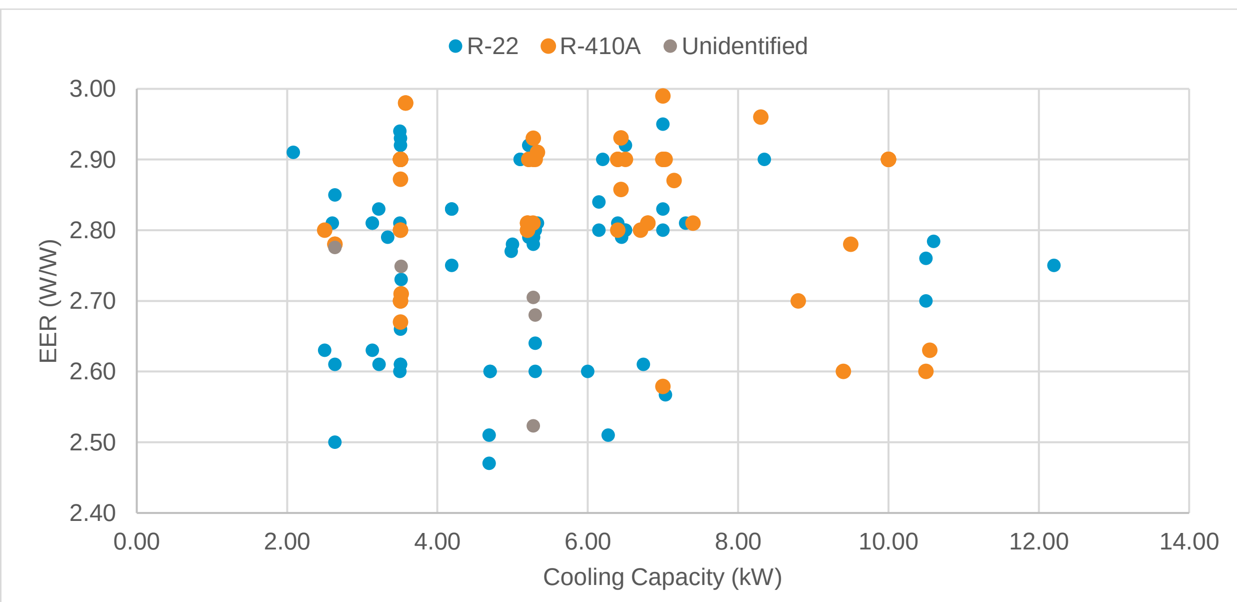
*Figure 7: Low efficiency RACs sold in 10 African countries with locally manufactured share indicated*




## Compressor Types & Refrigerants

While the compressor type was not available for 10% of the low efficiency units, from the data available, 98% of the low efficiency units were fixed speed units. The refrigerant used in the low efficiency units was reported as primarily R-22 (78%) with at least 15% using R-410A.[57] In general, among small to medium-sized RACs, R-22 RACs reported the lowest energy performance levels on the African market.

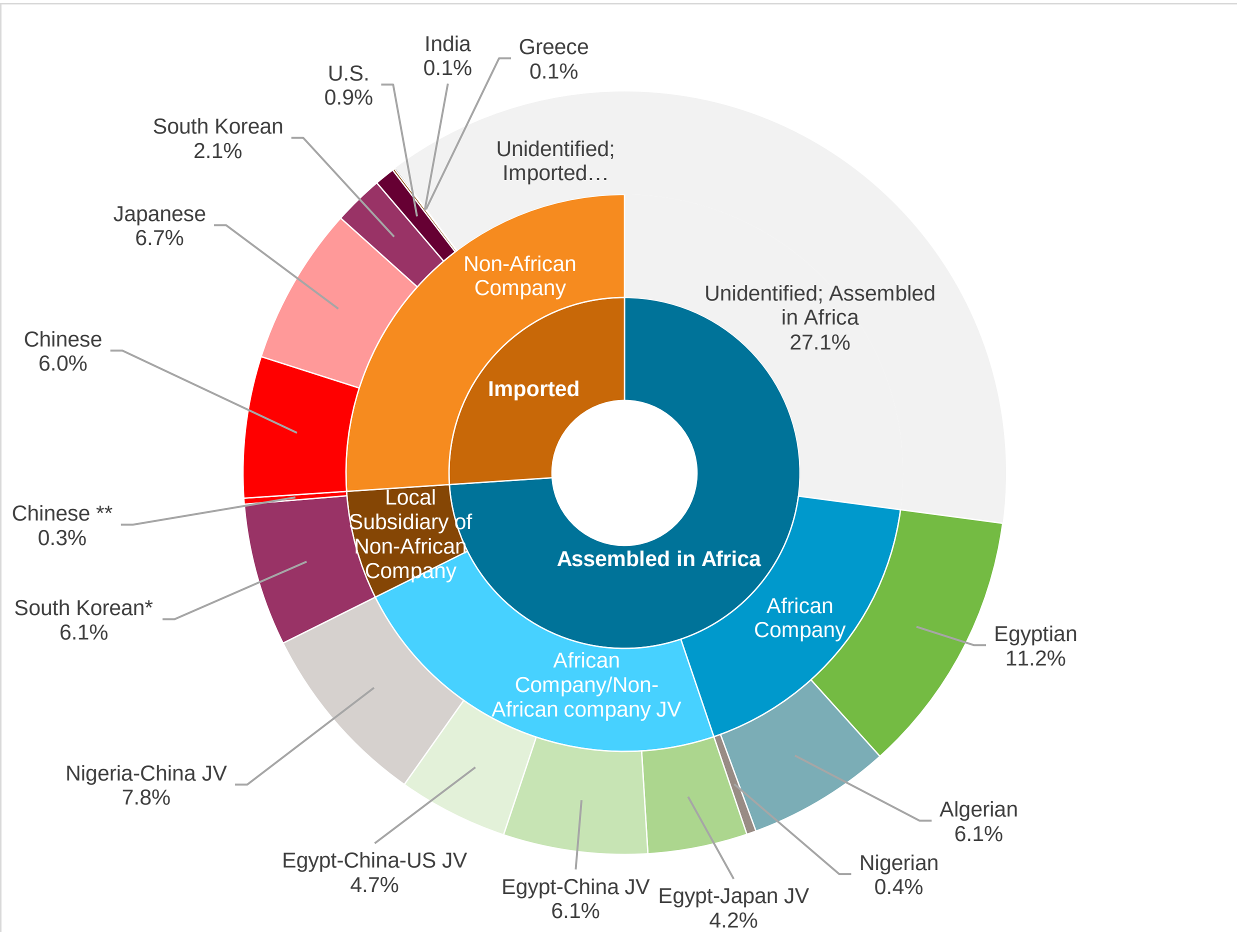
*Figure 8: Distribution of low efficiency RAC efficiencies by refrigerant type (N=166, V=651,723)*




[57] The refrigerant type for 6% of the low efficiency models was not provided and although 2 models were reported to use the R-32 refrigerant, this information could not be verified.

## Brands and Sources

*Figure 9: Sources of low efficiency RACs sold in 10 African countries (N=651,273)[58]*




CLASP identified 30 unique brands[59] selling low efficiency units across the 10 countries.

- Chinese brands: Gree, Chigo, Haier, Midea, RTEC, Hisense
- Japanese brands: Panasonic, Daikin, General, Mitsubishi
- South Korean brands: Samsung, LG
- US brands: York, Trane, Carrier
- Egyptian brands: Unionaire, Fresh, Power, Sharp,[60], Miraco Carrier[61]
- Nigerian Brands: Haier Thermocool
- Algerian brands: Géant, ENIEM, Starlight, Condor

[58] South Korean* and Chinese** refer to products assembled by local subsidiaries of South Korean and Chinese brands
[59] Brand and/or manufacturer was not identified by BSRIA for 37% of the low efficiency models in the BSRIA dataset.
[60] The Sharp brand R-22 RACs in Africa are assembled in Egypt under an Egypt-Japan partnership between the El-Araby group and Sharp Corp. https://www.japantimes.co.jp/country-report/2019/01/25/egypt-report-2019/el-araby-contributing-egypt-japan-relationship/#.XbG_r-hKhPY
[61] Miraco Carrier is a joint venture established in 1992 and is now the leading HVAC company in Africa. Miraco Carrier sells Carrier, Midea and Toshiba products. The Carrier branded RACs assembled in Egypt should be considered Miraco Carrier.

- Ghanaian brand: Brühm
- Kenyan brand: Von Hotpoint
- Indian brand: Blue star
- Greek Brand: Inventor

### Local Assembly of Low Efficiency RACs

**Table 3** below details the volume of locally assembled low efficiency RAC units in four African countries by company type (local company, joint venture between an African company and one or more non-African companies, local subsidiary of non-African company). In all four countries with local RAC assembly, the low efficiency RACs are sold under a mix of international and local brands. Low efficiency RACs sold under Chinese, South Korean, Japanese, and US branding such as Gree, Carrier, LG, and Sharp are locally assembled by either local companies that have entered into joint ventures with the large non-African manufacturers, such as Tiba Mzalawi in Egypt that assembles Gree units, or local subsidiaries of the non-African companies such as the Gree subsidiary in Nigeria.

Independent African companies also assemble and sell a significant portion of the low efficiency units. For example, in Egypt, Unionaire, Fresh[62] and Power sell 43% of the low efficiency units while in Algeria, local brands Géant, Eniem, Starlight and Condor sell 74% of the low efficiency units.

*Table 3: Volume of low efficiency RACs assembled locally in Egypt, Nigeria, Algeria and Tunisia*

| Brand Type | Assembled in: | | | | Total by Brand Type |
|---|---|---|---|---|---|
| | Egypt | Nigeria | Algeria | Tunisia | |
| Egyptian Companies | 73,065 | - | - | - | **73,065** |
| Egypt-China-US JVs[63] | 30,369 | - | - | - | **30,369** |
| Egypt-China JVs | 39,833 | - | - | - | **39,833** |
| Egypt-Japan JVs | 27,498 | - | - | - | **27,498** |
| Nigeria-China JVs | - | 51,150 | - | - | **51,150** |
| Algerian Companies | - | | 39,605 | - | **39,605** |
| Subsidiaries of South Korean Companies | - | 39,450 | - | - | **39,450** |
| Subsidiaries of Chinese Companies | - | | - | 1,641 | **1,641** |
| Unidentified[64] | - | 165,000 | 11,668 | - | **176,668** |
| **Total by Country** | **170,765** | **255,600** | **51,273** | **1,641** | **479,279** |

### Imported Low Efficiency RACs

Table 4 details the source country of imported low efficiency RACs. According to the BSRIA data, low efficiency RACs were imported from 8 countries.[65] While some of those units were imported from Japan, the source country for majority of the units was not specified. Across the 10 focus countries, China is the largest source of the low efficiency imports at 50% of imports, followed by South Korea (3.9%), the U.S. (3.2%), and Japan (1.6%). Intraregional trade of low efficiency units is also evidenced by the units exported to Ghana and Kenya from Nigeria and Egypt, respectively.

[62] Fresh assembles splits and windows with parts supplied from Asia. (Information obtained by BSRIA).
[63] The joint ventures in the table are private JVs between Egyptian or Nigerian companies and large non-African companies. They are not government level JVs.
[64] Brand was not identified for 37% of locally assembled low efficiency models in the dataset. This indicates a need for further research and transparency of information.
[65] The source country was not available for 37% of the dataset.

When analyzed by source country, at least 48% of the imported low efficiency units were imported from China. Most of these Chinese units are imported into Tanzania (approximately 50,000 units) and Ghana[66] (approximately 24,000 units) with the rest going to Ethiopia, Kenya, Morocco and a few hundred units to Egypt. Low efficiency units from South Korea are mostly imported to South Africa with the other units going to Algeria, Ethiopia, Kenya, Morocco and Tanzania (**Table 4**).

*Table 4: Imported low efficiency RACs by importing country and country of origin*

| Importing Country | Imported from: | | | | | | | | | Total by Import Country |
|---|---|---|---|---|---|---|---|---|---|---|
| | China | South Korea | US | Japan | India | Greece | Nigeria | Egypt | Others | |
| Ghana | 48,000 | - | - | - | - | - | 2,614 | - | 11,668 | **62,281** |
| Nigeria | - | - | - | - | - | - | | - | 36,300 | **36,300** |
| Tanzania | 13,658 | 2,550 | 400 | 380 | 610 | - | - | - | 5,802 | **23,400** |
| Ethiopia | 12,757 | 680 | 205 | 1,710 | - | 400 | - | - | 2,680 | **18,432** |
| Kenya | 3,408 | 1,000 | 650 | 770 | - | - | - | 40 | 8,080 | **13,948** |
| Morocco | 7,967 | 988 | 1,216 | - | - | - | - | - | - | **10,171** |
| Algeria | 920 | 1,431 | 2,044 | - | - | - | - | - | - | **4,395** |
| Egypt | - | - | - | - | - | - | - | | 2,177 | **2,177** |
| Tunisia | 306 | - | 1,035 | - | - | - | - | - | - | **1,341** |
| South Africa | - | - | - | - | - | - | - | - | - | **-** |
| **Total by Source Country** | **87,015** | **6,649** | **5,550** | **2,860** | **610** | **400** | **2,614** | **40** | **66,707** | **172,444** |

[66] Although the threshold used for low efficiency in this report is 3.0 W/W, out of the RACs imported into Ghana that fall into this category, only 7% of the reported units sold were below the Ghana RAC MEPS of 2.8W/W

# 4. The Case of R-22 RACs in Africa

## 4.1 Main Findings

- R-22 room air conditioner (RAC) sales account for 47% of overall RAC sales in the ten African focus countries.[67] R-22 RAC market size is about 800,000 units.
- A large portion of R-22 units are assembled locally (82%), mostly due to national requirements and policies that provide incentives for national assembly (i.e., lower import duties for components) or bans on the import of assembled units.
- 49% of R-22 RACs on the market come from joint ventures between local Egyptian or Nigerian assemblers and international Asian companies.
- China is the largest source of imported R-22 RACs (57%), followed by Egypt (11%), the US (3%), Nigeria (1.6%), and South Korea (0.6%). This share of imports from each country could be even larger - country of origin was not available for 27% of the imported R-22 RAC models in the dataset.
- The average efficiency level of R-22 RAC units is around EER 2.9 W/W. This efficiency level is well below MEPS of major trading partners (including China, South Korea, the US, and the EU).

## 4.2 Market Based Evidence

Based on RAC market data collected by BSRIA and Kenyan market data previously collected by CLASP,[68] CLASP analyzed the market for R-22 RACs in ten African countries: Algeria, Egypt, Morocco, Tunisia, Ghana, Nigeria, Ethiopia, Kenya, Tanzania and South Africa. R-22 RACs were present in 9 of the 10 countries[69] – South Africa is the only country in the study which appears to have no new R-22 RACs on the market.

Overall, across the 9 countries where new R-22 RACs are sold, manufacturers reported selling just under 800,000 new R-22 RACs. Of these RACs, 81% were assembled locally, and 19% were imported. Countries manufacturing R-22 RACs locally included three North African countries – Egypt, Algeria, and Tunisia – and Nigeria (**Figure 10**). The remaining five countries exclusively imported R-22 RACs. The tendency towards local assembly in Egypt can be explained by the high tariffs Egypt imposes on products imported from countries outside of the Gulf Cooperation Council.[70] Similarly, in Nigeria local assembly is encouraged by significantly lower import duties (5%) for completely knocked down units[71] as compared to imported assembled units (20%). In contrast to Egypt and Nigeria's tariff measures, Algeria outright bans importation of fully assembled RACs and is experimenting with a preferential tariff for higher efficiency RACs below 24,000 btu/hr.

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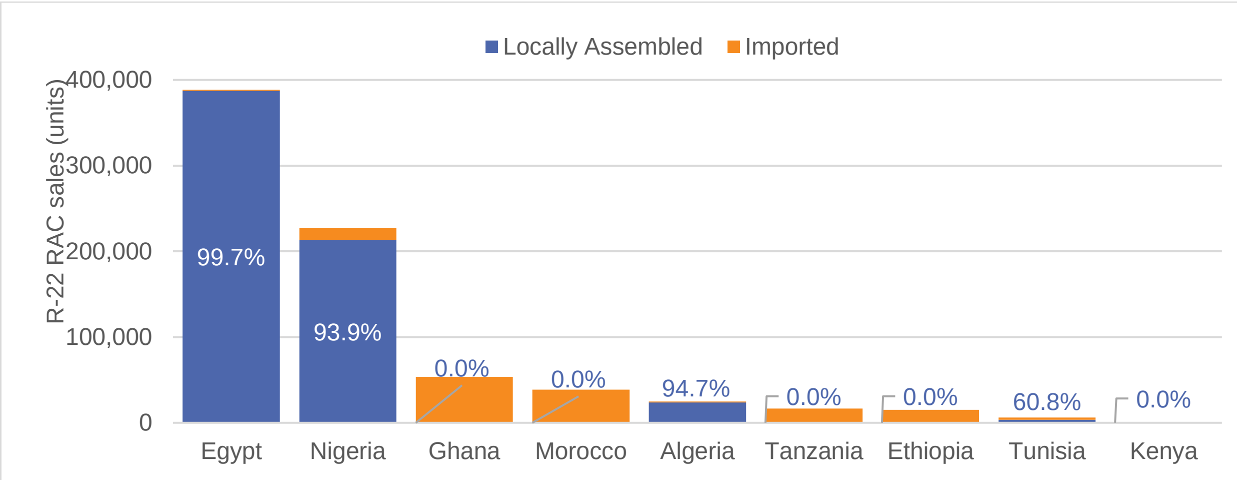
[67] Based on BSRIA sales weighted data for 10 countries. R-410A RACs accounted for 49% of sales, R-32 RACs accounted for 1% of sales, and refrigerant type was not available for the remaining 3%.
[68] CLASP. 2019. *Kenya Room Air Conditioner Market Assessment and Policy Options Analysis.* https://clasp.ngo/publications/kenya-rac-market-assessment-and-policy-options-analysis-2019
[69] Based on BSRIA data, the R-22 market in Kenya appears to be quite small; however, the market is likely larger than appears here, based on the results of CLASP's 2019 Kenya RAC Market Assessment, wherein 27% of the 103 models observed were used R-22 refrigerant.
[70] The import tariff for RACs is 60%. Source: Decree of the President of the Republic of Egypt No. 538 of 2016. http://capexil.org/decree-of-the-president-arab-republic-of-egypt-no-538-2016-harmonized-customs-tariff/. Accessed 14 April 2020
[71] Knocked-down units refers to kits containing all the components for assembling an RAC.

*Figure 10: R-22 RACs sold in 10 African countries with locally manufactured share indicated*

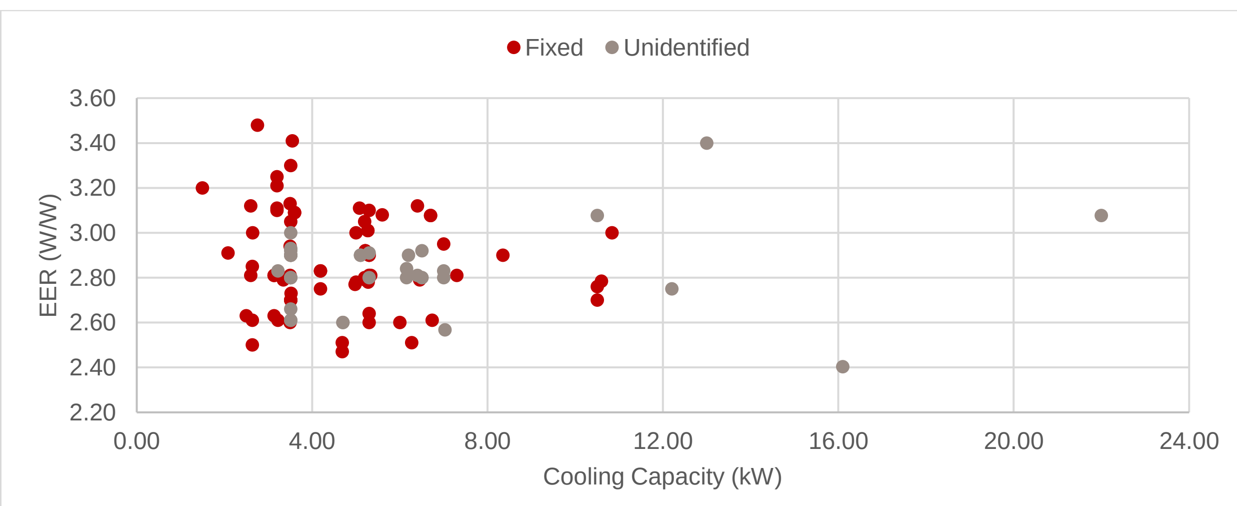



Imported R-22 RACs were reported to BSRIA as originating from six countries, China, South Korea, the US, Egypt, and Nigeria. With respect to African regional trade, Brühm RACs were imported from Nigeria by Ghana and Egyptian Carrier RACs were imported by Morocco. Of the R-22 RAC's imported by the nine countries, China is the largest source at 64% of imports. Source country of imported RACs was not available for 17% of the RACs in the BSRIA dataset, meaning imports from China could be much greater, around 81%.[72]

## Compressor Type & Efficiency

95% of the R-22 RACs were reported to be fixed speed units, and the remaining 5% did not report the compressor type. Based on efficiency levels provided for those units that did not report the compressor type, the remaining 5% of R-22 models are likely to be fixed speed units as well.

*Figure 11: R-22 RAC models cooling capacity vs. efficiency by compressor type (N=114, V=780,668)*




[72] 2016-2018 RAC imports/exports data from the UN International Trade Statistics Database (Comtrade) for the 10 focus countries show that Chinese RACs account for 79-83% of RAC imports in Africa. Comtrade data does not differentiate RACs by refrigerant type.

The highest efficiency R-22 model reported an EER of 3.48 W/W; however, the average efficiency level of R-22 units is much lower, around EER 2.9 W/W.[73] The average efficiency level of imported R-22 RACs is slightly higher than the average efficiency of R-22 RACs assembled locally in Egypt, Nigeria, Algeria and Tunisia. The range of efficiency levels is also wider for imported R-22 RACs compared to those produced locally in Africa.

*Figure 12: Distribution of efficiencies of R-22 RACs in Africa (N=780,668)*

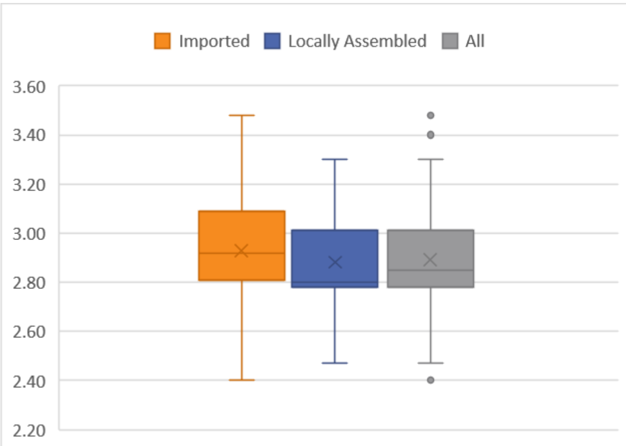
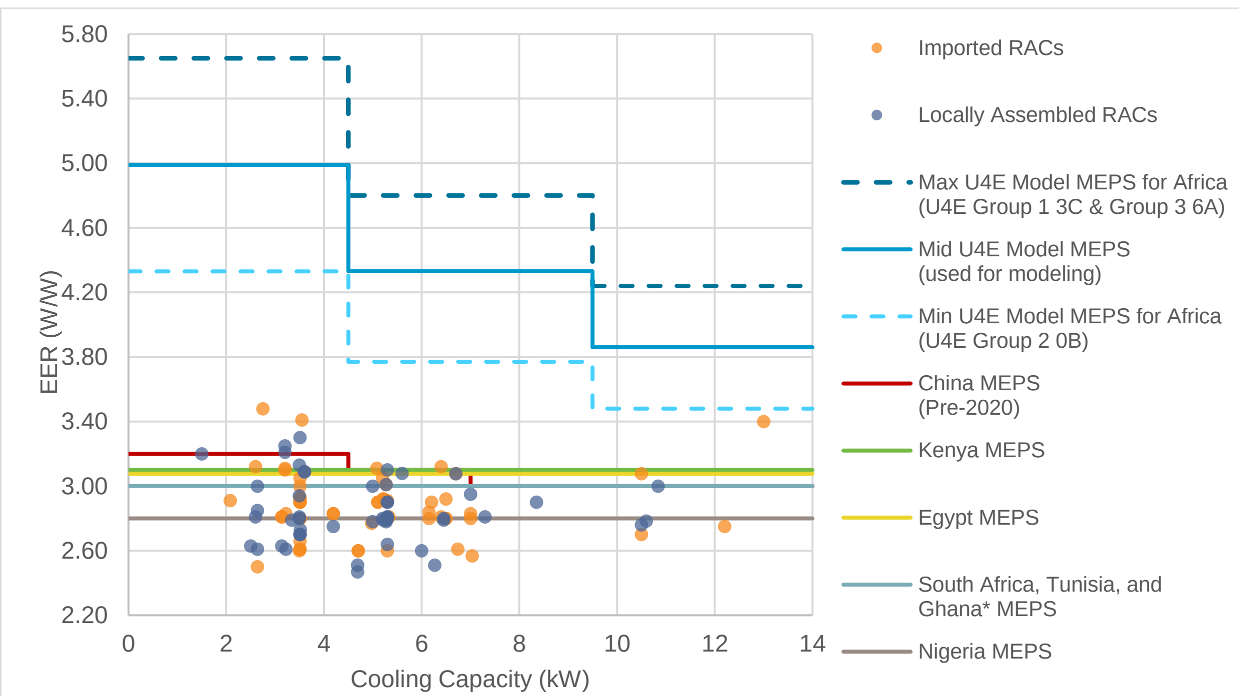



*Figure 13: R-22 RACs in Africa compared to MEPS (N=114, V=789,778)[74]*

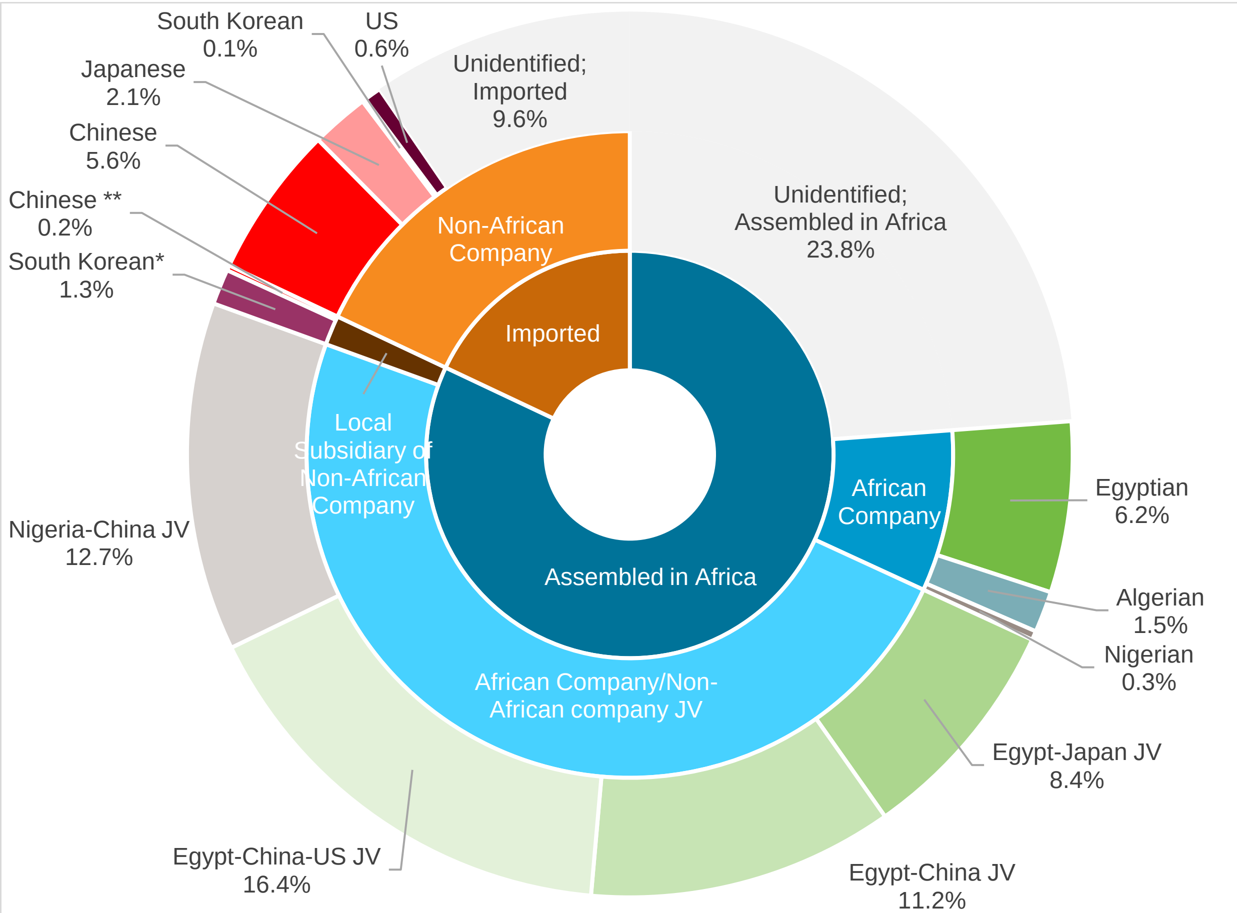



*Ghana recently committed to revising the MEPS from EER 2.80 W/W to 3.0 W/W

[73] This is a sales weighted average.
[74] MEPS levels in the chart are reported in EER. For the max, mid, and min U4E model MEPS, the levels were converted from ISO CSPF to EER using the formula EER = CSPF / 1.062 in accordance with ISO Testing Standard 16358-1:2013. https://www.iea.org/policies/6832-minimum-energy-performance-standards-and-labelling-for-air-conditioners-with-cooling-capacity-71kw

### Brands and Sources

*Figure 14: Sources of R-22 RACs sold in Africa (N=789,778)* [75]




CLASP identified 27 unique brands[76] selling RACs using R-22 refrigerant across the nine countries with R-22 RACs. The majority of R-22 RACs on the market are sold under non-African brands and assembled by joint ventures between African companies and Chinese, US, or Japanese companies.

- Chinese brands: Gree[77], Haier[78], Midea,[79] Fitco, RTEC, Chigo, Hisense
- Japanese brands: Daikin, Panasonic
- South Korean brands: Samsung[80], LG
- US brands: York, Trane

[75] South Korean* and Chinese** refer to products from the subsidiaries of South Korean and Chinese companies in Africa.
[76] Brand and/or manufacturer was not identified by BSRIA for 33% of the R-22 models in the BSRIA dataset.
[77] 92% of the Gree R-22 units in Africa are locally assembled in Egypt and Nigeria, the remaining 8% are imported from China
[78] 47% of the Haier R-22 units in Africa are imported from China, the remaining 53% are produced in Tunisia.
[79] 49% of the Midea R-22 units in Africa are imported from China, the remaining 51% are produced by Miraco Carrier in Egypt.
[80] Samsung is a South Korean brand; however, based on the data collected by BSRIA, 100% of the Samsung units in Africa produced in Egypt and Nigeria.

- Egyptian brands: Unionaire, Fresh[81], Power, Sharp (El Araby),[82] Miraco Carrier[83]
- Algerian brands: ENIEM
- Nigerian brands: Haier Thermocool, Brühm

## Local Assembly of R-22 RACs

The table below details the volume of locally assembled low efficiency RAC units in four African countries by company type (local company, joint venture between an African company and one or more non-African companies, local subsidiary of non-African company). At least 22% of the RACs assembled in the four manufacturing countries are assembled by independent African companies and at least 46% of locally assembled products come from joint ventures between local companies and large non-African companies.

*Table 5: Volume of R-22 RACs assembled locally in Egypt, Nigeria, Algeria and Tunisia*

| Company Type | Assembled in: | | | | Total by Company Type |
|---|---|---|---|---|---|
| | Egypt | Nigeria | Algeria | Tunisia | |
| Egyptian Companies | 123,392 | - | - | - | **123,392** |
| Egypt-China-US JVs[84] | 112,239 | - | - | - | **112,239** |
| Egypt-China JVs | 73,626 | - | - | - | **73,626** |
| Egypt-Japan JVs | 65,994 | - | - | - | **65,994** |
| Nigeria-China JVs | - | 40,950 | - | - | **40,950** |
| Algerian Companies | - | - | 11,901 | - | **11,901** |
| Subsidiaries of South Korean Companies | 3,000 | 7,200 | - | - | **10,200** |
| Subsidiaries of Chinese Companies | - | - | - | 1,463 | **1,463** |
| Unidentified[85] | 9,110 | 165,000 | 11,668 | 2,190 | **187,968** |
| **Total by Country** | **387,361** | **213,150** | **23,569** | **3,653** | **627,732** |

## Imported R-22 RACs

When analyzed by source country, at least 56% of the imported R-22 units originated in China. Most of these Chinese units are imported into Ghana (approximately 50,000 units) and Morocco (approximately 38,000 units) with the rest going to Tanzania and Ethiopia, and a few hundred units to Kenya. R-22 units from South Korea are only imported by Morocco. Large capacity R-22 units from the US were imported into Egypt, Tunisia, and Algeria (see **Table 6)**.

[81] Fresh assembles splits and windows with parts supplied from Asia. (Information obtained by BSRIA).
[82] The Sharp brand R-22 RACs in Africa are assembled in Egypt under an Egypt-Japan partnership between the El-Araby group and Sharp Corp. https://www.japantimes.co.jp/country-report/2019/01/25/egypt-report-2019/el-araby-contributing-egypt-japan-relationship/#.XbG_r-hKhPY
[83] Miraco Carrier is a joint venture established in 1992 and is now the leading HVAC company in Africa. Miraco Carrier sells Carrier, Midea and Toshiba products. All the Carrier R-22 RACs and 51% of the Midea units in the BSRIA dataset are assembled in Egypt.
[84] The joint ventures in the table are private JVs between Egyptian or Nigerian companies and large international brands from the countries mentioned. They are not government level JVs.
[85] Brand was not identified for 30% of locally assembled R-22 models in the dataset. This indicates a need for further research and transparency of information.

*Table 6: Imported R-22 RACs by importing country and country of origin*

| Importing Country | Imported from | | | | | | Total by Importing Country |
|---|---|---|---|---|---|---|---|
| | China | South Korea | US | Egypt | Nigeria | Others | |
| Ghana | 48,000 | - | - | - | 2,614 | 2,899 | **53,512** |
| Morocco | 20,155 | 988 | - | 17,409 | - | - | **38,552** |
| Egypt | - | - | 1,244 | | - | 19,277 | **20,521** |
| Tanzania | 11,032 | - | - | - | - | 5,550 | **16,582** |
| Ethiopia | 12,412 | - | - | - | - | 2,680 | **15,092** |
| Nigeria | - | - | - | - | | 13,800 | **13,800** |
| Tunisia | - | - | 2,358 | - | - | - | **2,358** |
| Algeria | - | - | 1,329 | - | - | - | **1,329** |
| Kenya | 300 | - | - | - | - | - | **300** |
| South Africa | - | - | - | - | - | - | **-** |
| **Total by Source Country** | **91,899** | **988** | **4,930** | **17,409** | **2,614** | **44,206** | **162,045** |

# 5. Policy Landscape in Africa

## 5.1 Main Findings

- Five out of the 10 focus countries have mandatory MEPS, while six countries have mandatory energy labelling for RACs.
- All 10 countries have either ratified or acceded to the Montreal Protocol and at least 8 have passed regulations limiting the manufacture, sale or use of ozone-depleting substances; 4 (Ghana, Nigeria, Ethiopia, South Africa) have ratified or acceded to the Kigali Amendment to the Montreal Protocol as of May 2020. (**Table 8**)
- Based on on-the-ground surveys in 4 countries, the main challenges faced in implementation of the ODS regulations include: lack of awareness among stakeholders, illegal shipment of the restricted refrigerants, inadequate resources for enforcement personnel, lack of adequate financial and technical resources for local manufacturers to transition away from R-22 refrigerant and limited institutional capacity.
- All ten countries have ratified or acceded to the Basel Convention on the control of transboundary movements of hazardous wastes and their disposal.
- Only four out of the 10 countries have ratified the Bamako Convention on the ban on the import into Africa and the control of transboundary movement and management of hazardous wastes within Africa.
- Only Egypt, Ghana and Nigeria have regulations explicitly controlling or restricting the importation and sale of secondhand RACs.
- Ghana has implemented a complete ban on the import of all secondhand refrigerators and RACs that has led to significant market transformation from over 400,000 used refrigerators imported into Ghana in 2012 to just 9,500 in 2014. This ban has led to estimated energy savings of 3,624 GWh.
- In Kenya, the RAC S&L program has limited the importation of secondhand RACs.
- The main challenges identified by interviewees in Ghana and Nigeria regarding the implementation of regulations controlling the importation of secondhand RACs include the political implications of an outright ban and the limited resources of border control agencies.

## 5.2 AC energy efficiency standards and labeling policies in Africa

**Table 7** below summarizes the energy efficiency standards and labelling programs in the 10 focus countries. Further details on the policies are included in the individual country profiles in the Annexes. Five out of the 10 countries have mandatory MEPS for RACs, while in Nigeria the MEPS is still in the voluntary phase. Six countries have mandatory energy labelling requirements for RACs. The Egypt and Ghana standards and labeling programs began in 2002 and 2005, respectively, and are therefore the longest-tenured on the continent.

*Table 7: RAC Energy Efficiency standards and labelling policies in 10 focus countries*

| Country | Legal Framework | Minimum Energy Performance Standards (MEPS) | Energy Labelling |
|---|---|---|---|
| Algeria | None | None | None |
| Egypt | Ministerial decree No. 171/2011 | Egypt Standard 3795-1/2016 and 3795-2/2017<br>(Mandatory) | Egypt Standard 3795-1/2016 and 3795-2/2017<br>(Mandatory) |

| Country | Legal Framework | Minimum Energy Performance Standards (MEPS) | Energy Labelling |
|---|---|---|---|
| | | MEPS for split RACs: EER of 3.077 W/W for fixed speed units and SEER of 11 btu/hr/W for inverter units | |
| Ethiopia | Energy Proclamation No. 810/2013 | None | None |
| Ghana | L.I 1815 – Energy Efficiency Standards and Labelling (Non-ducted air conditioners and self-ballasted fluorescent lamps) Regulations, 2005 | Ghana Standard 362:2001 (Mandatory – Under review)<br>MEPS for split RACs: EER 2.80 W/W<br><br>Ghana has recently committed to raising the MEPS for spit RACs to 3.0 W/W. | Ghana Standard 362:2001 (Mandatory) |
| Kenya | The Energy (Appliances' Energy Performance and Labelling) Regulations, 2016 | KS 2463:2019 - Non-ducted air conditioners — testing and rating performance<br>(Mandatory)<br>MEPS for split RACs: EER 3.10 W/W | KS 2463:2019 - Non-ducted air conditioners — testing and rating performance (Mandatory) |
| Morocco | Law No. 47-09 of 2011 | Under Development | NM 14.2.300 - 2012 (Mandatory) |
| Nigeria | | NIS: ECOSTAND 071-2:2017EE<br>(Voluntary)<br>MEPS for split RACs: 2.8W/W | NIS: ECOSTAND 071-2:2017EE<br>(Voluntary) |
| South Africa | Compulsory Specification for Energy Efficiency And Labeling of Electrical and Electronic Apparatus (VC 9008) – 2014 | SANS 941<br>(Mandatory – Under review)<br>MEPS for split RACs: EER 3.0 W/W<br>(EU B-class) | SANS 941<br>(Mandatory) |
| Tanzania | None | None | None |
| Tunisia | Energy Conservation Law of 2004 | (Mandatory)<br>MEPS for RACs equivalent to EU Class B (3.0 W/W) | Mandatory |

## 5.3 Policies regulating ozone depleting substances (ODS) in Africa

### The Montreal Protocol on Substances that Deplete the Ozone Layer

The Montreal Protocol (MP), was signed in 1987 and entered into force in 1989, is the landmark international treaty that controls the global production and consumption of ozone depleting substances (ODSs).[86] Three main substances regulated under the Protocol are chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and hydrofluorocarbons (HFCs). These ODSs have various applications, most notably as refrigerants in air conditioners and refrigerators. When released into the atmosphere, ODSs damage the stratospheric ozone layer[87] and contribute directly to climate change as they are powerful greenhouse gases with much higher global warming potential than carbon dioxide.

The MP sets the phase out schedule for different ODS groups. It requires CFCs to be completely phased out in Non-Article 5 Parties (developed countries) by 1996 and in Article 5 Parties (developing countries) by 2010.[88] Due to their lower ozone depleting potential, HCFCs, such as R-22, replaced some uses of

[86] UNDP. "Ozone layer protection." https://www.undp.org/content/undp/en/home/2030-agenda-for-sustainable-development/planet/environment-and-natural-capital/montreal-protocol.html
[87] This ozone hole lets ultraviolet radiation enter the Earth, which increases the prevalence of skin cancer and cataracts in humans, reduces agricultural output, and disrupts both land and marine ecosystems.
[88] UN Environment, Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer, Thirteenth Edition, 2019.

CFCs as a first step and then were replaced by ozone-safe alternatives in the second step of phase-out.[89] However, CFCs were never used as refrigerants in RACs where R-22 dominated use prior to the Montreal Protocol. Because HCFCs are also potent greenhouse gases, they are subject to a phase-out schedule. The production and consumption of HCFCs should be phased out by 2020 in Non-Article 5 Parties and by 2030 in Article 5 Parties.[90]

Since its inception the MP has been ratified by all 196 nation states and the European Union and amended five times.[91] All ten countries in this study have ratified the MP and established National Ozone Units to regulate ODSs within their borders (**Table 8**). The most recent amendment was the Kigali Amendment, finalized in 2016 and entered into force on January 1, 2019. The Amendment, ratified by 81 parties to date, including EU, controls the production and consumption of HFCs.[92] Four countries in this study have ratified the Kigali Amendment as of May 2020.

### The Kigali Amendment

HFCs have been widely used as alternatives to CFCs and HCFCs because they do not deplete the ozone layer. However, HFCs, like CFCs and HCFCs, contribute significantly to climate change. Two common refrigerants, R-32 and R-410A, belong to this group. The Kigali Amendment aims to decrease the production and consumption of HFCs internationally by at least 80% by 2047. Under the amendment, countries are divided into four groups, each of which is subject to a suitable phase-down schedule.

*Table 8: International and national policies regulating ozone depleting substances (ODSs)*

| Country | Montreal Protocol | Kigali Amendment | National Ozone Office | National Ozone Regulations |
|---|---|---|---|---|
| Algeria | Acceded to 20 October 1992 | Not yet ratified | Yes, under the Environmental Ministry and the National Agency of Climate Change (Ministère de l`Environnement et de l`Agence Nationale des Changements Climatiques) | Executive Decree No. 13-110 of 17 March 2013 on the Regulation of Ozone Depleting Substances, their mixtures and products that contain it |
| Egypt | Ratified 9 May 1988 | Ratification process ongoing at national level[93] | Yes, under the Egyptian Environmental Affairs Agency | Regulations for Ozone Layer Protection, 2018 |
| Ethiopia | Acceded to 11 October 1994 | Ratified 5 Jul 2019 | Yes, under the Solid and Hazardous Waste Compliance Monitoring Directorate, Ministry of Environment Forest and Climate Change | Control of Ozone Layer Depleting Substances Proclamation No. 716/2011 |
| Ghana | Acceded to 24 July 1989 | Ratified 2 Aug 2019 | Yes, under Environmental Protection Agency | Management of Ozone Depleting Substances And Products Regulations, 2005 (L.I. 1812) |
| Kenya | Acceded to 9 November 1988 | Ratification process ongoing at national level | Yes, under the Ministry of Environment, Natural Resources and Regional Development Authorities | Environmental Management and Co-ordination (Controlled Substances) Regulations, 2007 |

[89] National Geographic. “Without the Ozone Treaty, You’d Get Sunburned in 5 Minutes.” https://www.nationalgeographic.com/news/2017/09/montreal-protocol-ozone-treaty-30-climate-change-hcfs-hfcs/
[90] UN Environment, Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer, Thirteenth Edition, 2019.
[91] London, Copenhagen, Montreal, Beijing and Kigali amendments
[92] Ratification Status of the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer https://kigali-amendment.openclimatedata.net/
[93] Source: A representative of the Ministry of Environment, Egypt

| Country | Montreal Protocol | Kigali Amendment | National Ozone Office | National Ozone Regulations |
|---|---|---|---|---|
| Morocco | Ratified 28 December 1995 | Not yet ratified | Yes, under the Ministry of Energy, Mines, Water & Sustainable Development (Ministre de l'Energie, des Mines, de l'Eau et de l'Environnement, chargé de l'Environnement) | |
| Nigeria | Acceded to 31 October 1988 | Ratified 20 Dec 2018 | Yes, under the Federal Ministry of Environment | National Environmental (Ozone Layer Protection) Regulations, 2009 (S.I. No. 32 of 2009 |
| South Africa | Acceded to 15 January 1990 | Ratified 1 Aug 2019 | Yes, under the Department of Environmental Affairs | Regulations Regarding the Phasing-out and Management of Ozone Depleting Substances, 2014 |
| Tanzania | Acceded to 7 April 1993 | Not yet ratified | Yes, in the Vice President's Office | Ozone Depleting Substance, Regulation, December 2007 |
| Tunisia | Acceded to 25 September 1989 | Not yet ratified | Yes, under the National Agency for the Protection of the Environment | |

### National Policies Regulating the Ozone Depleting Substances

The information on the implementation of national regulations regulating ODS refrigerants was collected through on-the-ground surveys in Egypt, Nigeria, Ghana, and Kenya. All four countries have national regulations controlling the manufacture, importation and sale of ozone depleting substances as follows:

- In Egypt, there are various Regulations controlling the importation and sale of these substances including *Decree No. 770* that controls importation of ODSs and the Egyptian Regulations for Ozone Layer Protection, 2018 that provide guidelines on licensing requirements.
- In Nigeria, the *National Environmental (Ozone Layer Protection) Regulations, 2009* are currently under revision. The main changes to the regulation will involve: ODS destruction strategies and plans, incorporating obligations under the Kigali Amendment, requirements on technician training and certification and incorporating refrigerant standards. An environmental protection policy is currently under development at the regional (ECOWAS) level and the Nigerian government is waiting on this policy in order to align with that regional policy.
- In Ghana, the *L.I 1812 Management of Ozone Depleting Substances and Products Regulations, 2005* regulate ODSs.
- In Kenya the *Environmental Management and Co-Ordination (Controlled Substances) Regulations, 2007* limit the use of ODSs.

In all four countries, there are government agencies identified and charged with enforcing the regulations. In Egypt[94], Ghana and Nigeria, the regulations control the manufacture and importation of RACs containing ODSs such as R-22. However, the current Kenyan regulations are under review to incorporate a clause limiting the importation of RACs containing ODS refrigerants because currently, the regulations only limit the importation of the refrigerant not the equipment that use them. The Kenyan regulations are expected to

[94] Source: A representative of the Egyptian Environmental Affairs Agency

be revised in early 2021 to incorporate restrictions on HCFC-based cooling appliances with the intention to ban the importation of these appliances by 2021.[95]

In countries that manufacture RACs, local manufacturers require some support transitioning to more climate friendly refrigerants. In Egypt, the Environmental Affairs Agency is providing technical and financial support to local manufacturers to ensure the appliances produced comply with the regulations. For countries that are purely import markets, transitioning away from RACs using HCFCs is easier since alternatives are available in global markets. For example, the local Samsung subsidiary in Kenya no longer imports R-22 RACs citing the global transition away from R-22 RACs as the reason for the switch.[96]

#### *Challenges in* implementation *of national policies regulating ozone depleting substances*

While all four countries have regulations controlling the importation of HCFCs, there are challenges related to the implementation of these regulations, including:

- **Lack of awareness among stakeholders** – This was cited as a challenge by the enforcement agencies in Nigeria, Kenya and Egypt. This lack of awareness affects the agencies' ability to effectively phase out HCFCs and eventually HFCs. The e-waste recycler in Nigeria stated that by the time the secondhand cooling appliances get to their facilities, the refrigerants have already been released into the atmosphere. So, although the recycler has de-gassing equipment, there is rarely a need to use it.
- **Illegal shipment of restricted refrigerants** – This was cited as a challenge in Kenya. The refrigerants are imported illegally by mislabeling the containers or mis-declaration of the shipment.
- **Inadequate training and resources for enforcement personnel** – This was identified as a challenge in Nigeria and Kenya. The enforcement mechanisms for ODSs require the environmental agencies to coordinate with border control agencies. Border control personnel have limited resources to dedicate to enforcement of refrigerant regulations.
- **Lack of adequate resources for local manufacturers to transition away from R-22 RACs** – As detailed in the "*The case of R-22 RACs in Africa"* section, 81% of the R-22 units sold in the 10 focus countries are locally assembled. According to the on-the-ground survey conducted in Egypt, the main barriers for local manufacturers to transition away from R-22 are the lack of both financial resources and technical assistance to change production lines.[97]
- **Limited institutional capacity** – In Egypt and Kenya, the time lag between development and implementation of necessary regulation slows down the transition away from environmentally-harmful refrigerants.
- **Lack of dedicated HS codes for HFC refrigerants** – While R-22 has a dedicated HS code, the enforcement agencies in Egypt and Kenya identified the lack of dedicated HS codes for HFCs as a potential problem for when agencies start regulating HFCs as required by the Kigali Amendment.

## 5.4 Policy regulating hazardous waste in Africa

#### The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal

The Basel Convention is an international treaty that seeks to reduce hazardous waste generation and restrict the movements of hazardous waste between the countries. The treaty, entered into force in 1992, was a response to the discovery of toxic waste shipments in the 1980s from industrialized countries to East Europe, Africa, and other parts of the world where environmental regulations were not as stringent.[98] The Basel Convention covers a wide range of hazardous wastes, including ODSs[99] and electronic waste, as

[95] Source: National Ozone Office, Ministry of Environment and Forestry.
[96] Source: Samsung Kenya representative
[97] Source: A representative of the Industrial Modernization Center, Egypt.
[98] Basel Convention. (2019). "E-waste: Overview." http://www.basel.int/Implementation/Ewaste/Overview/tabid/4063/Default.aspx
[99] Basel convention only covers the ODS waste that i) possess a hazard characteristic listed in Annex III such as being flammable, explosive or toxic, and listed in Annex I or VIII; ii) ODS containing other materials at levels that exhibit one of the hazardous

well as two types of other wastes, namely household waste and incinerator ash. Radioactive waste is excluded from the treaty. As of September 2019, there are 187 parties to the Convention. All ten countries in this study (**Table 9**) have either ratified or acceded to the Basel Convention.

The Basel Convention aims to minimize the movement of hazardous waste. The Parties must not export hazardous waste and other wastes, if they have sufficient disposal and recycling facilities in their countries, except when the wastes are needed as raw materials for recycling or recovery industries in the importing countries. If a country exports hazardous waste, it must notify the countries of import and transit before the shipment takes place. Only after all concerned countries have given their written permission can the shipment proceed. In addition, parties to the Convention are not allowed to ship hazardous waste and other wastes to non-parties, unless there are environmentally sound agreements on hazardous waste management between these countries.

In 2002, the Basel convention started to address issues associated with e-waste, which usually contains hazardous elements. The efforts have focused around environmentally sound management, preventing illegal imports to developing countries, and capacity building.[100] Secondhand equipment that is destined for re-use often falls outside the scope of Basel Convention, and statistics on imports and exports of used electronic equipment is hard to come by.[101] There is an ongoing discussion among the Convention Parties on whether the equipment destined for re-use may be considered as a waste.

Notably, the Ban Amendment to the Basel Convention came into effect on December 5, 2019. The Amendment prohibits the export of hazardous waste from Liechtenstein, EU, and OECD countries for any reason to any other countries.[102]

### The Bamako Convention on the Ban on the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa

Unlike the international treaties above, the Bamako Convention is a regional treaty among African nations aimed to ban the import of hazardous waste into the continent.[103] This treaty addresses the weakness of the Basel Convention, which still permits the transboundary movement of hazardous waste for recycling and recovery. The Bamako Convention prohibits the import of all hazardous and radioactive wastes into Africa for any reason, minimizes and controls the movement of these wastes within the continent, and prohibits ocean, inland water dumping, and incineration of these wastes. The convention entered into force in 1998 and currently has 25 parties. Four out of the 10 focus countries have ratified the Bamako Convention.

*Table 9: International and regional policies regulating hazardous waste*

| Country | Basel Convention | Bamako Convention |
|---|---|---|
| Algeria | Acceded to 15 Sep 1998 | Not yet ratified |
| Egypt | Ratified 8 Jan 1993 | Ratified 18 May 2005 |
| Ethiopia | Acceded to 12 Apr 2000 | Ratified 24 July 2003 |
| Ghana | Acceded to 30 May 2003 | Not yet ratified |
| Kenya | Acceded to 1 Jun 2000 | Not yet ratified |
| Morocco | Acceded to 28 Dec 1995 | Not yet ratified |
| Nigeria | Ratified 13 Mar 1991 | Not yet ratified |

characteristics listed in Annex III; iii) in the cases when Convention Party is considering the ODS under domestic legislation as hazardous waste and has officially notified the Secretariat of it, and is also involved in the import, export or transit of the waste.

[100] Basel Convention. (2019). "E-waste: Overview." http://www.basel.int/Implementation/Ewaste/Overview/tabid/4063/Default.aspx

[101] Baldé, C.P., Forti V., Gray, V., Kuehr, R., Stegmann,P. (2017). *The Global E-waste Monitor – 2017*, United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna. https://www.itu.int/dms_pub/itu-d/opb/gen/D-GEN-E_WASTE.01-2017-PDF-E.pdf

[102] Basel Convention. (2019). "Entry into force of amendment to UN treaty boosts efforts to prevent waste dumping." http://www.basel.int/Implementation/PublicAwareness/PressReleases/BanAmendmententryintoforce/tabid/8120/Default.aspx

[103] UN Environment. "The Bamako Convention." https://www.unenvironment.org/explore-topics/environmental-rights-and-governance/what-we-do/meeting-international-environmental

| Country | Basel Convention | Bamako Convention |
|---|---|---|
| South Africa | Acceded to 5 May 1994 | Not yet ratified |
| Tanzania | Acceded to 7 Apr 1993 | Ratified 15 Feb 1993 |
| Tunisia | Acceded to 11 Oct 1995 | Ratified 6 April 1992 |

## 5.5 National policies and regulations controlling the secondhand RAC market

The information on secondhand market for appliances for this study was collected through desk review and on-the-ground surveys in Nigeria, Ghana, Egypt and Kenya.

Secondhand, or "used," appliances found in African countries are either imported from larger appliance markets or generated internally from households or businesses replacing old appliances. The information on national policies regulating the importation and sale of secondhand appliances was collected from on-the ground surveys in Egypt, Ghana, Nigeria and Kenya.

### Secondhand RACs in Egypt

In Egypt, the *Decree No. 770* passed in 2005 controls the importation of secondhand equipment. This regulation does not prohibit the importation of secondhand RACs. However, RACs containing ozone-depleting refrigerants are prohibited and those that do not contain ODSs are subject to inspection.[104] Additionally, Egypt does not have regulations restricting or controlling the importation, generation and treatment of electronic waste.[105]

Egypt claims to not have a secondhand RAC market.[106]

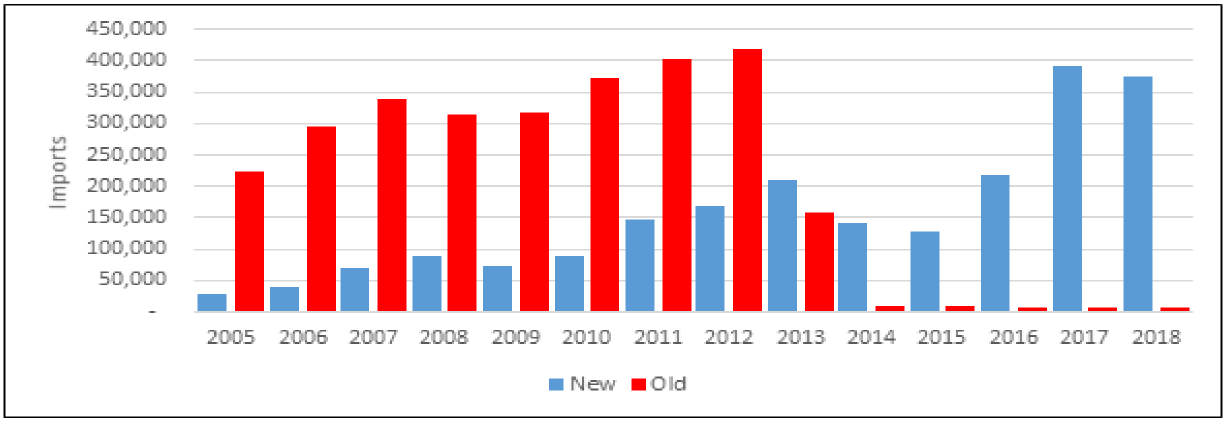
### Secondhand RACs in Ghana

In 2008, Ghana passed a regulation, *L I 1932: Prohibition of Manufacture, Sale or Importation of Incandescent Filament Lamp, Used Refrigerator, Used Refrigerator/Freezer, Used Freezer and Used Air conditioner) Regulations, 2008,* to ban the importation of secondhand RACs and refrigerators. The government of Ghana decided to ban secondhand appliances to limit the importation of appliances containing harmful substances such as CFCs and HCFCs. At the time, the majority of secondhand RACs sold were imported mostly from the Felixstowe port in the United Kingdom.[107] The enforcement of this regulation began in 2013. Previously, the secondhand appliances imported could be up to 10 years old and would contain these substances that the government was phasing out due to environmental concerns. Additionally, the ban was to help safeguard the energy efficiency strides made as a result of the implementation of energy efficiency policies such as the MEPS for RACs and refrigerators. At the request of industry, the implementation of the ban was delayed until 2013. Once the ban was in effect, the Ghana Energy Commission worked with the border control agency to implement the regulation.

The ban has been effective in limiting the number of secondhand cooling appliances imported into Ghana. Since the ban came into effect, the government of Ghana has seized 38,933 secondhand refrigerators and 9,767 secondhand air conditioners. **Figure 15** below shows the impact the ban has had on the ratio of new versus secondhand refrigerators imported into Ghana with a significant drop in importation of secondhand refrigerators. Before the ban was implemented, there were over 400,000 secondhand refrigerators imported into Ghana, in 2014, this number was just 9,500.[108] Based on the growth of the secondhand refrigerator imports, without the ban, the imports would have increased to approximately 560,000 units annually. The Ghana Energy Commission estimates that this ban has resulted in energy savings of 3,624 GWh.

[104] Source: Representative of the Egypt Ministry of Environment
[105] Ibid
[106] Sources: Representatives from the Cairo Chamber of Commerce and Ministry of Environment
[107] Source: Ghana Energy Commission
[108] This is the number of used refrigerators confiscated by the customs authorities and the Ghana Energy Commission.

*Figure 15: Number of new versus secondhand refrigerators imported into Ghana*[109]




### Secondhand RACs in Nigeria

In Nigeria, the *S.I. No 23 National Environmental (Electrical/Electronic sector) Regulation, 2010* controls the importation of secondhand electrical and electronic equipment. The regulation requires that importers register with the National Environmental Standards and Regulations Enforcement Agency (NESREA). The government of Nigeria has banned the importation of waste electrical and electronic equipment and equipment that is near its end-of-life. The *Guide for Importers of Used Electrical and Electronic Equipment into Nigeria* provides instructions on the required functionality and appearance of imported secondhand equipment.[110] The guidelines state that imported waste equipment is sent back to the port of origin. Proof of testing and/inspection is required for each secondhand appliance meant for import into Nigeria. The Guide indicates that import of refrigerators and RACs containing ozone depleting refrigerants is prohibited.

In Nigeria, the secondhand market is made up of units imported from countries in Europe and Asia. A 2015 study found that these units were imported from China (including Hong Kong), Japan, Singapore, South Korea, Italy and Germany. CLASP's on-the-ground survey also identified Germany as a source country for secondhand RACs, but also the United Kingdom and China.[111] According to the survey, the units imported from China are not just secondhand units but also units that have defects originating in the manufacturing process.[112] These secondhand and defective units are usually refurbished by the dealers. Most of the units imported have damaged compressors and relays that must be replaced.

An interview with an e-waste recycler, Hinckley Recycling, based in Nigeria identified manufacturers as the main source of cooling appliances they recycle. They recycle at least 200 refrigerators and 50 air conditioners each month. HPZ, the manufacturer of the Haier Thermocool brand, is a major source of the cooling appliances that Hinckley has recycled in the past.

### Secondhand RACs in Kenya

In Kenya, the draft *Environmental Management and Co-Ordination (E-Waste Management) Regulations were developed in 2013 but have not yet been adopted.* These draft regulations propose to control the importation waste electrical and electronic waste. Therefore, currently the importation of secondhand RACs is not restricted. However, since the implementation of the standards and labelling program began in 2018, the importation of these products has reduced significantly.[113] This is because the S&L program requires that all RACs imported into the Kenyan market need to submit a test report to the Energy and Petroleum Regulatory Authority before importation. This testing requirement increases the cost of secondhand RACs eliminating the price advantages this equipment would enjoy when compared to the price of new RACs.

[109] Ghana Energy Commission
[110] A copy of the Guide can be accessed here: https://www.env.go.jp/recycle/yugai/reg/nigeria_20130419_2.pdf
[111] Source: A representative of the Electrical Dealers Association of Nigeria
[112] These are units that do not pass the manufacturer's quality and performance checks
[113] Source: Energy and Petroleum Regulatory Authority

Kenya RAC market is significantly smaller than the Nigerian and Ghana markets, therefore importation of secondhand RACs is rare. However, secondhand refrigerators are imported, mostly from the United Kingdom.[114] These refrigerators are imported in consignments with other secondhand equipment

#### *Challenges in* implementing *policies regulating the importation and sale of secondhand RACs*

Among the four countries surveyed, only 2 have regulations specific to the importation and sale of secondhand equipment, Ghana and Nigeria. The challenges identified in enforcing the regulations include:

- **Political implications of an outright product ban** – In Ghana, the implementation of the secondhand appliances ban was delayed due to the political implications of the ban i.e. banning products means closure of some businesses or business lines. This is a consideration in many African countries where the SME sector is a major employer.
- **Limited resources for customs officials** – Since the regulations aim to control the importation of secondhand and waste equipment, customs officials are important stakeholders in the enforcement of these regulations. With limited resources, mis-identified equipment can go undetected at the border points. In Ghana, the Ghana Energy Commission is very active at the border points and recently stopped the importation of a shipment of secondhand refrigerators at the Felixstowe port in the UK[115]. However, there are still a few secondhand refrigerators that still make it into the market. Market surveillance would be required to better enforce these regulations.

[114] Source: Interviews with secondhand refrigerator dealers
[115] Source: Ghana Energy Commission

# 6. Status and Impact of Low Efficiency, High GWP RACs in North Africa

CLASP and our partners collected data and analyzed the RAC markets of four major economies in North Africa: Algeria, Egypt, Morocco and Tunisia. Three of the four countries are members of the Arab Maghreb Union (AMU), an economic agreement between five Arab states in North Africa, including: Algeria, Libya, Mauritania[116], Morocco, Tunisia.

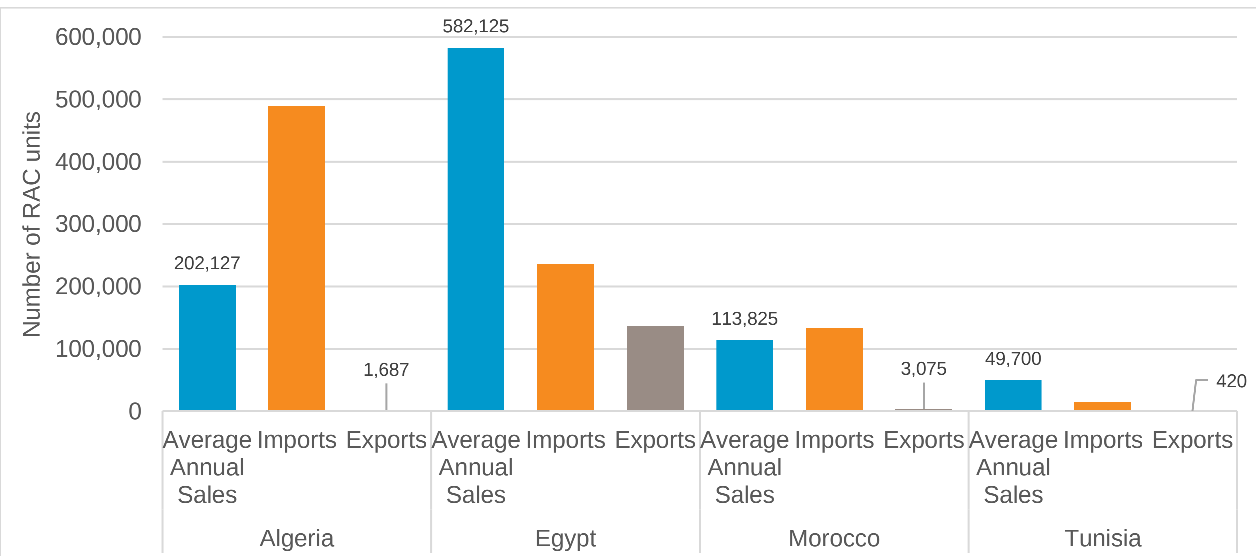
While the success of the AMU in facilitating economic unity between these five countries has been debated, there does appear to be a significant amount of trade in RACs and RAC components between AMU members and other North African countries, namely Egypt.

## 6.1 North Africa Market Characteristics and Trade Flows

Egypt has the largest RAC market among the four countries analyzed in the North African region with Tunisia being the smallest. Algeria, Egypt and Tunisia incentivize local RAC assembly, and this is reflected in the portion of the units sold in 2018 that were locally assembled – 87% in Algeria, 92% in Egypt and 55% in Tunisia, respectively.

The Morocco RAC market is import-only. In Morocco, units from China have the largest market share but intra-regional trade is indicated by the portion of RACs sold that come from Egypt – 20%.[117] Comparing the 2017 country sales to Comtrade imports data indicates that Algeria and Morocco import many more RAC units than are sold domestically (**Figure 16**). This may indicate importation of RACs for re-export to other countries but data on re-exports is sparse.

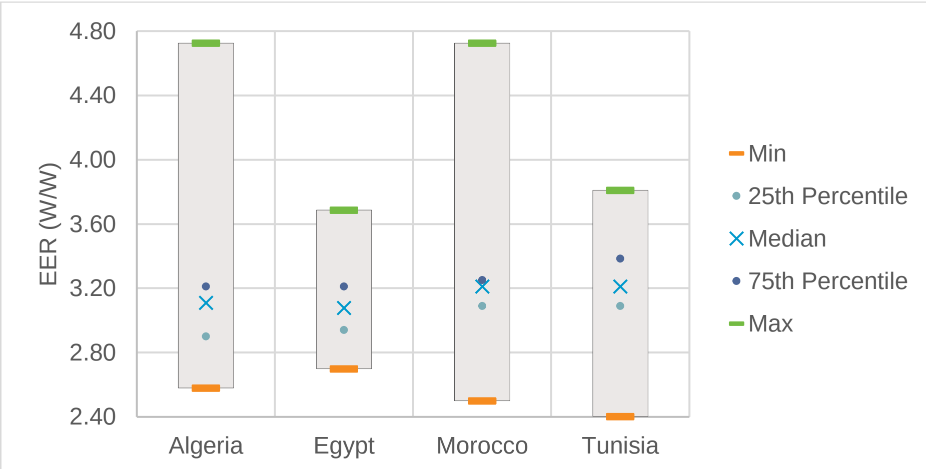
*Figure 16: Comparison of RAC sales and trade in Algeria, Egypt, Morocco and Tunisia (2017)*




The efficiency levels of units sold in the four countries vary, but in all four most units have efficiency levels of between 3.0 – 3.5 W/W. However, all the countries have a portion of the market with lower efficiency levels of between 2.5 – 3.0 W/W. The portion of these lower efficiency units varies from 9% in Morocco to 31% in Egypt.

[116] Per UN regional categorizations, Mauritania is included in West Africa for modeling purposes.
[117] However, this is not reflected in the Comtrade export data from Egypt which shows only a few units exported to Morocco in 2017.

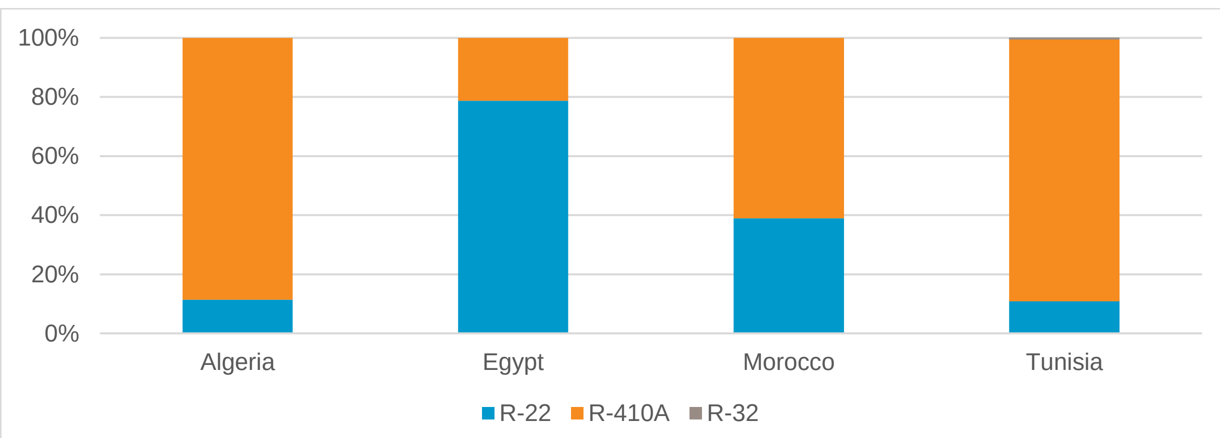
*Figure 17: Range of RAC efficiencies in North Africa by country*




Since most of the units in the Algerian, Egyptian and Tunisian markets are locally assembled, these low efficiency units are mostly locally assembled. The compressors that are most likely used to assemble these low efficiency units are imported primarily from China with some coming from Thailand, India, Spain, France, Italy among other countries. In Morocco, the lowest efficiency units are mostly imported from China.

In the Algeria, Morocco and Tunisia's RAC markets, units containing R-410A make up the largest share of the market. However, in Egypt, units that use R-22, a HCFC, make up 79% of the market (**Figure 18**).

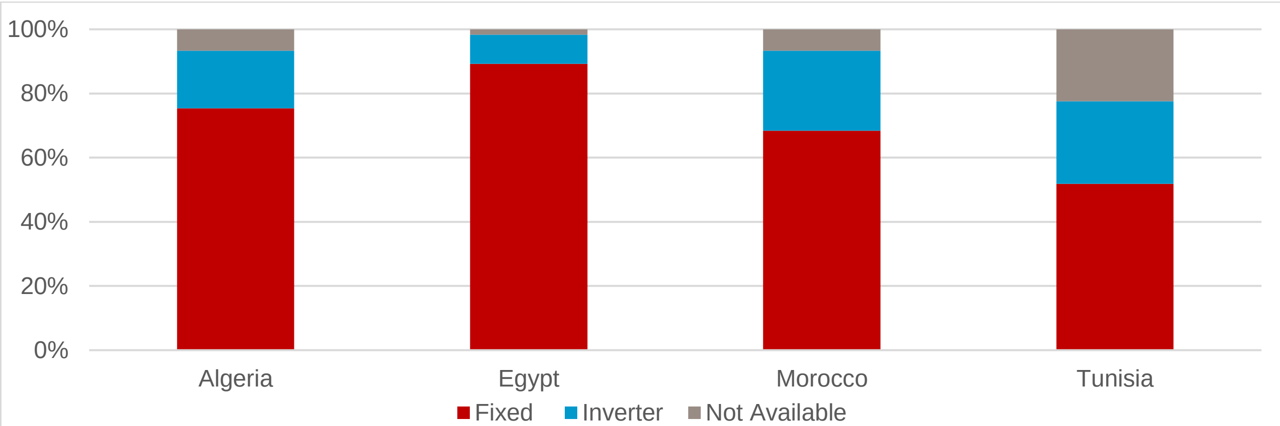
*Figure 18: RAC Refrigerants in Algeria, Egypt, Morocco and Tunisia*




While R-22 units are mostly locally assembled in Algeria, Egypt and Tunisia, some of these units are imported from the US to Algeria and Tunisia. In Morocco, the R-22 units are imported mainly from China and Egypt. In Algeria, Egypt and Tunisia, Comtrade data shows that most of the R-22 refrigerant is imported from China. However, some of the refrigerant is imported from India, Germany and the UK.

Out of the four countries analyzed in the region, Tunisia has the lowest market share for fixed speed RACs at 52% while Egypt has the highest at 89% (**Figure 19**). When efficiency levels are analyzed according to RAC compressor types, more than 80% of the lowest efficiency units in each of the four countries are fixed speed RACs.

*Figure 19: Compressor types in RACs in Algeria, Egypt, Morocco and Tunisia*




## 6.2 Modeling the Impact of Low Efficiency, High GWP RACs in North Africa

To examine the impacts of the proliferation of low efficiency, high GWP RACs in North Africa, CLASP modeled a market transition to higher efficiency RACs with lower GWP refrigerants, CLASP developed three policy scenarios for RACs in North Africa and estimated the direct[118] and indirect[119] GHG emissions impact under each scenario:

- **Base Case (No Efficiency Policy + Unregulated Refrigerant Market):** This business-as-usual scenario assumes that the RAC market continues to grow at a constant compound annual growth rate annually through 2030, and that the current market share of R-22, R-410A, and R-32 RACs gradually changes in accordance with Montreal Protocol (MP) phase-out schedules for R-22 and phase-down schedules for R-410A. No additional energy efficiency or refrigerant policies are assumed in this scenario.
- **Policy Scenario 1 (U4E MEPS + Unregulated Refrigerant Market)**: A scenario in which the countries in the region adopt RAC energy efficiency standards equivalent to the U4E Model MEPS[120] in 2022. There are no low-GWP requirements for the RAC refrigerants in this scenario.
- **Policy Scenario 2 (U4E MEPS + U4E Refrigerant Regulation):** A scenario in which the countries in the region adopt RAC energy efficiency standards equivalent to the U4E Model MEPS in 2022 and require the use of refrigerants with GWP ≤ 750 in 2022. For the purpose of modeling, this scenario assumes that all RACs on the market from 2022 onwards use R-32 refrigerant, which has a GWP of 675.
- **Policy Scenario 3 (U4E MEPS + BAT Refrigerant Policy)**: A scenario in which the countries in the region adopt RAC energy efficiency standards equivalent to the U4E Model MEPS in 2022 and require the use of best-available-technology (BAT) refrigerants with GWP < 150 in 2022. For the purpose of modeling, this scenario assumes that all RACs on the market from 2022 onwards use R-290 refrigerant. Recent research estimates the R-290 has a GWP of <1;[121] however, without a more specific value and to keep estimated impacts conservative, CLASP assumes a 100-yr GWP of 1 for the R-290 refrigerant in this scenario.

[118] Direct emissions refers to the emissions from RAC refrigerant leaks and the disposal of the RAC refrigerants at the end-of-life.
[119] Indirect emissions refers to the emissions from the operation (use) of RACs (i.e. the emissions calculated based on the energy consumption of the RACs).
[120] See **Table 1** in Methodology.
[121] See Appendix A in WMO (World Meteorological Organization), Scientific Assessment of Ozone Depletion: 2018, Global Ozone Research and Monitoring Project – Report No. 58, 588 pp., Geneva, Switzerland, 2018. https://www.esrl.noaa.gov/csd/assessments/ozone/2018/

To approximate the direct and indirect emissions from RACs in North Africa under each scenario CLASP identified cooling capacity and efficiency levels for two baseline RAC models identified through analysis of market data collected by BSRIA. The parameters of these baseline models, as well as the refrigerant distributions in the market, are summarized below.

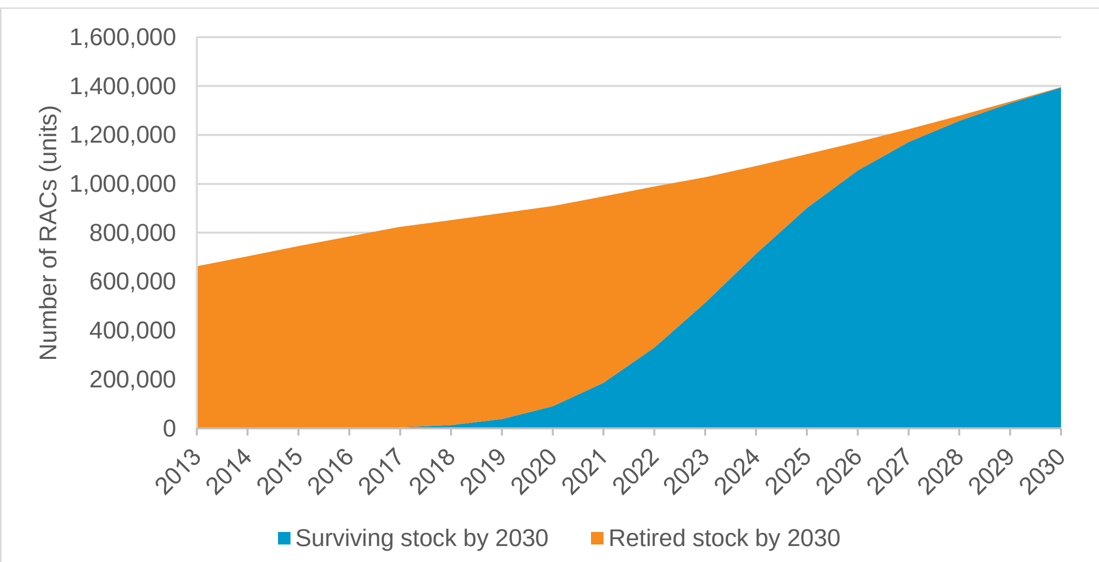
*Table 10: Baseline models selected for analysis (North Africa)*

| RAC Market Segment | Market Share | Cooling Capacity | Energy Efficiency Ratio (EER) | Average MSP | Refrigerant Share | | |
|---|---|---|---|---|---|---|---|
| | | | | | R-22 | R-410A | R-32 |
| CC ≤ 4.5 kW | 50% | 3.51 kW | 3.21 W/W | 347 USD | 51% | 49% | 0% |
| CC > 4.5 kW | 50% | 5 kW | 3.00 W/W | 616 USD | 57% | 43% | 0% |

For the three policy options, CLASP analyzed energy savings and GHG emissions reductions from the base case by forecasting energy use of RACs sold from 2013 to 2030. We assume that every unit sold in a specific year has an EER equal to one of two baseline EERs in **Table 10**. CLASP used Euromonitor's 2004-2018 split RAC sales estimates and 2019-2023 projections to approximate a the regional RAC sales volume across six North African countries, as defined by the UN,[122] between 2010 and 2023. Euromonitor's 2019-2023 projections averaged a **4.5% compound annual growth rate (CAGR)** at the regional level. This CAGR of 4.5% was used to forecast regional sales for 2024-2030.

In estimating both the indirect and direct emissions from RACs, CLASP accounts for the retirement of a portion of the RAC stock using a survival function based on a normal distribution of the median life of RACs in Africa (7 years).[123] **Figure 20** shows the sales forecast per year, the portion of the stock (from those annual sales) that survives in 2030 and the portion that has been retired.[124]

*Figure 20: Surviving and retired RAC stock in North Africa (2013-2030)*




[122] The United Nations includes the following sixteen countries (for which Euromonitor data was available) in the Northern Africa subregion: Algeria, Egypt, Libya, Morocco, Sudan, and Tunisia.
[123] Average RAC operating lifetime estimates were available. CLASP assumed an average lifetime of 7 years based on survey findings from Nigeria and the findings of an in-depth RAC market assessment recently conducted in Kenya. CLASP. 2019. Kenya RAC Market Assessment and Policy Options Analysis.[https://clasp.ngo/publications/kenya-rac-market-assessment-and-policy-options-analysis-2019](https://clasp.ngo/publications/kenya-rac-market-assessment-and-policy-options-analysis-2019)
[124] Surviving stock in 2030 refers to the number of units purchased in a year X that are still operating in 2030. Retired stock refers to the units that are no longer operating due to failure.

## Indirect Emissions

CLASP used the Policy Analysis Modeling System (PAMS) to estimate indirect greenhouse gas emissions from the operation of RAC equipment in North Africa. In the model, total energy consumption is estimated per year for the stock of RACs in use under each policy scenario. Emissions are estimated using the estimated surviving RAC stock for each segment of the market, annual unit energy consumption (UEC) of the baseline RAC models,[125] an electricity grid $CO_2$-intensity emissions factor, and the transmission and distribution (T&D) loss factor. The estimates used for North Africa are:

- Grid Emissions Factor is assumed to be **0.715 kg/kWh**.[126]
- T&D Loss Factor is assumed to be **14.9%**.[127]
- Annual operating hours is assumed to be **771 hours**.[128]
- Unit energy consumption was calculated based on the baseline values in **Table 10** using the formula:

$$UEC = \frac{Cooling\ Capacity}{EER \times 1000} \times Annual\ operating\ hours$$

The results of CLASP's analysis of indirect emissions associated with RAC usage in North Africa are presented in **Table 11**.

*Table 11: Indirect GHG emissions in North Africa*

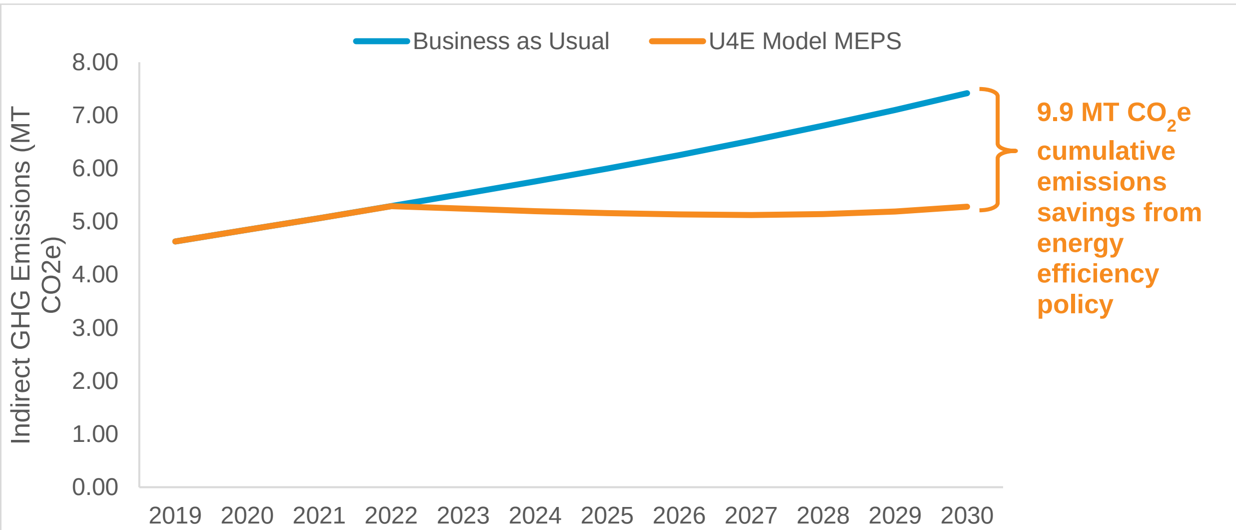
| | Scenario | | | |
|---|---|---|---|---|
| | Base Case (No Policy + Unregulated Ref. Market) | Policy Scenario 1 (U4E MEPS + Unregulated Ref. Market) | Policy Scenario 2 (U4E MEPS + U4E Ref. Regulation) | Policy Scenario 3 (U4E MEPS + BAT Ref. Regulation) |
| **Annual in 2030** | | | | |
| Energy Consumption (GWh) | 8.82 | 6.28 | 6.28 | 6.28 |
| Emissions (MT $CO_2e$) | 7.42 | 5.28 | 5.28 | 5.28 |
| Savings (MT $CO_2e$) | - | 2.14 | 2.14 | 2.14 |
| % of Base Case Emissions | - | 28.8% | 28.8% | 28.8% |
| **Cumulative 2020 – 2030** | | | | |
| Energy Consumption (GWh) | 79.2 | 67.4 | 67.4 | 67.4 |
| Emissions (MT $CO_2e$) | 66.6 | 56.7 | 56.7 | 56.7 |
| Savings (MT $CO_2e$) | - | 9.91 | 9.91 | 9.91 |
| % of Base Case Emissions | - | 14.9% | 14.9% | 14.9% |

[125] UEC refers to the amount of energy, measured in kWh, consumed annually by a given RAC model.
[126] Weighted average grid emissions factor for Northern Africa, weighted according to split RAC sales volume. Grid emissions factors were calculated using average $CO_2$ emissions factors from across Annex 1 countries and data on electricity generation from the following World Bank sources: World Bank. 2014. Electric power transmission and distribution losses (% of output), Electricity production from coal sources (% of total), Electricity production from oil sources (% of total), Electricity production from natural gas sources (% of total), Electricity production from nuclear sources (% of total), Electricity production from renewable sources, excluding hydroelectric (% of total), Electricity production from hydroelectric sources (% of total). Available at: https://data.worldbank.org/
[127] Weighted average T&D loss factor, weighted according to split RAC sales volumes. World Bank. 2014. Electric power transmission and distribution losses (% of output) available at: https://data.worldbank.org/
[128] Weighted average annual operating hours for RACs in Northern Africa, weighted according to split RAC sales volume. Operating time was estimated based on the product of cooling degree days reported in each country and air conditioner percent operating days.

Under a business-as-usual scenario, in which no changes are made to the MEPS for RACs in the six North African countries, CLASP projects that in 2030 RAC usage will require approximately **8.8 GWh of electricity** and indirectly generate **7.4 MT $CO_2e$** of greenhouse gas emissions.

However, if in 2022 the North African countries were to align their MEPS for RACs with the U4E Model MEPS, as per Policy Scenario 1, annual indirect emissions could be reduced by approximately 29% in 2030, saving **2.1 MT $CO_2e$**. In the eight-year period from 2022-2030, the implementation of these stronger MEPS could allow for a cumulative reduction of 9.9 MT $CO_2e$.

*Figure 21: Indirect GHG Emissions in North Africa (2019-2030)*




## Direct Emissions

To analyze the climate benefits of introducing a requirement for the use of refrigerants with lower GWP, emissions of greenhouse gases from the refrigerants needs to be considered.

CLASP estimated the global warming potential of the baseline RAC models in North Africa using the *GWPdirect* formula described below.

$$GWPdirect = GWP \times m \times L_{annual} \times n + GWP \times m \times (1 - \alpha_{recovery})$$

GWP = Global Warming Potential of the refrigerant
m = refrigerant charge
$L_{annual}$ = leakage rate per annum
n = operating life
$\alpha_{recovery}$ = recycling factor from 0 to 1

The leakage rate (**10%**), operating life (**7 years**), and recycling factor (**0**) are held constant throughout the model and are identical to those used in the analyses conducted for the other three regions.[129]

The typical refrigerant charges[130] for the North African baseline RAC models identified in **Table 10** are shown in **Table 12** alongside the GWP values for current and alternative refrigerants.[131]

[129] See **Table 2** in the Methodology section for further detail on these inputs were chosen for this report.
[130] BSRIA did not collect charge information in the RAC market data collected. For R-22, R-410A, and R-32 refrigerant charges, approximate average charges were estimated based on RAC market data collected by CLASP in 2018 for the Vietnamese and Thai markets. Because CLASP did not find R-290 RACs in the African market, approximate average charges for R-290 RACs were obtained from the India Bureau of Energy Efficiency database.
[131] IPCC Fourth Assessment Report: Climate Change 2007 (AR4).

*Table 12: Refrigerant charges and GWP values for North Africa baseline models*

| Market segment & Baseline Cooling Capacity | R-22 | | R-410A | | R-32 | | R-290 | |
|---|---|---|---|---|---|---|---|---|
| | Average Charge (kg) | GWP ($CO_2e$) | Average Charge (kg) | GWP ($CO_2e$) | Average Charge (kg) | GWP ($CO_2e$) | Average Charge[132] (kg) | GWP[133] ($CO_2e$) |
| CC ≥ 4.5 kW (3.51 kW model) | 0.85 | 1810 | 0.77 | 2088 | 0.71 | 675 | 0.30 | 1 |
| CC > 4.5kW (5 kW model) | 1.19 | | 0.99 | | 0.92 | | 0.33 | |

Using the retired stock of RACs from 2020 – 2030, and the corresponding *GWPdirect*, we estimated the cumulative value of greenhouse gas emissions by 2030 from their refrigerants charge as:

$$Cumulative\ GHG_{2030} = \sum_{y=2020}^{2030} Retired\ stock\ in\ 2030\ (y) \times GWPdirect\ (y)$$

Per **Table 10**, the market share of RACs with cooling capacities under 4.5 kW is 50%. Approximately 51% of these RACs use R-22 and approximately 49% of these RACs use R-410A. For the remaining 50% of RACs with cooling capacities above 4.5 kW, approximately 57% use R-22 and 43% use R-410A. CLASP used these values to develop a methodology for weighting the retired stock of RACs for each market segment.

For the policy scenarios (Base Case and Policy Scenario 1) for which there is no requirement to transition to lower GWP refrigerants, we assessed direct emissions for each RAC market segment under analysis (CC < 4.5 kW as represented by the 3.51 kW baseline and CC ≥ 4.5 kW as represented by the 5 kW baseline model). Direct emissions were calculated according to the share of R-22, R-410A, and R-32 RACs found within each market segment, as per the data from BSRIA, using the corresponding GWP values. For the period 2019-2030, CLASP assumed the following changes to the market share of refrigerants in accordance with Montreal Protocol phase-out and phase-down schedules for R-22 and R-410A:

- R-22 RACs are phased out completely by 2030, in conjunction with the R-22 production ceasing in the China and India. CLASP assumes a constant rate of decrease in R-22 market share in this unregulated refrigerant market scenario. The decrease in R-22 share is accounted for primarily by an increase to R-410A share.
- Beginning in 2022, R-32 share increases by 1%. CLASP has observed in other markets (e.g. the Philippines)[134] that without ambitious refrigerant or efficiency policies, R-32 enters developing AC markets slowly.

[132] Because CLASP did not find R-290 RACs in the African market, approximate average charges were obtained from the India Bureau of Energy Efficiency database.
[133] The GWP of R-290 is estimated to be <1. To model an R-290 transition in a conservative manner, CLASP assumed a GWP equal to 1 for R-290.
[134] Based on prior research conducted by CLASP, between 2015 and 2018 the market penetration of R-32 RACs grew from 0% to 7.8%. By comparison, the market for R-410A RACs grew from 0% to 32% over the same period. CLASP. 2019. *Philippines Room Air Conditioner Market Assessment and Policy Options Analysis.* https://clasp.ngo/publications/philippines-rac-market-assessment-and-policy-options-analysis-2019

*Table 13: North Africa Base Case RAC refrigerant share assumptions*

| | 3.51 kW Baseline Model | | | 5 kW Baseline Model | | |
|---|---|---|---|---|---|---|
| Year | R-22 Share | R-410A Share | R-32 Share | R-22 Share | R-410A Share | R-32 Share |
| **2019** | **51.1%** | **48.9%** | **0.0%** | **57.2%** | **42.8%** | **0.0%** |
| **2020** | 46.4% | 53.6% | 0.0% | 52.0% | 48.0% | 0.0% |
| **2021** | 41.8% | 58.2% | 0.0% | 46.8% | 53.2% | 0.0% |
| **2022** | **37.1%** | **61.9%** | **1.0%** | **41.6%** | **57.4%** | **1.0%** |
| **2023** | 32.5% | 65.5% | 2.0% | 36.4% | 61.6% | 2.0% |
| **2024** | 27.9% | 69.1% | 3.0% | 31.2% | 65.8% | 3.0% |
| **2025** | 23.2% | 72.8% | 4.0% | 26.0% | 70.0% | 4.0% |
| **2026** | 18.6% | 76.4% | 5.0% | 20.8% | 74.2% | 5.0% |
| **2027** | 13.9% | 80.1% | 6.0% | 15.6% | 78.4% | 6.0% |
| **2028** | 9.3% | 83.7% | 7.0% | 10.4% | 82.6% | 7.0% |
| **2029** | 4.6% | 87.4% | 8.0% | 5.2% | 86.8% | 8.0% |
| **2030** | **0.0%** | **91.0%** | **9.0%** | **0.0%** | **91.0%** | **9.0%** |

For Policy Scenario 2, all RACs sold in and after 2022 are assumed to use R-32. Therefore, CLASP follows the weighting methodology described above through 2021, and then assumes the R-32 GWP of 675 from 2022-2030.

For Policy Scenario 3, all RACs sold in and after 2022 are assumed to use R-290. Therefore, CLASP follows the weighting methodology described above through 2021, and then assumes the R-290 GWP of 1 from 2022-2030.

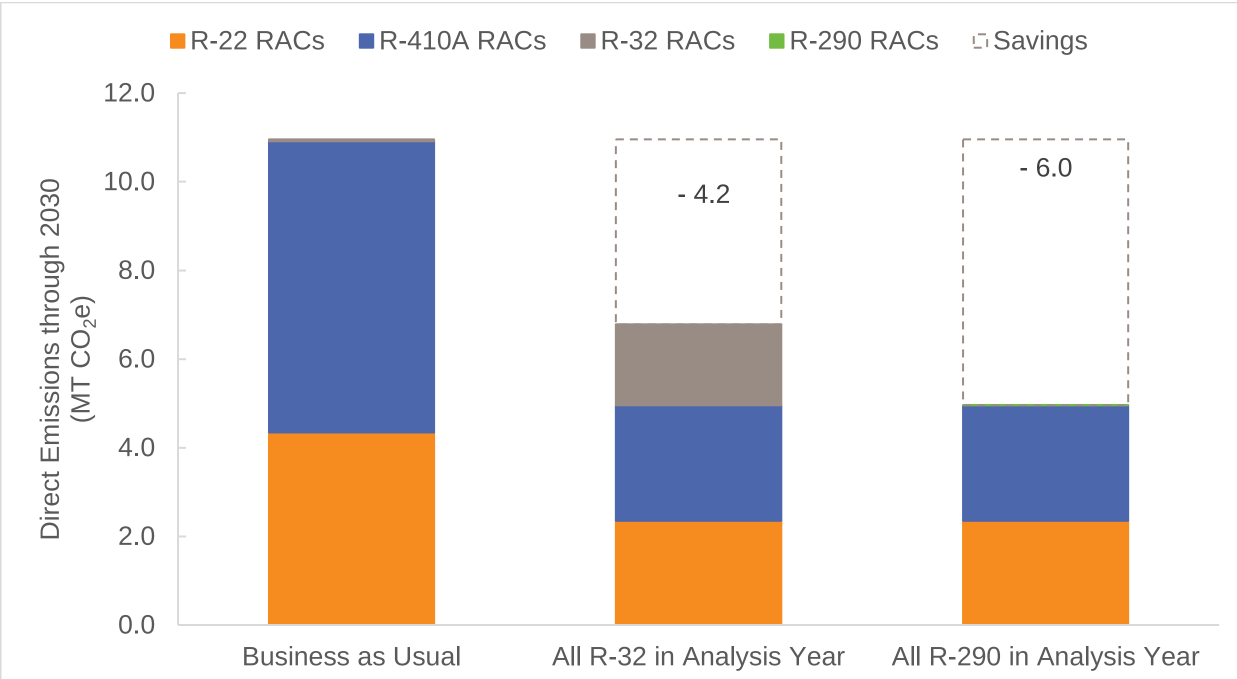
Results from the direct emissions analysis above are presented in **Table 14**.

*Table 14: Cumulative direct GHG emissions from retired RACs in North Africa in 2020-2030*

| Source | Direct Emissions by Scenario (MT $CO_2e$) | | | |
|---|---|---|---|---|
| | **Base Case** (No Efficiency Policy + Unregulated Ref. Market) | **Policy Scenario 1** (U4E MEPS + Unregulated Ref. Market) | **Policy Scenario 2** (U4E MEPS + U4E Ref. Regulation) | **Policy Scenario 3** (U4E MEPS + BAT Ref. Regulation) |
| R-22 RACs | 4.35 | 4.35 | 2.35 | 2.35 |
| R-410A RACs | 6.57 | 6.57 | 2.61 | 2.61 |
| R-32 RACs | 0.04 | 0.04 | 1.83 | 0.00 |
| R-290 RACs | 0.00 | 0.00 | 0.00 | 0.00 |
| **Total** | **11.0** | **11.0** | **6.8** | **5.0** |
| Savings | - | - | 4.2 | 6.0 |
| % of BAU Emissions | - | - | 38.1% | 54.7% |

**Figure 22** illustrates the potential savings from emissions savings from refrigerant policy in North Africa and demonstrates that transitioning both R-22 and R-410A RACs to lower GWP refrigerant types would reduce direct emissions substantially.

*Figure 22: Cumulative direct GHG emissions from retired RACs in North Africa 2020-2030*




### Total Equivalent Warming Impact

By adding together the indirect and direct emissions estimates we calculated, CLASP approximated the Total Equivalent Warming Impact of RACs in Southern Africa. The results of the full analysis are summarized in **Table 15**.

*Table 15: Total 2020-2030 GHG emissions from RACs in North Africa under four scenarios*

| Source | Cumulative Indirect & Direct Emissions 2020-2030 (MT $CO_2$e) | | | |
|---|---|---|---|---|
| | **Base Case** (No Efficiency Policy + Unregulated Ref. Market) | **Policy Scenario 1** (U4E MEPS + Unregulated Ref. Market) | **Policy Scenario 2** (U4E MEPS + U4E Ref. Regulation) | **Policy Scenario 3** (U4E MEPS + BAT Ref. Regulation) |
| Indirect emissions | 66.6 | 56.7 | 56.7 | 56.7 |
| Direct Emissions | 11.0 | 11.0 | 6.80 | 5.00 |
| **Total** | **77.6** | **67.7** | **63.5** | **61.7** |
| Savings | - | 9.9 | 14.1 | 15.9 |
| % of BAU Emissions | - | 12.8% | 18.2% | 20.5% |

*Figure 23: Cumulative 2020-2030 GHG emissions from RACs in North Africa under four scenarios*

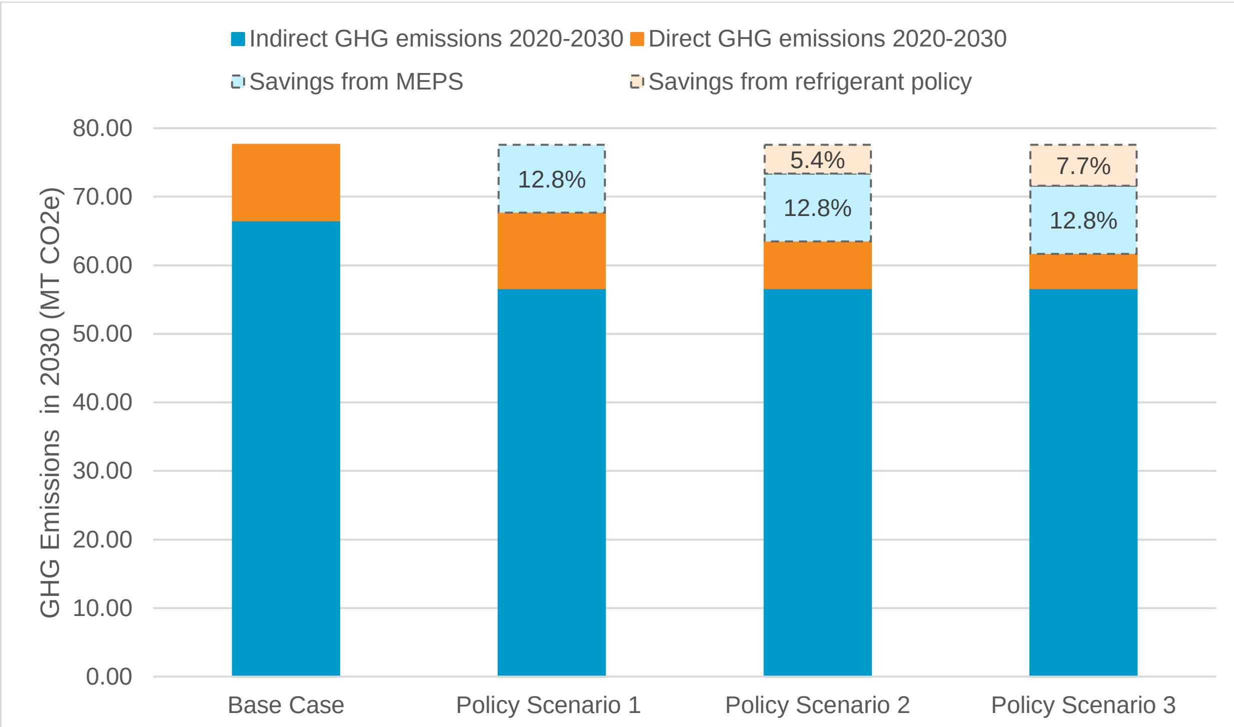



**Figure 23** provides a side by side comparison of total greenhouse gas emissions under each policy scenario. These are indicative values based off modeling conducted exclusively with market data for Algeria, Egypt, Morocco, and Tunisia. The efficiency levels available in the other North African markets, as well as the availability of RACs using each refrigerant type should be expected to vary from country to country. Thus, the benefit of stronger energy efficiency policies in North Africa could be larger or smaller than what CLASP has estimated here, but this analysis provides preliminary insights into the potential benefit from new policies for RACs.

According to this analysis, while energy efficiency can save roughly 12.8% of the cumulative 2020-2030 greenhouse gas emissions from RACs in North Africa, combining energy efficiency policy with refrigerant policy could reduce 2020-2030 greenhouse gas emissions by up to 20.5%. There is clearly room for improvement in the North African regional RAC market. Policymakers should look to implement or increase MEPS for RACs and to potentially restrict the type of refrigerants allowed to be used in RACs. Such policies can complement trade measures to reduce any environmental dumping of inefficient, high GWP RACs from more advanced RAC markets into North Africa.

# 7. Status and Impact of Low Efficiency, High GWP RACs in West Africa

CLASP and our partners collected data and analyzed the RAC markets of two largest economies in West Africa, Nigeria and Ghana. Both countries are members of the Economic Community of West African States (ECOWAS), an economic union of 15 West African states[135] with a mandate to promote economic integration between the member states. ECOWAS member states include:

- Benin
- Burkina Faso
- Cabo Verde
- Cote d'Ivoire
- The Gambia
- **Ghana**
- Guinea
- Guinea-Bissau
- Liberia
- Mali
- Niger
- **Nigeria**
- Senegal
- Sierra Leone
- Togo

In addition to ECOWAS, another regional union exists: the West African Economic and Monetary Union (WAEMU).[136] WAEMU aims to similarly promote regional economic integration though unified external tariffs among the member states. This eight-member union consists of the following French speaking West African states:

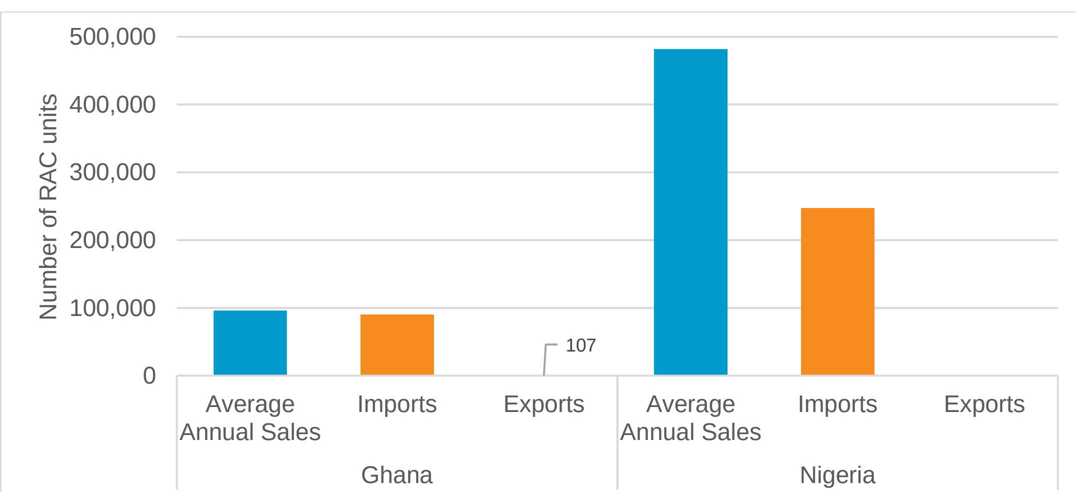
- Benin
- Burkina Faso
- Cote d'Ivoire
- Guinea-Bissau
- Mali
- Niger
- Senegal
- Togo

Because we only focused on two countries in West Africa, drawing out regional trends is difficult. Despite being the two largest economies in West Africa, based on recent Comtrade data, Ghana and Nigeria do not export a substantial quantity of RACs to other states in West Africa. However, since 2016 ECOWAS member states have been working together to develop and implement regional energy efficiency standards for RACs and refrigerators, and to design a regional product database to support the growing regional market for cooling appliances. As these efforts continue and as demand for cooling products continues to grow, the volume of intraregional trade may increase.

## 7.1 West Africa Market Characteristics and Trade Flows

Nigeria has by far the largest RAC market in the West African region, almost 5 times the size of the Ghanaian market.

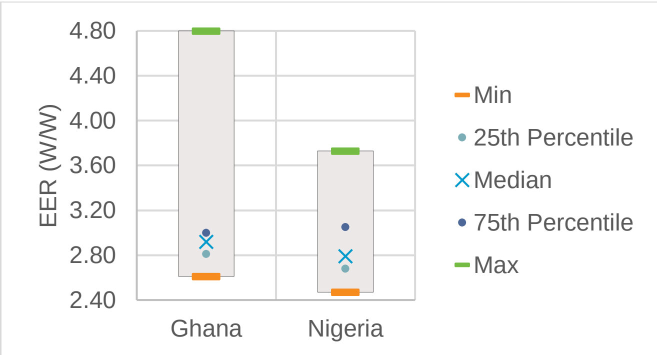
*Figure 24: Comparison of RAC sales and trade in Nigeria and Ghana (2017)*




[135] Mauritania, which is included in West Africa for modeling purposes, used to be a member of ECOWAS but withdrew.
[136] Also know by the French name, Union Economique et Monétaire Ouest Africaine (UEMOA)

The efficiency levels of units sold in both countries vary somewhat with a larger range of efficiencies available in Nigeria's market. Noticeably, while 76% of the RACs in Ghana's market report efficiencies over 3.0W/W or higher, only 29% of RACs in Nigeria fall into these higher efficiency buckets, and a very small portion of the market includes models below 2.5 W/W. The greater diversity in RACs on the Nigerian market is unsurprising given the size of the market.

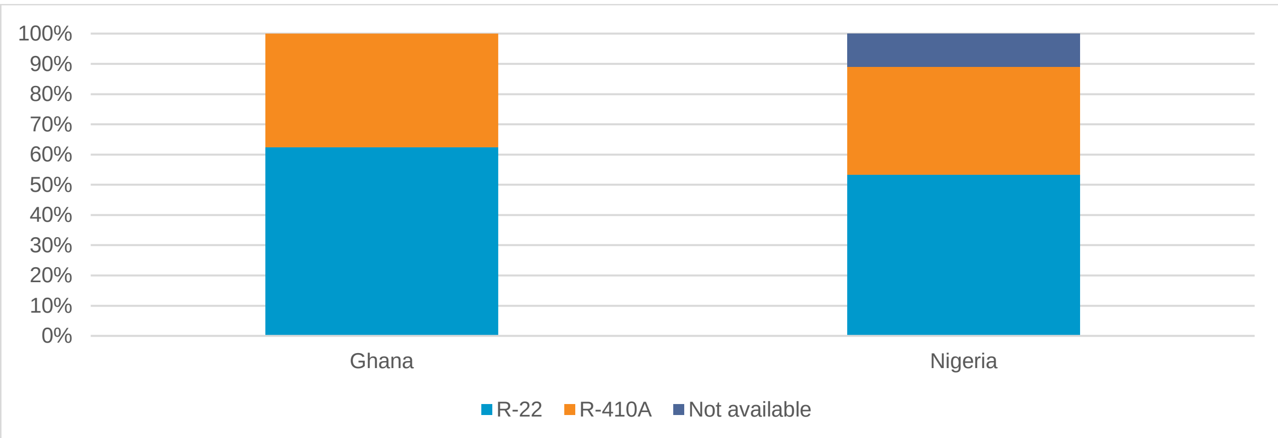
*Figure 25: Range of RAC efficiencies in West Africa by country*




One of the key differences between the two countries is the amount of local manufacturing. Whereas Ghana imports 80% of the RACs on the market, companies in Nigeria assemble 86% of the RACs available for sale. In Nigeria, the lowest efficiency units are assembled locally under Chinese, South Korean, and Japanese brands. However, slightly higher efficiency products are also assembled locally. The compressors used in the assembly of these RACs more than likely originate in China, which regularly supplies more than 90% of the compressors for refrigeration equipment imported into the country.[137] In Ghana, the lower efficiency units are primarily produced by international companies like Bruhm and Panasonic.

In Ghana and Nigeria, more than half of the RAC's on the market use either R-410A or R-22 refrigerants (**Figure 26**). In Nigeria, these R-22 units are assembled locally and sold under non-African brands like Haier, Gree and Daikin. However, in Ghana, almost all units are imported and because the source country data is not available, it is difficult to say which countries the R-22 RACs are coming from.

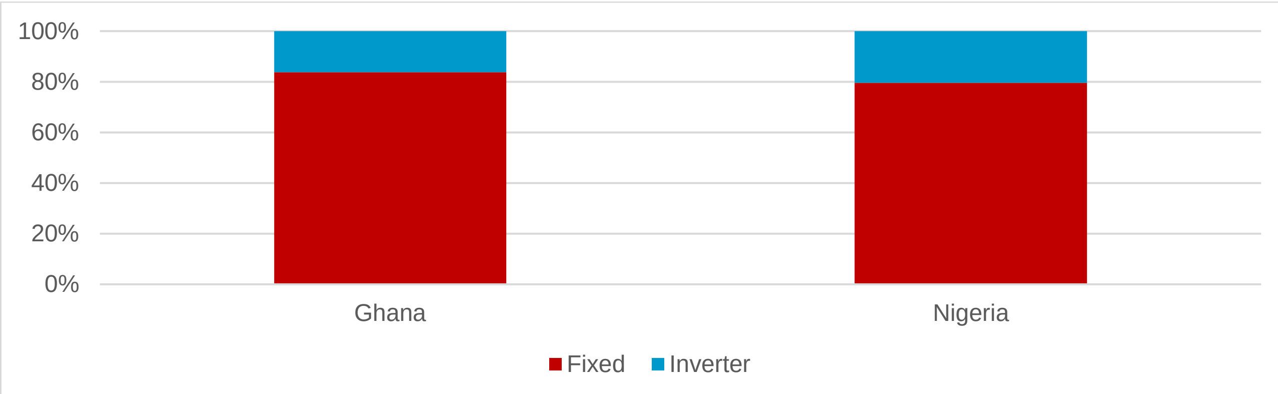
*Figure 26: RAC refrigerants in Ghana and Nigeria*




Fixed speed RACs make up more than 80% of the units sold in Ghana and Nigeria (**Figure 27**). All the lowest efficiency units and those containing R-22 refrigerant are fixed speed units in both countries are fixed speed RACs.

[137] See Annex 6 – Nigeria Country Profile for details on compressor imports.

*Figure 27: RAC compressor types in Ghana and Nigeria*




## 7.2 Modeling the Impact of Low Efficiency, High GWP RACs in West Africa

To examine the impacts of a transition to higher efficiency RACs with lower GWP refrigerants, CLASP developed three policy scenarios for RACs in West Africa and estimated the direct and indirect GHG emissions impact under each scenario. The same scenarios as those defined on **page 42**, were used for impacts evaluation for West Africa.

- **Base case (No Efficiency Policy + Unregulated Refrigerant Market)**
- **Policy Scenario 1 (U4E Model MEPS + Unregulated Refrigerant Market)**
- **Policy Scenario 2 (U4E Model MEPS + U4E Refrigerant Regulation)**
- **Policy Scenario 3 (U4E Model MEPS + BAT Refrigerant Regulation)**

To approximate the direct and indirect emissions from RACs in West Africa under each scenario CLASP identified cooling capacity and efficiency levels for two baseline RAC models identified through analysis of market data collected by BSRIA. The parameters of these baseline models, as well as the refrigerant distributions in the market, are summarized below.

*Table 16: Baseline models selected for analysis (West Africa)*

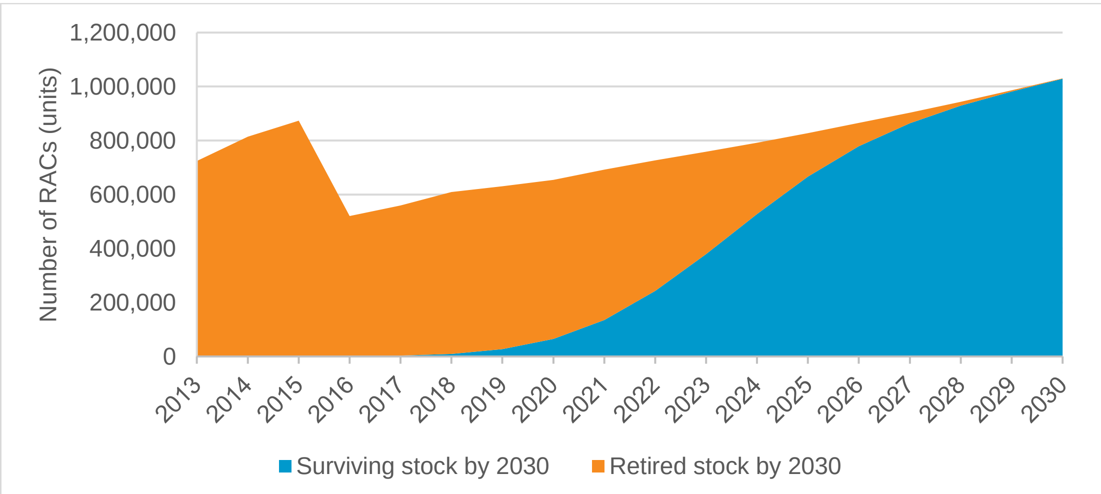
| RAC Market Segment | Market Share | Cooling Capacity | Energy Efficiency Ratio (EER) | Average MSP | Refrigerant Share | | |
|---|---|---|---|---|---|---|---|
| | | | | | R-22 | R-410A | R-32 |
| CC ≤ 4.5 kW | 53% | 3.14 kW | 2.90 W/W | 431 USD | 51% | 49% | 0% |
| CC > 4.5 kW | 47% | 5.22 kW | 3.10 W/W | 726 USD | 71% | 29% | 0% |

For the three policy options, CLASP analyzed energy savings and GHG emissions reductions from the base case by forecasting energy use of RACs sold from 2020 to 2030. We assume that every unit sold in a specific year has an EER equal to one of two baseline EERs in **Table 16**. CLASP used Euromonitor's 2004-2018 split RAC sales estimates and 2019-2023 projections to approximate a the regional RAC sales volume across sixteen West African countries, as defined by the UN,[138] between 2010 and 2023. Euromonitor's 2019-2023 projections averaged a 4.5% compound annual growth rate (CAGR) at the regional level. This CAGR of 4.5% was used to forecast regional sales for 2024-2030.

[138] The United Nations includes the following sixteen countries (for which Euromonitor data was available) in the Western Africa subregion: Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo.

In estimating both the indirect and direct emissions from RACs, CLASP accounts for the retirement of a portion of the RAC stock using a survival function based on a normal distribution of the median life of RACs in Africa (7 years).[139] **Figure 28** shows the sales forecast per year, the portion of the stock (from those annual sales) that survives in 2030 and the portion that has been retired.[140] Increases and decreases in annuals sales, such as that which occurred between 2015 and 2016, are reflected in the retired and surviving stock values.

*Figure 28: Surviving and retired RAC stock in West Africa (2013-2030)*




## Indirect Emissions

CLASP used the Policy Analysis Modeling System (PAMS) to estimate indirect greenhouse gas emissions from the operation of RAC equipment in South Africa. In the model, total energy consumption is estimated per year for the stock of RACs in use under each policy scenario. Emissions are estimated using the estimated surviving RAC stock for each segment of the market, annual unit energy consumption (UEC) of the baseline RAC models,[141] an electricity grid $CO_2$-intensity emissions factor, and the transmission and distribution (T&D) loss factor. The estimates used for West Africa are:

- Grid Emissions Factor is assumed to be **0.494 kg/kWh**.[142]
- T&D Loss Factor is assumed to be **14.9%**.[143]
- Annual operating hours is assumed to be **2,677 hours**.[144]

[139] Average RAC operating lifetime estimates were available. CLASP assumed an average lifetime of 7 years based on survey findings from Nigeria and the findings of an in-depth RAC market assessment recently conducted in Kenya. CLASP. 2019. Kenya RAC Market Assessment and Policy Options Analysis.https://clasp.ngo/publications/kenya-rac-market-assessment-and-policy-options-analysis-2019
[140] Surviving stock in 2030 refers to the number of units purchased in a year X that are still operating in 2030. Retired stock refers to the units that are no longer operating due to failure.
[141] UEC refers to the amount of energy, measured in kWh, consumed annually by a given RAC model.
[142] Weighted average grid emissions factor for Western Africa, weighted according to split RAC sales volume. Grid emissions factors were calculated using average $CO_2$ emissions factors from across Annex 1 countries and data on electricity generation from the following World Bank sources: World Bank. 2014. Electric power transmission and distribution losses (% of output), Electricity production from coal sources (% of total), Electricity production from oil sources (% of total), Electricity production from natural gas sources (% of total), Electricity production from nuclear sources (% of total), Electricity production from renewable sources, excluding hydroelectric (% of total), Electricity production from hydroelectric sources (% of total). Available at: https://data.worldbank.org/
[143] Weighted average T&D loss factor, weighted according to split RAC sales volumes. World Bank. 2014. Electric power transmission and distribution losses (% of output) available at: https://data.worldbank.org/
[144] Weighted average annual operating hours for RACs in Western Africa, weighted according to split RAC sales volume. Operating time was estimated based on the product of cooling degree days reported in each country and air conditioner percent operating days.

- Unit energy consumption was calculated based on the baseline values in **Table 16** using the formula:

$$UEC = \frac{Cooling\ Capacity}{EER \times 1000} \times Annual\ operating\ hours$$

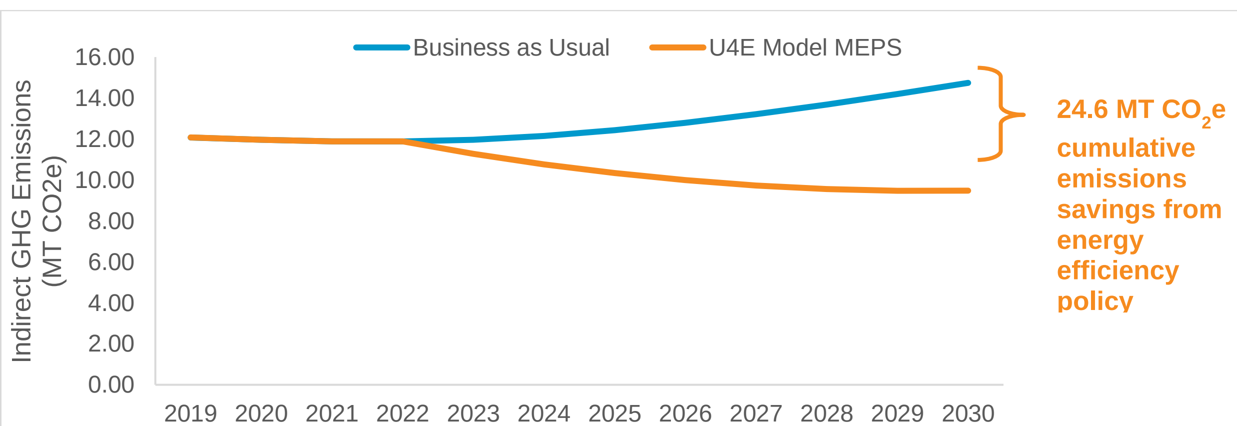
The results of CLASP's analysis of indirect emissions associated with RAC usage in West Africa are presented in **Table 17**.

- Under a business-as-usual scenario, in which no changes are made to the MEPS for RACs in the sixteen West African countries, CLASP projects that in 2030 RAC usage will require approximately **25.4 GWh of electricity** and indirectly generate **14.7 MT $CO_2$e** of greenhouse gas emissions.
- However, if in 2022 the West African countries were to align their MEPS for RACs with the U4E Model MEPS, as per Policy Scenario 1, annual indirect emissions could be reduced by approximately 36% in 2030, saving **5.3 MT $CO_2$e**. In the eight-year period from 2022-2030, the implementation of these stronger MEPS could allow for a cumulative reduction of 24.6 MT $CO_2$e.

*Table 17: Indirect GHG emissions in West Africa*

| | Scenario | | | |
|---|---|---|---|---|
| | **Base Case** (No Efficiency Policy + Unregulated Ref. Market) | **Policy Scenario 1** (U4E MEPS + Unregulated Ref. Market) | **Policy Scenario 2** (U4E MEPS + U4E Ref. Regulation) | **Policy Scenario 3** (U4E MEPS + BAT Ref. Regulation) |
| **Annual in 2030** | | | | |
| Energy Consumption (GWh) | 25.4 | 16.4 | 16.4 | 16.4 |
| Emissions (MT $CO_2$e) | 14.7 | 9.48 | 9.48 | 9.48 |
| Savings (MT $CO_2$e) | - | 5.26 | 5.26 | 5.26 |
| % of Base Case Emissions | - | 35.7% | 35.7% | 35.7% |
| **Cumulative 2020 – 2030** | | | | |
| Energy Consumption (GWh) | 243 | 200 | 200 | 200 |
| Emissions (MT $CO_2$e) | 141 | 116 | 116 | 116 |
| Savings (MT $CO_2$e) | - | 24.6 | 24.6 | 24.6 |
| % of Base Case Emissions | - | 17.4% | 17.4% | 17.4% |

*Figure 29: Indirect GHG Emissions in West Africa (2019-2030)*



### Direct Emissions

To analyze the climate benefits of introducing a requirement for the use of refrigerants with lower GWP, emissions of greenhouse gases from the refrigerants needs to be considered.

CLASP estimated the global warming potential of the baseline RAC models in West Africa using the *GWPdirect* formula described below.

$$GWPdirect = GWP \times m \times L_{annual} \times n + GWP \times m \times (1 - \alpha_{recovery})$$

GWP = Global Warming Potential of the refrigerant
m = refrigerant charge
$L_{annual}$ = leakage rate per annum
n = operating life
$\alpha_{recovery}$ = recycling factor from 0 to 1

The leakage rate (**10%**), operating life (**7 years**), and recycling factor (**0**) are held constant throughout the model and are identical to those used in the analyses conducted for the other three regions.[145]

The typical refrigerant charge[146] for the West African baseline RAC models identified in **Table 16** are shown in **Table 18** alongside the GWP values for current and alternative refrigerants.[147]

*Table 18: Refrigerant charges and GWP values for West Africa baseline models*

| Market segment & Baseline Cooling Capacity | R-22 | | R-410A | | R-32 | | R-290 | |
|---|---|---|---|---|---|---|---|---|
| | Average Charge (kg) | GWP ($CO_2e$) | Averag e Charge (kg) | GWP ($CO_2e$) | Average Charge (kg) | GWP ($CO_2e$) | Average Charge[148] (kg) | GWP ($CO_2e$) |
| CC ≥ 4.5 kW (3.14 kW model) | 0.68 | 1810 | 0.71 | 2088 | 0.61 | 675 | 0.30 | 1 |
| CC > 4.5kW (5.22 kW model) | 1.19 | | 1.08 | | 0.91 | | 0.34 | |

Using the retired stock of RACs from 2020 – 2030, and the corresponding *GWPdirect*, we estimated the cumulative value of greenhouse gas emissions by 2030 from their refrigerants charge as:

$$Cumulative\ GHG_{2030} = \sum_{y=2020}^{2030} Retired\ stock\ in\ 2030\ (y) \times GWPdirect\ (y)$$

Per **Table 16**, the market share of RACs with cooling capacities under 4.5 kW is 53%. Approximately 51% of these RACs use R-22 and approximately 49% of these RACs use R-410A. For the 47% of RACs with cooling capacities above 4.5 kW, approximately 71% use R-22 and 29% use R-410A. CLASP used these values to develop a methodology for weighting the retired stock of RACs for each market segment.

For the policy scenarios (Base Case and Policy Scenario 1) for which there is no requirement to transition to lower GWP refrigerants, we assessed direct emissions for each RAC market segment under analysis (CC < 4.5 kW as represented by the 3.14 kW baseline and CC ≥ 4.5 kW as represented by the 5.22 kW baseline model). Direct emissions were calculated according to the share of R-22, R-410A, and R-32

[145] See **Table 2** in the Methodology section for further detail on these inputs were chosen for this report.
[146] BSRIA did not collect charge information in the RAC market data collected. For R-22, R-410A, and R-32 refrigerant charges, approximate average charges were estimated based on RAC market data collected by CLASP in 2018 for the Vietnamese and Thai markets. Because CLASP did not find R-290 RACs in the African market, approximate average charges for R-290 RACs were obtained from the India Bureau of Energy Efficiency database.
[147] IPCC Fourth Assessment Report: Climate Change 2007 (AR4).
[148] Because CLASP did not find R-290 RACs in the African market, approximate average charges were obtained from the India Bureau of Energy Efficiency database.

RACs found within each market segment, as per the data from BSRIA, using the corresponding GWP values. For the period 2019-2030, CLASP assumed the following changes to the market share of refrigerants in accordance with Montreal Protocol phase-out and phase-down schedules for R-22 and R-410A:

- R-22 RACs are phased out completely by 2030, in conjunction with the R-22 production ceasing in the China and India. CLASP assumes a constant rate of decrease in R-22 market share in this unregulated refrigerant market scenario. The decrease in R-22 share is accounted for primarily by an increase to R-410A share.
- Beginning in 2022, R-32 share increases by 1%. CLASP has observed in other markets (e.g. the Philippines)[149] that without ambitious refrigerant or efficiency policies, R-32 enters developing AC markets slowly.

*Table 19: West Africa Business-as-Usual RAC Refrigerant Share Assumptions*

| | 3.14 kW Baseline Model | | | 5.22 kW Baseline Model | | |
|---|---|---|---|---|---|---|
| Year | R-22 Share | R-410A Share | R-32 Share | R-22 Share | R-410A Share | R-32 Share |
| 2019 | **51.1%** | **48.9%** | **0.0%** | **71.5%** | **28.5%** | **0.0%** |
| 2020 | 46.5% | 53.5% | 0.0% | 65.0% | 35.0% | 0.0% |
| 2021 | 41.8% | 58.2% | 0.0% | 58.5% | 41.5% | 0.0% |
| 2022 | **37.2%** | **61.8%** | **1.0%** | **52.0%** | **47.0%** | **1.0%** |
| 2023 | 32.5% | 65.5% | 2.0% | 45.5% | 52.5% | 2.0% |
| 2024 | 27.9% | 69.1% | 3.0% | 39.0% | 58.0% | 3.0% |
| 2025 | 23.2% | 72.8% | 4.0% | 32.5% | 63.5% | 4.0% |
| 2026 | 18.6% | 76.4% | 5.0% | 26.0% | 69.0% | 5.0% |
| 2027 | 13.9% | 80.1% | 6.0% | 19.5% | 74.5% | 6.0% |
| 2028 | 9.3% | 83.7% | 7.0% | 13.0% | 80.0% | 7.0% |
| 2029 | 4.6% | 87.4% | 8.0% | 6.5% | 85.5% | 8.0% |
| 2030 | **0.0%** | **91.0%** | **9.0%** | **0.0%** | **91.0%** | **9.0%** |

For Policy Scenario 2, all RACs sold in and after 2022 are assumed to use R-32. Therefore, CLASP follows the weighting methodology described above through 2021, and then assumes the R-32 GWP of 675 from 2022-2030.

For Policy Scenario 3, all RACs sold in and after 2022 are assumed to use R-290. Therefore, CLASP follows the weighting methodology described above through 2021, and then assumes the R-290 GWP of 1 from 2022-2030.

Results from the direct emissions analysis above are presented in **Table 20**.

*Table 20: Cumulative direct GHG emissions from retired RACs in West Africa 2020-2030*

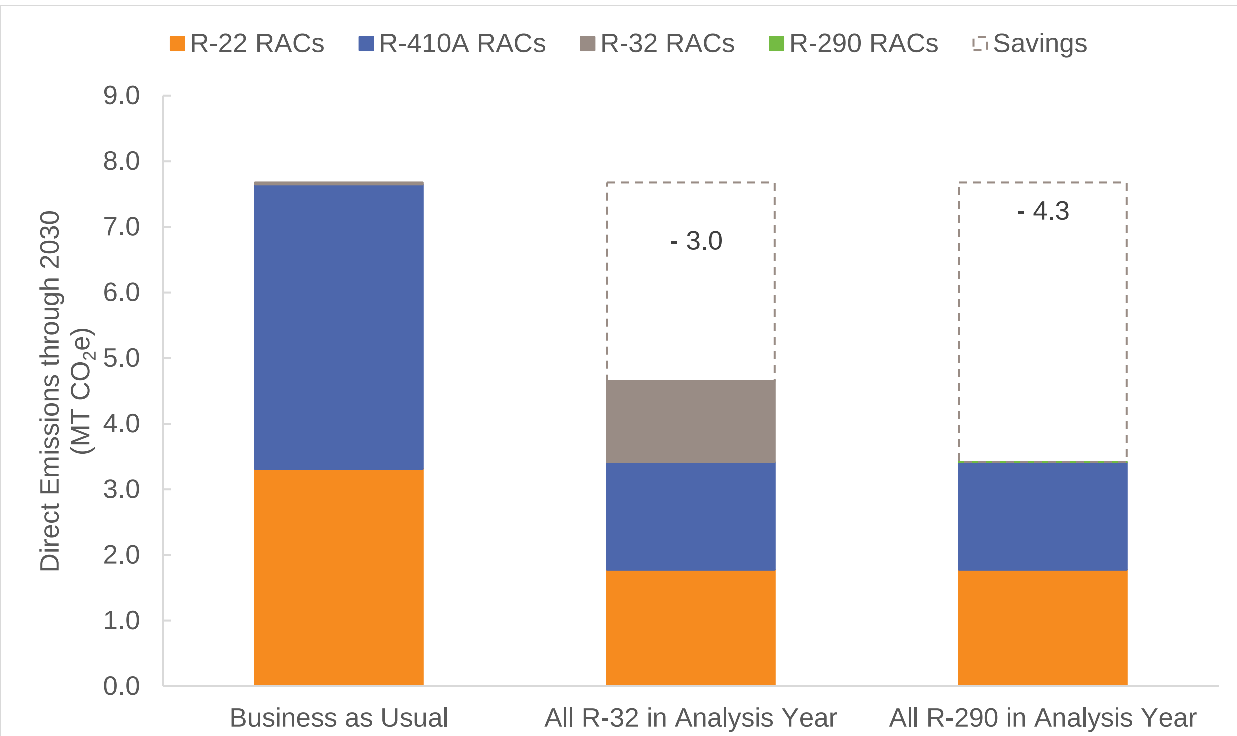
| Source | Direct Emissions by Scenario (MT $CO_2$e) |
|---|---|

[149] Based on prior research conducted by CLASP, between 2015 and 2018 the market penetration of R-32 RACs grew from 0% to 7.8%. By comparison, the market for R-410A RACs grew from 0% to 32% over the same period. CLASP. 2019. *Philippines Room Air Conditioner Market Assessment and Policy Options Analysis.* https://clasp.ngo/publications/philippines-rac-market-assessment-and-policy-options-analysis-2019

| | Base Case (No Efficiency Policy + Unregulated Ref. Market) | Policy Scenario 1 (U4E MEPS + Unregulated Ref. Market) | Policy Scenario 2 (U4E MEPS + U4E Ref. Regulation) | Policy Scenario 3 (U4E MEPS + BAT Ref. Regulation) |
|---|---|---|---|---|
| R-22 RACs | 3.31 | 3.31 | 1.78 | 1.78 |
| R-410A RACs | 4.33 | 4.33 | 1.64 | 1.64 |
| R-32 RACs | 0.03 | 0.03 | 1.24 | 0.00 |
| R-290 RACs | 0.00 | 0.00 | 0.00 | 0.001 |
| **Total** | **7.68** | **7.68** | **4.65** | **3.42** |
| Savings | - | - | 3.02 | 4.26 |
| % of BAU Emissions | - | - | 39.4% | 55.5% |

**Figure 30** illustrates the potential savings from emissions savings from refrigerant policy in West Africa and demonstrates that the bulk of direct emissions are likely to come from the R-410A RACs with both high GWP and the largest share of the West African market.

*Figure 30: Cumulative direct GHG emissions from retired RACs in West Africa 2020-2030*




## Total Equivalent Warming Impact

By adding together the indirect and direct emissions estimates we calculated, CLASP approximated the Total Equivalent Warming Impact of RACs in East Africa. The results of the full analysis are summarized in **Table 21**.

*Table 21: Total 2020-2030 GHG emissions from RACs in West Africa under four scenarios*

| Source | Cumulative Indirect & Direct Emissions 2020-2030 (MT $CO_2e$) | | | |
|---|---|---|---|---|
| | **Base Case** (No Efficiency Policy + Unregulated Ref. Market) | **Policy Scenario 1** (U4E MEPS + Unregulated Ref. Market) | **Policy Scenario 2** (U4E MEPS + U4E Ref. Regulation) | **Policy Scenario 3** (U4E MEPS + BAT Ref. Regulation) |
| Indirect emissions | 141 | 116 | 116 | 116 |
| Direct Emissions | 7.68 | 7.68 | 4.65 | 3.42 |
| **Total** | **149** | **124** | **121** | **119** |
| Savings | - | 24.6 | 27.6 | 28.8 |
| % of BAU Emissions | - | 16.5% | 18.6% | 19.4% |

*Figure 31: Cumulative 2020-2030 GHG emissions from RACs in West Africa under four scenarios*

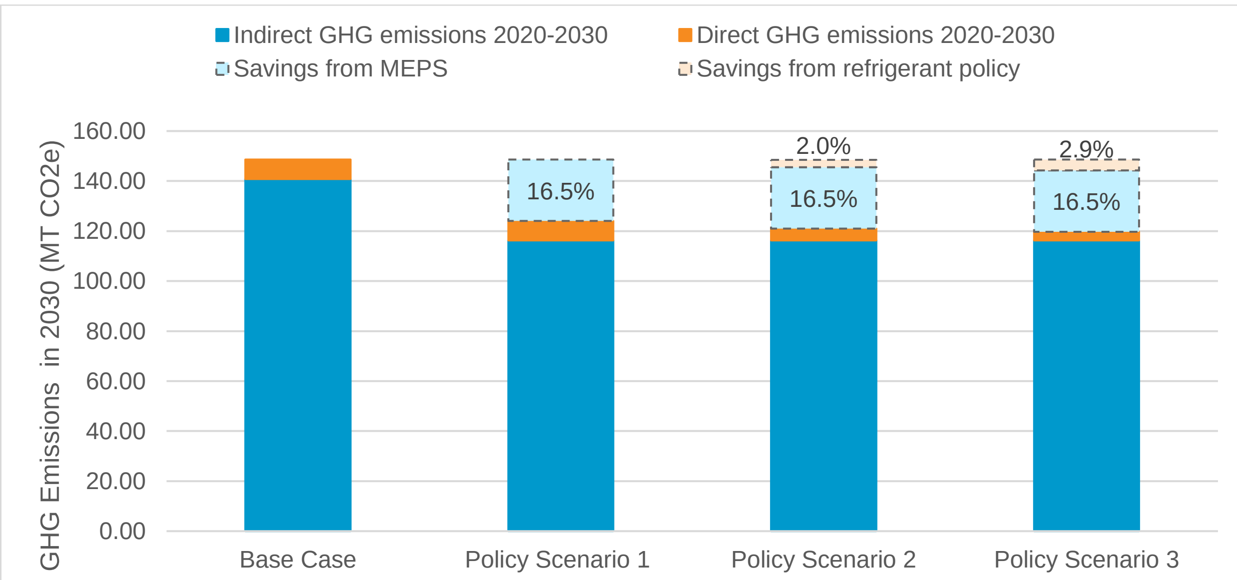



**Figure 31** provides a side by side comparison of total greenhouse gas emissions under each policy scenario. These are indicative values based off modeling conducted exclusively with market data for Ghana and Nigeria. The efficiency levels available in the other West African markets, as well as the availability of RACs using each refrigerant type should be expected to vary from country to country. Thus, the benefit of stronger energy efficiency policies in West Africa could be larger or smaller than what CLASP has estimated here, but this analysis provides preliminary insights into the potential benefit from new policies for RACs.

According to this analysis, while energy efficiency can save roughly 16.5% of the cumulative 2020-2030l greenhouse gas emissions from RACs in West Africa, combining energy efficiency policy with refrigerant policy could reduce 2020-2030 greenhouse gas emissions by up to 19.4%. There is clearly room for improvement in the West African regional RAC market. Policymakers should look to implement or increase MEPS for RACs and to potentially restrict the type of refrigerants allowed to be used in RACs. Such policies can complement trade measures to reduce any environmental dumping of inefficient, high GWP RACs from more advanced RAC markets into West Africa.

# 8. Status and Impact of Low Efficiency, High GWP RACs in East Africa

CLASP and our partners collected data and analyzed the RAC markets of three major economies in East Africa: Ethiopia, Kenya, and Tanzania. There are three main customs unions in the region:

- Common Market for East and Southern Africa (COMESA) – Ethiopia and Kenya are members
- East African Community (EAC) – Kenya and Tanzania are members
- Southern African Development Community (SADC) –Tanzania is a member (along with another country covered in this study, South Africa).

## 8.1 East Africa Market Characteristics and Trade Flows

Tanzania has the largest RAC market in the East and Southern African region (42,000 units reported sold in 2017) while the other two countries analyzed have smaller market sizes of around 35,000 units sold annually (**Figure 32**). All three countries are import-only RAC markets but Kenya re-exports a small number of RACs to neighboring countries.

Even though Ethiopia and Kenya are part of COMESA, there is minimal RAC trade recorded on Comtrade between the countries, just a few units exported to Ethiopia from Kenya. There is some RAC trade with other COMESA member states like imports of RACs from Egypt to Ethiopia and Kenya.

As members of the EAC, Kenya and Tanzania have some RAC trade with each other: Kenya re-exports units to Tanzania and Tanzania also reported some re-exports to Kenya. In the general East African region, Kenya also re-exports RAC units to Uganda, Rwanda, Tanzania, South Sudan, Somalia and the D.R Congo, while Tanzania re-exports to D.R Congo and Burundi.

As a member of SADC, Tanzania reported some RAC imports from South Africa. The two countries also trade with other SADC members such as Namibia, Mozambique, Zambia, and Botswana, among others.

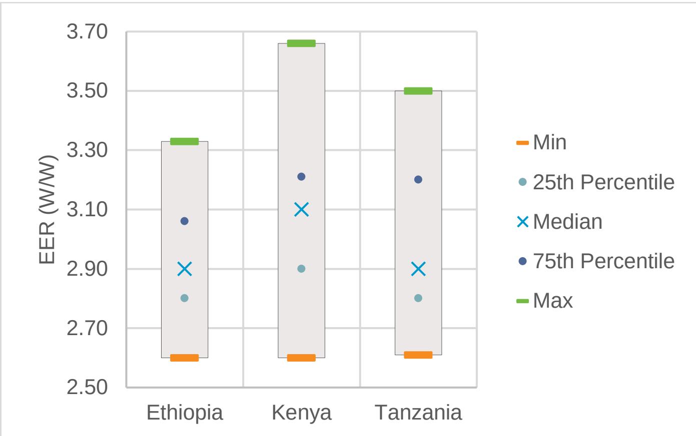
*Figure 32: Comparison of RAC sales and trade in Ethiopia, Kenya, South Africa and Tanzania (2017)*[150]


In East Africa, the Ethiopian market has the largest share (65%) of low efficiency units, 2.5 W/W – 3.0W/W, while Tanzania also has a high prevalence of low efficiency units at 44%. The Kenyan market has some (17%) low efficiency units. The low efficiency units in Ethiopia are sold under Chinese, Japanese and other non-African branding and imported from China, United Arab Emirates (UAE), and other countries. The situation is similar in Tanzania with the low efficiency units being Chinese, South Korean and Japanese brands imported primarily from China and Thailand.

[150] 2017 RAC imports/exports data was not available for Ethiopia. To allow for comparison of market size, the averages of Ethiopia's RAC imports and exports over the preceding three years, 2014-2016, is plotted in the chart.

In Ethiopia and Tanzania, RACs containing R-22 make up a significant market share, approximately 50% in Ethiopia and 42% in Tanzania. The share of R-22 units sold in Kenya is smaller at 27%. These R-22 units are primarily Chinese brands. In Kenya other R-22 units are imported from Egypt, India and Thailand.

*Figure 33: Range of RAC efficiencies in East Africa by country*




## 8.2 Modeling the Impact of Low Efficiency, High GWP RACs in East Africa

To examine the impacts of a transition to higher efficiency RACs with lower GWP refrigerants, CLASP developed three policy scenarios for RACs in East Africa and estimated the direct and indirect GHG emissions impact under each scenario. The same scenarios as those defined on **page 42**, were used for impacts evaluation for East Africa.

- **Base case (No Efficiency Policy + Unregulated Refrigerant Market)**
- **Policy Scenario 1 (U4E Model MEPS + Unregulated Refrigerant Market)**
- **Policy Scenario 2 (U4E Model MEPS + U4E Refrigerant Regulation)**
- **Policy Scenario 3 (U4E Model MEPS + BAT Refrigerant Regulation)**

To approximate the direct and indirect GHG emissions from RACs in East Africa under each scenario CLASP identified cooling capacity and efficiency levels for two baseline RAC models identified through analysis of market data collected by BSRIA. The parameters of these baseline models, as well as the refrigerant distributions in the market, are summarized in **Table 22.**

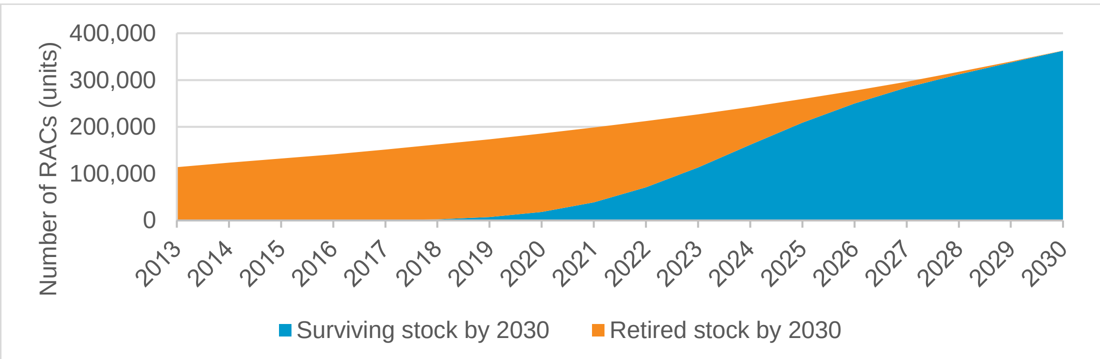
*Table 22: Baseline models selected for analysis (East Africa)*

| RAC Market Segment | Market Share | Cooling Capacity | Energy Efficiency Ratio (EER) | Average MSP | Refrigerant Share | | |
|---|---|---|---|---|---|---|---|
| | | | | | R-22 | R-410A | R-32 |
| CC ≤ 4.5 kW | 57% | 3.51 kW | 2.90 W/W | 431 USD | 35% | 65% | 0% |
| CC > 4.5 kW | 43% | 6.50 kW | 3.10 W/W | 726 USD | 27% | 73% | 0% |

For the three policy options, CLASP analyzed energy savings and GHG emissions reductions from the base case by forecasting energy use of RACs sold from 2020 to 2030. We assume that every unit sold in a specific year has an EER equal to one of two baseline EERs in **Table 22**. CLASP used Euromonitor's 2004-2018 split RAC sales estimates and 2019-2023 projections to approximate a the regional RAC sales volume across twenty East African countries, as defined by the UN,[151] between 2010 and 2023. Euromonitor's 2019-2023 projections averaged a 6.9% compound annual growth rate (CAGR) at the regional level. This CAGR of 6.9% was used to forecast regional sales for 2024-2030.

In estimating both the indirect and direct emissions from RACs, CLASP accounts for the retirement of a portion of the RAC stock using a survival function based on a normal distribution of the median life of RACs in Africa (7 years).[152] **Figure 34** shows the sales forecast per year, the portion of the stock (from those annual sales) that survives in 2030 and the portion that has been retired.[153]

*Figure 34: Surviving and retired RAC stock in East Africa (2013-2030)*




## Indirect Emissions

CLASP used the Policy Analysis Modeling System (PAMS) to estimate indirect greenhouse gas emissions from the operation of RAC equipment in East Africa. In the model, total energy consumption is estimated per year for the stock of RACs in use under each policy scenario. Emissions are estimated using the estimated surviving RAC stock for each segment of the market, annual unit energy consumption (UEC) of the baseline RAC models,[154] an electricity grid $CO_2$-intensity emissions factor, and the transmission and distribution (T&D) loss factor. The estimates used for East Africa are:

- Grid Emissions Factor is assumed to be **0.420 kg/kWh**.[155]
- T&D Loss Factor is assumed to be **15.7%**.[156]
- Annual operating hours is assumed to be **1,161 hours**.[157]

[151] The United Nations includes the following twenty countries ((for which Euromonitor data was available) in the Eastern Africa subregion: Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mayotte, Mozambique, Reunion, Rwanda, Seychelles, Somalia, South Sudan, Tanzania, Uganda, Zambia, and Zimbabwe.
[152] Average RAC operating lifetime estimates were available. CLASP assumed an average lifetime of 7 years based on survey findings from Nigeria and the findings of an in-depth RAC market assessment recently conducted in Kenya. CLASP. 2019. Kenya RAC Market Assessment and Policy Options Analysis.https://clasp.ngo/publications/kenya-rac-market-assessment-and-policy-options-analysis-2019
[153] Surviving stock in 2030 refers to the number of units purchased in a year X that are still operating in 2030. Retired stock refers to the units that are no longer operating due to failure.
[154] UEC refers to the amount of energy, measured in kWh, consumed annually by a given RAC model.
[155] Weighted average grid emissions factor for Eastern Africa, weighted according to split RAC sales volume. Grid emissions factors were calculated using average $CO_2$ emissions factors from across Annex 1 countries and data on electricity generation from the following World Bank sources: World Bank. 2014. Electric power transmission and distribution losses (% of output), Electricity production from coal sources (% of total), Electricity production from oil sources (% of total), Electricity production from natural gas sources (% of total), Electricity production from nuclear sources (% of total), Electricity production from renewable sources, excluding hydroelectric (% of total), Electricity production from hydroelectric sources (% of total). Available at: https://data.worldbank.org/
[156] Weighted average T&D loss factor, weighted according to split RAC sales volumes. World Bank. 2014. Electric power transmission and distribution losses (% of output) available at: https://data.worldbank.org/
[157] Weighted average annual operating hours for RACs in Eastern Africa, weighted according to split RAC sales volume. Operating time was estimated based on the product of cooling degree days reported in each country and air conditioner percent operating days.

- Unit energy consumption was calculated based on the baseline values in **Table 22** using the formula:

$$UEC = \frac{Cooling\ Capacity}{EER \times 1000} \times Annual\ operating\ hours$$

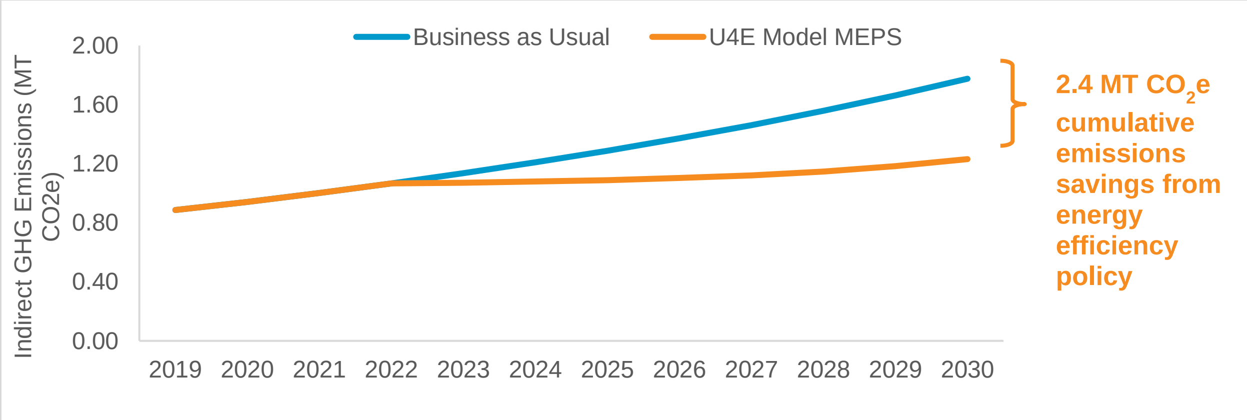
The results of CLASP's analysis of indirect emissions associated with RAC usage in East Africa are presented in **Table 23**.

- Under a business-as-usual scenario, in which no changes are made to the MEPS for RACs in the twenty East African countries, CLASP projects that in 2030 RAC usage will require approximately **3.6 GWh of electricity** and indirectly generate **1.8 MT $CO_2$e** of greenhouse gas emissions.
- However, if in 2022 the East African countries were to align their MEPS for RACs with the U4E Model MEPS, as per Policy Scenario 1, annual indirect emissions could be reduced by approximately 31% in 2030, saving **0.5 MT $CO_2$e**. In the eight-year period from 2022-2030, the implementation of these stronger MEPS could allow for a cumulative reduction of 2.4 MT $CO_2$e.

*Table 23: Indirect GHG emissions in East Africa*

| | **Base Case** (No Efficiency Policy + Unregulated Ref. Market) | **Policy Scenario 1** (U4E MEPS + Unregulated Ref. Market) | **Policy Scenario 2** (U4E MEPS + U4E Ref. Regulation) | **Policy Scenario 3** (U4E MEPS + BAT Ref. Regulation) |
|---|---|---|---|---|
| **Annual in 2030** | | | | |
| Energy Consumption (GWh) | 3.57 | 2.47 | 2.47 | 2.47 |
| Emissions (MT $CO_2$e) | 1.78 | 1.23 | 1.23 | 1.23 |
| Savings (MT $CO_2$e) | - | 0.54 | 0.54 | 0.54 |
| % of Base Case Emissions | - | 16.9% | 16.9% | 16.9% |
| **Cumulative 2020 – 2030** | | | | |
| Energy Consumption (GWh) | 29.1 | 24.2 | 24.2 | 24.2 |
| Emissions (MT $CO_2$e) | 14.5 | 12.0 | 12.0 | 12.0 |
| Savings (MT $CO_2$e) | - | 2.44 | 2.44 | 2.44 |
| % of Base Case Emissions | - | 16.9% | 16.9% | 16.9% |

*Figure 35: Indirect GHG Emissions in East Africa (2019-2030)*



### Direct Emissions

To analyze the climate benefits of introducing a requirement for the use of refrigerants with lower GWP, emissions of greenhouse gases from the refrigerants needs to be considered.

CLASP estimated the global warming potential of the baseline RAC models in East Africa using the *GWPdirect* formula described below.

$$GWPdirect = GWP \times m \times L_{annual} \times n + GWP \times m \times (1 - \alpha_{recovery})$$

GWP = Global Warming Potential of the refrigerant
m = refrigerant charge
$L_{annual}$ = leakage rate per annum
n = operating life
$\alpha_{recovery}$ = recycling factor from 0 to 1

The leakage rate (**10%**), operating life (**7 years**), and recycling factor (**0**) are held constant throughout the model and are identical to those used in the analyses conducted for the other three regions.[158]

The typical refrigerant charges[159] for the East African baseline RAC models identified in **Table 22** are shown in **Table 24** alongside the GWP values for current and alternative refrigerants.[160]

*Table 24: Refrigerant charges and GWP values for East Africa baseline models*

| Market segment & Baseline Cooling Capacity | R-22 | | R-410A | | R-32 | | R-290 | |
|---|---|---|---|---|---|---|---|---|
| | Average Charge (kg) | GWP ($CO_2e$) | Average Charge (kg) | GWP ($CO_2e$) | Average Charge (kg) | GWP ($CO_2e$) | Average Charge[161] (kg) | GWP[162] ($CO_2e$) |
| CC ≥ 4.5 kW (3.51 kW model) | 0.85 | 1,810 | 0.77 | 2,088 | 0.71 | 675 | 0.30 | 1 |
| CC > 4.5kW (6.5 kW model) | 1.10 | | 1.08 | | 1.03 | | 0.38 | |

Using the retired stock of RACs from 2020 – 2030, and the corresponding *GWPdirect*, we estimated the cumulative value of greenhouse gas emissions by 2030 from their refrigerants charge as:

$$Cumulative\ GHG_{2030} = \sum_{y=2020}^{2030} Retired\ stock\ in\ 2030\ (y) \times GWPdirect\ (y)$$

Per **Table 22**, the market share of RACs with cooling capacities under 4.5 kW is 57%. Approximately 35% of these RACs use R-22 and approximately 65% of these RACs use R-410A. For the 43% of RACs with cooling capacities above 4.5 kW, approximately 27% use R-22 and 73% use R-410A. CLASP used these values to develop a methodology for weighting the retired stock of RACs for each market segment.

For the policy scenarios (Base Case and Policy Scenario 1) for which there is no requirement to transition to lower GWP refrigerants, we assessed direct emissions for each RAC market segment under analysis (CC < 4.5 kW as represented by the 3.51 kW baseline and CC ≥ 4.5 kW as represented by the 6.5 kW

[158] See **Table 2** in the Methodology section for further detail on these inputs were chosen for this report.
[159] BSRIA did not collect charge information in the RAC market data collected. For R-22, R-410A, and R-32 refrigerant charges, approximate average charges were estimated based on RAC market data collected by CLASP in 2018 for the Vietnamese and Thai markets. Because CLASP did not find R-290 RACs in the African market, approximate average charges for R-290 RACs were obtained from the India Bureau of Energy Efficiency database.
[160] IPCC Fourth Assessment Report: Climate Change 2007 (AR4).
[161] Because CLASP did not find R-290 RACs in the African market, approximate average charges were obtained from the India Bureau of Energy Efficiency database.
[162] The GWP of R-290 is estimated to be <1. To model an R-290 transition in a conservative manner, CLASP assumed a GWP equal to 1 for R-290.

baseline model). Direct emissions were calculated according to the share of R-22, R-410A, and R-32 RACs found within each market segment, as per the data from BSRIA, using the corresponding GWP values. For the period 2019-2030, CLASP assumed the following changes to the market share of refrigerants in accordance with Montreal Protocol phase-out and phase-down schedules for R-22 and R-410A:

- R-22 RACs are phased out completely by 2030, in conjunction with the R-22 production ceasing in the China and India. CLASP assumes a constant rate of decrease in R-22 market share in this unregulated refrigerant market scenario. The decrease in R-22 share is accounted for primarily by an increase to R-410A share.
- Beginning in 2022, R-32 share increases by 1%. CLASP has observed in other markets (e.g. the Philippines)[163] that without ambitious refrigerant or efficiency policies, R-32 enters developing AC markets slowly.

*Table 25: East Africa Business-as-Usual RAC Refrigerant Share Assumptions*

| | 3.51 kW Baseline Model | | | 6.5 kW Baseline Model | | |
|---|---|---|---|---|---|---|
| Year | R-22 Share | R-410A Share | R-32 Share | R-22 Share | R-410A Share | R-32 Share |
| 2019 | **34.9%** | **65.1%** | **0.0%** | **26.6%** | **73.4%** | **0.0%** |
| 2020 | 31.7% | 68.3% | 0.0% | 24.2% | 75.8% | 0.0% |
| 2021 | 28.6% | 71.4% | 0.0% | 21.8% | 78.2% | 0.0% |
| 2022 | **25.4%** | **73.6%** | **1.0%** | **19.4%** | **79.6%** | **1.0%** |
| 2023 | 22.2% | 75.8% | 2.0% | 17.0% | 81.0% | 2.0% |
| 2024 | 19.0% | 78.0% | 3.0% | 14.5% | 82.5% | 3.0% |
| 2025 | 15.9% | 80.1% | 4.0% | 12.1% | 83.9% | 4.0% |
| 2026 | 12.7% | 82.3% | 5.0% | 9.7% | 85.3% | 5.0% |
| 2027 | 9.5% | 84.5% | 6.0% | 7.3% | 86.7% | 6.0% |
| 2028 | 6.3% | 86.7% | 7.0% | 4.8% | 88.2% | 7.0% |
| 2029 | 3.2% | 88.8% | 8.0% | 2.4% | 89.6% | 8.0% |
| 2030 | **0.0%** | **91.0%** | **9.0%** | **0.0%** | **91.0%** | **9.0%** |

For Policy Scenario 2, all RACs sold in and after 2022 are assumed to use R-32. Therefore, CLASP follows the weighting methodology described above through 2021, and then assumes the R-32 GWP of 675 from 2022-2030.

For Policy Scenario 3, all RACs sold in and after 2022 are assumed to use R-290. Therefore, CLASP follows the weighting methodology described above through 2021, and then assumes the R-290 GWP of 1 from 2022-2030.

Results from the direct emissions analysis above are presented in **Table 26**.

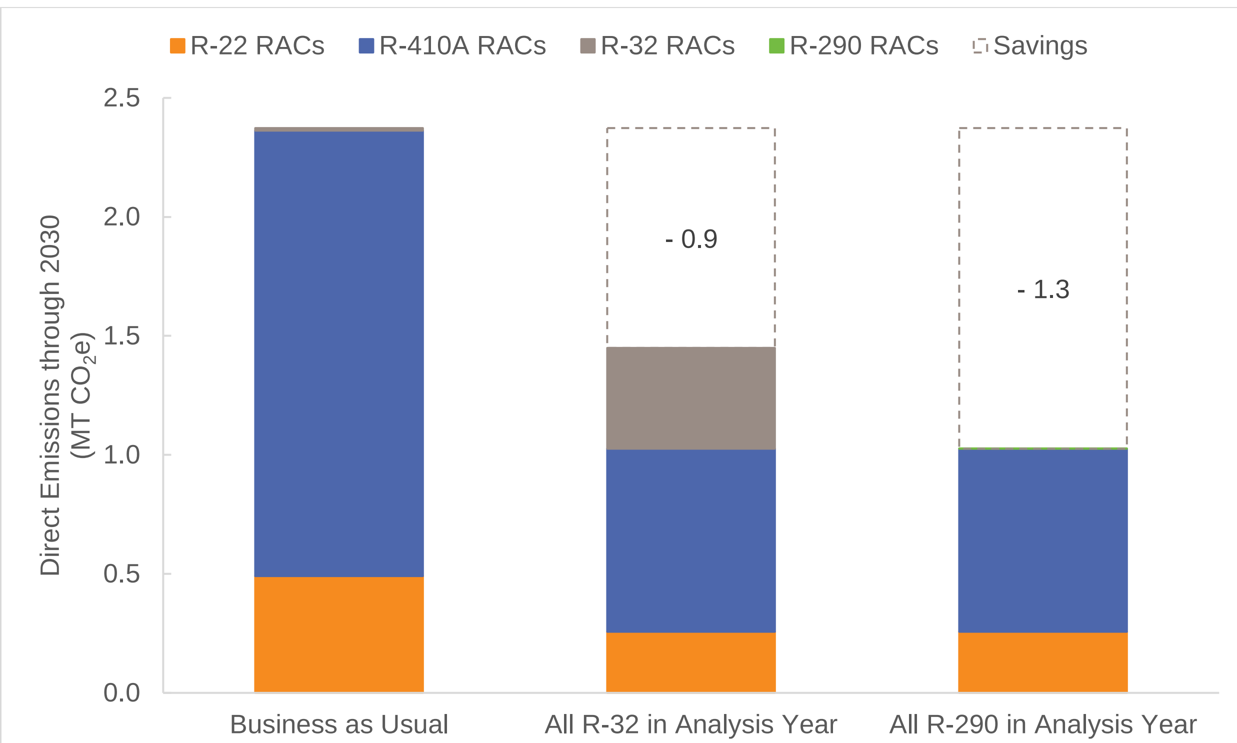
[163] Based on prior research conducted by CLASP, between 2015 and 2018 the market penetration of R-32 RACs grew from 0% to 7.8%. By comparison, the market for R-410A RACs grew from 0% to 32% over the same period. CLASP. 2019. *Philippines Room Air Conditioner Market Assessment and Policy Options Analysis.* https://clasp.ngo/publications/philippines-rac-market-assessment-and-policy-options-analysis-2019

*Table 26: Cumulative direct GHG emissions from retired RACs in East Africa 2020-2030*

| Source | Direct Emissions by Scenario (MT $CO_2$e) | | | |
|---|---|---|---|---|
| | **Base Case** (No Efficiency Policy + Unregulated Ref. Market) | **Policy Scenario 1** (U4E MEPS + Unregulated Ref. Market) | **Policy Scenario 2** (U4E MEPS + U4E Ref. Regulation) | **Policy Scenario 3** (U4E MEPS + BAT Ref. Regulation) |
| R-22 RACs | 0.49 | 0.49 | 0.26 | 0.26 |
| R-410A RACs | 1.87 | 1.87 | 0.77 | 0.77 |
| R-32 RACs | 0.01 | 0.01 | 0.42 | 0.00 |
| R-290 RACs | 0.00 | 0.00 | 0.00 | 0.0002 |
| **Total** | **2.37** | **2.37** | **1.45** | **1.03** |
| Savings | - | - | 0.92 | 1.35 |
| % of BAU Emissions | - | - | 38.9% | 56.8% |

**Figure 36** illustrates the potential emissions savings from refrigerant policy in East Africa and demonstrates that the bulk of direct emissions are likely to come from the R-410A RACs with both high GWP and the largest share of the East African market.

*Figure 36: Cumulative direct GHG emissions from retired RACs in East Africa 2020-2030*




## Total Equivalent Warming Impact

By adding together the indirect and direct emissions estimates we calculated, CLASP approximated the Total Equivalent Warming Impact of RACs in East Africa. The results of the full analysis are summarized in **Table 27.**

*Table 27: Total 2020-2030 GHG emissions from RACs in East Africa under four scenarios*

| Source | Cumulative Indirect & Direct Emissions 2020-2030 (MT $CO_2e$) | | | |
|---|---|---|---|---|
| | **Base Case** (No Efficiency Policy + Unregulated Ref. Market) | **Policy Scenario 1** (U4E MEPS + Unregulated Ref. Market) | **Policy Scenario 2** (U4E MEPS + U4E Ref. Regulation) | **Policy Scenario 3** (U4E MEPS + BAT Ref. Regulation) |
| Indirect emissions | 14.5 | 12.0 | 12.0 | 12.0 |
| Direct Emissions | 2.37 | 2.37 | 1.45 | 1.03 |
| **Total** | **16.8** | **14.4** | **13.5** | **13.1** |
| Savings | - | 2.44 | 3.36 | 3.78 |
| % of BAU Emissions | - | 14.5% | 20.0% | 22.4% |

*Figure 37: Cumulative 2020-2030 GHG emissions from RACs in East Africa under four scenarios*

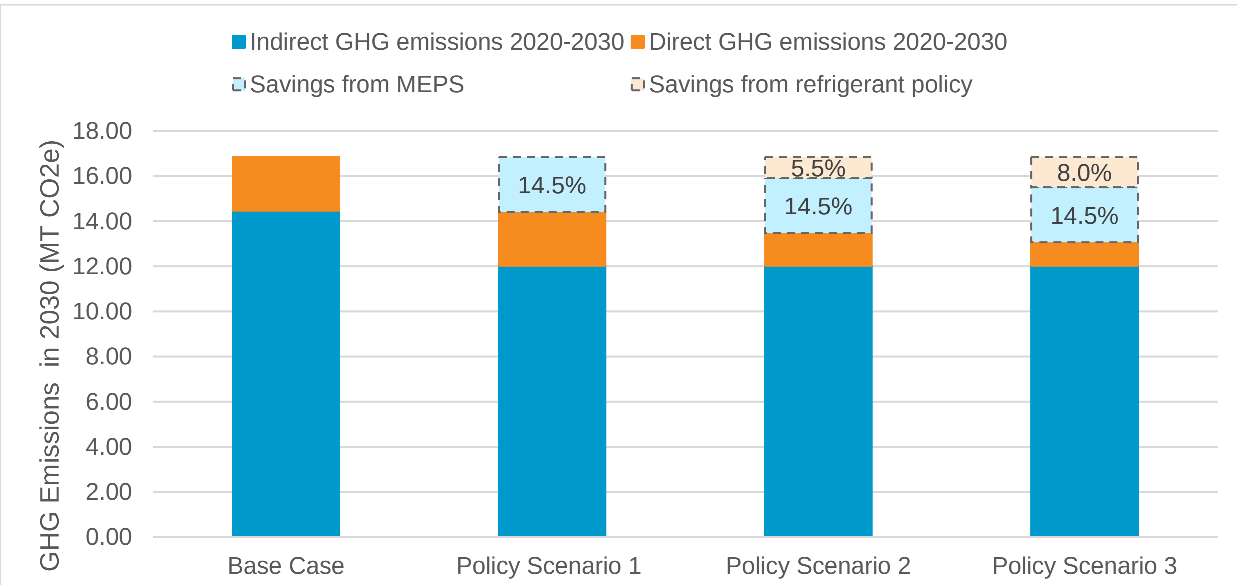



**Figure 37** provides a side by side comparison of total greenhouse gas emissions under each policy scenario. These are indicative values based off modeling conducted exclusively with market data for Kenya, Ethiopia, and Tanzania. The efficiency levels available in the other East African markets, as well as the availability of RACs using each refrigerant type should be expected to vary from country to country. Thus, the benefit of stronger energy efficiency policies in East Africa could be larger or smaller than what CLASP has estimated here, but this analysis provides preliminary insights into the potential benefit from new policies for RACs.

According to this analysis, while energy efficiency can save roughly 14.5% of the cumulative 2020-2030 greenhouse gas emissions from RACs in East Africa, combining energy efficiency policy with refrigerant policy could reduce 2020-2030 greenhouse gas emissions by up to 22.4%. There is clearly room for improvement in the East African regional RAC market. Policymakers should look to implement or increase MEPS for RACs and to potentially restrict the type of refrigerants allowed to be used in RACs. Such policies can complement trade measures to reduce any environmental dumping of inefficient, high GWP RACs from more advanced RAC markets into East Africa.

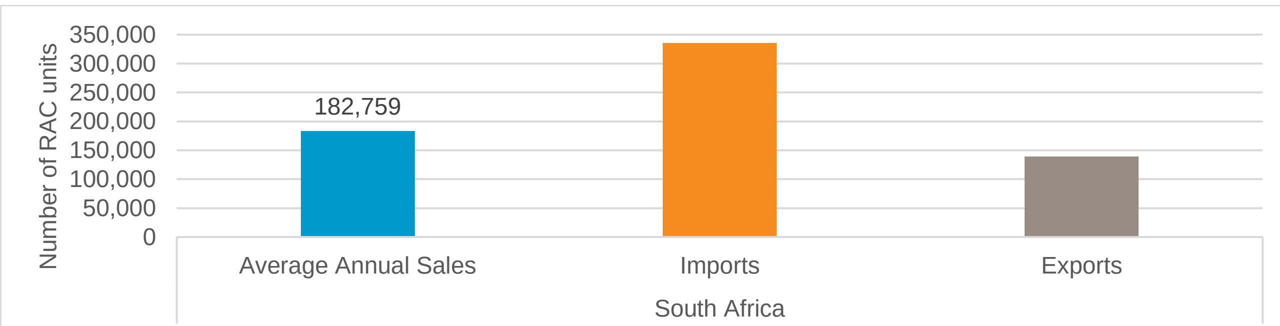
# 9. Status and Impact of Low Efficiency, High GWP RACs in Southern Africa

CLASP and our partners collected data and analyzed the RAC market of the largest economy in Southern Africa: South Africa. South Africa is a member of the Southern African Development Community (SADC), along with another country covered in this study, Tanzania. Data on the other Southern African countries, namely Botswana, Eswatini, Lesotho, and Namibia, was not collected as part of this study.[164]

## 9.1 Southern Africa Market Characteristics and Trade Flows

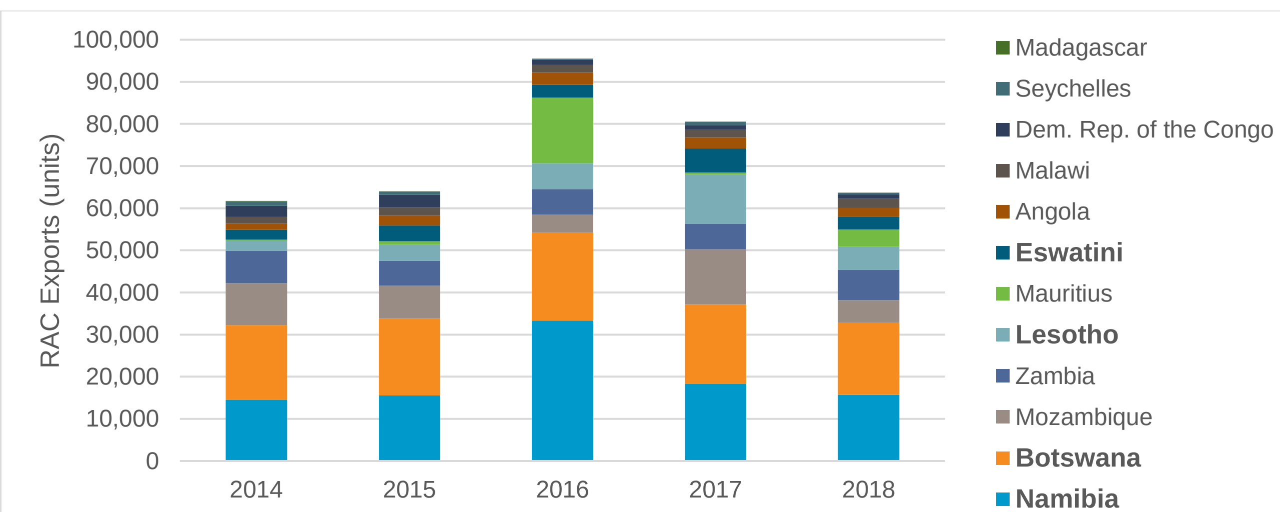
South Africa has the largest RAC market in the Southern African region (180,000 units sold in 2017) while the other countries in the region have much smaller markets[165] (**Figure 38**). South Africa is an imports only RAC market, but also re-exports a significant number of RACs to neighboring countries.

*Figure 38: RAC sales and trade in South Africa*




According to Comtrade South African export data, South Africa reports some RAC trade with other SADC member such as Tanzania, Namibia, Mozambique, Zambia, and Botswana, among others.

*Figure 39: South Africa RAC exports to SADC member states (2014-2018)*




[164] For the purposes of modeling impacts in the next section, Euromonitor modeled data on sales volumes in the remaining four Southern African countries was included.
[165] CLASP was not able to obtain market size estimates for the other Southern African countries. The RAC markets in the other countries is believed to be quite small based on rough estimates modeled by Euromonitor.

The South African market has some of the highest efficiency levels in Africa, with none of the RACs reported sold having efficiencies lower than 3.0 W/W. Additionally, South Africa's market does not have any R-22 with R-410A – a HFC – making up 91% of the market. However, this market for higher efficiency, non-R-22 RACs may be unique to South Africa within the Southern African region, as South Africa has a long-standing standards and labeling programs for RACs which has driven market transformation in the country.

## 9.2 Modeling the Impact of Low Efficiency, High GWP RACs in Southern Africa

To examine the impacts of a transition to higher efficiency RACs with lower GWP refrigerants, CLASP developed three policy scenarios for RACs in Southern Africa and estimated the direct and indirect GHG emissions impact under each scenario. The same scenarios as those defined on **page 42**, were used for impacts evaluation for Southern Africa.

- **Base case (No Efficiency Policy + Unregulated Refrigerant Market)**
- **Policy Scenario 1 (U4E Model MEPS + Unregulated Refrigerant Market)**
- **Policy Scenario 2 (U4E Model MEPS + U4E Refrigerant Regulation)**
- **Policy Scenario 3 (U4E Model MEPS + BAT Refrigerant Regulation)**

To approximate the direct and indirect GHG emissions from RACs in Southern Africa under each scenario CLASP identified cooling capacity and efficiency levels for two baseline RAC models identified through analysis of market data collected by BSRIA. The parameters of these baseline models, as well as the refrigerant distributions in the market, are summarized in **Table 28.**

*Table 28: Baseline models selected for analysis (Southern Africa)*

| RAC Market Segment | Market Share | Cooling Capacity | Energy Efficiency Ratio (EER) | Average MSP | Refrigerant Share | | |
|---|---|---|---|---|---|---|---|
| | | | | | R-22 | R-410A | R-32 |
| CC ≤ 4.5 kW | 35% | 3.5 kW | 4.20 W/W[166] | 1,121 USD | 0% | 87% | 13% |
| CC > 4.5 kW | 65% | 7 kW | 3.21 W/W | 1,037 USD | 0% | 93% | 7% |

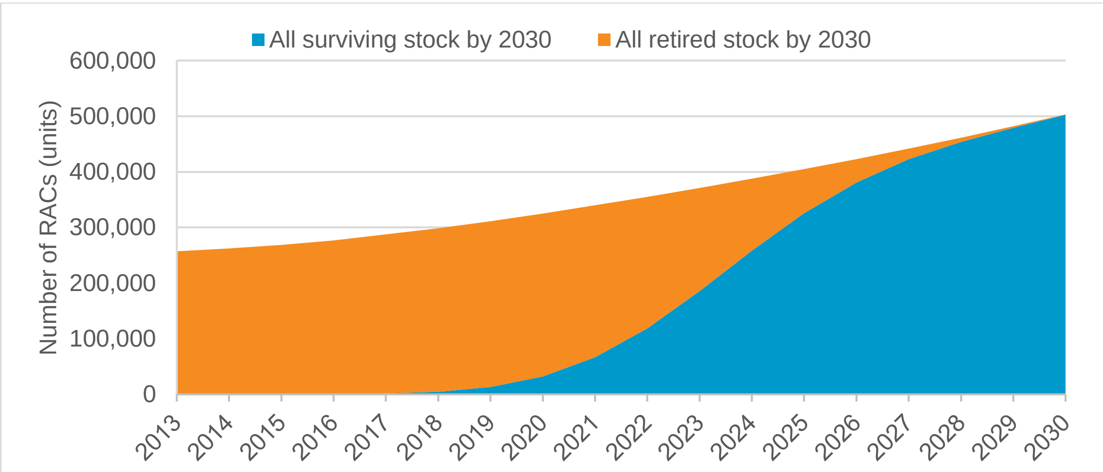
For the three policy options, CLASP analyzed energy savings and GHG emissions reductions from the base case by forecasting energy use of RACs sold from 2020 to 2030. We assume that every unit sold in a specific year has an EER equal to one of two baseline EERs in **Table 28.** CLASP used Euromonitor's 2004-2018 split RAC sales estimates and 2019-2023 projections to approximate a the regional RAC sales volume across five Southern African countries, as defined by the UN,[167] between 2010 and 2023. Euromonitor's 2019-2023 projections averaged a **4.4% compound annual growth rate (CAGR)** at the regional level. This CAGR of 4.4% was used to forecast regional sales for 2024-2030.

In estimating both the indirect and direct emissions from RACs, CLASP accounts for the retirement of a portion of the RAC stock using a survival function based on a normal distribution of the median life of

[166] In the case of South Africa, in order to better represent the distribution of smaller capacity models on the market, CLASP used the median EER at the most popular cooling capacity rather than the most frequently occurring EER, as used in the other analyses in this report.
[167] The United Nations includes the following five countries (for which Euromonitor data was available) in the Southern Africa subregion: Botswana, Eswatini, Lesotho, Namibia, and South Africa.

RACs in Africa (7 years).[168] **Figure 40** shows the sales forecast per year, the portion of the stock (from those annual sales) that survives in 2030 and the portion that has been retired.[169]

*Figure 40: Surviving and retired RAC stock in Southern Africa (2013-2030)*




## Indirect Emissions

CLASP used the Policy Analysis Modeling System (PAMS) to estimate indirect greenhouse gas emissions from the operation of RAC equipment in South Africa. In the model, total energy consumption is estimated per year for the stock of RACs in use under each policy scenario. Emissions are estimated using the estimated surviving RAC stock for each segment of the market, annual unit energy consumption (UEC) of the baseline RAC models,[170] an electricity grid $CO_2$-intensity emissions factor, and the transmission and distribution (T&D) loss factor. The estimates used for Southern Africa are:

- Grid Emissions Factor is assumed to be **1.022 kg/kWh**.[171]
- T&D Loss Factor is assumed to be **8.39%**.[172]
- Annual operating hours is assumed to be **515 hours**.[173]
- Unit energy consumption was calculated based on the baseline values in **Table 28** using the formula:

$$UEC = \frac{Cooling\ Capacity}{EER \times 1000} \times Annual\ operating\ hours$$

[168] Average RAC operating lifetime estimates were available. CLASP assumed an average lifetime of 7 years based on survey findings from Nigeria and the findings of an in-depth RAC market assessment recently conducted in Kenya. CLASP. 2019. Kenya RAC Market Assessment and Policy Options Analysis.https://clasp.ngo/publications/kenya-rac-market-assessment-and-policy-options-analysis-2019

[169] Surviving stock in 2030 refers to the number of units purchased in a year X that are still operating in 2030. Retired stock refers to the units that are no longer operating due to failure.

[170] UEC refers to the amount of energy, measured in kWh, consumed annually by a given RAC model.

[171] Weighted average grid emissions factor for Southern Africa, weighted according to split RAC sales volume. Grid emissions factors were calculated using average $CO_2$ emissions factors from across Annex 1 countries and data on electricity generation from the following World Bank sources: World Bank. 2014. Electric power transmission and distribution losses (% of output), Electricity production from coal sources (% of total), Electricity production from oil sources (% of total), Electricity production from natural gas sources (% of total), Electricity production from nuclear sources (% of total), Electricity production from renewable sources, excluding hydroelectric (% of total), Electricity production from hydroelectric sources (% of total). https://data.worldbank.org/

[172] Weighted average T&D loss factor, weighted according to split RAC sales volumes. World Bank. 2014. Electric power transmission and distribution losses (% of output) available at: https://data.worldbank.org/

[173] Weighted average annual operating hours for RACs in Southern Africa, weighted according to split RAC sales volume. Operating time was estimated based on the product of cooling degree days reported in each country and air conditioner percent operating days.

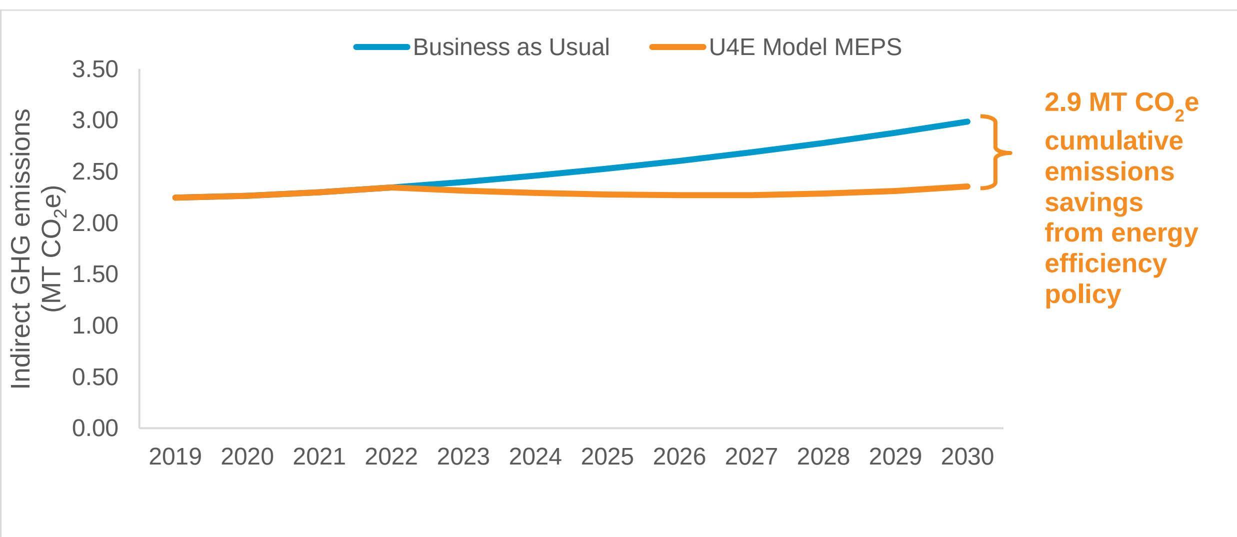
The results of CLASP's analysis of indirect emissions associated with RAC usage in Southern Africa are presented in **Table 29.**

- Under a business-as-usual scenario, in which no changes are made to the MEPS for RACs in the five Southern African countries, CLASP projects that in 2030 RAC usage will require **2.7 GWh of electricity** and indirectly generate **3 MT $CO_2$e of greenhouse gas emissions**.
- However, if in 2022 the Southern African countries were to align their MEPS for RACs with the U4E Model MEPS, as per Policy Scenario 1, annual emissions could be reduced by approximately 21% in 2030, saving **0.6 MT $CO_2$e**. In the eight-year period from 2022-2030, the implementation of these stronger MEPS could allow for a cumulative reduction of 2.9 MT $CO_2$e.

*Table 29: Indirect GHG emissions in Southern Africa*

| | Base Case (No Efficiency Policy + Unregulated Ref. Market) | Policy Scenario 1 (U4E MEPS + Unregulated Ref. Market) | Policy Scenario 2 (U4E MEPS + U4E Ref. Regulation) | Policy Scenario 3 (U4E MEPS + BAT Ref. Regulation) |
|---|---|---|---|---|
| **Annual in 2030** | | | | |
| Energy Consumption (GWh) | 2.68 | 2.11 | 2.11 | 2.11 |
| Emissions (MT $CO_2$e) | 2.99 | 2.36 | 2.36 | 2.36 |
| Savings (MT $CO_2$e) | - | 0.63 | 0.63 | 0.63 |
| % of Base Case Emissions | - | 10.4% | 10.4% | 10.4% |
| **Cumulative 2020 – 2030** | | | | |
| Energy Consumption (GWh) | 25.3 | 22.7 | 22.7 | 22.7 |
| Emissions (MT $CO_2$e) | 28.2 | 25.3 | 25.3 | 25.3 |
| Savings (MT $CO_2$e) | - | 2.94 | 2.94 | 2.95 |
| % of Base Case Emissions | - | 10.4% | 10.4% | 10.4% |

*Figure 41: Indirect GHG Emissions in Southern Africa (2019-2030)*



## Direct Emissions

To analyze the climate benefits of introducing a requirement for the use of refrigerants with lower GWP, emissions of greenhouse gases from the refrigerants needs to be considered.

CLASP estimated the global warming potential of the baseline RAC models in Southern Africa using the *GWPdirect* formula described below.

$$GWPdirect = GWP \times m \times L_{annual} \times n + GWP \times m \times (1 - \alpha_{recovery})$$

GWP = Global Warming Potential of the refrigerant
m = refrigerant charge
$L_{annual}$ = leakage rate per annum
n = operating life
$\alpha_{recovery}$ = recycling factor from 0 to 1

The leakage rate (**10%**), operating life (**7 years**), and recycling factor (**0**) are held constant throughout the model and are identical to those used in the analyses conducted for the other three regions.[174]

The typical refrigerant charges[175] for the Southern African baseline RAC models identified in **Table 28** are shown in **Table 30** alongside the GWP values for current and alternative refrigerants.[176]

*Table 30: Refrigerant charges and GWP values for Southern Africa baseline models*

| Market segment & Baseline Cooling Capacity | R-22 | | R-410A | | R-32 | | R-290 | |
|---|---|---|---|---|---|---|---|---|
| | Average Charge (kg) | GWP ($CO_2e$) | Average Charge (kg) | GWP ($CO_2e$) | Average Charge (kg) | GWP ($CO_2e$) | Average Charge[177] (kg) | GWP[178] ($CO_2e$) |
| CC ≥ 4.5 kW (3.5 kW model) | 0.85 | 1810 | 0.77 | 2088 | 0.71 | 675 | 0.30 | 1 |
| CC > 4.5kW (7 kW model) | 1.60 | | 1.41 | | 1.15 | | 0.38 | |

Using the retired stock of RACs from 2020 – 2030, and the corresponding *GWPdirect*, we estimated the cumulative value of greenhouse gas emissions by 2030 from their refrigerants charge as:

$$Cumulative\ GHG_{2030} = \sum_{y=2020}^{2030} Retired\ stock\ in\ 2030\ (y) \times GWPdirect\ (y)$$

Per **Table 28**, the market share of RACs with cooling capacities under 4.5 kW is 35%. Approximately 87% of these RACs use R-410A and approximately 13% of these RACs use R-32.[179] For the 65% of RACs with cooling capacities above 4.5 kW, approximately 93% use R-410A and 7% use R-32. CLASP used these values to develop a methodology for weighting the retired stock of RACs for each market segment.

For the policy scenarios (Base Case and Policy Scenario 1) for which there is no requirement to transition to lower GWP refrigerants, we assessed direct emissions for each RAC market segment under analysis

[174] See **Table 2** in the Methodology section for further detail on these inputs were chosen for this report.
[175] BSRIA did not collect charge information in the RAC market data collected. For R-22, R-410A, and R-32 refrigerant charges, approximate average charges were estimated based on RAC market data collected by CLASP in 2018 for the Vietnamese and Thai markets. Because CLASP did not find R-290 RACs in the African market, approximate average charges for R-290 RACs were obtained from the India Bureau of Energy Efficiency database.
[176] IPCC Fourth Assessment Report: Climate Change 2007 (AR4).
[177] Because CLASP did not find R-290 RACs in the African market, approximate average charges were obtained from the India Bureau of Energy Efficiency database.
[178] The GWP of R-290 is estimated to be <1. To model an R-290 transition in a conservative manner, CLASP assumed a GWP equal to 1 for R-290.
[179] The South African market data from BSRIA was unique in that no R-22 RACs were detected on the market.

(CC < 4.5 kW as represented by the 3.5 kW baseline and CC ≥ 4.5 kW as represented by the 7 kW baseline model). Direct emissions were calculated according to the share of R-22, R-410A, and R-32 RACs found within each market segment, as per the data from BSRIA, using the corresponding GWP values. For the period 2019-2030, CLASP assumed the following changes to the market share of refrigerants in accordance with Montreal Protocol phase-out and phase-down schedules for R-22 and R-410A:

- Beginning in 2022, R-32 share increases by 1%. CLASP has observed in other markets (e.g. the Philippines)[180] that without ambitious refrigerant or efficiency policies, R-32 enters developing AC markets slowly.

*Table 31: Southern Africa Business-as-Usual RAC Refrigerant Share Assumptions*

| | 3.5 kW Baseline Model | | | 7 kW Baseline Model | | |
|---|---|---|---|---|---|---|
| Year | R-22 Share | R-410A Share | R-32 Share | R-22 Share | R-410A Share | R-32 Share |
| **2019** | **0%** | **86.8%** | **13.2%** | **0%** | **92.7%** | **7.3%** |
| **2020** | 0% | 86.8% | 13.2% | 0% | 92.7% | 7.3% |
| **2021** | 0% | 86.8% | 13.2% | 0% | 92.7% | 7.3% |
| **2022** | **0%** | **85.8%** | **14.2%** | **0%** | **91.7%** | **8.3%** |
| **2023** | 0% | 84.8% | 15.2% | 0% | 90.7% | 9.3% |
| **2024** | 0% | 83.8% | 16.2% | 0% | 89.7% | 10.3% |
| **2025** | 0% | 82.8% | 17.2% | 0% | 88.7% | 11.3% |
| **2026** | 0% | 81.8% | 18.2% | 0% | 87.7% | 12.3% |
| **2027** | 0% | 80.8% | 19.2% | 0% | 86.7% | 13.3% |
| **2028** | 0% | 79.8% | 20.2% | 0% | 85.7% | 14.3% |
| **2029** | 0% | 78.8% | 21.2% | 0% | 84.7% | 15.3% |
| **2030** | **0%** | **77.8%** | **22.2%** | **0%** | **83.7%** | **16.3%** |

For Policy Scenario 2, all RACs sold in and after 2022 are assumed to use R-32. Therefore, CLASP follows the weighting methodology described above through 2021, and then assumes the R-32 GWP of 675 from 2022-2030.

For Policy Scenario 3, all RACs sold in and after 2022 are assumed to use R-290. Therefore, CLASP follows the weighting methodology described above through 2021, and then assumes the R-290 GWP of 1 from 2022-2030.

Results from the direct emissions analysis above are presented in **Table 32.**

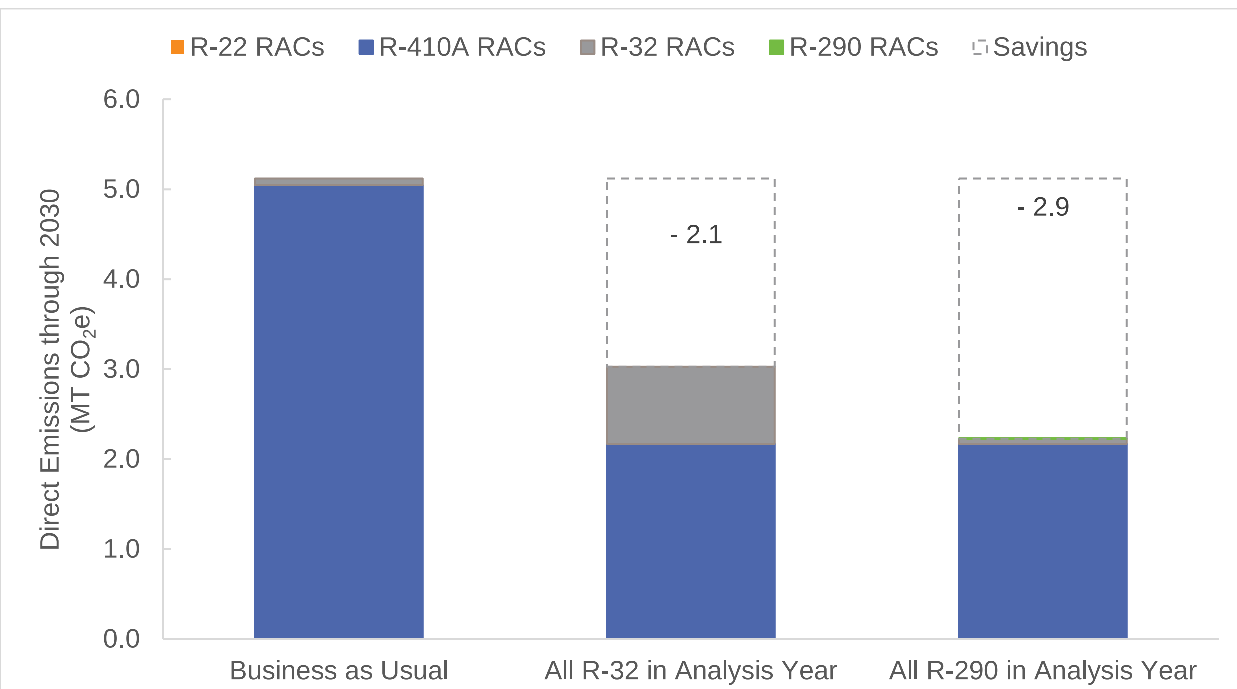
[180] Based on prior research conducted by CLASP, between 2015 and 2018 the market penetration of R-32 RACs grew from 0% to 7.8%. By comparison, the market for R-410A RACs grew from 0% to 32% over the same period. CLASP. 2019. *Philippines Room Air Conditioner Market Assessment and Policy Options Analysis.* https://clasp.ngo/publications/philippines-rac-market-assessment-and-policy-options-analysis-2019

*Table 32: Cumulative direct GHG emissions from retired RACs in Southern Africa 2020-2030*

| Source | Direct Emissions by Scenario (MT $CO_2$e) | | | |
|---|---|---|---|---|
| | **Base Case** (No Efficiency Policy + Unregulated Ref. Market) | **Policy Scenario 1** (U4E MEPS + Unregulated Ref. Market) | **Policy Scenario 2** (U4E MEPS + U4E Ref. Regulation) | **Policy Scenario 3** (U4E MEPS + BAT Ref. Regulation) |
| R-22 RACs | 0.00 | 0.00 | 0.00 | 0.00 |
| R-410A RACs | 5.04 | 5.04 | 2.17 | 2.17 |
| R-32 RACs | 0.08 | 0.08 | 0.86 | 0.06 |
| R-290 RACs | 0.00 | 0.00 | 0.00 | 0.00 |
| **Total** | **5.12** | **5.12** | **3.03** | **2.23** |
| Savings | - | - | 2.09 | 2.89 |
| % of BAU Emissions | - | - | 40.9% | 56.5% |

**Figure 42** illustrates the potential savings from emissions savings from refrigerant policy in Southern Africa and demonstrates that the bulk of direct emissions are likely to come from the R-410A RACs with both high GWP and the largest share of the Southern African market.

*Figure 42: Cumulative direct GHG emissions from retired RACs in Southern Africa 2020-2030*




## Total Equivalent Warming Impact

By adding together the indirect and direct emissions estimates we calculated, CLASP approximated the Total Equivalent Warming Impact of RACs in Southern Africa. The results of the full analysis are summarized in **Table 33.**

*Table 33: Total 2020-2030 GHG emissions from RACs in Southern Africa under four scenarios*

| Source | Cumulative Indirect & Direct Emissions 2020-2030 (MT $CO_2e$) | | | |
|---|---|---|---|---|
| | **Base Case** (No Efficiency Policy + Unregulated Ref. Market) | **Policy Scenario 1** (U4E MEPS + Unregulated Ref. Market) | **Policy Scenario 2** (U4E MEPS + U4E Ref. Regulation) | **Policy Scenario 3** (U4E MEPS + BAT Ref. Regulation) |
| Indirect emissions | 28.2 | 25.3 | 25.3 | 25.3 |
| Direct Emissions | 5.12 | 5.12 | 3.03 | 2.23 |
| **Total** | **33.3** | **30.4** | **28.3** | **27.5** |
| Savings | - | 2.95 | 5.04 | 5.84 |
| % of BAU Emissions | - | 8.8% | 15.1% | 17.5% |

*Figure 43: Cumulative 2020-2030 GHG emissions from RACs in Southern Africa under four scenarios*

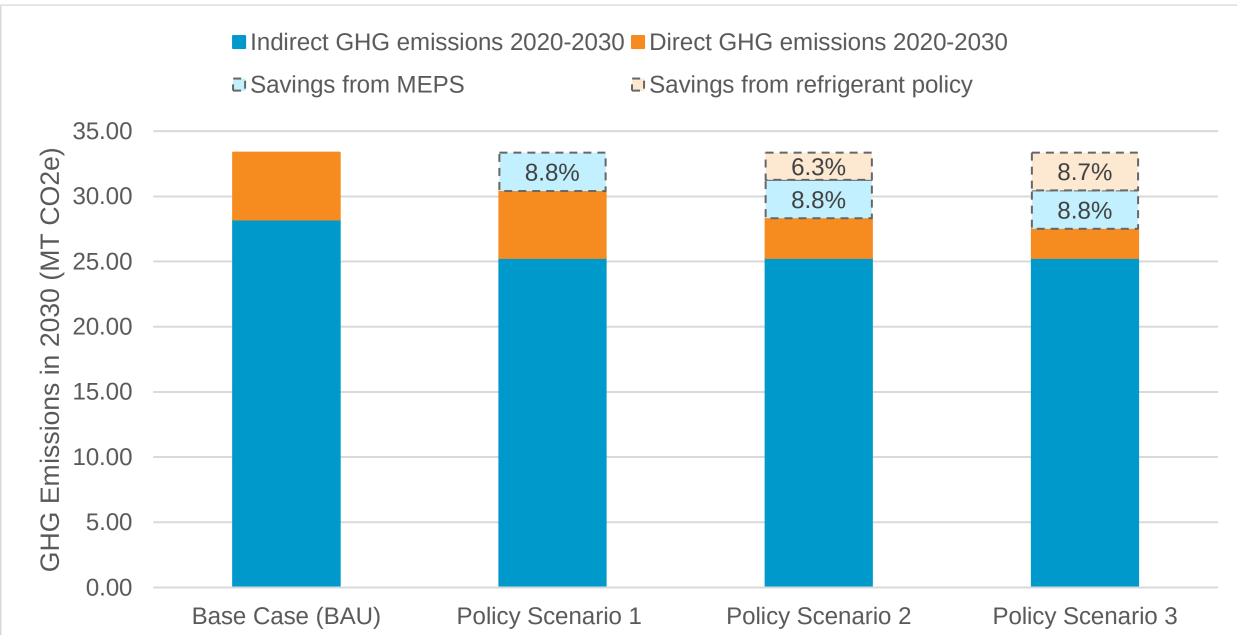



**Figure 43** provides a side by side comparison of total greenhouse gas emissions under each policy scenario. These are indicative values based off modeling conducted exclusively with South African market data. Given how advanced South Africa's RAC market is and the long-standing RAC MEPS in South Africa, the efficiency levels available in the markets of the Botswana, Eswatini, Lesotho, and Namibia are likely somewhat lower, on average, than those used in this analysis. Thus, the benefit of stronger energy efficiency policies in Southern Africa could be larger than what CLASP has estimated here.

According to this analysis, while energy efficiency can save roughly 8.8% of the cumulative 2020-2030 greenhouse gas emissions from RAC in Southern Africa, combining energy efficiency policy with refrigerant policy could reduce 2020-2030 greenhouse gas emissions by up to 17.5%. There is clearly room for improvement in the Southern African regional RAC market. Policymakers should look to implement or increase MEPS for RACs and to potentially restrict the types of refrigerants allowed to be used in RACs. Such policies can complement trade measures to reduce any environmental dumping of inefficient, high GWP RACs from more advanced RAC markets into Southern Africa.

# 10. Conclusion

## Results of Assessment

The market for room air conditioners in Africa is growing, and each country will face unique challenges in limiting negative environmental impacts from the RACs entering their markets. Energy efficiency and refrigerant policies can play a significant role in reducing future GHG emissions from RACs across all four regions covered by this study. Adopting U4E Model MEPS in 2022 could reduce cumulative 2022-2030 GHG emissions in the four regions by **40 MT $CO_2$e**. Simultaneously adopting the U4E guidance to disallow refrigerants with GWPs greater than 750 could save an additional **10 to 15 MT $CO_2$e** through 2030, depending on the level of ambition.

*Table 34: Cumulative GHG emissions reductions potential in Africa under U4E Model Regulations*

| Region | Cumulative Indirect Emissions Reductions from Energy Efficiency Policy | Cumulative Direct Emissions Reductions from Refrigerant Policy | |
|---|---|---|---|
| | | GWP ≤ 750 | GWP ≤ 1 |
| Northern Africa | 9.9 | 4.2 | 6.0 |
| Western Africa | 24.6 | 3.0 | 4.3 |
| Eastern Africa | 2.4 | 0.9 | 1.3 |
| Southern Africa | 2.9 | 2.1 | 2.9 |
| **Total** | **39.9 MT $CO_2$e** | **10.3 MT $CO_2$e** | **14.5 MT $CO_2$e** |

This study presents evidence of the environmental dumping of inefficient, high-GWP RACs into the African market:

- RACs with efficiencies of less than 3.0 W/W make up 35% of the overall RAC sales in the ten African focus countries. The market size for these low efficiency units is about 650,000 units.
- RACs containing R-22, an HCFC refrigerant with a 100-yr GWP of 1,810, scheduled to be phased out globally in accordance with the Montreal Protocol, still account for 47% of overall RAC sales in the ten focus countries.

Environmental dumping is occurring not only when non-African companies export lower efficiency products to Africa, but also through the less direct practice of forming joint ventures between African and non-African companies to manufacture products less efficient than those produced by the non-African JV partners for their own domestic markets. Most low efficiency, high-GWP RACs found in Africa through this study were assembled by local subsidiaries of non-African companies and joint ventures between local companies in Nigeria and Egypt and non-African companies. However, this practice is a form of environmental product dumping, as key components for locally assembled units, such as refrigerants and compressors, typically originate abroad. Without robust energy efficiency policies to restrict the types of RACs allowed on the market, imports-only markets in Africa will continue to be flooded with lower efficiency products.

## Recommendations to Policymakers

Based on the finding of this report, and drawing from IGSD's anti-environmental dumping "toolkit," described in "Defining the legal and Policy Framework to Stop the Dumping of Environmentally Harmful Products," African policymakers can take the following steps to halt environmental RAC dumping and ensure a transition to highly-efficient, low-GWP RACs in the African market:

1. **Ratify the Kigali Amendment to the Montreal Protocol and adopt implementing policies:** Ratifying and implementing the Kigali amendment, for those African countries that have not already done so, demonstrates a commitment to pursuing a low-GWP path for cooling technologies. R-22 RACs are still highly prevalent in Africa, however as African countries prepare to phase out R-22 under the Montreal Protocol, in the absence of other policies, R-410A RACS are expected to flood

the market, especially as other countries adopt early HFC phasedown strategies. Ratifying and implementing the Kigali Amendment will convey the message to local and non-African RAC manufacturers ad exporters that the African market for RACs will require alternative refrigerants. Manufacturers may be more encouraged to bring R-32 and R-290 products into the African market more quickly.

2. **Design and implement MEPS & labeling policies consistent with major countries of export.** Currently, the MEPS for RACs in the few African countries with MEPS tend to be low in comparison to the MEPS in place in the countries that manufacture RACs and RAC components. Implementing MEPS at levels comparable to MEPS in RAC source countries can prevent the environmental dumping of inefficient products and provide substantial GHG emissions savings over time.
3. **Strengthen institutional arrangements.** Institutional arrangements, including how administrative responsibilities for energy efficiency and refrigerants are allocated within a particular government, are critical for efforts to minimize dumping of cooling equipment and components. This includes efforts to combat fraud in MEPS certifications, labeling and product performance claims. Similarly, coordination between authorities responsible for implementing energy efficiency and Montreal Protocol policies, including energy and customs authorities, is essential. Political support is critical for allied responses of champions within agencies and departments to combat anti-dumping.
4. **Revise tariffs on RACs to ensure compatibility with energy efficiency goals:** Trade policies can support or hinder energy efficiency policies. High import tariffs, like those protecting local RAC manufacturers in Egypt and Algeria from foreign competition, may perversely prevent newer technologies from entering the market and reduce the level of ambition from local assemblers and joint ventures. Similarly, high tariffs may drive the creation of black markets for unregulated or secondhand products, as observed in Tunisia. Preferential tariffs should be carefully evaluated to ensure that they do not perversely incentivize the assembly and sale of low efficiency products and should be coupled with robust MEPS.
5. **Ban the import of secondhand, including refurbished, and inefficient RACs and widely publicize and enforce the ban:** Bans on secondhand products, if properly enforced and publicized as in Ghana, can eliminate one official channel for out-of-date or unregulated products. Bans can specify financial penalties for everyone and every enterprise involved in the illegal supply chain.
6. **Organize bulk purchase and buyers' clubs:** Bulk purchases and buyers' clubs help to aggregate demand and purchase high efficiency and low GWP RACs at affordable prices. This type of program can be designed to target replacement of older and inefficient RAC equipment that contains high-GWP refrigerants. Replacement programs are a tool that governments can deploy to respond to economic downturn, as they create jobs in the service sector and benefit consumers by reducing electricity bills.
7. **Properly recycle and dispose of obsolete room ACs:** Policies to regulate the disposal of obsolete air conditioning and refrigeration equipment can help to reduce the environmental impacts of high-GWP refrigerants, by avoiding end-of-life leakage and preventing refurbishing and redeployment of used equipment in the secondhand market.[181]
8. **Elevate solutions to regional level.** Countries will be most successful in addressing environmental dumping when working together regionally to adopt and implement these recommendations (including harmonization around U4E model regulations). Absent regional coordination, if one country adopts policies to avoid environmental dumping, but a neighboring country does not, the neighboring country not only risks greater environmental dumping in its market, but also risks becoming a conduit for continued dumping into its neighbor due to the porous nature of many borders.

[181] In regions without existing infrastructure for disposal, refrigerant can be collected and destroyed in local cement kilns and old equipment can be recycled for parts and materials.

9. **Engage local groups profiting under current system by trading in obsolete equipment to be part of the solution.** For example, Ghana's Energy Commission brought together those involved in trading used cooling products to form an Association with elected leaders to facilitate agreement on a transition plan. For new equipment manufactured or assembled in Africa, identify financial incentives to allow local assemblers to modernize their equipment, organize buyers clubs and trainings so as to empower and engage local groups in the transition towards assemble more efficient RACs and Refrigerants.

### Recommendations in Action – Replacing Older ACs in Morocco

IGSD with participation of the Government of Morocco and private sector partners including BMCE Bank of Africa has developed a strategy to jump-start recovery from the COVID-19 recession, with year-round jobs and small enterprise profits while keeping Morocco on track for renewable energy, clean air, and climate protection. The plan is to transition from the business-as-usual (BAU) dumping of inefficient ACs using obsolete ozone-depleting and climate-forcing refrigerants to next generation technology made affordable by aggregating AC demand for a discount bulk purchase and properly installing and servicing *en masse* for sustained energy performance.

The work in Morocco will document the age, nameplate cooling capacity, energy efficiency, full load energy use, and refrigerant of the ACs that are replaced. The project also will calculate the estimated savings of the next-generation ACs that are installed. These calculations will prove the economic merit of expanding the AC replacement in Morocco and replicating the strategy throughout Africa. The model is likely appropriate for replacement of older refrigeration and AC equipment in all other applications.

The transition has its largest impact from replacing older room ACs that were inefficient when purchased, badly installed, and poorly maintained—but also gains from immediate upgrade of MEPS justified by the new lower price of energy efficient equipment and the appreciation for environmental performance of climate-friendly refrigerants. The obsolete R-22 and R-410A refrigerants will be recovered and destroyed in local cement kilns and the usable parts and materials will be recycled to create more jobs and to conserve natural resources and also to avoid redeployment.

Each aspect of the integrated approach has synergistic environmental and economic advantages:

1. Stopping the dumping of equipment with obsolete refrigerants removes the impulse to buy the lowest cost AC without consideration of long-term energy costs.
2. Bulk purchase and installation reduce the cost of proper choice more reliably than enlightened self-interest alone, allowing governments and consumers to go beyond self-interest to social interest in clean air and climate protection.
3. MEPS can be rapidly strengthened to reflect the lower cost of high efficiency as a result of aggregated demand and bulk purchase.
4. Replacing older equipment that was inefficient when purchased, improperly installed with too little air circulation or stacking and clustering of condensers, then poorly maintained, has a faster payback than installing new efficiency upgrades. AC replacement also supports a much larger market.
5. Replacement ACs en masse by trained technicians lowers the cost of refrigerant recovery, with technicians working on other tasks while the unattended recovery is underway. Replacement ACs *en masse* also lowers the installation cost with specialized training and tools and an inventory of spare parts at hand.
6. Refrigerant destruction in local cement kilns avoids the considerable cost of 1) storage while waiting for expensive permits, 2) permit preparation and tracking, 3) transport to distant dedicated destruction facilities, and 4) the higher cost of stand-alone destruction in facilities designed for high efficiency of more hazardous chemicals. Local cement kilns also have the

advantage of being able to destroy ODS and HFC whenever the incremental costs are lowest, rather than having to adhere to scheduled destruction regimens at destruction-only facilities.

7. Mandatory recycle of the old AC parts and materials and refrigerant destruction conserves natural resources and prevents re-sale and re-deployment of the old equipment.
8. The number of jobs to replace older equipment is eight or ten times greater than just installing equipment in new installations. These jobs would be immediately available during the first stages of economic recovery. AC replacement can be scheduled year-round to provide year-round full-time jobs and better utilization of tools. Contrast that with the installation jobs that typically are needed only at the beginning of the cooling season, with lay-offs during cooler periods and then recruitment and retraining for the next cooling season.
9. Manufacturers of the lower-GWP, super-efficient equipment specified in the bulk purchase are rewarded with higher sales and lower marketing cost, with higher employment for larger output. This is particularly appreciated during times of economic recovery, with economy of scale in manufacture allowing lower costs. The bulk purchase of components and materials also contributes to the ability to profit more, even with lower per-unit revenue.
10. Money saved on energy costs is spent locally and recirculates for the benefit of neighborhoods and nations, which is particularly appreciated during economic recovery. Lower ownership costs make cooling for reasons of health more affordable.
11. The Morocco scheme can be adapted to developed countries, since it is tailored to achieve jobs and profits during economic recovery and to secure lasting reductions in GHG emissions from lower-GWP refrigerants and higher efficiency. It also can be expanded from ACs to other appliances.

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### Directions for Future Research by CLASP, IGSD, and Cooperating Partners

This report is based on available market research and data by BSRIA and other respected sources. Insufficient data can often be one of the largest challenges in conducting market research in developing countries. CLASP identified five main areas for further research.

**On-the-ground market research to gather information on the informal, and sometimes illegal, secondhand product market**. This report is based on available market research and data by BSRIA and other respected sources. One of the main challenges in conducting the research was the lack of available data on secondhand air conditioner markets in Africa. In countries without specific bans on the import and sale of secondhand (or used) RACs there are not standard systems in place for tracking the sales of these products, this additional on-the-ground market research can fill that gap.

**Research in the supply chain of the air conditioning components market**. There is a significant amount of assembly of inefficient air conditioners using obsolete refrigerants in Africa, despite that many of the major non-African manufacturers associated with assembling, or providing the components for assembly of, these products have access to better components. Future environmental dumping research should examine the forces behind the environmental dumping via these mechanisms.

**Research on tools for African markets to leapfrog from R-22 RACs to R-32, R-290 RACs or other refrigerant blends with GWP under 750.** This report identifies that African countries moving away from R-22 are transitioning mostly to R-410A equipment. This trend exists despite similar efficiency levels and prices for R-410A and R-32 RACs. Further research can determine why this trend exists and identify tools available to policymakers to leapfrog AC market to other refrigerant blends with GWP under 750.

**Research on illegal trade of ozone depleting substances into Africa.** Currently, assessing the extent of illegal trade from Asian into Africa of ODSs and products using ODSs is made difficult by a lack of data and reporting on such trade. However, there appears to be some data and reports on such trade between Asian countries.

**Research on the scale of non-compliance with MEPS in Africa.** There is little information on the extent of compliance issues in Africa countries were MEPS have been implemented. Further study is needed to determine the scale of non-compliant activities such as false/counterfeit labeling, false statements of compliance with MEPS by local assemblers, suppliers and manufacturers, and false product performance claims.