DOMESTIC REFRIGERATING APPLIANCE AND ROOM AIR CONDITIONER MARKET AND FEASIBILITY ASSESSMENT

ECOWAS Refrigerators and ACs Initiative (ECOFRIDGES) in Ghana

FINAL REPORT
March 2020

Authors: Centre for Energy, Environment, and Sustainable Development (CEESD)

For: United for Efficiency (U4E) and
Basel Agency For Sustainable Energy (BASE)

With the support from: Kigali Cooling Efficiency Program

EXECUTIVE SUMMARY

1. Introduction

This report was prepared as part of the first phase of the ECOWAS Refrigerators and Air Conditioners Initiative (ECOFRIDGES). ECOFRIDGES is a joint project by UNEP's United for Efficiency initiative (U4E), the Governments of Ghana and Senegal, and the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE). ECOFRIDGES aims to introduce into the market highly energy-efficient products that are available at scale in other markets but not yet in Ghana, that will target consumers who can be early adopters which in turn will benefit all consumers in the years ahead as these newly introduced products become more familiar and proven in the Ghanaian context. The Basel Agency for Sustainable Energy (BASE) provides technical expertise on the market and feasibility assessment, and the development and launch of a financial mechanism to accelerate the adoption of energy-efficient and climate-friendly cooling products in the residential and light commercial sectors. The African Development Bank (AfDB) is engaged as a potential financier. ECOFRIDGES is enabled via funding support by the Kigali Cooling Efficiency Program (KCEP).

Increased electricity generation has been the traditional response to increasing energy demand. In recent times, however, the global focus has been on harnessing the potential of energy efficiency and its related benefits. Energy efficiency facilitates delivery of the same, and in some cases, more services for less energy. Additionally, it helps to mitigate a key driver of climate change. Furthermore, it helps the global economy by saving consumers and businesses alike money in terms of the cost of energy and cost of providing additional generation capacity. Adoption of increased energy efficiency related activities is profitable and critical for increased individual benefit and national development.

In Ghana, domestic refrigeration and air-conditioning (AC) appliances constitute a significant portion of the residential electricity consumption. Refrigerators are the first main appliances purchased by most households. Air-conditioners are also acquired for cooling as income increases. These appliances present a significant potential for energy efficiency improvement (typically 50 per cent in cost effective energy savings[1]) and appear always as a priority in any market transformation strategy.

2. Objective and methodology of assignment

[1] UNDP, 2010, Promotion of Appliances of Energy Efficiency and Transformation of the Refrigeration Appliances Market in Ghana: Project Document

In this assignment, the objective was to carry out market research and feasibility assessment for the introduction of energy-efficient refrigerators and air-conditioners as replacement for older and inefficient ones in use in homes and small businesses. The assignment was carried out mainly through desk studies, surveys, field trips and semi-structured interviews with actors and stakeholders. The desk study comprehensively examined relevant, previous initiatives as they present useful lessons, which can be effectively considered for this project. The fieldwork included a survey of households and interviewing of stakeholders using structured and semi-structured questionnaires. A total of 599 households were surveyed, consisting of the most populous cities drawn from each of the geographical zones of the country: Tamale (northern), Kumasi (middle) and Accra (southern zone), and more than 26 other key stakeholders were interviewed. Verification of household data was done randomly using completed questionnaires. Data obtained were analysed and information obtained used to define potential market segments, market size, barriers and opportunities. Based on the outcome of the analysis, two broad financing approaches have been proposed.

3. Other initiatives on appliances

Other initiatives on appliances in Ghana include:

- Efficient Air – Conditioning Programme in Ghana - (Under the Kigali Cooling Efficiency Programme (KCEP) – supported by UNDP
- Green Cooling Africa Initiative – supported by GIZ
- Hydrochlorofluorocarbon Phase-out Management Plan (HPMP) – supported by the Multilateral Fund under the Montreal Protocol

The three initiatives generally focus on the adoption of cooling technologies that use natural refrigerants, with the aim to reduce GHG emissions. However, the initiatives also ensure that energy efficiency of adopted appliances conforms to the MEPS and labelling in Ghana. The implementing agency of all the three initiatives is the Environmental Protection Agency (EPA).

3.1 Efficient Air – Conditioning Programme in Ghana

The key activities under the project were:

- Determine the energy consumption baseline for the AC sector in Ghana;
- Assess the feasibility of a rebate scheme for the AC sector and provide recommendations on implementation modality and potential co-funding source;
- Capacity building for enforcement of energy efficiency in the AC sector; and
- Presentation of findings to national stakeholders

Among other outputs, the project analysed various financial delivery mechanisms for a rebate scheme for ACs - volume rebates, growth rebates, retention rebates, mixed rebates and price masking rebates. The project recommended a trade-in and replacement programme through a

price masking rebate for ACs in Ghana, similar to the refrigerator rebate scheme that was implemented by the Energy Commission. However, funding for recommended rebate scheme for ACs has not yet been secured, so the scheme has been put on hold until funding becomes available.

3.2 Green Cooling Initiatives

The project has four key components:

- Framework conditions
- Policy advice
- Technology transfer
- Capacity building

GIZ is also submitting a proposal for funding (approx. US$ 42.5 million) to the Green Climate Fund on the project "GCF Green Cooling Project (Ghana component)."

3.3 Hydrochlorofluorocarbon Phase-out Management Plan (HPMP)

In the period 2013-2019, the EPA has converted 10,000 ACs in Ghana from R22 refrigerants to hydrocarbon R290 refrigerants, under the HPMP with funding from the Multilateral Fund of the Montreal Protocol.

3.4 Synergy between ECOFRIDGES Ghana and other initiatives on appliances

The three other initiatives on ACs aim to transform the AC market in Ghana through the shift from cooling technologies using high GWP refrigerants to low GWP hydrocarbon R290 refrigerants, whilst also ensuring that all adopted ACs are highly energy-efficient and conforming to the MEPS and labelling in Ghana. Thus, engagement with the EPA will be pursued to build synergy between ECOFRIDGES and the three other initiatives on ACs.

4. Market assessment and characteristics of refrigerators and air conditioners

4.1 Market overview

The study estimated that about US$ 600 million will be required to replace all second-hand domestic refrigerators and another US$ 46 million will be required for second-hand domestic air-conditioners in Ghana. As of January 2019, there were approximately 1.6 million domestic second-hand refrigerators in Ghana in addition to 190,000 refrigerators that were purchased new but are older than 10 years since first installation. Similarly, second-hand air-conditioners and those older than 10 years since first installation are about 12,000 and 90,000 units respectively.

Generally, the proliferation of ACs was found to be lower than refrigerators. A total number of 576 households representing 96.1 per cent of household sampled had refrigerators as compared

to 102 households (representing 17.0 per cent of households sampled), which had air-conditioners. However, increased demand for both appliances are projected for the coming years due to growth in middle-income households, urbanisation and expansion of national electrification coverage. Additional factors include population growth, increased expendable income, ease of installation and increased estate development.[2] Major refrigerator brands used in households include Nasco, Samsung, Hisense, Legacy, Akai, Bruhm, Beko, Midea and LG. Nasco and Hisense, which are new entrants, constituted the dominant brands on the market. This observation could be attributed to their relatively lower prices and the fact that their quality is yet to be tested. Frequently used air-conditioning brands include Galanz, Bruhm, Beko, Samsung, Akai, Hisense, Craft, Nasco, TCL, Sanyo, LG, Chigo, Breeze, and Midea. New appliances are usually obtained from specialised shops while the used units are obtained from second-hand street vendors. Almost all households surveyed paid cash (99 per cent) for the appliances with less than 1 per cent using mobile money, bank transfer, or debit card as means of payment.

It was found that despite awareness creation efforts by Energy Commission and its allied partners on the benefits of new and efficient appliances as well as a ban on importation of second-hand refrigerators, used refrigerators and ACs constitute about 50 per cent and 30 per cent respectfully of appliances found in households. This could be due to the long-standing perception that places a premium on electronic appliances originating from Europe and North America compared to the same products from Asia[3]. Further the purchase price of second-hand refrigerators and air-conditioners were found to be about 40 per cent cheaper than new ones with similar cooling capacities.

4.2 Factors which influence household decision to purchase

Results from the study indicate that price, quality, energy consumption and access to finance are the major factors which influence household decision to purchase a refrigerator. Similarly, for air-conditioners, quality, energy consumption, access to finance and price were found to be the major influencing factors. Generally, household income was found to be low (<GHS1,000 per month). The majority (51 per cent) of respondents had bank accounts mainly with commercial banks, but only 10 per cent of bank account holders have ever taken loans from their banks even though they have been doing business with their respective banks for an average of 7 years.

However, access to finance still remains a challenge due to the number of conditions that need to be satisfied. Some of the conditions to having a successful loan application include evidence of banking with the financial institutions for a period of not less than 5 years, access to collateral, a minimum of two guarantors, and a liquid account. The case was much easier for government workers because loan repayments could easily be deducted from their employer, while their end

[2] German Green Cooling Initiative, GIZ, 2018
[3] Interview with households

of service benefit/severance package was used to serve as collateral while colleagues readily guarantee for each other.

5. Feasibility analysis

The study observed that households could pay back the cost of acquiring a new room AC with a loan at market rate (25%) in about 2.1 years through a monthly saving made from electricity bills, while for a domestic refrigerator, it will take them 4.1 years to payback the cost of replacing their old refrigerators. Also, taking a loan at market rate (25%) to replace an old inefficient refrigerator seems to be quite motivating and the cost of borrowing affects the cost-benefit payback period significantly. Moreover, loans remove the barrier of high upfront cost of acquiring a new refrigerator by providing households the opportunity to pay small monthly amounts.

5.1 Financial mechanism options

The present market and feasibility assessment considered an initial variety of non-exclusive financial mechanism options and filtered down to two that are best-suited for further consideration as possible options to transform the Ghanaian market for domestic cooling appliances, namely, consumer-targeted and supplier/distributor targeted financing mechanisms. For instance the consumer-targeted mechanisms (CTM) could offer consumers attractive capital with special financing and repayment conditions through commercial banks (green loans, employee loans), retailers (vendor financing, rebates) or the utilities (on-bill financing) to acquire more efficient appliances and address the high upfront cost and traditionally low access to finance barriers. For example, the supplier/distributor targeted mechanisms (SDTM) aimed at motivating suppliers to import only highly efficient and climate-friendly appliances at lower cost through rebate negotiations or by providing distributors and retailers energy efficiency loans from local financial institutions with special conditions to address similar financial and technical market barriers.

5.2 Sensitivity and risk analysis

Perceived risks with such interventions include: uncertainties about performance of appliances and reliability of energy savings, technology risks, exchange rate risks, tariff manipulation, contract risk (suppliers/distributors), high interest rate, and delays in reimbursements/payments to suppliers. Risk mitigation instruments such as credit risk guarantees, and positive list are recommended to reduce the perceived financial and technical risks.

Sensitivity analysis for refrigerators indicate that a disposal/recycling reward scheme in the form of reduced loan interest rates to households who return their old refrigerators to purchase a new one could be quite attractive. For instance, access to a loan with zero interest rate to acquire a new refrigerator would reduce the payback period by about 17 per cent from 4.1 to 3.4 years.

Payback periods for both a new refrigerator and a new AC are influenced by factors including electricity tariff, refund, loan and interest rate, as well as loan tenor and repayment.

6. Conclusions

It is estimated that about US$ 600 million will be required to replace all second-hand domestic refrigerators and another US$ 46 million is required for second-hand domestic air-conditioners in Ghana. Price, quality, energy consumption and access to finance constitute the main factors influencing a household's decision to purchase a refrigerator. Similarly, access to finance, energy consumption and price of AC were the main factors determining a household's decision to purchase an air-conditioning unit. Two broad financing mechanisms are proposed for the Ghanaian market, namely, consumer-targeted and supplier/distributor targeted financing mechanisms respectively.

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ABBREVIATIONS

AC	Air conditioner
AfDB	African Development Bank
AFD	French Development Agency
AGI	Association of Ghana Industries
BASE	Basel Agency for Sustainable Energy
CEESD	Centre for Energy, Environment and Sustainable Development
CEPS	Customs, Excise and Preventive Service (CEPS)
CFC	Chlorofluorocarbon
CFL	Compact fluorescent lamp
CREK	Centre for Renewable Energy and EE – Kumasi Technical University
CSO	Civil Society Organisation
EC	Energy Commission
ECG	Electricity Company of Ghana
ECOFRIDGES	ECOWAS Refrigerators and Air Conditioners Initiative
ECOWAS	Economic Community of West African States
EE	Energy efficiency
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EU	European Union
GIZ	German Agency for International Cooperation
GRIDCo	Ghana Grid Company
GSS	Ghana Statistical Service
Hhs	Households
IIR	Institute of Industrial Research
INDCs	Intended Nationally Determined Contributions
JRAIA	Japan Refrigeration and Air Conditioning Industry Association
KfW	German Development Bank
LI	Legislative Instrument
MESTI	Ministry of Environment, Science, Technology and Innovation
MoE	Ministry of Energy
NARWOA	National Air-Conditioning and Refrigeration Workshops Owners Association
NEEAP	National Energy Efficiency Action Plan
PAC	Precision Air Conditioning
RAC	Refrigerators and Air Conditioners
RE	Renewable energy
SEforAll	Sustainable Energy for All
SUNREF	Sustainable Use of Natural Resources and Energy Finance
U4E	UNEP's United for Efficiency initiative
UNDP	United Nations Development Programme
VRA	Volta River Authority

I. INTORDUCTION

1.1 Background

Electricity consumption in sub-Saharan Africa is projected to increase significantly in the coming decades. Most efforts to meet growing demand have focused on building generation capacity for transmission, and distribution. Little effort has been galvanized towards improving energy access through energy efficiency (EE). EE is viewed as a low hanging fruit with a significant potential to reduce the cost of energy for end-users while, improving the competitiveness of consumers in industry and commerce. Interventions in EE result in reduction in energy bills, which translate into cash, made available for other activities in households in both urban and rural communities. In addition, EE supports effective provision of energy for delivering services in education, health, water, and security, among others. Other benefits of EE include improved reliability and security in the supply of electricity as well as contributing to climate change mitigation due to decreased consumption of petroleum fuels. In many instances, investments into new power infrastructure are avoided simply by embarking on EE initiatives, which substantially reduce peak loads.

EE is recognised in UN'S Sustainable Development Goal 7, which calls for doubling of global rate in EE improvements. In the West African sub-region, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) has developed a regional policy on energy efficiency, highlighting strategies for improving EE, covering transmission, distribution and end-use.[4] The policy, which received the endorsement of Heads of States and Governments of the ECOWAS region in July 2013, aims to enhance EE levels to international standards by 2020.

In Ghana, efforts at EE improvement date back to the late 90s when the country experienced its first drought-induced power crisis which severely hampered both industrial and service sector outputs and limited GDP growth to 2 per cent (UNDP-Ghana, 2014).[5] Recognizing this need as well as the potential benefits of energy efficiency, the Energy Foundation was formed (1997/1998) to kick-start a process of regulatory and programmatic development. Several EE regulations and programmes were introduced by government targeting various appliances including air conditioners (ACs), refrigerators and lamps with support from development partners. In addition, a National EE Action Plan (NEEAP) was developed within the

[4] ECREEE 2013. ECOWAS Energy Efficiency Policy. Available http://www.ecreee.org/sites/default/files/documents/basic_page/081012-ecowas-ee-policy-final-en.pdf, Accessed 02 September 2019

[5] UNDP-GHANA. Promoting of Appliance of Energy Efficiency and Transformation of the Refrigerating Appliances Market in Ghana. Project document, UNDP, Accra.

implementation framework of ECOWAS EE Policy, defining goals, strategies and targets for achieving EE in appliances such as refrigerators, among other areas (Ministry of Energy, 2015).[6]

As the standard of living in Ghana improves and urbanisation increases, energy expenditure is expected to grow rapidly as more households obtain income to purchase refrigeration and space conditioning appliances for their basic comfort and household energy needs (GIZ, 2018).[7] Domestic refrigeration appliances account for a significant portion of the residential electricity consumption in Ghana, and refrigerators are the first main appliances to be purchased by households (UNDP-Ghana, 2014). Domestic refrigeration appliances present a significant potential for EE improvements (typically 50 per cent in cost effective energy savings) and appear always as a priority in any market transformation strategy.

It is estimated that an average of 6 million refrigerators are installed in Ghana (GIZ 2018). Refrigerating appliances consume an average of 1,140 kWh/year in Ghana and according to Gyamfi et al. (2018)[8] over 2 million inefficient refrigeration appliances are used in households in Ghana, presenting economic cost that runs into hundreds of millions of dollars in electricity bills to the national economy while resulting in increased carbon footprint of the country (each inefficient appliance generates over 0.7 tons of carbon emissions annually). On the other hand, the annual energy consumption of ACs range between 1,532 to 2,680 kWh/yr depending the cooling capacity (GIZ 2018). Furthermore, most of the old refrigerators and ACs use environmentally harmful refrigerants that are released into the atmosphere, especially in cases when they are improperly discarded. At least 2 tons of ozone-depleting substances are released into the atmosphere through this phenomenon.[9] Despite interventions rolled out to get rid of old and inefficient refrigerators, there are still significant numbers of inefficient units in the country. Thus, continuous EE interventions are critical to reducing demand for electricity. Introducing best available technology to the Ghanaian market can lead to an emission reduction potential of up to 1.9 Mt CO_2eq by 2030 and 4.3 Mt CO_2eq by 2050 annually compared to the BAU scenario (GIZ 2018).

To support ongoing interventions by government on EE, ECOFRIDGES will be implemented with the ultimate aim of securing funding to support the replacement of 50,000 old and inefficient refrigerating devices and AC appliances with efficient and climate-friendly units in the residential and light commercial sectors in an economically sustainable manner in Ghana and Senegal. About US$ 25 million is expected to be raised to finance interventions under ECOFRIDGES through

[6] Ministry of Energy 2015. National Energy Efficiency Action Plan (NEEAP). Accra, Ghana.
[7] GIZ, (2018) Green Cooling Initiative
[8] Gyamfi S., Diawuo F.A., Kumi E.N., Sika F., Modjinou M. (2017). The energy efficiency situation in Ghana. Renewable and Sustainable Energy Reviews 82. 1415–1423.
[9] UNDP, In Ghana, a victory for energy efficiency, accessed from (https://www.undp.org/content/undp/en/home/ourwork/ourstories/in-ghana--a-victory-for-energy-efficiency.html)

innovative financial mechanisms in both countries. ECOFRIDGES supports national goals on continuous improvements in EE. It links directly into Ghana's SE4All plan which calls for the conduct of energy access and consumer research surveys to bridge data gaps. Thus, ECOFRIDGES addresses the challenge of funding that has been identified in the quest to improve EE, including sustained awareness creation.

1.2 Objectives of the assignment

The overall objective of this study was to carry out market research and feasibility assessment on the introduction of energy-efficient domestic refrigerators and room air-conditioning units as replacement to older, inefficient and climate-unfriendly ones currently in use in majority of homes and small businesses in Ghana. The specific objectives were to:

- identify key stakeholders and assess their capacity to play roles and responsibilities under ECOFRIDGES;
- define potential market segments and market size;
- identify barriers and opportunities in the RAC sector;
- highlight consumer preferences (technical and financial);
- undertake financial analysis on representative investments, return on investment, payback, sensitivity analysis; and
- analyse the feasibility of financial mechanisms, support mechanisms, and risk mitigation instruments

The outcome of this study will be used to inform the design of a financial mechanism for households that wish to replace old and operational refrigerator or air conditioner that might be at least 10 years old.

1.3 Methodology and Study Areas

The study employed several methods including quantitative study, qualitative study and desktop review, allowing the generation of comprehensive data for analysis. This method also enabled triangulation of data, enhancing the credibility of the study conclusions. The study was carried out through desk studies, surveys, field trips and semi-structured interviews with actors and stakeholders including household users, suppliers, financial institutions and regulators (Appendix A).

1.3.1 Quantitative component

The study area consisted of the most populous cities drawn from each of the geographical zones of the country: Tamale (northern zone), Kumasi (middle zone) and Accra (southern zone).[10] The study population, defined as households that use refrigerators from the selected cities, was estimated to be 770,864 (Appendix B). Two levels of sampling were used for the survey. The first level involved proportional stratified sampling of households within each city based on the number of households owning refrigerators and air-conditioning units. An examination of data from Ghana Statistical Service (GSS) revealed that many households do not have ACs installed (Appendix B) which is attributed to the fact that AC units are considered a luxury.

Within each city, five suburbs with the highest household population were selected for a second round of proportional sampling. The final sample size for each city and each suburb is presented in Appendix C. Heads of household or adult household members who purchased the appliances or those with adequate knowledge on the operations of the gadgets were interviewed. A structured questionnaire prepared by BASE was used as a measuring instrument for the survey. The questionnaire was first reviewed and subsequently piloted by the consultant to strengthen its applicability. After the pilot study, additional changes were made for effective data collection. Questionnaire administration was carried out using face-to-face interviews.

1.3.2 Qualitative component

Personal interviews were conducted with key informants. Twenty-six (26) stakeholders were interviewed, including seven (7) suppliers and retailers and nine (9) financial institutions. The list of stakeholders engaged is provided in Appendix A. A semi-structured questionnaire prepared by U4E and BASE was used for all engagements (Appendix D).

1.4 Structure of the report

The report is presented in five sections. Section 1 underscores the background to the study. Section 2 covers the major stakeholders involved in the industry and presents the state of the sector. In Section 3, analysis of fieldwork is discussed while Section 4 assesses the feasibility of replacing old domestic refrigerators and room air conditioners with energy-efficient models. Section 5 presents the conclusions of the study.

[10] Northern zone - Upper East, Upper West, Northern, Savannah, and North East regions; Middle zone - Ashanti, Eastern, Ahafo, Bono, and Bono East regions; and Southern zone - Western, Volta, Greater Accra, Western North, Central, and Oti regions

II. POLICY, INSTITUTIONAL AND REGULATORY FRAMEWORKS ON ENERGY EFFICIENCY

This section provides an overview of the legal, policy and institutional frameworks that have shaped EE programmes and actions in Ghana over the years. Relevant policies are briefly highlighted and regulations and laws that served as the backbone of various EE programmes are also captured.

2.1 Energy efficiency policies and regulations

Since the mid-2000s, the government of Ghana (GOG) has shown commitment by enacting and implementing policies and regulations on EE. The main policies, legal and regulatory frameworks on EE developed over the years are outlined in Table 1. The first EE regulations in Ghana were promulgated in 2005 with a law on ACs and compact fluorescent lights (CFLs). ACs were selected because of their contribution to peak electricity demand, and also because much of the market in Ghana consists of new equipment unlike refrigerators. Later in 2015, a similar regulation was promulgated for refrigerator units (Table 2.1).

Table 2.1 Major policies and regulations on EE

Name	Relevant objective	Scope and targets	Comment
Policies			
National Energy Policy, 2010	Ensure efficient production and transportation as well as end-use efficiency and conservation of energy.	Policy recognises the challenges of inadequate financing and limited awareness creation on EE. Policy direction includes implementing programmes and measures to help consumers optimise their energy use as well as promoting awareness creation on conservation.	Presently under review. UNDP is funding a study to mainstream gender issues into the draft.[11]
National Climate Change Policy (NCCP), 2012	Sets out measures to be taken to reduce climate change	Under Focus area 10, actions to improve EE in production and consumption of energy is to be promoted	Implemented by MESTI[12]
Millennium Challenge Compact (Compact II), 2014	EE and demand side management are among the five main areas of the compact.	Reduce demand for electricity; assist consumers to save money by improving EE, reducing peak demand, and increasing technical	Funding: US$ 25.4 million

[11] http://procurement-notices.undp.org/view_notice.cfm?notice_id=58909, accessed 26 September 2019
[12] Ministry of Environment, Science, Technology and Innovation

Name	Relevant objective	Scope and targets	Comment
		capacity for efficiency retrofits and creating awareness among the public in EE.	
Ghana's intended nationally determined contributions (INDCs), 2015	Contains mitigation and adaptation actions taken by Ghana to curb climate change	Targets EE improvements in industrial facilities by installing power factor correction devices in 1,000 commercial and industrial facilities (capacitor banks).	Ultimate aim is to reduce electricity demand and expenditure.
Laws and legislations			
Customs, Excise and Preventive Services (CEPS) Law (PNDC L330), 1993	Enacted to consolidate existing laws on the operations of CEPs	Empowers CEPS to regulate imports and exports of goods, and used whenever a legislative vacuum is found on any goods or substance.	
Environmental Protection Agency (EPA) Act, Act 490, 1994	An Act enacted to amend and consolidate environmental protection laws and pesticides control.	Enables EPA to develop and enforce environmental and climate regulations.	Use of hazardous chemicals are addressed by the Act.
Export and Import Act, (Act 503), 1995	Ministry of Trade	Act enables restrictions on use of goods known to be injurious to human health or unfriendly to the environment, including appliances with ozone depleting substances	
Legislative Instrument (LI) 1812, 2005	Management of ozone-depleting substances (ODS) and products	Empowers CEPs to prevent importation of ODS equipment in order to meet obligations under Montreal Protocol	
LI 1815, 2005	EE standards and labelling (non-ducted air conditioners and self-ballasted fluorescent lamps) regulations	Gives legal backing to the use of energy- efficient ACs and fluorescent lamps.	Minimum performance (EER) of 2.8 was established for ACs.
LI 1932, 2008	EE regulation	Regulation legally prohibited the importation and sale of incandescent filament lamp, used refrigerator, used refrigerator-freezer, used freezer and used AC), with effect from January 2012.	
LI 1958, 2009	EE standards and labelling (household refrigerating appliances) regulations.	Provides for the enforcement of minimum energy efficiency and labelling for household refrigerating appliances	

Name	Relevant objective	Scope and targets	Comment
LI 1652, 1999	Environmental Assessment Regulations	Empowers EPA to deny environment permits to undertakings that do not conform to national laws and regulations, as well as global protocols	
Act 917, 2016	Hazardous and electronic waste control management act	Law passed to control management and disposal of electrical and electronic waste. Act mandates inspection and receipt of advanced eco-levy, at the country of origin, on imported electrical and electronic equipment.	
LI 2250, 2016	Hazardous, electronic and other wastes (classification), control and management regulations	Provides for efficient control, management and disposal of hazardous, electrical and electronic waste	
Ghana Building Code 2018	Comprises requirements, recommendations, planning, management and practices on operation and construction of residential and non-residential buildings.	Requires buildings to follow EE standards	

2.2 Other initiatives on appliances

In partnership with UNDP and GIZ, there have been several initiatives by government, to improve the energy efficiency situation in Ghana (Table 2.2). One of the recent initiatives is the energy-efficient refrigerator project, implemented between 2014 and 2015, which successfully replaced 10,000 (with energy consumption of 250 kWh/year) out of the targeted 15,000 (Gyamfi et al., 2018) old and inefficient refrigerators in the households in Ghana which on average consumed 1,200 kWh/year (Bawakyillenuo and Agbelie, 2016). Despite these gains, there still remain a large number of old and inefficient refrigerators and air-conditioning units in use in households since. Lessons from the project indicate the need for sustained replacement is critical for energy efficiency in Ghana.

Other initiatives on appliances in Ghana include:

- Efficient Air – Conditioning Programme in Ghana - (Under the Kigali Cooling Efficiency Programme (KCEP)) – supported by UNDP
- Green Cooling Africa Initiatives – supported by GIZ

- Hydrochlorofluorocarbon Phase-out Management Plan (HPMP) – supported by Mulitilateral Fund under the Montreal Protocol

Table 2.2 Major EE programmes, projects and actions

Name	Relevant objective	Scope and targets	Comment
EE standards and labelling for ACs 2005	Imported ACs expected to meet minimum EE standard as set by the Energy Commission, verified by GSA and enforced by CEPs.		National peak demand estimated to have been reduced by 250 MW (Gyamfi et al., 2017)
EE improvement in public buildings 2009	Capacity banks were installed in selected buildings	Ministry of Energy installed equipment for correction of power factors in public universities. Power factor improved from 0.83 to 1.00 in some of the universities.	
Refrigerator rebate programme 2012	Programme aimed to replace used refrigerators with new and efficient ones, marked with EE labels.	Significant reduction in power consumption was achieved, resulting in decreased burden on power plants.[13]	Implemented by EC
CFL programme, 2008	Initiated in response to energy crisis in 2007	Energy Commission supervised the distribution of 6 million CFLs to households for replacement of incandescent lamps, with funding from the government. Penetration of CFLs increased from 20 per cent (2007) to 79% (2009).	Initiative led to peak load reduction of 124 MW and emissions reduction of 116,000 t CO_2-eq.

[13] Kumi E. N. 2017. The Electricity Situation in Ghana: Challenges and Opportunities. CGD Policy Paper. Washington, DC: Centre for Global Development. https://www.cgdev.org/publication/electricity-situation-ghana-challenges-and-opportunities

Name	Relevant objective	Scope and targets	Comment
HFC Inventory GHANA 2011-2014[14]	Study carried out inventory on consumption of hydrofluorocarbon (HFC)	HFC use, as replacement to ODS, was found to be increasing. HFC-134a consumption was estimated at 57% of all HFCs.	There are steps to phase out HFCs owing to their capacity to trap heat though they do not interfere with the ozone layer.
Compact II of the Millennium Development Authority (MIDA) 2014	US$ 25.4 million to be used to fund EE and Demand Side Management (EEDSM) programme	Procurement and adoption or upgrading of standards for appliances (TVs, fans, blenders, etc.). Development of LI to enforce standards	Activities are currently in progress by GSA and Energy Commission
		Setting up of two centres for training and certification of professionals in EEDSM	Process underway in competitive bidding.

The three other initiatives generally focus on the adoption of cooling technologies that use natural refrigerants, with the aim to reduce GHG emissions. However, the initiatives also ensure that energy efficiency of adopted appliances conforms to the MEPS and labelling in Ghana. The implementing agency of all the three initiatives is the EPA.

2.2.1 Efficient Air – Conditioning Programme in Ghana - (Under Kigali Cooling Efficiency Programme (KCEP))

In 2019, the UNDP in partnership with the EPA and the Energy Commission (EC) embarked on a project "Efficient Air-Conditioning Programme in Ghana" that is aligned with the K-CEP Window 2. The project was to support the Government of Ghana to achieve the Outcome 1: on Policy, Standards and the Outcome 2: "High-efficiency technology increases its market penetration in target markets" of the K-CEP Strategic Plan.

The key activities under the project were:

- Determine the energy consumption baseline for the AC sector in Ghana;
- Assess the feasibility of a rebate scheme for the AC sector and provide recommendations on implementation modality and potential co-funding source;
- Capacity building for enforcement of energy efficiency in AC sector; and
- Presentation of findings to national stakeholders

[14] Owusu-Achaw K, 2015. HFC Inventory Ghana: 2011-2014. CCAC/UNDP/EPA publication.

Among other outputs, the project analysed various financial delivery mechanisms for a rebate scheme for ACs - volume rebates, growth rebates, retention rebates, mixed rebates and price masking rebates). The project recommended a trade-in and replacement programme through price masking rebate for ACs in Ghana, similar to the refrigerator rebate scheme that was implemented by the Energy Commission. The key stakeholders in the proposed AC rebate scheme are: i) consumers; ii) AC retailers; iii) financial institutions and iv) waste management companies. The project listed potential funding sources for the AC rebate scheme, including climate financing sources: Global Environment Facility (GEF), Green Climate Fund (GCF), International Climate Initiative (IKI), the Electricity Demand Management Fund (EDMF) and financial institutions. However, funding for recommended rebate scheme for ACs has not yet been secured, so the scheme has been put on hold until funding becomes available.

2.2.2 Green Cooling Initiative

In 2017, GIZ initiated the Green Cooling Initiative (GCI) programme in three African countries - Ghana, Kenya and Seychelles. The objective to promote the adoption of sustainable and innovative cooling technologies that use natural refrigerants in emerging and developing countries, and thereby reduce GHG emissions and boost energy efficiency. The Green Cooling Initiative is being funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), with the Environmental Protection Agency (EPA) as the implementing agency in Ghana. The project has four key components to be implemented in two phases:

- Framework conditions
- Policy advice
- Technology transfer
- Capacity building

Phase 1 was in 2017-2018, whilst Phase 2 was planned for 2018-2021. The status of the project components is summarized in Table 2.3.

Table *1* Status of Green Cooling Africa Initiative in Ghana

Project component	Activity	Status
Framework conditions	Development of GHG inventory & monitoring, reporting and verification (MRV) for the RAC sector (UNFCCC Tier 2)	To be implemented in **Phase 2**
	Economic assessment of RAC technology options (Technology Gap Analysis -PHASE 1	Implemented in **Phase 1** – Report available

	Policy analysis and roadmap development for the introduction of green cooling technologies	To be implemented in **Phase 2**
Policy advice	Development of Implementation Plan for RAC Sector	To be implemented in **Phase 2**
	Proposal for tax incentive on R290 AC equipment	To be implemented in **Phase 2**
	Concept for restructuring AC star rating (labelling classes)	To be implemented in **Phase 2**
Technology transfer	Pilot introduction of 30 efficient R290 ACs from India and monitoring of energy consumption	Implemented in **Phase 1** – R290 ACs observed to be highly energy-efficient
	Procurement and sale of 380 efficient R290 ACs from China and introduction in cooperation with two local distributers	Under implementation in **Phase 1** with 2 distributors – *Flexi-Space* Ltd & *Electroland Ltd; 87% of* R290 ACs (*Midea & Miller brands*) sold
Capacity building	International training of 6 technicians on hydrocarbon technologies	3 RAC trainer-technicians trained in Italy under **Phase 1**
	Local training of 28 RAC technicians on the safe handling of R290 ACs (installation and maintenance)	Trainer-technicians trained 44 RAC technicians from 11 RAC workshops under **Phase 1**
	Draft concept and technical advice to for RAC technician certification scheme	To be implemented in **Phase 2**

The GIZ is also finalizing a proposal to be submitted to the Green Climate Fund for funding of the project "GCF Green Cooling Project (Ghana component)" with the following project background:

- The project is expected to accelerate the development of the nascent market for green air conditioning appliances, shifting market development away from climate-damaging (high-GWP refrigerants) and energy-inefficient AC and towards radically lower-emission technologies;
- The project aims to reduce 36.6 million tCO_2eq during the project lifespan;
- The project is expected to be cost-effective, offering a mitigation cost to the GCF of US$ 1.29/tCO_2eq;
- Expected GCF funding: US$ 42.5 million (total estimated for all 3 participating countries);
- Project duration: 7 years (2022-2028);
- Potential partner countries: Indonesia, Ghana, Costa Rica

The project set-up and approach are presented in Figures 2.1 and 2.2.

2.2.3 Hydrochlorofluorocarbon Phase-out Management Plan (HPMP)

In the period 2013-2019, the EPA has converted 10,000 ACs in Ghana from R22 refrigerants to hydrocarbon R290 refrigerants, under the HPMP with funding from the Multilateral Fund of the Montreal Protocol.

2.2.4 Synergy between ECOFRIDGES Ghana and other initiatives on appliances

As indicated, the three initiatives on ACs aim to transform the AC market in Ghana through the shift from cooling technologies using high GWP refrigerants to low GWP hydrocarbon R290 refrigerants, whilst also ensuring that all adopted ACs are highly energy-efficient and conforming to the MEPS and labelling in Ghana. Thus, engagement with the EPA will be pursued to build synergy between ECOFRIDGES and the three other initiatives on ACs. In particular, opportunities should be explored for the harmonizing the proposed AC rebate scheme under the Efficient Air – Conditioning Programme in Ghana - (under KCEP) with the GO financial mechanism.

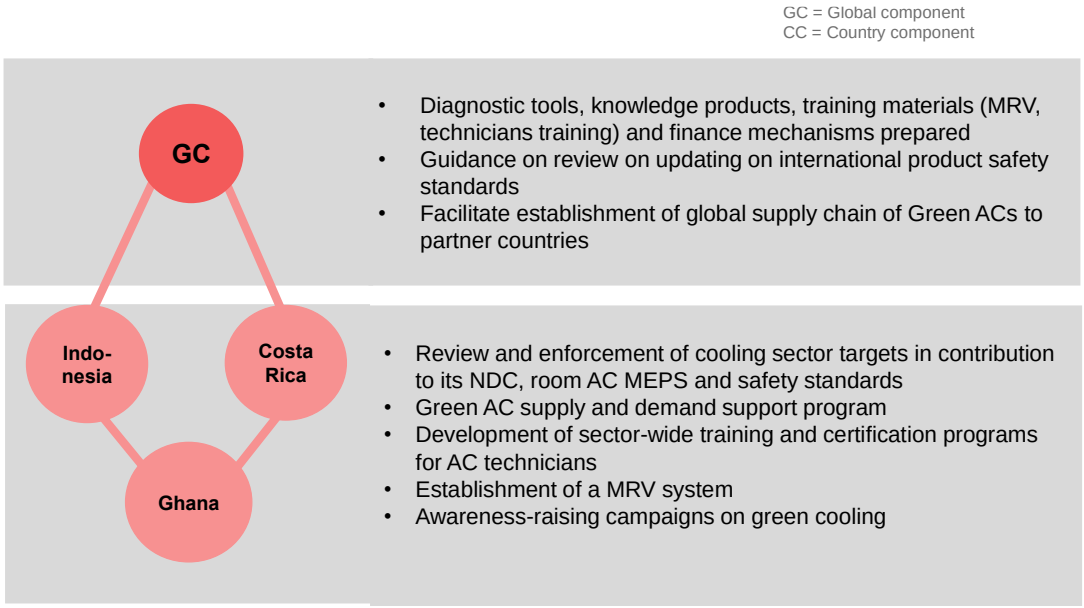


Figure 2 Project set-up of GIZ project "GCF Green Cooling Project (Ghana component)"

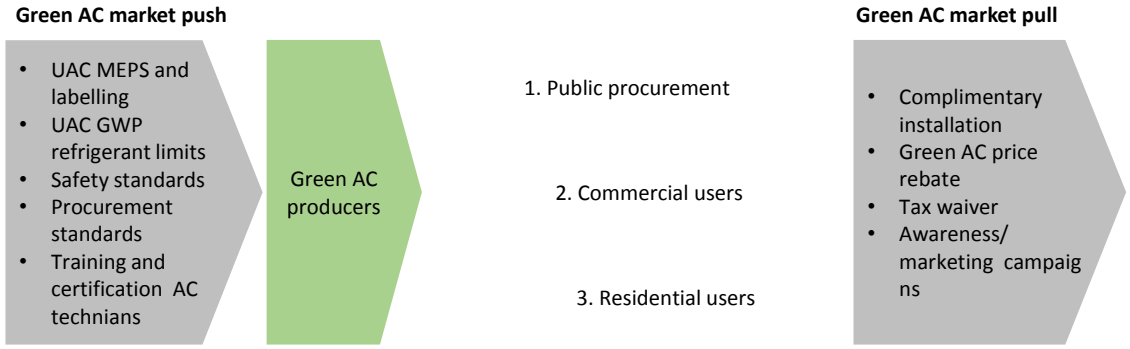


Figure *3* Project approach of GIZ project "GCF Green Cooling Project (Ghana component)"

2.3 Institutional framework

The institutional framework in EE involves policy making, regulation, standards development and enforcement of laws as shown in Table 2.4. The Ministries of Energy (MoEN) and Environment, Science, Technology and Innovation (MESTI) are responsible for overall policy development. The

regulatory frameworks on the importation, sale and use of refrigerators and ACs are under the responsibility of the Energy Commission (EC). The regulation of equipment that contains ozone depleting substances and hydrofluorocarbons (HFCs) are under the control of the Ozone Unit of EPA. Development of standards on EE equipment are carried out by Ghana Standards Authority (GSA) while enforcement of regulations, laws and standards on importations reside with Customs, Excise and Preventive Service (CEPS). CEPS work closely with GSA to prevent importation of banned and sub-standard RAC equipment.

Table 4 Institutional mandate in energy efficiency

Institution	Mandate and functions
Policy and financing	
Ministry of Energy	Responsible for policy formulation on EE Designs overall strategy for development
MESTI	MESTI formulates and executes policies that promote the use of environmentally friendly technologies
Regulation	
Energy Commission	Provide policy recommendations to the Minister for Energy on EE matters Formulate and implement technical regulations (technical and service quality standards, licensing, permit requirements, etc.) Promote public education and awareness on EE Recommend for exemptions from customs, levies and other duties on EE equipment and machinery Ensure compliance with labelling of RAC equipment Certify officers that supervise compliance of the labelling laws Consider petitions challenging product seizures Dispose forfeited shipments of non- compliant goods
Environmental Protection Agency (EPA)	Develop environmental and climate regulations Responsible for prevention, reducing, and elimination of pollution Supervise regulatory oversight on ODS and HFCs Responsible for ensuring phasing out of HCFC and based equipment as well as recovery and disposal of ODS
Standards	
Ghana Standards Authority (GSA)	Develop standards for EE technologies. Minimum performance standards for RAC equipment have been established. Certify that imported EE equipment meet standards
Enforcement	
Customs, Excise and Preventive Service (CEPS)	Enforce standards and laws on importation and use of energy efficiency equipment
Utility	
Power Distribution Services (PDS)	PDS is one of two power distribution agencies in Ghana after taking over the operations of ECG in 2019. It covers an operation area of about 36% of Ghana PDS main attention in EE is focused in reducing distribution losses PDS installs smart meters for industrial and other high-consuming customers. The main challenge has been the extra cost involved. Note: PDS involvement has recently been abrogated by government of Ghana, citing fraud on the part of PDS.

Institution	Mandate and functions
Electricity Company of Ghana (ECG)	ECG's role in EE also relates to reducing distribution losses in order to maximize revenues. Presently, ECG assumes the mandate of PDS due to the abrogation of the contract between government and PDS.
Northern Electricity Distribution Company (NEDCo)	NEDCo is a wholly owned subsidiary of Volta River Authority (VRA) that distributes power to households in the mainly savannah areas of Ghana covering the Savannah, Oti, Northern and Brong Ahafo Regions, and the Upper East, North-East and Upper West Regions. Geographically NEDCo covers about 64% of the entire country. NEDCo's main activity in EE is focused in reducing transmission losses and promotion of using energy-efficient appliances.

2.4 Other stakeholders

Other notable actors in the EE sector include (see Table 2.5):

- Technology and research centres
- Energy Foundation
- Repair and Maintenance technicians
- Importers, distributors and retailers of RAC equipment
- Consumer groups
- Financial institutions (banks)
- Development partners (e.g. GIZ)

Table 5 Other actors within the EE sector

Theme	Organisations
Technology centres/institutes and training bodies	Key technology centres/institutes include Institute of Industrial Research (CSIR-IIR), Brew-Hammond Energy Centre-KNUST and Centre for RE&EE-KsTU, etc. Personnel from the institutes have been involved in field activities and data gathering on EE standards and labelling, as well as surveys on RAC equipment under the coordination of Energy Commission. Training institutes such as National Vocational and Technical Institutes (NVTIs), Technical Institutes, Polytechnics, Technical Universities and Public Universities have units that train students on RAC.
Importers, distributors and retailers	Some notable importers, distributors and retailers include Hisense Ghana, Melcom, Somotex Ghana Ltd., Bosch, Siemens Home Appliances; most provide servicing and logistics facilities.
Financial institutions	Ecobank Ghana and Fidelity banks are the leading financial institutions opening up to RE & EE projects
RAC repair and maintenance workshops	The National Air-conditioning and refrigeration workshops owners association (NARWOA) is a trade association of workshops that repair RAC equipment. It has been involved in past programmes on replacement of CFC refrigerants with more environmentally friendly ones such as hydrocarbons. It is a vital body in any programme that targets RAC sector.
Development partners	GIZ, SNV, USAID, UNDP, AfDB, WBG, and the EU, among others, have all been involved in EE programmes by providing financial and technical support to government. Table 8 provides details of support provided.
Technical partners	The Energy Foundation was founded in 1998, under public-private arrangement, to provide technical support in the development and implementation of EE

Theme	Organisations
	programmes, including standards and legislations. They are also involved in awareness creation campaigns.
CSOs	CSOs such as CEESD and KITE are noted for conducting field studies in RE, EE and related areas.

2.5 Challenges and gaps in the EE sub-sector

Some of the key challenges facing the penetration of efficient room AC equipment and/or efficient refrigerator in households and small businesses include:

- Lack of long-term awareness creation on benefits of EE investments
- Poor data collection and management regarding energy-saving appliances
- Lack of review in the star-ratings of air-conditioners since 2005 to reflect the technological improvements across the globe.[15]
- Weak enforcement of regulation as well as poor control on importation of used equipment at the ports
- Inability of households to afford the cost of new and efficient appliances especially in rural areas and peri-urban areas
- Lack of flexible financing arrangements for purchase of EE appliances

[15] Owusu-Achaw K. and Bimpong H. (2009) Efficient air-conditioning programme in Ghana

III. MARKET ASSESSMENT AND CHARACTERISTICS OF REFRIGERATORS AND AIR CONDITIONERS

A total of 599 households were surveyed with 96 per cent having refrigerators, 17 per cent using ACs, and 13 per cent owning both appliances. By type, 63.3 per cent declared having a refrigerator-freezer, while respectively, 24 per cent and 12.8 per cent had a refrigerator only and a freezer only. The following sections present findings of the market characteristics of household survey conducted in Ghana across the southern, middle and northern belts of the country. 96 per cent of households declared earning a monthly income of less than GHS1,000 Cedis (US$200) which is defined as low-income for this study.[16] In comparison, national statistics showed that the mean monthly household income for Ghana was GHS1,387.1 in 2014[17] (see Table 3.1).

Table 6 Mean monthly household and per capita income by quintile group in Ghana

Quintile	Mean monthly household income (GHS)	Mean monthly per capita income (GHS)	Mean household size	Percentage share of monthly income
First (Lowest)	547.7	96.1	6.1	5.3
Second	891.5	180.1	5.0	10.3
Third	1,235.3	279.8	4.4	16.4
Fourth	1,409.1	403.4	3.6	22.4
Fifth	2,100.1	874.4	2.6	45.6
Ghana	1,387.1	445.6	4.0	100.0

Source: Ghana Statistical Service (2014): Ghana Living Standards Survey Round 6

3.1 Sales and market size[18]

3.1.1 Refrigerators

Refrigerators are among the appliances that are prioritised in households. The percentage of households owning refrigerators in Ghana increased from 21.2 per cent in 2006 to 33 per cent in 2013[19], and further increased to 36 per cent in 2017 (Figure 3.1). From Figure 3.1, the penetration rates are higher in urban centres compared to rural areas due to the higher incomes and standard of living among urban populations.

[16] Low income (<1000 cedis); Middle income (1000-3000 cedis); High income (>3000 cedis)
[17] Ghana Statistical Service (2014): Ghana living standards survey round 6 (GLSS6) http://www.statsghana.gov.gh/gssmain/fileUpload/Living%20conditions/GLSS6_Main%20Report.pdf
[18] Based on data from GSS 2014. 2010 Population and Housing Census, District Analytical Reports for Accra, Kumasi and Tamale Metropolitan Areas, Ghana Statistical Service, Accra, and World Population Review: Available: http://worldpopulationreview.com/world-cities/tamale-population/#popData
[19] Ghana Statistical Service (2014): Ghana living standards survey round 6 (GLSS6) http://www.statsghana.gov.gh/gssmain/fileUpload/Living%20conditions/GLSS6_Main%20Report.pdf

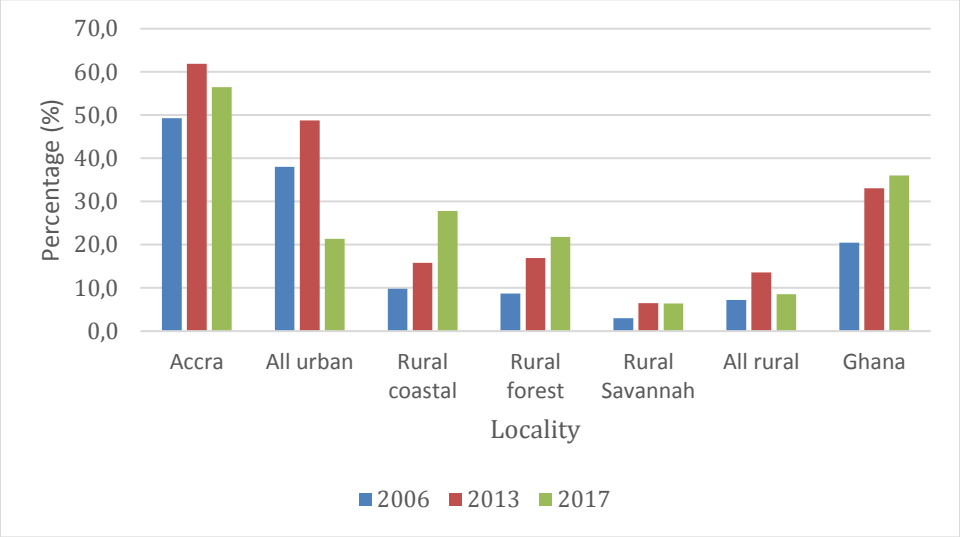
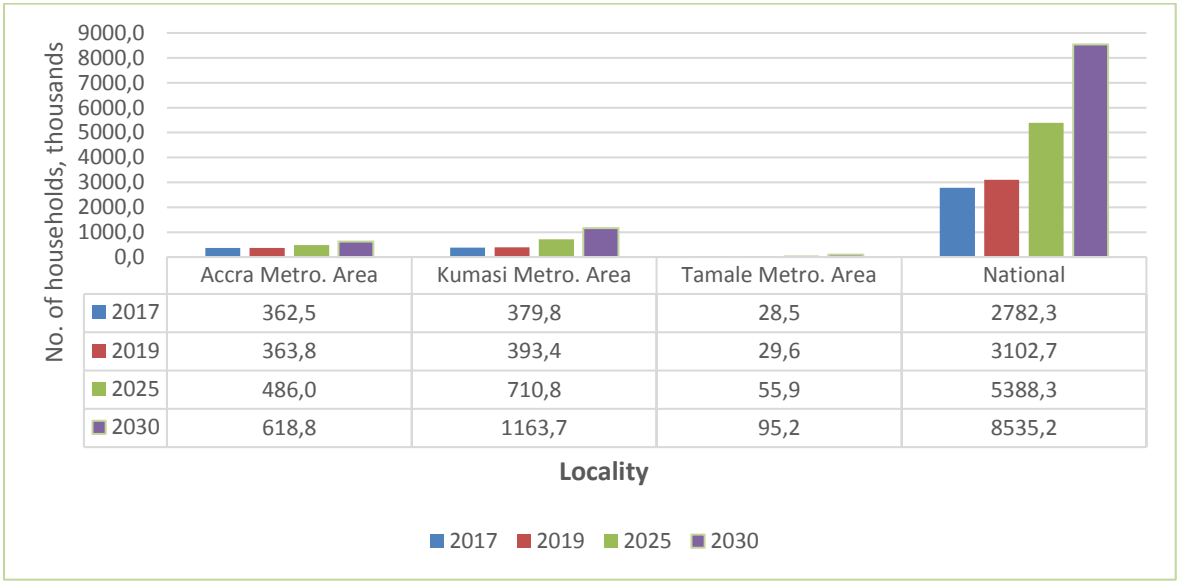


Figure* 7 *Proportions of households owning refrigerators

The estimated number of households owning refrigerators in 2019 as well as projections for 2025 and 2030 are detailed in Appendix B and summarised in Figure 3.2 for the cities studied and at the national level.



	Accra Metro. Area	Kumasi Metro. Area	Tamale Metro. Area	National
2017	362,5	379,8	28,5	2782,3
2019	363,8	393,4	29,6	3102,7
2025	486,0	710,8	55,9	5388,3
2030	618,8	1163,7	95,2	8535,2

Figure 8 Estimated number of households owning refrigerators

3.1.2 Air conditioners

Unlike refrigerators, AC availability in households is low even in the cities where the penetration rate was between 1-3.6 per cent (GSS 2008; GSS 2014). A recent estimate pegged the penetration

rate at approximately 4 per cent (GIZ-GCI, 2018). Based on industry data from Japan Refrigeration and Air Conditioning Industry Association (JRAIA), sales of room AC units increased from 84,000 in 2013 to 113,000 in 2018 (Figure 3.3).[20] Demand for commercial AC units were about 11-14 per cent of total sales over the period (JRAIA, 2019). Nearly 99 per cent of room ACs sold were of the split type (single) while commercial units were mainly Precision Air Conditioning (PAC)[21]. Also known as a CCU (close control units) or CRAC (computer room air conditioner), PACs are refrigerating equipment specifically designed to provide precise control of temperature and humidity in all applications in which is required a very high degree of precision. The precision air conditioners are used in server rooms, data centres, mobile laboratories and many other industrial applications, where the refrigeration loads required can vary from 5 to 20 kW,.[22] The demand for ACs is expected to increase (by 23 per cent annually[23]) in the coming years due to growth in middle income households, urbanisation and expansion of national electrification coverage.

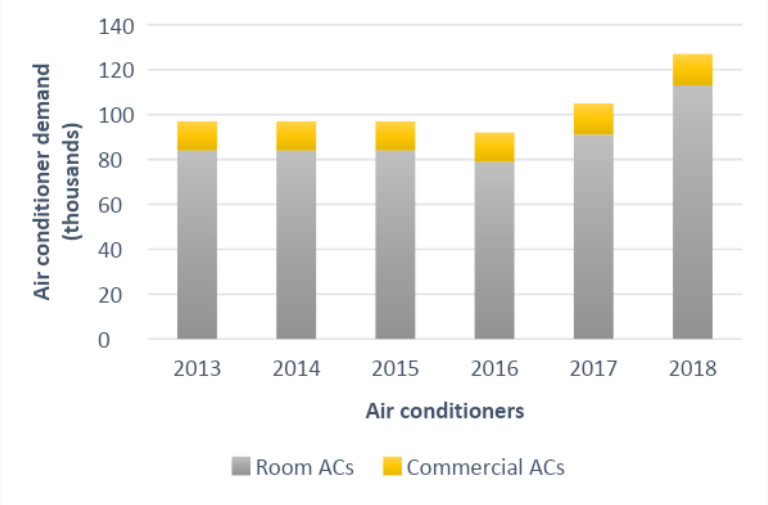


Figure 9 Annual demand for air conditioners
Source: data from JRAIA.

The penetration of ACs in households has been estimated using data from the Ghana Statistical Service (Figure 3.4). Since ACs are usually considered as a luxury, their use among households are generally low. However, the penetration rates are far higher in urban households.

[20] JRAIA 2019. World Air Conditioner Demand by Region.
[21] Precision Air Conditioning (PAC) system is one designed for cooling datacentre and server room environments rather than one designed for general building (homes, commercial offices and retail)
[22] https://www.hidros.eu/applications/precision-air-conditioners
[23] JRAIA 2019.

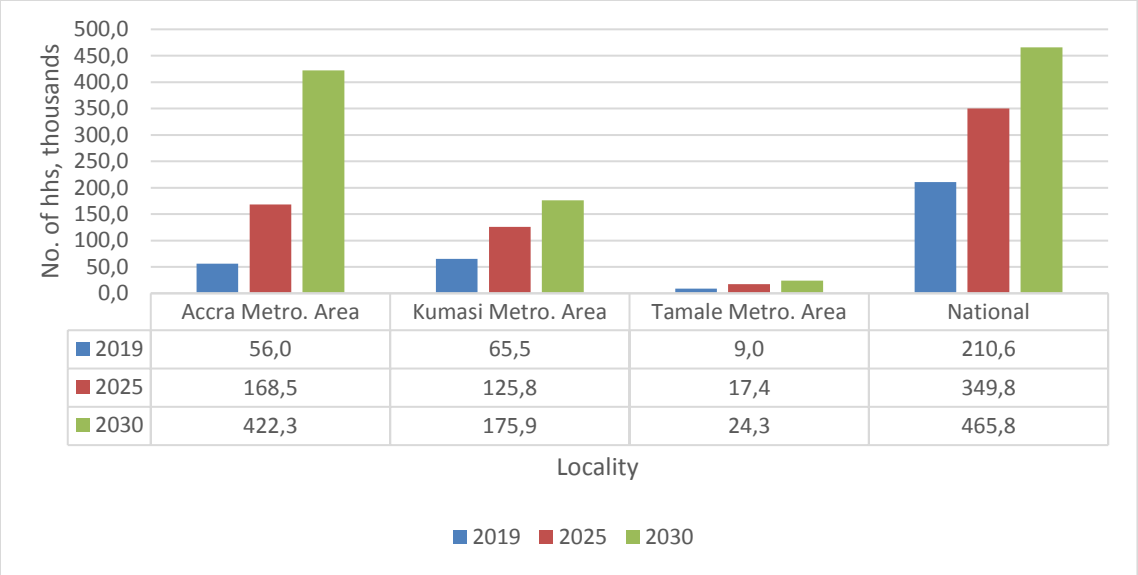


Figure 10 Estimated number of households owning AC

3.1.3 Investment opportunities for replacing inefficient cooling appliances

Tables 3.2 and 3.3 summarize the investment requirement for replacing all second-hand and old (at least 10 years since installation) refrigerators and ACs, respectively. The tables also provide an estimate of the number of refrigerators and air-conditioners that could be replaced in the target cities and country-wide in 2019. It is estimated that about US$ 600 million will be required to replace all second-hand domestic refrigerators and another US$ 46 million is required for second-hand domestic room air-conditioners in Ghana, as shown in Table 3.2 and Table 3.3.

The estimates are made based on the following considerations;

i. Old ACs are replaced with a new 1.5-2.0 hp AC (accounts for over 60 per cent of the Ghanaian market)[24]
ii. The average market price of a 4-star mid-size AC (1.5 -2.0 hp) is GHS 2,650
iii. Old refrigerators are replaced with a new 4-star double door refrigerator with a total capacity of 250 litres[25]. This type of refrigerator is used by over 60 per cent of the households surveyed.
iv. The average market price of such refrigerator is GHS 1,950.

As of January 2019, there were approximately 1.6 million domestic second-hand refrigerators in addition to 190,000 refrigerators bought new but older than 10 years since first installation in Ghana (see Table 6). Similarly, second-hand air conditioners and those older than 10 years since installation are about 12,000 and 90,000 units, respectively (GLSS 6, Opoku et al., 2019), as

[24] CLASP (2018). Africa Airconditioner market study, pp 18
[25] https://pricesghana.com/prices-of-fridges-freezes-in-ghana/ (2019). Accessed 23/10/2019

presented in Table 3.3. These categories of cooling appliances are considered energy-inefficient and could be replaced with energy-efficient models. Replacing these inefficient cooling appliances will save the country several hundreds of megawatts in electricity consumption and millions of dollars in electricity generation. Total electricity cost savings potential of about US$ 1.96 billion can be achieved by the year 2030 with higher EER air-conditioners in public and commercial buildings alone in Ghana.[26]

Table 11 Market size and investment requirement for old refrigerators

	Accra Metro Area	Kumasi Metro Area	Tamale Metro Area	All target cities	National
Number of refrigerators 10 or more years old: purchased new (2019)	25,465	18,885	-	44,350	188,270
Number of second-hand refrigerators (2019)	181,894	264,391	4,434	450,719	1,631,675
Investment required for refrigerators older than 10 years (US$ Million)	9.3	6.9	-	16.2	68.9
Investment required for second-hand refrigerators (US$ million)	66.5	96.7	1.6	164.9	597.0

Table 12 Market size and investment requirement for old air-conditioners

	Accra Metro Area	Kumasi Metro Area	Tamale Metro Area	All target cities	National
Number of ACs 10 or more years old: purchased new (2019)	-	7,078	-	7,078	11,793
Number of second-hand ACs (2019)	18,472	34,213	2,804	55,489	91,395
Investment required for AC older than 10 years (US$ million)	-	3.5	-	3.5	5.9
Investment required for second-hand AC (US$ million)	9.2	17.1	1.4	27.7	45.7

3.2 Household characteristics and financing

The nature of families in urban Ghana is characteristically nuclear (90%) with an average household size of 4.1 and the houses having an average of 2 rooms (Table 3.4).

Table 13 Income level, household size, and number of rooms in house

[26] Opoku et al (2019). Energy efficiency and cost saving opportunities in public and commercial buildings in developing countries - The case of air-conditioners in Ghana

Parameter	Monthly Income, (GHS)	Number of family members	Number of rooms in house
Mean	405.55	4.06	2.05
Mode	200	4	2
Minimum	50	1	1
Maximum	6,000	20	17

Most of the respondents are employed (Figure 3.5) with low-income levels, just above the minimum wage (Table 3.4). It is important to note that the reported income level represents that of just the respondent. It is, however, estimated that the actual household income could be 2-3 times higher.

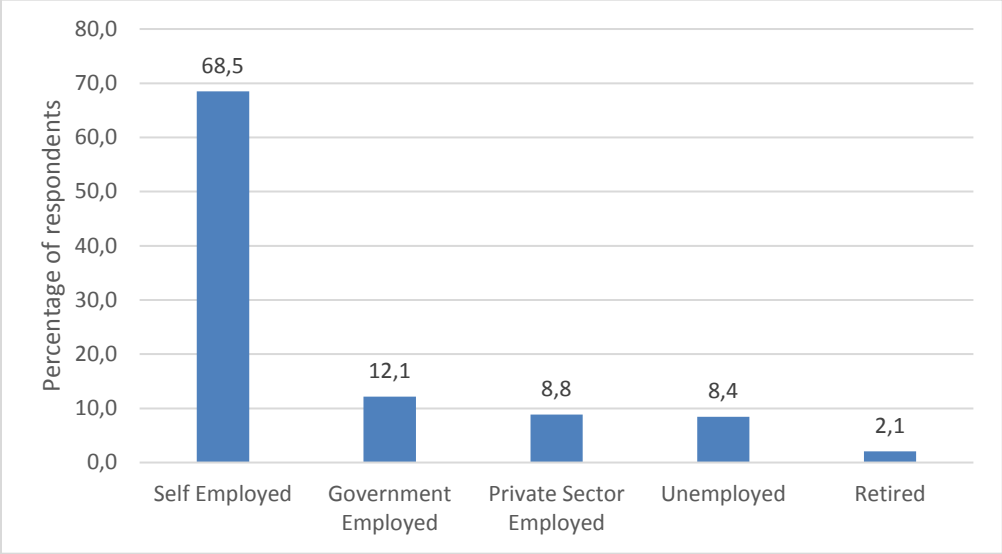


Figure 14 Employment status of households

3.3 Major AC and refrigerator brands

142 different refrigerator brands and 38 AC brands were observed in the various households. The refrigeration and air conditioning market in Ghana is replete with numerous brands. The use of second-hand cooling technologies is very prominent in Ghana even though there are several suppliers of new refrigerators and ACs. About 50 per cent of households use second-hand (used) refrigerators while 30 per cent of households use second-hand ACs. The ten (10) most common brands of new and second-hand refrigerators are shown in Figure 3.6.

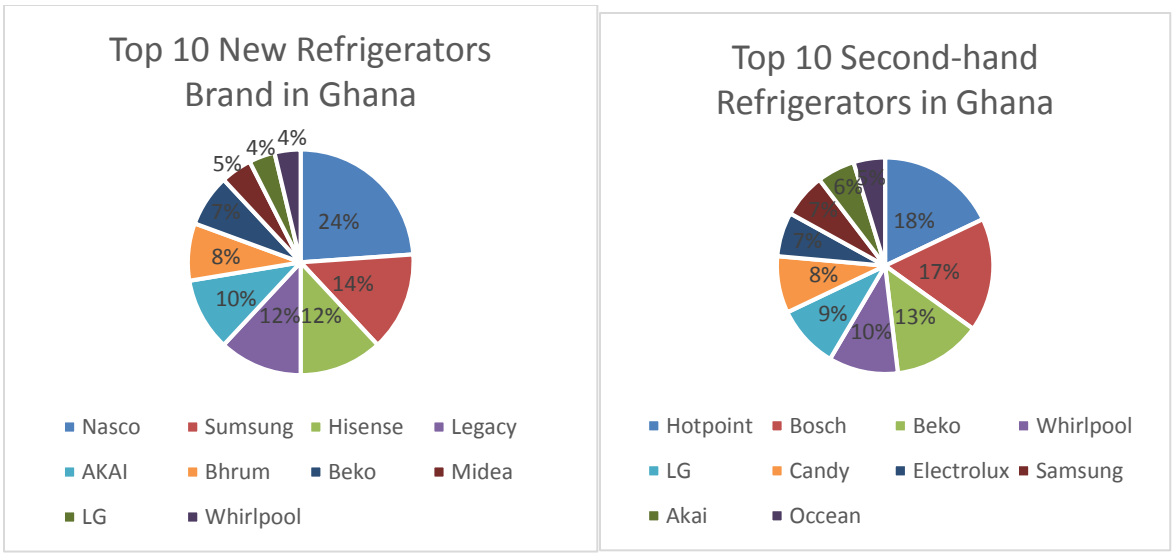


Figure 15 Common refrigerator brands in Ghanaian households
(Left: Newly bought, Right: Second-hand)

The 15 most common ACs are presented in Figure 3.7. All Craft ACs are second-hand ACs imported into the country. Nasco and Hisense dominate the newly bought residential AC market in Ghana. It is important to note that these AC brands are market entrants and have relatively lower prices compared to more established brands such as Samsung and LG. Hisense, for instance, introduced products onto the market in 2001.

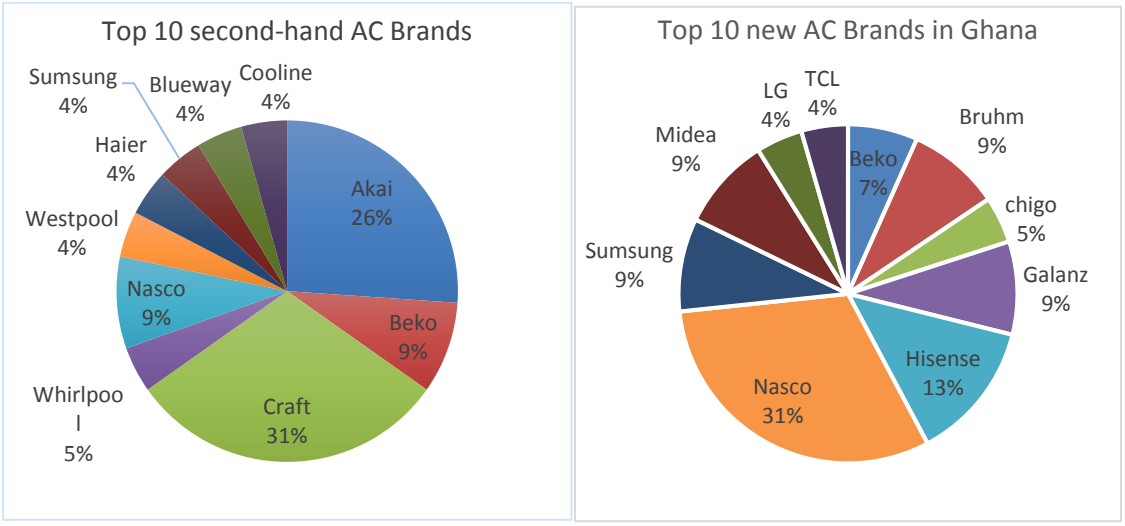


Figure 16 Top 10 AC brands in Ghanaian households *(Second-hand: Right; New: Left)*

These appliances are acquired mostly from specialized shops and second-hand street vendors (Figure 3.8). Almost all households surveyed paid cash (99%) for the appliances with less than 1 per cent using mobile money, bank transfer, or debit card as means of payment.

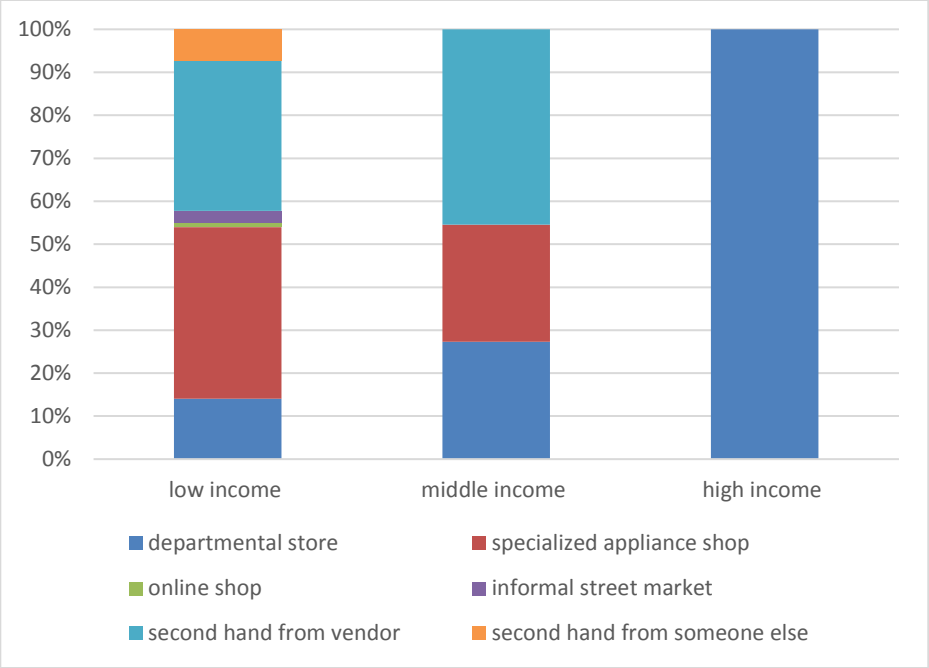


Figure 17 Locations where ACs and refrigerators are purchased by households

3.4 Characteristics and performance data of ACs and refrigerators

Households prefer refrigerators which have both freezing and refrigeration capabilities as shown in Figure 3.9. The mini-split wall-mounted ACs are common AC types used in the households followed by the window-mounted types.

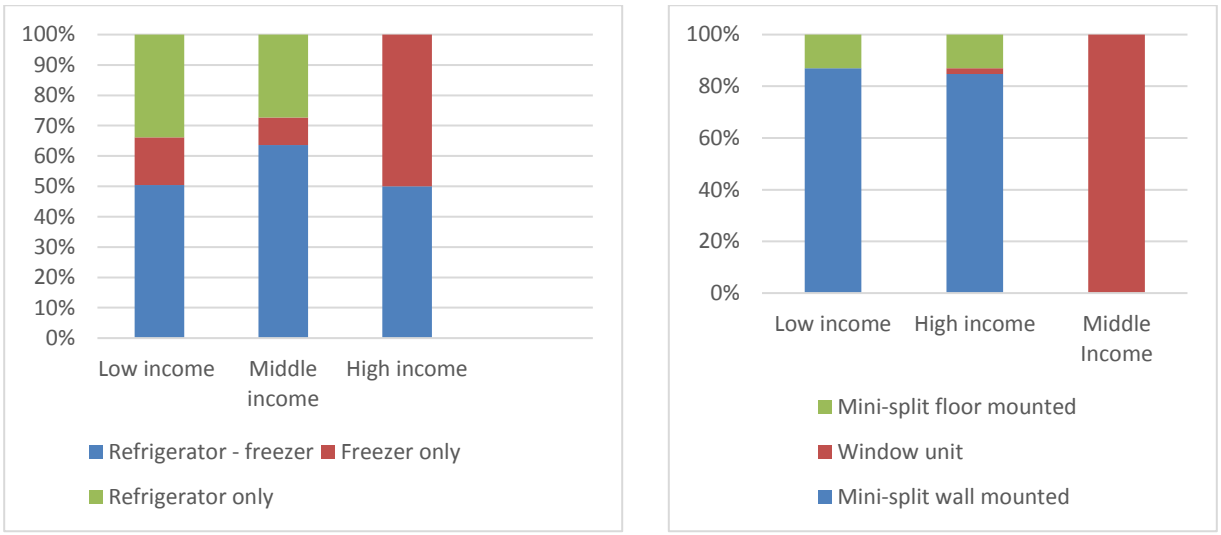


Figure 18 Types of refrigerators (left) and ACs (right) used in households based on income

3.4.1 Energy performance and star ratings

Despite the numerous energy efficiency campaigns rolled out by the Energy Commission and partners in the past, it appears more than half of all refrigerators and ACs surveyed which were

purchased second-hand do not meet the minimum EE rating as shown in Figure 3.10. This could be as a result of the upfront cost of the energy-efficient appliances as more efficient ones are perceived to be more expensive by most consumers. All second-hand appliances were not rated by the Energy Commission and are considered affordable by consumers. From the household survey, second-hand refrigerators are for instance about 40 per cent cheaper to purchase than new ones (Figure 3.11), though typically much more expensive to own and operate compared to efficient, new ones. Some respondents claimed they had purchased new refrigerators and ACs which had no labels – 30 per cent respondents on refrigerators and 42 per cent on ACs, as in Figures 10a and 10b. This could be that these appliances were purchased before the standards and labels programme was implemented or the labels had just been removed.

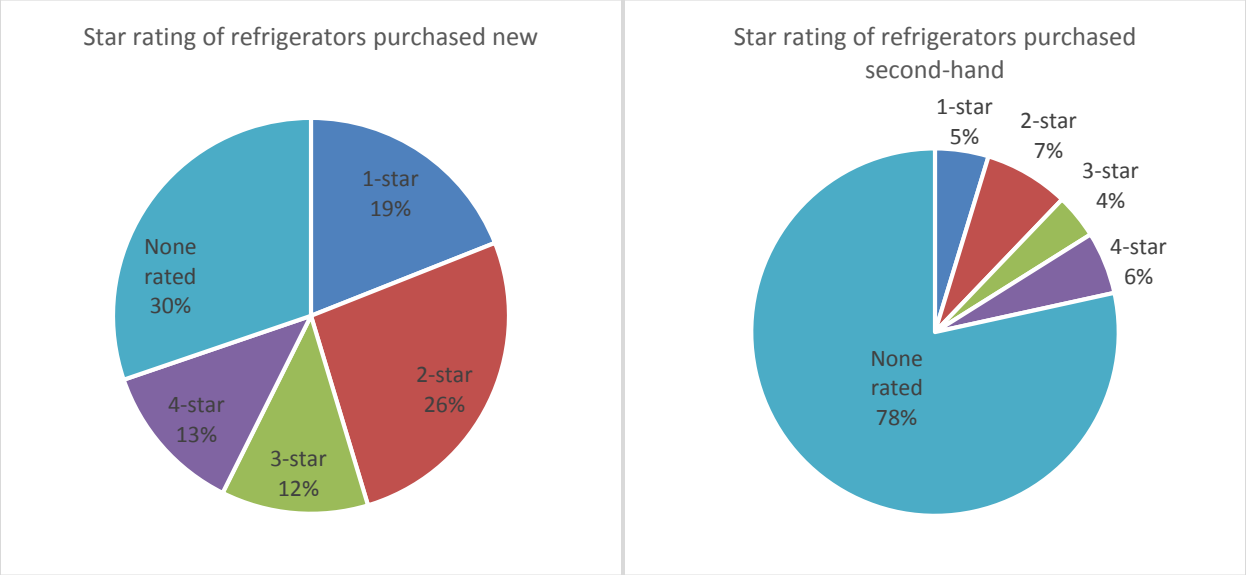


Figure 19 Star ratings of refrigerators purchased new and second-hand[27]

[27] Source: Household survey (2019)

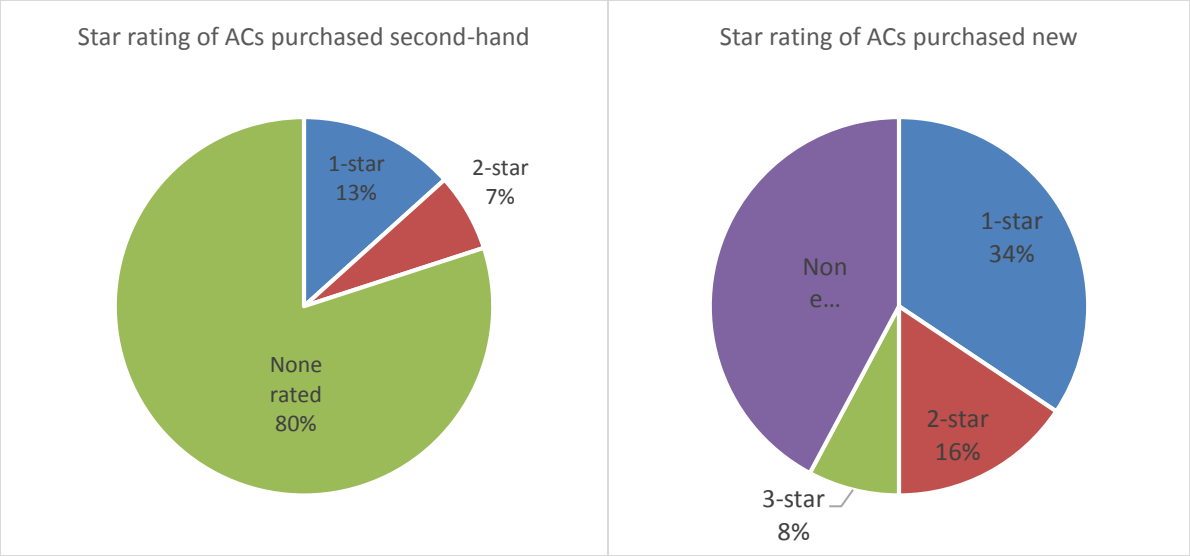


Figure 20 Star ratings of ACs purchased new and second-hand[28]

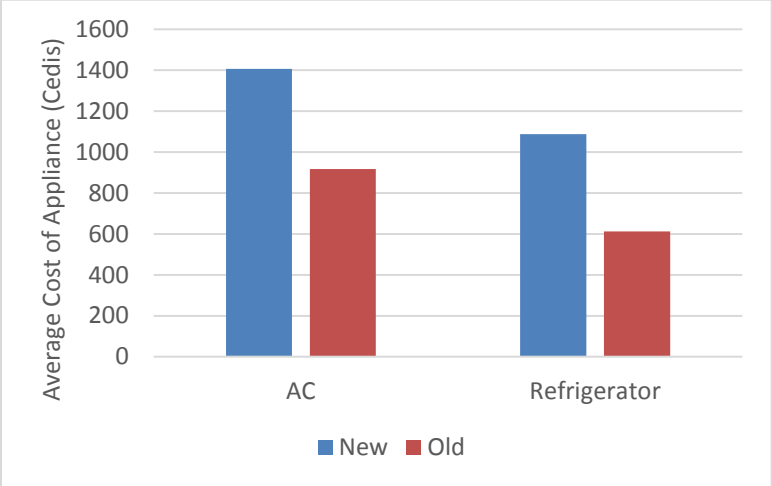


Figure 21 Average cost of old and new ACs and refrigerators[29]

The energy consumption data for refrigerators was obtained from labels on the appliances. Where the labels were not available, the details were obtained using the Energy Efficiency App created by the Energy Commission. The data indicated that, on the average, old refrigerators (irrespective of the size/capacity) consume more electricity than new ones (Figure 3.12). Even for those within the energy efficiency space, using a 4-star refrigerator-freezer could save an average of 40 per cent in electricity bill annually over a 1-star refrigerator-freezer. Similarly, buying a 3-star AC would save a household about 35 per cent in electricity bill (Figure 3.13).

[28] Source: Household survey (2019)
[29] Source: Household survey (2019)

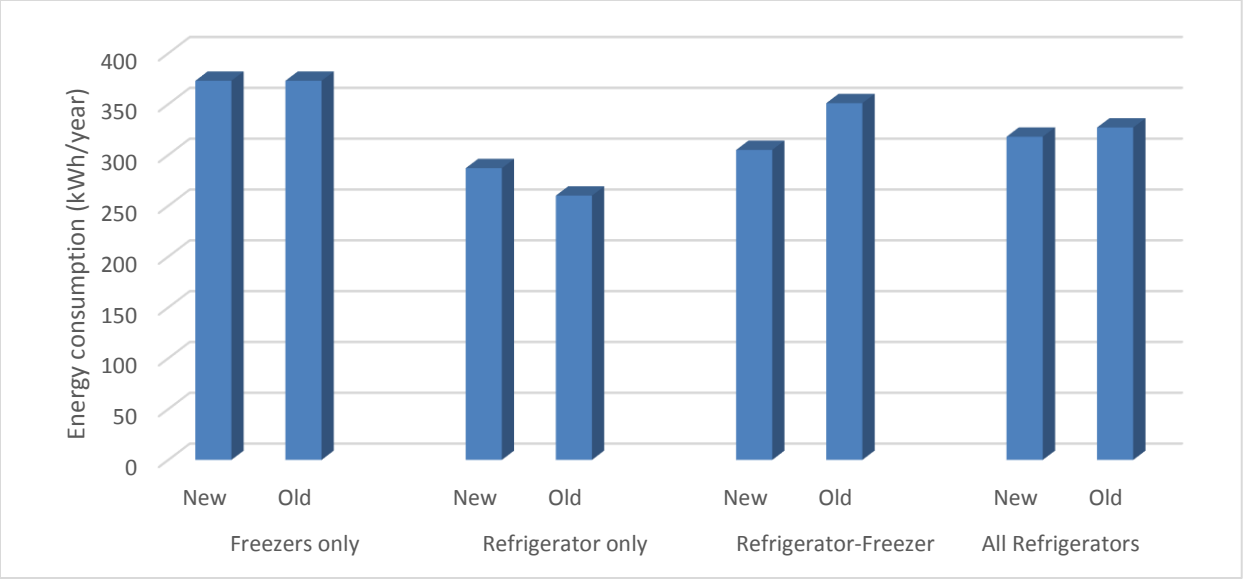


Figure 22 Energy consumption of new and used refrigerators[30]

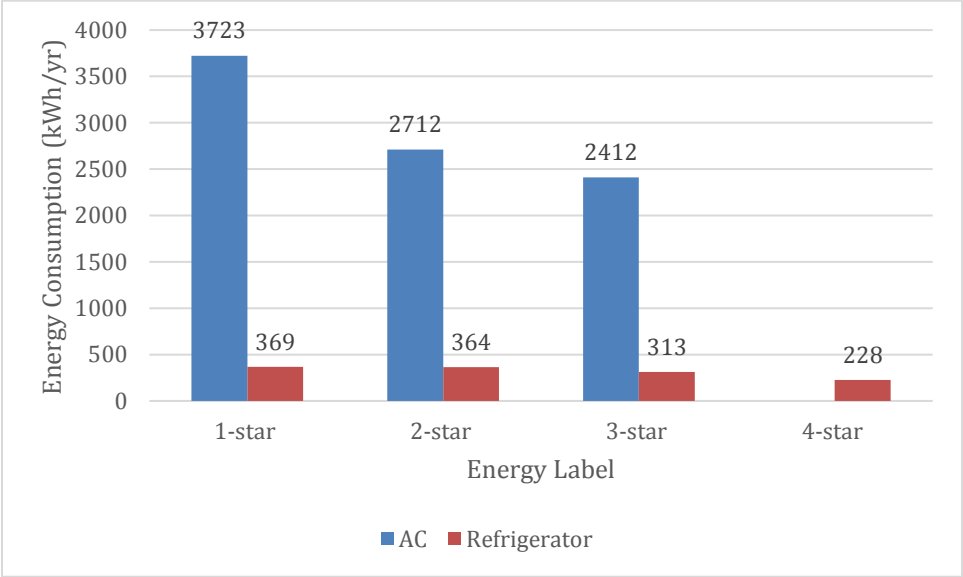


Figure 23 Energy consumption of the different star ratings of ACs and refrigerators

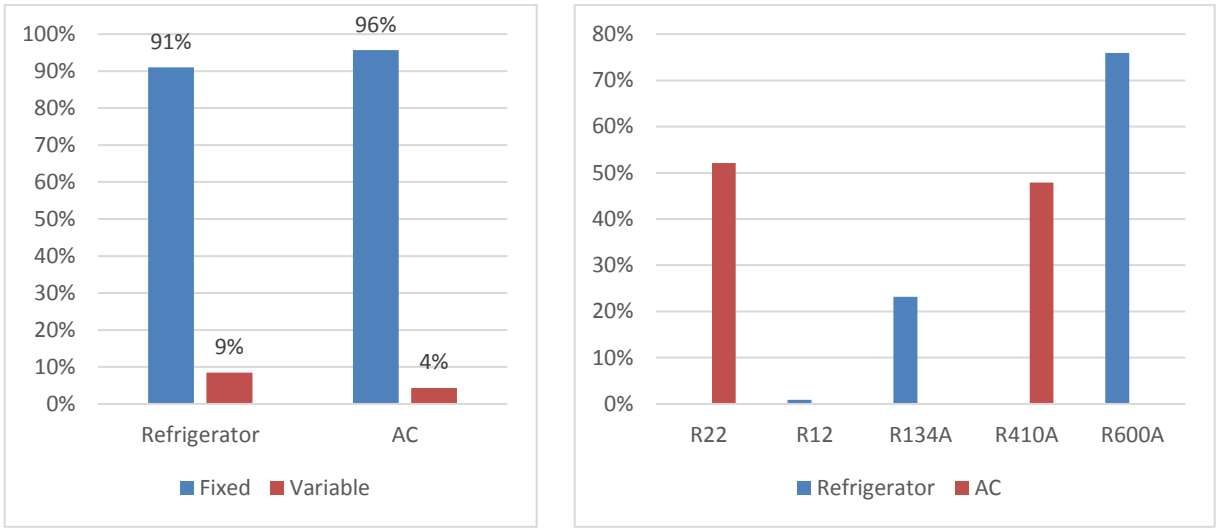
3.4.2 Inverters and refrigerants

The inverter technology for refrigerators and ACs can be considered revolutionary. It enables appliances to operate with lower noise at stable storage temperatures, facilitates fast freezing and provides better preservation of freshness for stored products.[31] More importantly, it improves the energy efficiency of the appliance to which it is applied by adjusting the required cooling load. Inverter technologies for refrigerators and ACs are available on the Ghanaian

[30] Source: Household survey (2019)
[31] Chang et al, 2008

market but with very limited presence (Figure 3.14). The survey results revealed that majority of respondents utilized appliances with fixed inverters. This might be due to the higher cost associated with inverter ACs and a lack of consumer awareness on the advantages of inverter technology. [32] The use of refrigerant types R-410A and R-600A for ACs and refrigerators respectively are on the rise although R-22 and R-12 are still on the market[33].

R-12 and R-22 are halogenated chlorofluorocarbons with ozone depleting potential (ODP). As a result of Montreal Protocol (1987) which sought to reduce depletion of the ozone layer, these gases were replaced with those including R-134a which have close to zero ODP[34]. However, these were found to have global warming potential (GWP). Amendments to the protocol, adopted in Kigali 2016 require that these gases be replaced with efficient and eco-friendly gases such as R-410a and R-600a[35].



(a) (b)

Figure 24 Compressor types and refrigerants used in ACs and refrigerators

3.5 Factors influencing the purchase of ACs and refrigerators

The price, quality, energy consumption and access to finance are the main factors that determine a households' decision to purchase a refrigerator (Figure 3.15a). There is a long-standing perception that slightly used electronic appliances imported from Europe and North America are of higher quality than brand new ones from Asia[36]. This could explain why many households (about 50 percent) still patronize slightly used refrigerators as observed in the survey. Similarly,

[32] CLASP (2018). Africa Air Conditioner Market Scoping Study
[33] GIZ, (2018) Green Cooling Initiative
[34] Refrigerants, https://www.secop.com/solutions/compressor-qa-tools/refrigerants/
[35] BOC, Industrial Gases UK, https://www.boconline.co.uk/en/products-and-supply/refrigerant-gases/natural-refrigerants/care10-r600a/care10-r600a.html
[36] Interviews with respondents from households

quality, access to finance, energy consumption, and price of AC are factors considered by households before purchasing an AC. This is shown in Figure 3.15 (b) and (c). Other factors were not considered influential. For instance, transport (which in this context referred to delivery to the recipient's home) was not found to be an influential factor. Though the phenomenon is not commonplace among suppliers, it appears to be gradually gaining momentum as a marketing tool, especially by the online stores like Jumia.

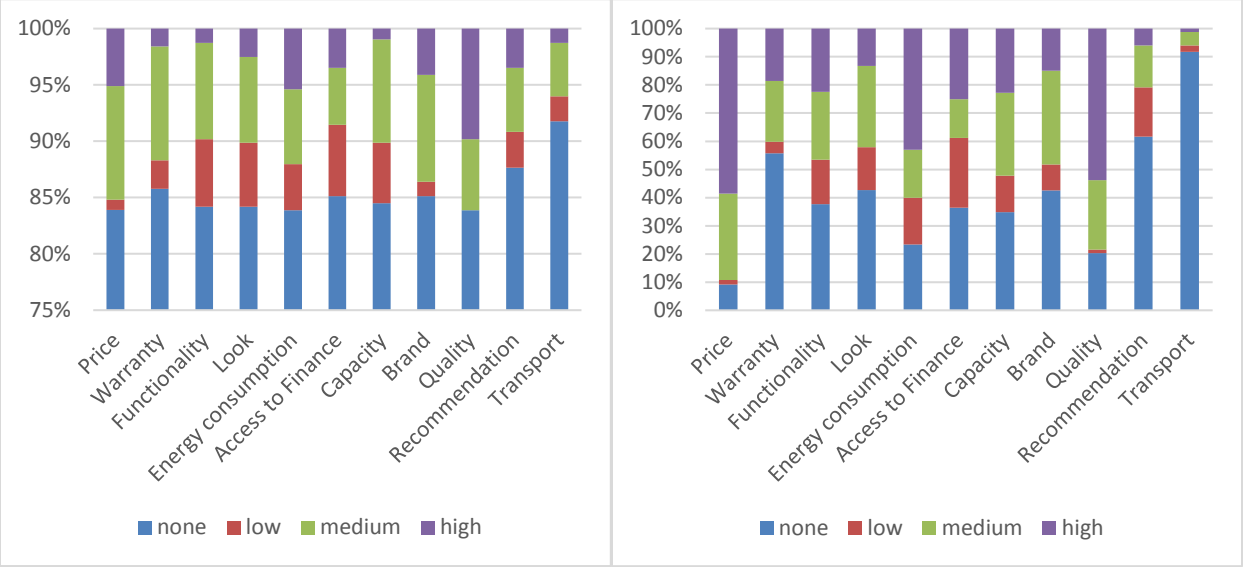


Figure 25 Factors influencing the purchase of cooling technologies for low-income households in Ghana*:*
(left) ACs and (right) Refrigerators

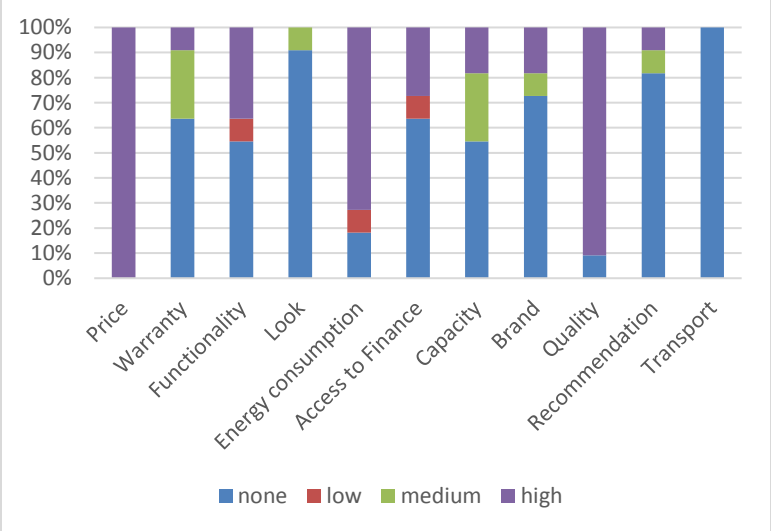


Figure 26 Factors influencing the purchase of refrigerators for middle-income households in Ghana

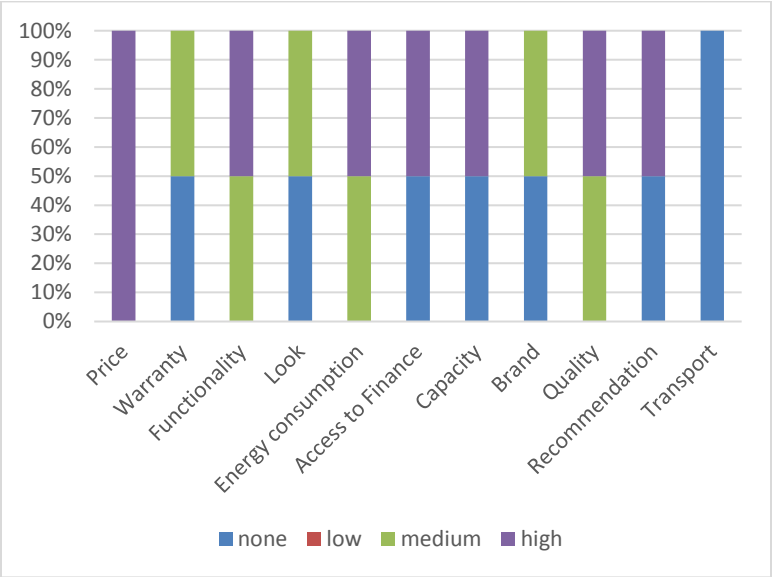


Figure 27 Factors influencing the purchase of refrigerators for high-income households in Ghana

3.6 Bank accounts and access to finance

Fifty-one percent of respondents have bank accounts, with nine out of 10 being savings accounts. The breakdown of the type of account with respect to income levels is shown in Figure 3.16. About three-quarters of households (i.e. heads of household) have a bank account with commercial banks. The breakdown is presented in Figure 3.17.

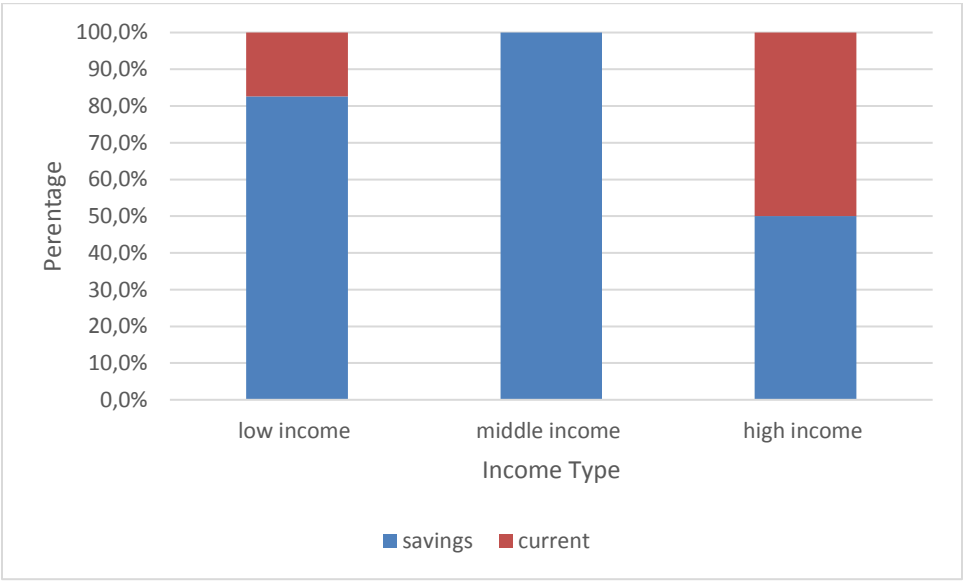


Figure 28 Households having a bank account (N=599)

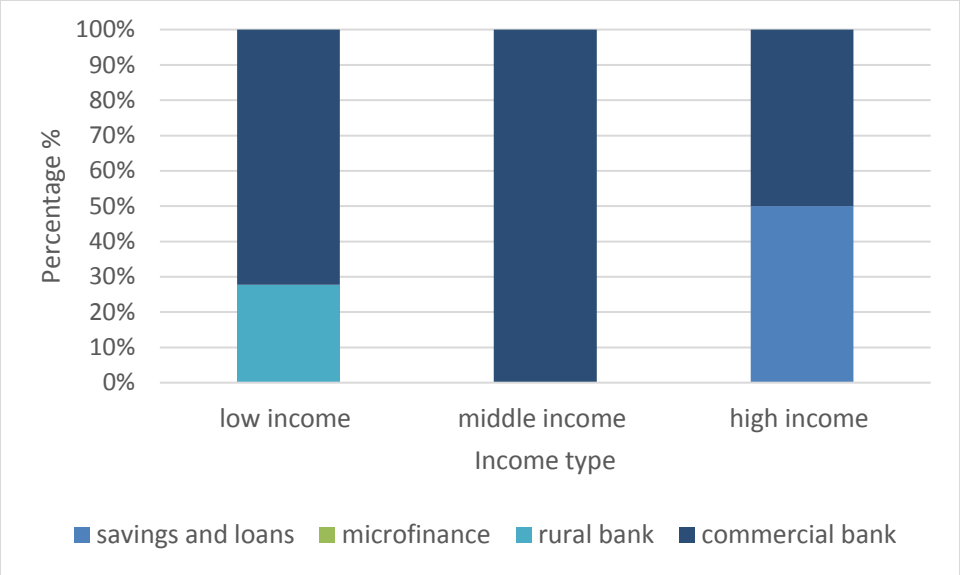


Figure 29 Types of financial institutions

Only 10 percent of bank account holders have ever taken loans from their banks. These customers have been doing business with their respective banks for an average of 7 years and hence qualify for loans. The low patronage of loans is in agreement with national figures as published by the Ghana Statistical Service where only 10.9 per cent of people in urban localities had applied for loans. Additionally, it correlates well with the low percentage of salaried workers found in households (12%) which also agrees with national figures of 11.4 per cent of formal sector workers nationally (GLSSS 6). Usually clients who work with the public sector can easily acquire loans from banks. According to the GLSS 6, 78 per cent of loan applicants used their employers as guarantee while 71.3 per cent used their salaries. These figures give credence to the fact that, mainly salaried workers patronise loans from the banks. The low patronage of loan facilities by unsalaried workers could be due to the following requirements needed to be satisfied:

I. Banking with the institution for more than 7 years
II. Having a fluid and active bank accounts
III. Access to collateral sufficient to cover the loan asset
IV. Having a minimum of two guarantors who will in default of payment take up the responsibility of redeeming the loan.

These hard to meet requirements effectively puts out or limits the number of non-salaried workers from accessing loans.

3.7 Financial overview

Financial institutions can be classified into three broad categories – banking, insurance and capital market. In this work, the focus was on banks. Financial institutions refer to banks or

banking institutions which include commercial and investment banks, rural banks, savings and loans institutions and credit unions.

Eight (8) banking institutions were interviewed. These include Cal Bank, Ecobank, First Atlantic Bank, Asante Akyem Rural Bank, Odotobiri Rural Bank, MultiCredit Savings and Loans, Kumasi Technical University (KsTU) Credit Union and Crops Research Institute (CRI) Credit Union.

The main clients for the commercial banks and rural banks included SMEs, corporate and retail companies. KsTU and CRI credit unions target retail and micro clients respectively. Ecobank has 67 branches, the highest number among the 3 banks. It is followed by Cal Bank and First Atlantic Bank with 27 and 26 branches, respectively. All commercial banks operate a digital platform that enables mobile banking activities. The same was not the case with the credit unions. This could be attributed to the lack of interest of their clients for internet banking activities.

While financial institutions take deposits and offer loans and insurance products, loans (in various forms) constitute one of the major products offered to customers. Commercial banks offer customers debit cards while the rural banks and credit unions do not. Coupled with internet banking, debit cards are tools which have been deployed by the commercial banks to offer clients a 24-hour service to their cash and also to reduce queues in the banking hall. As iterated, it appears the rural banks and credit unions are yet to catch on to this technology.

While Ecobank has recently been accredited by the Green Climate Fund and is in the process of developing green credit lines, the bank is yet to provide green financing services. Some FIs expressed interest in development of green credit lines. However, this will require development of structures, capacity building and liquidity support.

With regards to EE, Cal Bank and First Atlantic Bank are currently financing options for customers to purchase energy-efficient equipment. Atlantic Bank offers customers up to GHS 40,000 (about EUR 7,000) to purchase energy-efficient appliances. The financing option is popular among the retail, SME and corporate clients. Both Cal Bank and Ecobank indicated interest in financing investments in EE appliances. Further, Cal Bank indicated financing suppliers of EE appliances.

The common risk perceived in financing EE appliances and/or equipment is non-repayment of loans. Other perceived barriers include late repayment of loans, technological risk, product quality, and warranty issues. To demonstrate their interest in the ECOFRIDGES project, most financial institutions agreed to provide feedback on draft documents, help raise awareness and facilitate piloting of new financial mechanisms.

A summary of information gathered from financial institutions is presented in Appendix E.

3.8 Existing and upcoming initiatives on EE in Ghana

The inability of financial institutions to offer green financing opportunities to customers can be attributed to, among other things, inadequate awareness, lack of capacity in renewable energy and EE, and lack of liquidity support. To this end, there have been some conferences and seminars to educate financial institutions in Ghana in 2017 organized by African Guarantee Fund (AGF), the International Trade Centre (ITC) and the Nordic Development Fund (NDF). Additionally, some studies have been conducted by UNEP FI through its partners at the Partnership for Action on Green Economy (PAGE) consisting of institutions including UNEP, ILO, UNITAR, UNIDO, and UNDP with the view to raise awareness of the need to integrate sustainability in the Ghana Business community, to enable private sector firms to benefit through the increased availability of "green" finance and new or increased revenue-generation projects or business lines that contribute to sustainable development (UNEP Finance Initiative, 2018[37]; PAGE, 2018[38]).

More recently, the French Development Agency (AFD) and Energy Commission (EC) has signed a Technical Assistance Facility (TAF) under the Sustainable Use of Natural Resources and Energy Finance (SUNREF) programme in Ghana, targeting SMEs. Aside AFD, there are several programmes in EE targeting various sectors and groups, that are under various phases of development by development partners. Some of the notable initiatives based on discussions with development partners are outlined in the Table below.

Table 30 Current and impending EE initiatives by development partners and donors

Organisation	Area of focus	Details of intervention
GIZ	Households and SMEs	GIZ is implementing EE programme for households and SMEs as a component under the programme Capacity for a Successful Implementation of the Renewable Energy Act (C-SIREA), which commenced in 2013. Several thousands of households and SMEs have been trained. Under C-SIREA, technical capacity building support to various organisations such as: regulatory bodies such as EC and PURC, distribution companies such as ECG and Northern Electricity Distribution Company (NEDCo), transmission grid operator - Ghana Grid Company (GRIDCo), generation bodies such as Volta River Authority (VRA), and others including Energy Foundation and universities.
	Industries	GIZ has established an Energy Service Centre, stationed at the office of the Association of Ghana Industries. The goal of the Centre is to offer advisory services on renewable energy and EE solutions to industries under the AGI. The Unit will also promote awareness creation of EE among AGI members.

[37] UNEP Finance Inititave,2018, Green finance study to take place in Ghana, (accessed at https://www.unepfi.org/news/industries/banking/page-green-finance-study-in-ghana/)

[38] Partnership for Action on Green Economy (PAGE), 2018, Ghana's Financial System driving the transition towards green economy, (accessed at https://www.un-page.org/ghana%E2%80%99s-financial-system-driving-transition-towards-green-economy)

	Public buildings	GIZ intends to establish a green certification scheme based on EE and other standards for public buildings. A green building for demonstration purposes is also expected to be put up.
USAID	Power sector modelling	USAID has funded the Integrated Resource and Resilience Planning (IRRP) programme. Under IRRP, a masterplan for the power sector in Ghana has been prepared, including EE and demand-side management programmes. Based on the model, EE at end-user side can reduce demand by 7 per cent in 2030 via the use of efficient ACs, refrigerators and industrial motors.
	Local content within power sector	USAID is planning to introduce a programme on mainstreaming the local content law into the power sector, with involvement of Energy Commission and other partners.

Organisation	Area of focus	Details of intervention
KfW	Residential	KfW will make available a green credit line to government for EE programmes targeting households. The credit will be managed by Bank of Ghana, and will be made available via commercial banks (Cal Bank, Ecobank and Stanbic Bank). The concessionary loan to government has a tenor of 38 years and comes with a grace period of 6 years. Details of the programme such as interest rates to be enjoyed by households and technical assistance to banks are under discussion.
World Bank	Efficient cookstoves and public sector	The World Bank is budgeting about US$ 10 m for efficient and improved cookstoves as well as the public sector, especially public buildings, for the next 3-4 years. Details are still under development.
AFD	EE in SMEs	AFD is implementing Sustainable Use of Natural Resources and Energy Finance (SUNREF) programme, where SMEs offering green products and services are supported. Already, AFD has allocated Euro 30 m, with funds made available to SMEs through banks.
	Power transmission and distribution	Interest is also in this area.
EU Delegation to Ghana	Public buildings, residential EE, industrial EE, and efficient cookstoves	EU Delegation to Ghana has provided technical assistance and capacity training to Accra Metropolitan Assembly on opportunities for reducing electricity bills in buildings administered under their control. Presently, based on EU Decision, Sustainable Socio-economic Development through Clean and Efficient Energy Solutions (Energy/2019/41-813), Ghana is among 6 countries selected to benefit from EUR 194 m. A mission to identify areas of funding support is in progress.
AfDB	Power sector and mini-grids	AfDB released a grant of US$ 1.5 m to support Ghana remove barriers to scaling up RE and EE in the electricity sector, with more effective private sector participation. AfDB has also been active in funding the development and deployment of mini-grids in island communities in Ghana.

From Table 3.5, it is clear that Ghana, through the assistance of its development partners, is working to improving energy efficiency in various sectors. While this is a good development, a cursory observation at the programmes reveal they have the same or similar objectives and

therefore well-coordinated and collaborated activities could, potentially, yield greater results than is currently envisaged.

3.9 Energy/load demand in Ghana

3.9.1 Energy demand and supply in 2018

The maximum peak energy demand in 2018 was 2,520 MW representing an increase of 367 MW or a growth of 17 per cent over the 2017 peak of 2,158 MW (EC, 2019).[39] The total energy consumption, including losses, was 15,960 GWh, representing a growth of 11.55 per cent over that of 2017. The total energy supplied (including imports from Cote D'Ivoire) was 15,960 GWh, comprising 6,017 GWh (39.6%) from hydro, 9,803 GWh (58.3%) from thermal and 1140 GWh (2.3%) from imports as observed in the electricity plan for 2019.

3.9.2 Projected energy demand and supply in 2019

The projected peak demand for 2019 is 2,666 MW (2,797 MW for a high case scenario). The reference peak demand represents an increase of 5.5 per cent over the 2018 peak demand. The projected energy consumption (including losses) for 2019 is 17,238 GWh representing an increase of 8 per cent over the consumption in 2018.

3.10 Demand and supply barriers for energy

The demand and supply barriers are discussed in the following sections:

3.10.1 Fuel security and adequacy

Fuel supply security and adequacy continues to remain a challenge to power supply reliability. However, the bottlenecks related to infrastructure are expected to be resolved this year. It is envisaged that the Takoradi-Tema Interconnection Project (TTIP), which will allow a tie-in between the Ghana Gas Pipeline System and the West African Gas Pipeline (WAGP) in Takoradi will facilitate reverse flow of surplus gas from Western offshore Ghana to Tema.

3.10.2 Low reserve margin

According to the Energy Commission (2019 Electricity Supply Plan), with the deployment of the committed generation capacity, there is adequate generation capacity to meet projected energy demand until 2023. However, the Plan indentifies that the reserve margin for 2024 falls short of the required reserve margin of 18 per cent (needed for the medium-term reliability of supply) and recommends procurement of additional generation capacity before 2024.

[39]EC 2019, Electricity Supply Plan, Energy Commission, Accra, Ghana.

3.10.3 Low transmission reliability

EC report (2019 Electricity Supply Plan) indicates low transmission reliability and recommends critical transmission additions and upgrades.

3.10.4 Lack of diversity in the electricity generation mix

There is heavy dependence on the Akosombo dam for electricity generation because it provides a cheap source of electricity generation compared to thermal and renewable energy sources (Kumi, 2017). Drop in operational water height leads to reduced generation and concentration on thermal sources, which are relatively more expensive to run. Electricity from renewable energy sources is still at an infantile stage.

3.10.5 Tariff structure

The Public Utilities Regulatory Commission (PURC) incorporated the Automatic Adjustment Formula (AAF) with the aim of sustaining the real value of the tariffs by accounting for variations in factors such as fuel price (light crude oil, natural gas, etc), foreign exchange, inflation and generation mix. The AAF allows the tariffs to be adjusted any time there are significant variations in any of the above factors. The electricity tariffs for 2018 have been increased twice already in 2019. It went up by 11.17 per cent in July 2019 and by 5.5 per cent October 2019. The increase affected all clients, although tariffs are lower for residential clients than commercial clients. To cater for very poor consumers, PURC has instituted the lifeline tariff for low-income consumers with significantly low consumption levels at tariffs below the cost of electricity provision. Lifeline consumers for residential category are households using between 0-50 kWh per month. Lifeline consumers are mostly in rural and peri-urban areas though. They purchase power for lighting and other basic home appliances. Some might be within ECOFRIDGES target market segments when it comes to power for small volume refrigerators. These consumers paid between 2.13 cedis and 17.68 cedis for electricity as at September 2019 (see Table below).

3.10.6 Losses in electricity generation and distribution system

Huge losses (during both generation and distribution) are experienced with the system. For instance, up to 2017, transmission losses for this period only averaged 3.9%, while distribution losses, which also include commercial losses, accounted for 16.2 per cent annually. These losses could be attributed to inefficiency of some equipment in the distribution systems due to their obsolete nature and also the loss of revenue for electricity consumed due to non-payment of bills and power theft.

Table **31** *Electricity tariff reckoner effective 1st July 2019*[40] *and effective* **1st October 2019**[41]

Jul-19	RESIDENTIAL						
Units (kWh)	Energy Charge	Street Light	Nat'al Elect Levy	Service Charge	TOTAL THIS MONTH	Total Gov't Subsidy	Net Charge
0	0.00	-	-	2.13	2.13	-	2.13
1	0.31	0.01	0.01	2.13	2.46	(0.61)	1.85
2	0.62	0.02	0.01	2.13	2.78	(0.61)	2.17
3	0.92	0.03	0.02	2.13	3.10	(0.61)	2.49
4	1.23	0.04	0.02	2.13	3.42	(0.61)	2.81
5	1.54	0.05	0.03	2.13	3.75	(0.61)	3.14
10	3.08	0.09	0.06	2.13	5.36	(0.61)	4.75
15	4.62	0.14	0.09	2.13	6.98	(0.61)	6.37
20	6.16	0.18	0.12	2.13	8.59	(0.61)	7.98
25	7.70	0.23	0.15	2.13	10.21	(0.61)	9.60
30	9.23	0.28	0.18	2.13	11.82	(0.61)	11.21
35	10.77	0.32	0.22	2.13	13.44	(0.61)	12.83
40	12.31	0.37	0.25	2.13	15.06	(0.61)	14.45
45	13.85	0.42	0.28	2.13	16.68	(0.61)	16.07
50	15.39	0.46	0.31	2.13	18.29	(0.61)	17.68
55	18.48	0.55	0.37	7.04	26.44	-	26.44
60	21.57	0.65	0.43	7.04	29.69	-	29.69
70	27.74	0.83	0.55	7.04	36.16	-	36.16

FOURTH SCHEDULE

Tariff Category (EUT)			Effective 1 October 2019
Residential			
0-50	-	(GHp/kWh)	32.6060
51-300	-	(GHp/kWh)	65.4161
301 – 600	-	(GHp/kWh)	84.8974
601+	-	(GHp/kWh)	94.3304
Service Charge:			
Lifeline Consumers	-	(GHp/month)	213.0000
Other Residential Consumers	-	(GHp/month)	745.6947

3.11 Demand and supply barriers for energy-efficient appliances

3.11.1 Demand side

Relative high cost of new refrigerators and air-conditioners

Considering the salary range of most Ghanaians, the cost of refrigerators is relatively high. While both are available, the cost of a new refrigerator is sharply contrasted by that of a used refrigerator. This makes the affinity for used refrigerators greater. In Ghana the second-hand refrigerators and other second-hand electrical devices, which are relatively inefficient, are purchased by low-income households (Buskirk, et al., 2007).

Income ranges and Access to finance

As a result of low salary income ranges, refrigerators and air-conditioners are obtained via cash saved over a long period of time or through loans or credit facilities offered by financial

[40] http://www.pdsghana.com/index.php/customer-service/services/current-tariff
[41] http://purc.com.gh/purc/sites/default/files/4th_qtr_aaf_electricity_and_water_tariffs_2019.pdf

institutions or consumer-finance institutions. Generally, the urge to replace an old and inefficient appliance with a new and efficient one (as long as it remains functional) is not strong enough to warrant obtaining a loan, which often comes with high interest rates. For salaried workers, accessing a loan facility may not necessarily be a challenge. For non-salaried workers, however, access to finance is a challenge especially because of the eligibility requirements they have to meet to obtain the loan.

Awareness creation of the energy efficiency practices

The Energy Commission has made efforts to create awareness about the need for the adoption of energy efficiency practices. However, its continued efforts are hampered by lack of funds to implement awareness programmes (Energy Commission, 2010; Dramani and Tewari, 2013; Issah Amin,2016).

3.11.2 Supply side

Competition with importers of used appliances

Importers of new refrigerators continue to face competition from those who import used refrigerators. Importation of used refrigerators is banned in Ghana[42], yet this practice is ongoing. Continued importation of used refrigerators into the country negatively impacts the business of those who import new refrigerators[43] and also hampers efforts to encourage utilization of efficient ones.

[42] National Energy Efficiency Action Plan (NEEAP) of Ghana: 2015-2020
[43] Interview with CEO - Electroland Ghana

IV. FEASIBILTY ANALYSIS

4.1 Cost benefit analysis for households with a loan at commercial interest rate

4.1.1 Air-conditioners

The analyses in this section are based on the following assumptions:

i. all second-hand ACs and refrigerators are inefficient and could be replaced by energy-efficient ones (3-star 1.5 Hp AC and 3-star[44] 250 litres[45] refrigerator-freezer models);
ii. energy-efficient (star-rated) ACs and refrigerators which are more than 10 years since installation are considered inefficient; and
iii. the payback period for a household replacing an inefficient AC or refrigerator is calculated based on electricity savings and financing costs.

With these assumptions and using data from household survey as well as electricity savings that could be made from using new ACs, it is observed that a household could pay back the cost of acquiring a new AC using a 24-month loan at commercial rate (25%) in about 2.1 years as shown in Table 4.1.

Table* 32 *Cost benefit analysis for household using 1.5 Hp AC for an average of 4 hours a day

Parameter	Value
Cost of new 1.5 Hp, 3-star AC (GHS)[46]	2,665
Average cost of old AC (GHS)	1,100
Average energy consumption old AC (kWh/year)	4,000
Average energy consumption 3-star AC (kWh/year)	2,400
Electricity tariff (GHS/kWh)[47]	0.8491
Average usage of AC by HHs (hours)	4
Electricity bill saving per year, GHS	1,334
Payback time (years):	2.1

[44] There are 4-star refrigerators in Ghana, however, this study only got prices for 3-star refrigerators for the shops surveyed.
[45] This is the average size of domestic refrigerators found in the households surveyed. 82 % of refrigerators found in households during the survey are within this size range
[46] CLASP (2018)
[47] PDS, as at October 2019 for tariff band Residential 301-600

4.1.2 Refrigerators

A similar analysis is carried out for replacing old refrigerator-freezers with new 3-star refrigerator using a 24-month loan at commercial rate (25%). The analysis is done for only refrigerator-freezer types as they are used mostly by households (64%). The analysis shows it will take them only 4.1 years to payback the cost of replacing their old refrigerators (Table 4.2) that is much shorter than the average lifetime of a refrigerator (15-25 years).

Table 33 Cost benefit analysis for replacing old residential refrigerators with new ones

Parameter	Value
Cost of new refrigerator (GHS)[48]	1,950
Average cost of old refrigerator (GHS)	600
Average energy consumption old refrigerator (kWh/year)	800
Average energy consumption 3-star refrigerator (kWh/year)	228
Energy savings per year (first year) %	71.5
Electricity tariff (GHS/kWh)[49]	0.8491
Average usage of refrigerator by HHs (hours)	24
Electricity bill saving per year (GHS)	486
Payback time in terms of electricity savings (Years):	4.1

4.2 Financing mechanisms

Majority of households in Ghana are low-income. From the survey, 96 per cent of respondents indicated they were earning less than GHS 1,000 cedis (US$ 200) per month. It is therefore imperative to consider financing mechanisms that provide some form of incentives along the supply chain to ensure households have access to attractive capital. The financing mechanisms should enable widespread adoption of energy efficiency improvements by scaling and leveraging secondary markets, reflecting a true assessment of risk, providing more liquidity, and reducing borrowing costs.

Two broad financing mechanisms are proposed for the Ghanaian market:

i. Consumer targeted; and
ii. Supplier/distributor targeted.

Consumer targeted programmes would offer consumers attractive capital through green loans with special financing and repayment conditions offered by commercial banks (green loans, employee loans), retailers (vendor financing, rebates) or the utilities (on-bill financing) to help them acquire more efficient and climate friendly appliances and address the high upfront cost and traditionally low access to finance barriers. Due to the high cost of borrowing in Ghana, such

[48] https://pricesghana.com/prices-of-fridges-freezes-in-ghana/
[49] PDS, as at September 2019

programmes should provide loans at reduced interest rates. In addition, the presence of reduced loan interest rate or a refund or cash-back for disposing used appliances could be perceived as an effective price signal and increase uptake of energy-efficient and climate friendly appliances. Such incentives would be partially financed by the valorisation of recycled gas and materials from the used appliance and bulk rebate negotiation from suppliers. However, a drawback of cash-back programme would be the massive operational costs required in delivering refunds to big numbers of beneficiaries on individual basis, while securing a sustainable financing for the recycling and disposal processes.

Suppliers can also be motivated to import highly efficient and climate friendly appliances into the market through bulk rebate negotiation practices, while distributors or retailers could be offered access to new premium demand from consumers benefiting from loans with special conditions from local financial institutions which themselves benefit from green credit lines. The introduction of highly efficient and climate friendly products into the market can also encourage wider adoption of such appliances and thus lead to a market transformation.

Since EE projects such as the replacements of old cooling appliances with new and efficient ones may not be proven from the onset, they carry along high risks. Moreover, the intervention may be too expensive for some households initially while others may be less motivated to replacing their old units. Thus, assessment of risks and developing appropriate mitigation strategies to address risks are crucial for success. The major risks foreseen and mitigation instruments are outlined in the Table 4.3. Risk mitigation instruments such as credit risk guarantees and support mechanisms like positive list are both recommended in order to reduce the perceived financial and technical risks.

Table 34 Examples of risk mitigation instruments for perceived risks

Risks	Elaboration of challenge	Mitigation instruments
Uncertainties about the performance and reliability of energy saving. Technology risks.	Low quality and inferior appliances that fail to deliver savings on electricity can erode consumers' confidence in the programme	(i) Agree on a positive list of energy-efficient technologies, certified technology providers, and suppliers, pre-approved for green lending with special conditions by financial institutions. (i) Select well-known brands and models. (ii) Deliver awareness creation effectively using all means including mass media as well as social media. (iii) Establish effective stakeholder participation. (iv) Prepare effective demand side management plan.
Exchange rate risks	Cost of appliances will rise with depreciation of Cedi since appliances are not locally manufactured and are therefore imported using foreign currency. Moreover, the depreciation rate of	A minimum payback period for loans received by households could be decided. Initial payment could be encouraged to reduce loan amount and repayment period.

Risks	Elaboration of challenge	Mitigation instruments
	the Cedi has been high over the years.	
Political intervention in tariffs	Occasionally, tariffs are subsidized based on political intervention. Since high electricity bills are a motivation for patronage of EE equipment, lowered bills could reduce interest in EE equipment.	While, this is always a possibility, it does not occur frequently. Investment in EE appliances should be promoted to mitigate the effects of energy subsidy reform in the residential and light commercial sectors.
Contract risks and uncertainties with suppliers	Careful selection of suppliers is necessary to ensure reliability of the supply chain over the period of the programme, including the supply of high quality and efficient and climate friendly appliances.	Only credible suppliers, registered with regulators such as Energy Commission and with presence in the target areas should be considered. Those with experience in past programmes such as Hisense could be prioritized provided they meet eligibility criteria set on a positive list.
High interest rates and limited access to capital	Financial institutions provide loans at high rates, while demanding collateral in some cases	ECOFRIDGES should provide technical assistance, including financial (e.g. green loans, vendor financing) and non-financial incentives (e.g. positive list, on-wage financing, on-bill financing), to help reduce non-payment risk, through the elaboration of streamlined programme eligibility criteria and a simplified yet robust application process for customers, and low risk recovery mechanisms. This would eventually reduce due diligence costs and lower interest rates.
Dismantling of old refrigerators/ACs and use/disposal of all components	Components of second-hand units that are replaced should be dismantled and appropriately disposed of by experienced firms.	Experienced firms should be selected to dismantle units replaced under monitoring by EPA and Energy Commission. Incentives (e.g. cash-back, reduced interest rates) and financing for disposing/recycling old appliances should be partially covered by the valorization of old components through the program in a sustainable manner.
Risks and delays on reimbursements/payments to suppliers	Suppliers have waited too long in previous programmes before they could grasp any programme incentives.	A robust and well-planned programme, with clear roles and responsibilities. Up-front reimbursements could provide a huge boost to the participation of suppliers in the programme.

4.3 Sensitivity and risk analysis

This section assesses the impact of several indicators on the payback period of a household that plans to replace an old refrigerator/AC, or buy a new and energy-efficient refrigerator/AC. The effect of loan tenor, interest rate, cedi depreciation (affects upfront cost of appliance), and electricity tariff are analysed. For each indicator three scenarios are considered.

4.3.1 Sensitivity analysis for refrigerators

Sensitivity analysis was undertaken for some selected factors which influence the payback period for a refrigerator purchased. These factors include electricity tariff, cedi depreciation, refund, loan and interest repayment and loan tenor. From the baseline scenario (see Table 4.4), it appears that taking a 24-month loan at market rate (25%) to replace an old inefficient refrigerator seems to be already quite motivating (payback of 4.1 years). Indeed, the cost of borrowing affects the cost-benefit payback period quite significantly. At a zero interest rate a household may break-even in about 3.4 years and if interest rate of about 35 per cent should apply, the payback period would be in about 4.3 years. In any case, loans remove the barrier of high upfront cost of acquiring a new refrigerator by providing households the opportunity to pay small monthly amounts of about GHS 90 (US$ 16) even if the loan is taken at prevailing interest rate of 25 per cent per annum. A disposal/recycling reward scheme in the form of access to loans at reduced interest rates to households who turn in their old refrigerators to purchase a new one would therefore look attractive.

The impact of electricity tariffs, cedi depreciation, loan and interest rate, loan tenor and repayment on the payback period for a new refrigerator is presented in Tables 4.4 to 4.6 respectively.

Table 35 Impact of electricity tariff on payback period for new refrigerator

	Case 1 (10 per cent reduction)	Case 2 (Baseline)	Case 3 (10 per cent increase)
Electricity tariff per kwh (GHS/kwh)	0.7642	0.8491	0.934
Electricity bill saving per year (GHS)	437	486	424
Payback period from electricity savings (years)	4.5	4.1	3.8
Percentage impact of indicator on payback period	**+9%**	**0%**	**-8%**

Table 36 Impact of cedi depreciation on payback period for new refrigerator[50]

	Case 1 (20% depreciation)	Case 2 (Baseline)	Case 3 (20 % appreciation)
Exchange rate (GHS: US$)	6.64	5.53	4.42
Cost of refrigerator (3-star)	2,340	1,950	1,560
Payback period from electricity savings (years)	4.7	4.1	3.4
Percentage impact of indicator on payback period	**+16%**	**0%**	**-17%**

Table 37 Impact of loan tenor on payback period and repayment amount for new refrigerator at 25 percent interest rate

[50] It is assumed here that cedi depreciation only affects cost of the new imported refrigerator. It is assumed that the cedi depreciation is fully passed on the upfront cost paid by consumers

	Case 1	Case 2	Case 3 (baseline)
Loan tenor[51] (months)	12	18	24
Total costs (interest and amortization)	2,196	2,316	2,440
Monthly loan repayment (GHS)	183	129	102
Payback period from electricity savings (years)	3.7	3.9	4.1
Percentage impact of indicator on payback period	**-9%**	**-5%**	**0%**

4.3.2 Sensitivity analysis for domestic air conditioners

A similar sensitivity analyses is presented for domestic air-conditioners. Here, the impact of loan tenor and repayment, interest rate, electricity tariff on the payback period for a new AC is presented in Tables 4.7 to 4.9 respectively.

Table 3 Impact of interest rate on payback period and repayment amount for new AC

	Case 1	Case 2 (baseline)	Case 3
Interest rate	20%	25%	30%
Total costs (interest and amortization) (GHS)	3,205	3,335	3,463
Monthly loan repayment (GHS)	134	139	144
Payback period from electricity savings (years)	2.1	2.1	2.2
Percentage impact of indicator on payback period	**0%**	**0%**	**+5%**

Table 4 Impact of loan tenor on payback period and repayment amount for new AC at 25 percent interest rate

	Case 1	Case 2	Case 3 (baseline)
Loan tenor (months)	12	18	24
Total costs (interest and amortization) (GHS)	3,001	3,165	3,335
Monthly loan repayment (GHS)	250	176	139
Payback period from electricity savings (years)	1.9	2.0	2.1
Percentage impact of indicator on payback period	**-7%**	**-3%**	**0%**

Table 5 Impact of electricity tariff on payback period for new AC

	Case 1 (10% decrease)	Case 2 (Baseline)	Case 3 (10 % increase)
Electricity tariff per kwh (GHS/kwh)	0.7642	0.8491	0.934
Electricity savings per year (GHS)	1,206	1,340	1,474
Payback period from electricity savings (years)	2.3	2.1	1.7
Percentage impact of indicator on payback period	**+11%**	**0%**	**-21%**

[51] Average tenor from the household survey is about 3 years

V. CONCLUSION

Based on the findings of the exercise, the following constitute the conclusions for this report:

1. Both refrigerators and ACs are sold in Ghana. However, the proliferation of ACs is much lower than that of refrigerators. 96 per cent of households sampled utilized refrigerators compared to 17 per cent who had ACs installed and 13 per cent use both AC and refrigerators. Further, findings reveal that second-hand refrigerators and ACs are still available on the market despite the ban on these appliances. These appliances are popular due to their affordability.

2. The current stock, in Ghana, for refrigerators utilized in households can be estimated at approximately 3 million. This number is projected to increase to about 5 million in 2025 and further increase to 8.5 million in 2030. For air-conditioning units, the current stock is estimated to be approximately 210,000. It is projected to increase to about 340,000 in 2025 and 465,000 in 2030.

3. It is estimated that about US$ 600 million will be required to replace all second-hand domestic refrigerators and another US$ 46 million is required for second-hand domestic air-conditioners in Ghana.

4. As of January 2019, there were approximately 1.6 million and 190,000 domestic second-hand refrigerators and refrigerators older than 10 years since first installation in Ghana respectively. Similarly, second-hand air conditioners and those older than 10 years since installation are about 12,000 and 90,000 pieces respectively.

5. There is a plethora of brands for both new refrigeration and air-conditioning units on the market in Ghana. The survey established the presence of approximately 142 refrigerator and 38 AC brands respectively. Generally, new appliances complied with the standards and labelling regulations.

6. Price, quality, energy consumption and access to finance constitute the main factors influencing a household's decision to purchase a refrigerator. Similarly, access to finance, energy consumption and price of AC were the main factors determining a household's decision to purchase an air-conditioning unit.

7. Several types of banks exist; however, the most popular are the commercial banks. Banks mainly provide unsecured loans to salaried workers. Unsalaried workers can access secured loans. The challenge for the unsalaried workers is meeting the eligibility requirements in order to access the loan.

8. Two broad financing mechanisms are proposed for the Ghanaian market, namely, consumer-targeted and supplier/distributor targeted financing mechanisms respectively. The consumer-targeted mechanisms (CTMs) would offer consumers attractive capital through loans with special financing and repayment conditions to acquire more energy-efficient and climate friendly appliances and reduced interest rates or refund as incentives for disposal/recycling of old appliances. These mechanisms might be offered by commercial banks (e.g. green loans, employee loans), retailers (e.g. vendor financing) or the utilities (e.g. on-bill financing) to households and small businesses to acquire more efficient and climate friendly appliances and address the high upfront cost and traditionally low access to finance barriers. It is suggested that such programmes must provide loans at reduced interest rates due to the high cost of borrowing in Ghana. This type of financing has the advantage of being easily targeted to a specific group in the society. It is envisaged that the drawback of programmes such as on-bill financing or refunds could be respectively the long implementation phase and massive operational costs required in adapting systems and delivering disposal/recycling refunds to big numbers of beneficiaries on individual basis if not designed in a sustainable manner. The supplier/distributor targeted mechanisms (SDTM) would be aimed at motivating suppliers to import only highly efficient and climate friendly appliances at cheaper cost through bulk rebate negotiation or by providing distributors or retailers energy efficiency loans from local financial institutions with special conditions to address similar financial and technical market barriers. The introduction of highly efficient and climate friendly products on the market would then encourage broader adoption of ambitious energy-efficient appliances and thus lead to market transformation.

9. Perceived risks related to an intervention such as ECOFRIDGES include: uncertainties about performance of appliances and reliability of energy savings, technology risks, exchange rate risks, tariff manipulation, contract risk (suppliers/distributors), high interest rate, delays in reimbursements/payments to suppliers.

10. Sensitivity analysis for refrigerators indicate that a disposal/recycling reward scheme in the form of an access to loan at reduced interest rate as incentives to households who return their old refrigerators to purchase a new one could be quite attractive.

11. The payback period of a new refrigerator is influenced by factors including electricity tariff, cedi depreciation, interest rate, loan tenor and repayment.

12. The payback period of a new AC is also influenced by factors including electricity tariff, hours of utilisation and thermal load of appliance, interest rate as well as loan tenor and repayment period.

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APPENDIXES

APPENDIX A LIST OF STAKEHOLDERS INTERVIEWED

	Institution	Contact person	Title/position	Phone/email	Interviewer
Government institutions					
1	Energy Foundation (EF)	Mr. Kwesi Annan-Takyi	Communications Officer	0302515613, 0303938222, 0303937247 kannantakyi@efghana.org	Joseph X. F. Ribeiro
2	Energy Commission (EC)	Mr. Kofi Agyarko	Director, RE, EE and Climate Change	0302815089 kofiagyarko@gmail.com	Edem C. Bensah
3	Ghana Standards Authority (GSA)	Ing. Daniel Vincent Arthur Mr. Francis M. Akpaloo	Head, Engineering Scientific Officer/Technical supervisor - Electro-technical Lab	0243131913, 0200777306 darthur@gsa.gov.gh 0208840565 fmakpaloo@gmail.com	Joseph X. F. Ribeiro
4	Environmental Protection Agency (EPA)	Mr. Emmanuel Osae Quansah	National Coordinator, National Ozone Office	0244633992 eosaequansah@yahoo.com	Joseph X. F. Ribeiro
5	Ministry of Energy (MoEN)	Mr. Solomon Adjetey	Director, Power Generation and Transmission	030268028, 0208154305 solomon.adjetey@energymin.gov.gh www.energymin.gov.gh	Joseph X. F. Ribeiro
6	Electricity Company of Ghana	Dr. George Eduful	General Manager, Energy Consulting and Telecommunications Business	0246132736 eduful@ieee.org	Joseph X. F. Ribeiro
7	Power Distribution Services (PDS)	Ing. Anthony M. Y. Esiape E. Ahorlu	Manager – Energy Efficiency and Renewable Energy; Electrical Engineer	aesiape@pdsghana.com; tonyesiape@gmail.com; +233(0)302234673 Ext: 1306 emahorlu@gmail.com	Edem C. Bensah
Financial institutions					

8	Cal Bank	Mr. Kobina Otu Okyne Mr. John Carl Tagbor Kwesi Baiden Mabel Amenyaglo	Environmental and Social Risk Manager Assistant ALM Officer Credit Analyst Secretary of the Green Team	0208245297 kokyne@calbank.net 0206154575 ctagbor@calbank.net 0561100835 kbaiden@calbank.net 0265417238 mamenyaglo@calbank.net	Joseph X. F. Ribeiro
9	Ecobank	Mr. Solomon Tettey-Akpeng Mr. Mark Ofori Kwafo	Deputy Country Risk Manager Risk Manager	0207847580 stettey-akpeng@ecobank.com 0263001461 mkwafo@ecobank.com	Joseph X. F. Ribeiro
10	Asante Akyem Rural Bank	Mr. Nicholas Benful	Branch Manager	0243136455 nicholabenful@gmail.com	Joseph X. F. Ribeiro
11	CRI Coop. Credit Union Limited	Mr. Alexander Osei Poku	Manager	0248398252 cricoopcu1997@gmail.com	Joseph X. F. Ribeiro
12	KsTU Credit Union Limited	Mrs. Mercy Opare Boakye	Manager	0277453686 boakyemercyopare@yahoo.com	Joseph X. F. Ribeiro
13	Odotobiri Rural Bank	Mr. Ernest Gyau	Audit Manager	0242378631 christibaff@yahoo.com ernest.gyau@odotobiribank.com	Joseph X. F. Ribeiro
14	MultiCredit Limited	Mr. Harrison Kwarteng	Credit Officer	0244702373 harrykwart80@gmail.com	Joseph X. F. Ribeiro
Suppliers					
15	Electroland Ghana Limited	Mr. Akanluga	Head of Logistics	0242946309 logistics@electrolandgh.com	Joseph X. F. Ribeiro
16	Afrique International Limited	Mr. Ansah	Manager	0302233057	Israel Nyadzor
17	Raviraj Ghana Limited	Mr. Lajash	Manager		Israel Nyadzor
18	Tonisac	Mr. Stephen Yeboah	Manager	0208402820	Israel Nyadzor
19	Jaydee Limited	Mr. Jimmy Thakur	Manager	0244487020	Israel Nyadzor
20	Home of Alaha	Mr. Odame	Manager	0244288504	Israel Nyadzor

21	Hisense Ghana	Amadu Yahaya	Manager	amadu.yahaya@hisense.com.gh ; +233(0)302550028	Joseph Ribeiro
Technology centres, institutes and NGOs					
22	CREK	Mr. Kodua	Solar Energy, Coord	0243126026	Joseph X. F. Ribeiro
23	Kwame Nkrumah University of Science and Technology (KNUST)	Dr. Richard Opoku	Air conditioning and refrigeration unit, Mechanical Eng. Dept., KNUST	richard.opoku.richardopoku@gmail.com	Edem C. Bensah
24	KITE	Mr. Ishmael Edjekumhene	Executive Director	iedjekumhene@kiteonline.net	Edem C. Bensah
Development partners					
25	KfW	Vanessa Eidt	Project Manager – Energy	vanessa.eidt@kfw.de	Edem C. Bensah
26	African Development Bank	Dr. Bumi Camara Dr. Sebastian O. Okeke	Senior Country Economist Country Programme Officer	b.camara@afdb.org s.okeke@afdb.org	Edem C. Bensah

APPENDIX B HOUSEHOLDS USING ACs AND REFRIGERATORS IN THE TARGET CITIES

Indicator	Accra Metro. Area	Kumasi Metro. Area	Tamale Metro. Area	National
Household (hhs) population in 2010 (P)[52]	1,599,914	1,674,862	219,971	24,076,327
Household size	3.5	3.8	6.2	4.5
Number of hhs in 2010 (Nh)	457,118	440,753	35,479	5,350,295
Average annual growth rate (r)[53]	3.10%	5.40%	5.90%	2.50%
Time in years (t), from 2010 to 2019	10	10	10	10
Hhs population in 2006	1,413,332	1,349,495	173,729	21,785,162
Hhs population in 2013 = P*EXP(r*t)	1,755,844	1,969,404	262,564	25,951,491
Hhs population in 2017 = P*EXP(r*t)	1,987,644	2,444,232	332,452	28,680,833
Hhs population in 2019 = P*EXP(r*t)	2,181,363	2,874,075	396,825	30,914,616
Hhs population in 2025	3,472,761	6,460,655	961,501	44,980,501
Hhs population in 2030	4,054,997	8,463,229	1,291,417	50,969,585
Household size, 2006 (GSS 2008)	3.3	3.6	3.6	4
Household size, 2013 (GSS 2014)	3.4	3.7	3.7	4
Household size, 2017 (GSS 2018)	3.4	3.7	3.7	4
Household size, 2019 (assumed to be same as 2017)	3.4	3.7	3.7	4
Household size, 2025 (assumed to be same as 2017)	3.4	3.7	3.7	4
Household size, 2030 (assumed to be same as 2017)	3.4	3.7	3.7	4
No. of hhs in 2006	428,282	374,860	48,258	5,446,290
No. of hhs in 2013	516,425	532,271	70,963	6,487,873
No. of hhs in 2017	584,601	660,603	89,852	7,170,208
Estimated no. of hhs in 2019	641,577	776,777	107,250	7,728,654
Estimated no. of hhs in 2025	1,021,400	1,746,123	259,865	11,245,125
Estimated no. of hhs in 2030	1,192,646	2,287,359	349,032	12,742,396
Indicator	**Accra Metro. Area**	**Kumasi Metro. Area**	**Tamale Metro. Area**	**National**
Refrigerators				

[52] GSS 2014. 2010 Population and Housing Census, District Analytical Reports for Accra, Kumasi and Tamale Metropolitan Areas, Ghana Statistical Service, Accra.

[53] Based on average of annual growth rates from 2005-2019 using data from GSS and World Population Review. Available: http://worldpopulationreview.com/world-cities/tamale-population/#popData

% hhs using refrigerators in 2006 (GSS 2008; GSS 2018)	49.40	37.70	20.90	21.2
% hhs using refrigerators in 2013 (GSS 2014; GSS 2018)	61.90	52.90	30.00	33
% hhs using refrigerators in 2017 (GSS 2018)	56.50	48.90	26.60	36
No. of hhs owning refrigerators (penetration rate) in 2006	211,571	141,322	10,086	1,154,614
No. of hhs owning refrigerators (penetration rate) in 2013	319,667	281,571	21,289	2,140,998
No. of hhs owning refrigerators (penetration rate) in 2017	330,300	323,035	23,901	2,581,275
Average yearly growth rate (%), 2006 - 2013	7.3	14.2	15.9	12.2
Average yearly growth rate (%), 2013 - 2017	0.8	3.7	3.1	5.1
Average yearly growth rate (%), 2006 - 2017	4.9	10.4	11.2	9.6
Estimate of hhs owning refrigerators 2019 (assuming penetration rate of 2017)	362,491	379,844	28,529	2,782,315
Estimate of hhs owning refrigerators 2019 (using compound growth rate)	363,788	393,439	29,561	3,102,695
Estimate of hhs that will own refrigerators in 2025 (assuming compound growth rate)	486,039	710,824	55,931	5,388,325
Estimate of hhs that will own refrigerators in 2030 (assuming 20% increase in penetration rate of 2017 rate)	618,761	1,163,676	95,156	8,535,245

Indicator	**Accra Metro. Area**	**Kumasi Metro. Area**	**Tamale Metro. Area**	**National**
Air conditioners				
% hhs using ACs in 2006 (GSS 2008)	1.8	0.1	0.1	0.4
% hhs using ACs in 2013 (GSS 2014)	3.6	1.0	1.0	1.1
No. of hhs using air conditioners in 2006	7,709	375	48	21,785
No. of hhs using air conditioners in 2013	18,591	5,323	710	71,367
Yearly growth in penetration rate (%), 2006-2013	20.2	188.6	195.8	32.5
Estimate of households owning ACs 2019	55,975	65,542	9,046	210,588
Estimate of households owning ACs 2025	168,532	125,761	17,382	349,810
Estimate of households owning ACs 2030	422,267	175,943	24,329	465,828

APPENDIX C FINAL SAMPLE SIZE FOR EACH CITY AND EACH SUBURB

Suburb	Population, 2010[54]	Estimated population, 2019	Estimated hhs, 2019	Estimated hhs owning refrigerator(s), 2019	Estimated hhs owning AC(s), 2019	Sample size (based on hhs with refrigerators)
Kumasi Metropolis						
Old Tafo	122,131	159,987	42,102	39.576	628	77
Bremang	91,005	119,213	31,372	29,490	468	58
Atonsu	65,225	85,442	22,485	21,136	335	41
Pankrono	57,745	75,644	19,906	18,712	297	37
Amakom	56,874	74,503	19,606	18,430	292	36
Subtotal			135,471	127,343	2,021	248
Accra Metropolis						
Abeka	85,692	116,835	33,381	31,712	1,793	67
Nima	80,843	110,223	31,492	29,918	1,691	63
Mamobi	61,724	84,156	24,045	22,842	1,291	48
Darkuman	61,562	83,935	23,981	22,782	1,288	48
Osu	59,460	81,069	23,163	22,005	1,244	46
Subtotal			136,062	129,259	7,307	271
Tamale Metropolis						
Lamashegu	19,733	26,372	4,254	3,998	63	5
Nyohini	15,978	21,353	3,444	3,237	51	4
Tishigu	14,707	19,655	3,170	2,980	47	4
Moshie Zongo	13,627	18,211	2,937	2,761	44	4
Zogbeli	11,932	15,946	2,572	2,418	38	3
Subtotal			16,377	15,394	244	20

[54] GSS 2014. 2010 Population and Housing Census, District Analytical Reports for Accra, Kumasi and Tamale Metropolitan Areas

APPENDIX D QUESTIONNAIRES USED FOR THE STUDY

Questionnaire for Households

Responses to this questionnaire are of critical importance to properly understand the market for refrigerators and air-conditioners in the country. The results will be used by UN Environment to help inform recommendations on policies and programs to increase adoption of energy-efficient products. UN Environment will treat questionnaire responses as business-sensitive information. The findings will be aggregated across the pool of organizations that participate to avoid attribution to any particular entity.

Point of Contact name	Title	Email	Phone	Location	Ghanapost GPS	Profession
				Name: [ ] District: [ ] Rural [ ] Urban		

General information on household

Type of family	Number of family members	Average revenue / month (GHS)	House size (m^2) / no. of rooms	Number of floors	Do you own the housing where you live?	How often have you changed addresses in the last 5 years
[ ] nuclear family [ ] single parent [ ] extended family [ ] childless family [ ] other, please specify:		Amount in GHS: [ ] low income [ ] medium income [ ] high income			[ ] Yes [ ] No	

General information on electricity consumption

Name of electricity provider	**Owned household appliances**	**Type of electric meter**	**Average monthly electricity consumption** **(amount paid in GHS)**	**Preferred payment method for your electric bills**
[ ] ECG [ ] PDS	[ ] refrigerator, # [ ] air-conditioner, # [ ] other, please specify:	[ ] Prepaid meter [ ] Post paid [ ] Smart meter [ ] Shared meter		[ ] cash [ ] bank payment [ ] mobile money [ ] credit [ ] other, please specify:

General information on household finance

Do you own a bank account? If so, what is the name of your financial institution / bank?	[ ] yes, name of bank: [ ] no, I do not have a bank account
What type of bank account do you have?	[ ] Savings [ ] Current [ ] other, please specify
How many years have you been with the financial institution / bank customer?	
Have you ever taken loans from your bank?	[ ] Yes [ ] No
If yes, what was the period (tenor) of the loan?	(number of years)
Do you own a credit card?	[ ] yes [ ] no
Do you use mobile banking solutions?	[ ] yes [ ] no
When was the last time you purchased an AC system?	(years)
When was the last time you purchased a refrigerator?	(years)
Where did you buy your AC or refrigerator from?	[] depart store [] specialized appliance shop []online shop []informal market street [] second hand from someone else [] second-hand from a vendor Name of store

How did you finance your AC or refrigerator?	[] credit from bank [] leasing [] own capital (cash, credit/debit card, bank payment, mobile money payment)
Which of these do you usually use?	[ ] mainly / only fans [ ] mainly / only ACs [ ] both
Do you own credit / debit card?	[ ] Yes [ ] No

**Bank would be grouped as commercial, microfinance, leasing company, etc*

Part A: Air conditioners

1. Operational profile

During which month is the AC used?	**Daily hours of use – dry season**	**Daily hours of use - rainy season**

2. Product characteristics

   Did you buy your unit [ ] brand new or [ ] second hand?

AC type:

[a] Mini – split wall mounted [b] Mini – split cassette [c] Mini – split floor mounted / portable [d] Mini – split / variable refrigerant flow
[e] Window unit [f] Personal / terminal air-conditioner [g] Air-based chiller [h] Water-based chiller
[ ]PTAC [ ] Ducted type-Central AC
[z] Other, please specify:

Energy label type: [a] Energy Star (Gh), [b] EU [z] Other, please specify:

Compressor type: [a] fixed [b] variable

Purchase origin: [a] local supplier (retailer) [b] importer based overseas [z] other, please specify … [**same for Refs**]

Age of AC: [a] 1 year [b] 2-3 years [c] 4-6 years [d] 7-10 years [e] < 10 years

Type of Air-conditioner and fans	New / used	No. of units in the house	Brand and model	Cooling capacity (kW)	Energy Efficiency (EER)	Comp. type	Ref. Gas (R-xxx)	Energy label [no of stars]	Age of AC (yrs) [years of use]	Product warranty (yrs)	Product upfront costs (GHS)

3. Operation and Maintenance

Yearly expense for electricity (GHS)	Average monthly electricity payment (GHS)	Proportion of electricity expense that is from air-conditioner use (0-100%)

4. How important is each of the following points when you decide to purchase an AC?

Price of the equipment	[ ] none [ ] low [ ] medium [ ] high
Warranty	[ ] none [ ] low [ ] medium [ ] high
Functional / practical	[ ] none [ ] low [ ] medium [ ] high
Look/design/Colour	[ ] none [ ] low [ ] medium [ ] high
Energy consumption	[ ] none [ ] low [ ] medium [ ] high
Access to finance	[ ] none [ ] low [ ] medium [ ] high
Capacity / size	[ ] none [ ] low [ ] medium [ ] high
Brand	[ ] none [ ] low [ ] medium [ ] high
Quality	[ ] none [ ] low [ ] medium [ ] high
Recommendation from people you know	[ ] none [ ] low [ ] medium [ ] high
Ability to transport, installation and maintenance services	[ ] none [ ] low [ ] medium [ ] high
Other, please specify …	[ ] none [ ] low [ ] medium [ ] high

Part B: Refrigeration

5. Product Characteristics

Did you buy your unit [ ] brand new or [ ] second hand?
Reference info:
Type of refrigerator: [a] refrigerator only [b] refrigerator - freezer [c] freezer only

[i] other, pls specify

Compressor type: [1] fixed [2] variable

Age of refrigerator: [a] 1 year [b] 2-3 years [c] 4-6 years [d] 7-10 years [ ] greater than 10 years

Type of ref.	No. of units in the house	Brand and model	Volume capacity (Btu/hrkW)	Energy Efficiency (EER, SEER, COP)	Comp. type	Ref. Gas (R-xxx)	Energy label (no of stars)	Age of refrigerator (yrs)	Product warranty (yrs)	Product upfront costs (GHS)	Used / brand new

6. Operation and Maintenance

Yearly expense for electricity (GHS)	Average monthly electricity payment (GHS)	Proportion of electricity expense that is from refrigerator use (0-100%)

7. How important is each of the following points when you decide to purchase a refrigerator?

Price of the equipment	[ ] none [ ] low [ ] medium [ ] high
Warranty	[ ] none [ ] low [ ] medium [ ] high
Look/Design/Colour	[ ] none [ ] low [ ] medium [ ] high
Functional / practical	[ ] none [ ] low [ ] medium [ ] high
Energy consumption	[ ] none [ ] low [ ] medium [ ] high
Access to finance	[ ] none [ ] low [ ] medium [ ] high
Capacity / size	[ ] none [ ] low [ ] medium [ ] high
Brand	[ ] none [ ] low [ ] medium [ ] high
Quality	[ ] none [ ] low [ ] medium [ ] high
Recommendation from people you know	[ ] none [ ] low [ ] medium [ ] high
Ability to transport, installation and maintenance services	[ ] none [ ] low [ ] medium [ ] high
Other, please specify …	[ ] none [ ] low [ ] medium [ ] high

Questionnaire for Financial Institutions

Responses to this questionnaire are of critical importance to properly understand the market for refrigerators and air-conditioners in the country. The results will be used by UN Environment to help inform recommendations on policies and programs to increase adoption of energy-efficient products. UN Environment will treat questionnaire responses as business-sensitive information. The findings will be aggregated across the pool of organizations that participate to avoid attribution to any particular entity.

Organization	Point of Contact Name	Title	Email	Phone

1. What are your main clients/sectors? [ ] SME [ ] Corporate [ ] Retail [ ] Micro [ ] Other, please specify

    a. How many clients per sector do you service?

SME	**[ ] 1-100 [ ] 101-200 [ ] 201-300 [ ] 301-400 [ ] 401-500 [ ] Other, please specify …**
Corporate	[ ] 1-100 [ ] 101-200 [ ] 201-300 [ ] 301-400 [ ] 401-500 [ ] Other, please specify …
Retail	[ ] 1-100 [ ] 101-200 [ ] 201-300 [ ] 301-400 [ ] 401-500 [ ] Other, please specify …
Micro	[ ] 1-100 [ ] 101-200 [ ] 201-300 [ ] 301-400 [ ] 401-500 [ ] Other, please specify …
Other …	[ ] 1-100 [ ] 101-200 [ ] 201-300 [ ] 301-400 [ ] 401-500 [ ] Other, please specify …

b. What is your annual credit allocation per sector?

SME	**[ ] please specify …**
Corporate	[ ] please specify …
Retail	[ ] please specify …
Micro	[ ] please specify …
Other …	[ ] please specify …

c. Where are you active? (e.g. country, regions, cities, urban, rural, other, …)

Which regions / cities do you supply?	**[ ] the whole country**	
	[ ] Upper East / City	[ ] Upper West / City
	[ ] Northern / City	[ ] Ashanti / City
	[ ] Brong Ahafo / City	[ ] Eastern / City
	[ ] Central / City	[ ] Greater Accra / City
	[ ] Volta / City	[ ] Western / City
	[ ] urban [ ] rural	

d. How many branches do you have? [ ] please specify
e. Who are your main competitors per sector?
f. What share of the market do you hold? [ ] 1-10% [ ] 11-20% [ ] 21-30% [ ] 31-40% [ ] Other, please specify

2. What kind of financing do you provide? [ ] loans [ ] savings [ ] insurance [ ] Other, please specify
   a. What are your most popular products / familiar products to clients? [ ] please specify
   b. Do you offer mobile banking / payment solutions? [ ] Yes [ ] No
   c. Do you issue [ ] credit/ [ ] debit / [ ] both debit and credit cards for your retail clients?
   d. If so, how many are your active credit/debit cardholders? # of credit cardholders [ ], # of debit cardholders [ ]

3. Do you have a green credit line? [ ] Yes [ ] No

   a. If yes, please specify?
   b. If not, would you be interested in developing a green credit line? [ ] Yes [ ] No
   c. What kind of support would you require to establish a green credit line? Please specify
   d. What type of product would you be the most interested in financing through such a green credit line?
      [ ] refrigerators [ ] air-conditioners [ ] solar PV [ ] other, please specify

4. How comfortable are you financing clients' investment in energy-efficient equipment?

[ ] comfortable [ ] very comfortable [ ] we do not finance clients' investment in energy-efficient equipment
Any reasons for your answer?

a. How popular is financing of investment in energy-efficient equipment for your clients (i.e. retail, SME/corporate, institutional)?

	Explanation
Retail	[ ] not popular [ ] popular [ ] very popular
SME	[ ] not popular [ ] popular [ ] very popular
Corporate	[ ] not popular [ ] popular [ ] very popular
Other	[ ] not popular [ ] popular [ ] very popular

b. Do you already finance suppliers of energy-efficient equipment (e.g. HVAC companies, retailers, others, …)? [ ] Yes [ ] No
c. Do you perceive any risk in financing energy-efficient equipment? [ ] Yes [ ] No
d. If yes, why?
e. What are the key barriers to financing energy-efficient equipment?
[ ] late repayment of loans [ ] inability to pay loans [ ] other, please specify

5. Do you have an Environmental and Social Risk Management System? [ ] Yes [ ] No

6. How would you like to be involved in the ECOFRIDGES project?
[ ] provide feedback on draft documents, [ ] help raise awareness, [ ] assist with capacity building activities, [ ] participate in waste management activities, [ ] help pilot new financial mechanisms, [ ] Other, please specify

7. Who else from your sector do you recommend should be involved in ECOFRIDGES in some way (see list of stakeholder interviewees), and how should they be involved?

Questionnaire for Suppliers (HVAC Companies, Retailers)

Responses to this questionnaire are of critical importance to properly understand the market for refrigerators and air-conditioners in the country. The results will be used by UN Environment to help inform recommendations on policies and programs to increase adoption of energy-efficient products. UN Environment will treat questionnaire responses as business-sensitive information. The findings will be aggregated across the pool of organizations that participate to avoid attribution to any particular entity.

Company name	**Where is your company located?** (GPS, name of place)	**Point of contact Name**	**Title**	**Email**	**Phone**

Company profile and market opportunity

What type of supplier are you?	[ ] importer [ ] retailer [ ] wholesaler [ ] other, please specify
How many employees do you have?	[ ] 1 – 10 [ ] 11-20 [ ] 21-30 [ ] other, please specify
Which appliances do you supply/sell?	[ ] only ACs [ ] only Refrigerators [ ] Both [ ] Other, please specify
Do you import directly?	[ ] yes [ ] no
Do you provide financing for your clients	[ ] yes [ ] no
If yes, what is the tenor and interest rate for this financing you offer?	____ months (if years, still express in number of months) ____ %
How do your clients usually finance the purchase of your products (i.e. upfront payments, credits, leasing]?	[ ] own capital [ ] credits [ ] leasing [ ] loans [ ] other, please specify
If applicable, what is the average tenor of the credit?	1-3 months { } 4-6 months { } 7-12 months { } 13-24 months { } 25-48 months { } >48 months { }
What are the main financial sources	[ ] technology supplier [ ] bank [ ] microfinance institution [ ] other please specify
Which financial institution(s) is your company working with?	

Do you provide warranty on your products and for how long?	[ ] yes [ ] no; If yes for _____ months
Which regions or cities do you supply?	[ ] Upper East / city [ ] [b] Upper West / City [ ] [ ] Northern / City [ ] [d] Ashanti / City [ ] [ ] Brong Ahafo / City [ ] [f] Eastern / City [ ] [ ] Central / City [ ] [h] Greater Accra / City [ ] [ ] Volta / City [ ] [j] Western / City [ ]
Can you estimate the total AC market in Ghana?	Amount in GHS: Amount in USD:
Can you estimate the total refrigerator market in Ghana?	Amount in GHS: Amount in USD:
What % of your **AC** sales come from systems that have more than two stars? If you had good financial mechanism, what would that % become?	% of sales from ACs: % of sales with good financial mechanism:
What %of your **refrigerator** sales come from systems that have more than two stars? If you had good financial mechanism, what would that % become?	% of sales from refrigerators: % of sales with good financial mechanism:
What is the typical lifetime of an **AC** system?	_____ years
What is the typical lifetime of an **refrigerator** system?	_____ years
How do you dispose AC equipment? How much does it cost?	
How do you dispose **refrigerator** equipment? How much does it cost?	
For AC, what is the annual cost of maintenance (in % of price of product)?	_____ %
How do you guarantee warranty of your products?	[a] written guarantee [b] contract warranty [c] manufacturer warranty [d] there is no guarantee [z] other, please specify

Part A: Air-conditioners

1. **Product characteristics and sales of the most common / popular products**

AC type:

[a] Mini – split wall mounted [b] Mini – split cassette [c] Mini – split floor mounted / portable [d] Mini – split / variable refrigerant flow
[e] Window unit [f] Personal / terminal air-conditioner [g] Air-based chiller [h] Water-based chiller
[z] Other, please specify:
Energy label type: [a] Energy Star (Gh), [b] EU [z] Other, please specify:

Type of AC	Brand and Model / Series	Cooling capacity (Btu/hr or kW)	Energy Efficiency (EER)	Compressor type [ ] fixed [ ] variable	Heat pump mode (Y/N)	Ref. gas (R-xxx)	Energy label type (if any)	Warranty period (months)	Country of origin	Quantity of units sold annually	Sales price per unit (GHS)	Sales price per kW (or per TR) (GHS/kW)

Note: add rows as needed to cover all commonly sold products

Do you supply used ACs? [ ] yes [ ] no

2. **Client profile**

Client type	In % of your total sales	What share of the projects do you think are new buildings rather than retrofitting existing buildings? [0-100%]	Average project size (GHS/USD)	Expected demand growth over next 3 years. Rank: [1] lowest opportunity [2] high opportunity [3] highest opportunity	Client's preferred method of payment
Commercial sector					
Public sector					

Residential sector					

3. Overall sales and market share

Type of Air-conditioner	In % of all your sales to commercial sector	In % of all your sales to public sector	In % of all your sales to residential sector
Window – type AC			
Mini – split (wall-mounted, floor-standing or cassette)			
Multi-split system / variable refrigerant flow			
Air-based chiller system			
Water-based chiller system			
Other, please specify			

4. Factors that impact your ability to sell more energy-efficient products to clients

*****_Rank: [1] not relevant [2] relevant [3] very relevant_

Factor	Rank	Explanation of what occurs and recommended solutions to address the challenges
High upfront cost		
Lack of trust that the products will achieve energy performance / payback claims		
Lack of awareness on energy savings in the long run		
Concerns about product quality and reliability		
Focus on purchase price instead of total ownership cost		
Power quality (impact of voltage fluctuations on VFD)		
Low electricity tariff		
Lack of suitable financing		
Taxes, duties, or incentives		

Policies or regulations		
Others, please describe		

5. Ways that you might want to be involved in the Air-conditioners aspect of this project

Participation opportunities	Explanation of how you could potentially contribute to any of these that are areas of interest
Provide feedback on draft policy documents	
Help raise awareness among consumers / public	
Assist with training for technicians, sales reps, or officials	
Participate in recycling / waste management programmes	
Participate in trials / demonstrations	
Pilot new financial mechanisms	
Other, please describe	

Part B: Refrigeration

Refrigerator type: [a] refrigerator only [b] refrigerator - freezer [c] freezer only [i] other, pls specify

Compressor type: [a] fixed [b] variable

6. Product Characteristics and Sales of the Most Common / Popular Products

Type of refrigerator	Brand and Model / Series	Volume (litres) or capacity	Energy Efficiency (kWh/year/volume)	Refrigerant gas (R-xxx)	Energy label type (if any)	Warranty period (months)	Country of origin	Quantity of units sold annually	Sales price per unit (GHS)	Sales price per liter (GHS/liter)

Note: add rows as needed to cover all commonly sold products

Do you supply used refrigerators? [ ] yes [ ] no

7. Clients' profile

Client type	In % of your total sales	What share of the projects do you think are new buildings rather than retrofitting existing buildings? (0-100%)	Average project size (GHS / USD)	Expected demand growth over next 3 years. Rank: [1] lowest opportunity [2] high opportunity [3] highest opportunity	Client's preferred method of payment
Commercial sector refs and freezers					
Public sector refs and freezers					
Residential sector refs and freezers					

8. Factors that impact your ability to sell more energy-efficient products to clients

*****Rank: [1] low [2] high [3] highest*

Factor	Rank	Explanation of what occurs and recommended solutions to address the challenges
High upfront costs		
Lack of trust that the products will achieve energy performance / payback claims		
Lack of awareness on energy savings in the long run		
Concerns about product quality and reliability		
Focus on purchase price instead of total ownership cost		
Power quality (impact of voltage fluctuations on VFD)		
Low electricity tariff		
Lack of suitable financing		
Taxes, duties, or incentives		

Policies or regulations		
Others, please describe		

9. Ways that you might want to be involved in the refrigerator aspect of this project

Participation opportunities	Explanation of how you could potentially contribute to any of these that are areas of interest
Provide feedback on draft policy documents	
Help raise awareness among consumers / public	
Assist with training for technicians, sales reps, or officials	
Participate in recycling / waste management programmes	
Participate in trials / demonstrations	
Pilot new financial mechanisms	

Questionnaire for Stakeholders (Agencies, Utilities, NGOs, Industry Organizations, Technical Institutes)

Responses to this questionnaire are of critical importance to properly understand the market for refrigerators and air conditioners in the country. The results will be used by UN Environment to help inform recommendations on policies, programs and innovative financial mechanisms to increase adoption of energy-efficient products. UN Environment will treat questionnaire responses as business-sensitive information. The findings will be aggregated across the pool of organizations that participate to avoid attribution to any particular entity.

Organization	Point of Contact Name	Title	Email	Phone

1. Is your organisation active country wide (yes / no)?
   a. If not, where?
   b. How many employees or members are there?
      [ ] 5-10 [ ] 11-20 [ ] 21-25 [ ] 25-30 [ ] 31-40 [ ] specific number … .[ ] Other, please specify
   c. What is your specific interest or area of expertise in energy efficiency?
      [ ] refrigerators [ ] air-conditioners [ ] both [ ] other, please specify
   d. Do you have on going / planned activities related to energy efficiency?
      [ ] Yes [ ] No
   e. If yes what is the planned activity?
      [ ] Awareness creation [ ] sale of products [ ] repair and maintenance training [ ] other, please specify
   f. Is your organisation more interested in energy efficiency initiatives in [ ] the residential, [ ] in the commercial, or [ ] in the public sector?
   g. Have you produced any relevant studies or reports on energy efficiency in the residential sector?
      [ ] Yes [ ] No
      If yes, kindly provide details

2. Is your organisation concerned with the energy efficiency of refrigerators or air conditioners (yes / no)?
   a. Why? (Please specify)
   b. If so, how is your organisation addressing it (specify what is underway, and what is planned for the near future)?

c. What barriers do your organisation face in this area
[ ] lack of awareness [ ] inadequate capacity [ ] lack of funding or finance options [ ] regulatory hurdles [ ] other, please specify

d. What would help overcome these barriers?
[ ] awareness campaign [ ] capacity building [ ] availability of funding or finance options [ ] regulations [ ] other, please specify

3. Is your organisation concerned with the refrigerant gasses used in these products? [ ] Yes [ ] No
   a. Why? (please specify)
   b. If so, how is your organisation addressing it (specify what is underway, and what is planned for the near future)?
   c. What barriers do your organisation face in this area, and what would help overcome these barriers?
   [ ] lack of awareness [ ] inadequate capacity [ ] lack of funding or finance options [ ] regulatory hurdles [ ] other, please specify
   d. What would help overcome these barriers?
   [ ] awareness campaign [ ] capacity building [ ] availability of funding or finance options [ ] regulations [ ] other, please specify
   e. Are you aware about the global warming and climate change? [ ] Yes [ ] No
   f. Are you taking or planning to take actions? [ ] Yes [ ] No

4. What do you hope to have addressed in the national policies recommendations and the financial mechanism that will be developed through the ECOFRIDGES project? (please specify)

5. How would you like to be involved in the ECOFRIDGES project?
   [ ] provide feedback on draft documents , [ ] help raise awareness, [ ] assist with capacity building activities [ ] participate in waste management activities
   [ ] help pilot new financial mechanisms [ ] other, please specify

6. Who else from your sector do you recommend should be involved in ECOFRIDGES in some way (see list of stakeholder interviewees), and how should they be involved? (please specify)