ADDRESS

Ghana Airways Avenue
Airport Residential Area
(behind Alliance Francaise)

Private Mail Bag
Ministries Post Office
Accra – Ghana

POST CODE

GA-037-3212

CONTACT

PHONE:
0302-813-756/7

FAX:
0302813764

WEBSITE:
www.energycom.gov.gh

EMAIL:
info@energycom.gov.gh

FOLLOW US:

EnergyCommissionGhana
EnergyCommissionGhana
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EVALUATION OF ENERGY EFFICIENCY POLICY MEASURES FOR COOLING APPLIANCES IN GHANA BETWEEN 2010 - 2020

FEBRUARY, 2022

EXECUTIVE SUMMARY

Cooling appliances (refrigerators, freezers and non-ducted single split air conditioners) have been identified as the most electricity consuming appliances in the residential sector. Whilst refrigerators and freezers consume averagely between 25% and 30% of the total electricity in the residential sector, air conditioners, on the other hand, consume 6.5%. Ghana has over 16 years of experience in appliance standards and labelling regulation.

This report aims to provide a quantitative evaluation of the energy, carbon dioxide (CO_2) and financial savings through the implementation of minimum energy performance standards (MEPS) and appliance labelling programmes for household cooling appliances in Ghana since 2010, using the **Mepsy modelling Tool: The Appliance & Equipment Climate Impact Calculator.**

This impact evaluation (ex-post) exercise indicates that the energy efficiency policies implemented for household cooling appliances have reduced energy consumption significantly, even more than previously projected. **By the end of 2020, a total of 10,159 GWh (10.16 TWh) of electricity has been saved on refrigerators and air conditioners, which is attributable to energy labels and MEPS, introduced in 2005. This intervention delayed additional capacity expansion of about 1,160 MW, equivalent to a third (31.8%) of the total Installed Thermal Generation Capacity (3,649 MW), in 2020.**

The energy savings from these regulatory actions can be expressed as financial savings in energy costs avoided, as well as reductions in CO_2 emissions by 2020. At the household level, about 18,306 kWh of electricity has been saved, resulting in a financial savings of about USD 1,920 on electricity bills. At the national level, over USD 1 billion has been saved on electricity bills and 6.32 million tonnes of CO_2eq reduction and thereby making the net-zero agenda a possibility.

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Energy Efficiency Programmes Impact Evaluation Team

Supervisor

Mr. Kofi Adu Agyarko,

Director, Renewable Energy, Energy Efficiency & Climate Change

Analysis & Report Writing

Mr. Edwin Kwasi Tamakloe

Report Review Team

Mr. Kofi Agyarko

Mr. Kennedy Amankwah

Mr. Edwin Kwasi Tamakloe

Mr. Hubert Nsoh Zan

Mr. Richard Donkor

Dr. Vitus Tankpa

CHAPTER ONE: INTRODUCTION AND BACKGROUND

1.1 Aim and Introduction

The residential sector in Ghana accounts for 47% of the total final energy consumption.[1] Used and inefficient cooling appliances (refrigerators/freezers and air conditioners) have been identified as the most electricity consuming appliances in the residential sector. Whilst refrigerators/freezers consume between 25% - 30% of the total electricity in the residential sector, air conditioners account for 6.5%.[2] The used and inefficient refrigerators and air conditioners consume, on average, 1,200 kWh[3] and 4,200 kWh[4] per unit per year respectively. Standards and labelling (S&L) were identified as potential means of reducing the energy consumption of cooling appliances and removing the used and inefficient ones from the market. ***Energy efficiency***, considered as "***low-hanging fruit***" and "***first fuel***" of the clean energy transition, have low implementation marginal cost than building new power plants. So, combined with significant potential for energy efficiency improvements, refrigerators and air conditioners have been targeted for regulation in the residential sector.

Improving the MEPS has the following advantages:

i. It improves consumers' economic circumstances by reducing their electricity bills through the reduction in energy consumption;
ii. It promotes energy security and frees kilowatts to expand access to meet the SDGs 7 and 13 goals;
iii. It reduces the environmental impacts of greenhouse gas (GHG) emissions and thereby helps in meeting international obligations pertaining to emissions;

[1] Ghana Energy Commission. National Energy Statistics, 2021
[2] Residential energy use and appliance ownership survey: Final Report on the Potential Impact of Appliance Performance Standards in Ghana
[3] Refrigerator efficiency in Ghana: Tailoring an appliance market transformation program design for Africa
[4] Energy efficiency and cost saving opportunities in public and commercial buildings in developing countries: The case of air-conditioners in Ghana

iv. It frees resources for the development of the economy in general and important sectors like health and education in particular; and
v. It stimulates the development of cost-effective and energy-efficient technologies and prevents the dumping of environmentally harmful appliances.

This report aims to provide a quantitative evaluation (ex-post) of the energy, CO_2 and financial savings through the implementation of energy efficiency standards and labelling programmes for household cooling appliances in Ghana since 2009, using Mepsy: The Appliance & Equipment Climate Impact Calculator. The Mepsy model, a free and publicly available impact model, was developed by the Collaborative Labeling and Appliance Standards Program (CLASP) to provide first-order policy impacts analysis using the "bottom-up" accounting approach.

Following this introduction, the report is structured as follows:

- Background information providing:
  - A review of refrigerator policy measures to date
  - A brief description of the Ghanaian cooling appliance market
- Summary of the methodological approach
- Key outcomes of the impact analysis:
  - Energy savings
  - Financial savings
  - Greenhouse gas (GHG) savings

1.2 Background

1.2.1 Review of Regulations for Household Cooling Appliances in Ghana

Ghana has a long history of policy/regulatory measures to improve the energy efficiency of household cooling appliances and lighting equipment. In 2002, Ghana identified the benefits of S&L for equipment and other electrical appliances such as

deep freezers, room air conditioners, refrigerators, industrial motors and lighting systems.[5] The S&L serves as catalysts in meeting the MEPS objectives. Therefore, between 2005 and 2017, the Energy Commission caused to be enacted four (4) major Legislative Instruments (L.I.s) by the Ghanaian Parliament. Table 1.1 lists the four major Regulations, their scope and targets, the year they were enacted and their implementation dates.

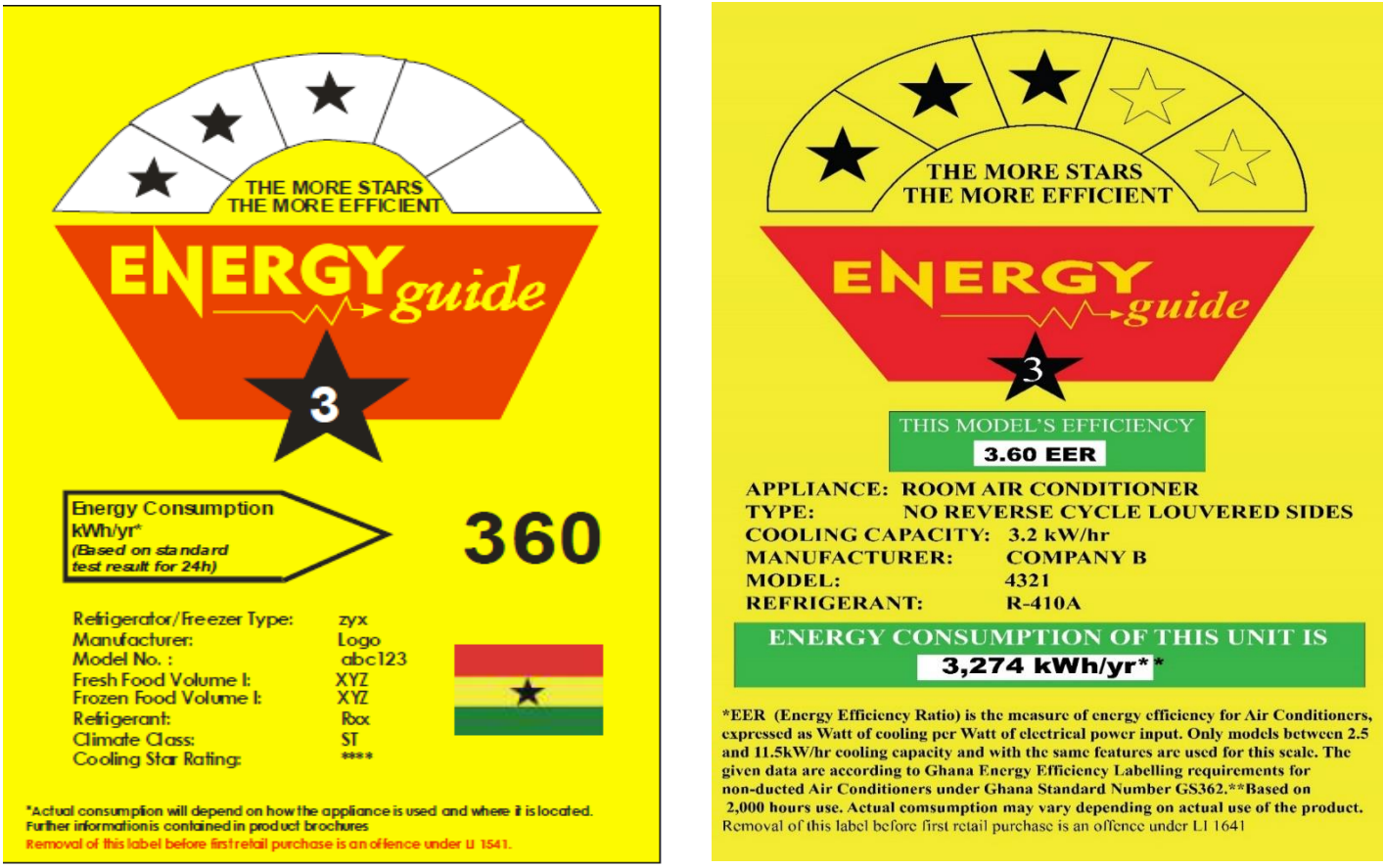
Table 1.1: Major Regulations on Energy Efficiency

L.I.	Regulation	Scope & Targets	Year Passed	Year Implemented
1815	Energy Efficiency Standards and Labelling (Non-Ducted Air Conditioners and Self-Ballasted Fluorescent Lamps) Regulations.	Gives legal backing to the use of energy-efficient non-ducted air conditioners and fluorescent lamps.	2005	2006
1932	Energy Efficiency (Prohibition of Manufacture, Sale or Importation of Incandescent Filament Lamp, Used Refrigerator, Used Refrigerator-Freezer, Used Freezer and Used Air-conditioner) Regulations.	Places total ban on the importation and sale of the incandescent filament lamp, used refrigerator, used refrigerator-freezer, used freezer and used air conditioners effective January 2012.	2008	2013
1958/1970	Energy Efficiency Standards and Labelling (Household Refrigerating Appliances) Regulations.	Provides for the enforcement of minimum energy efficiency and labelling for household refrigerating appliances.	2009	2010
2353	Energy Commission (Efficiency Standards and Labelling (Light Emitting Diode and Self-Ballasted Fluorescent Lamps) Regulations.	Provides for the enforcement of minimum energy efficiency and labelling for Light Emitting Diode and Self-Ballasted Fluorescent Lamps.	2017	2019

[5] Transforming the West African Market for Energy Efficiency: Ghana Leads the Way with Mandatory Standards and Labels

In 2013, to robustly enforce the L.I.s 1815 and 1958/1970, the Commission moved to the ports of entry. In line with good practices, there is the need to evaluate the actual impact of these policies after so many years of implementation. It is therefore imperative to review and establish the impact of the regulations regarding L.I.s 1815 and 1958/1970 (air conditioners and refrigerating appliances) between 2010 – 2020.

Examples of the current energy efficiency guide labels for refrigerators and air conditioners in Ghana are shown in Figure 1.1.



Sample Refrigerator label **Sample Air Conditioner label**

Figure 1.1: Examples of Energy Efficiency Guide Labels for refrigerators and Air conditioners in Ghana

1.2.2 Brief Description of the Cooling Appliances Market in Ghana

The enforcement of L.I.s 1815 and 1958/1970 at the ports of entry between 2005 – 2020 resulted in the importation of over 900,000 and 3.1 million new and efficient air conditioners and refrigerators respectively. About 55.4% of the air conditioners were 1-star rated, with 56.3% of total imports laden with R410a refrigerant. Also, over 66% (about 7 in 10) of the total refrigerators were 2- stars to 5-stars rated, with 87.2% of all refrigerator imports laden with R600a refrigerant. These refrigerants have both low global warming potential (GWP), low ozone depletion potential (ODP) and are more energy-efficient.

The rise in the importation and sale of efficient cooling appliances is primarily due to strict regulations, procedures and controls implemented at the ports of entry and regular market surveillance and stringent compliance monitoring. These measures help to ensure that only appliances that meet MEPS are permitted into the Ghanaian market. Figures 1.2 and 1.3 show how the cooling appliances market in Ghana has transformed over the years from being a completely used and inefficient refrigerator market (88.9% inefficient in 2005) to new and efficient ones (99.1% efficient in 2020) as a result of MEPS implementation.

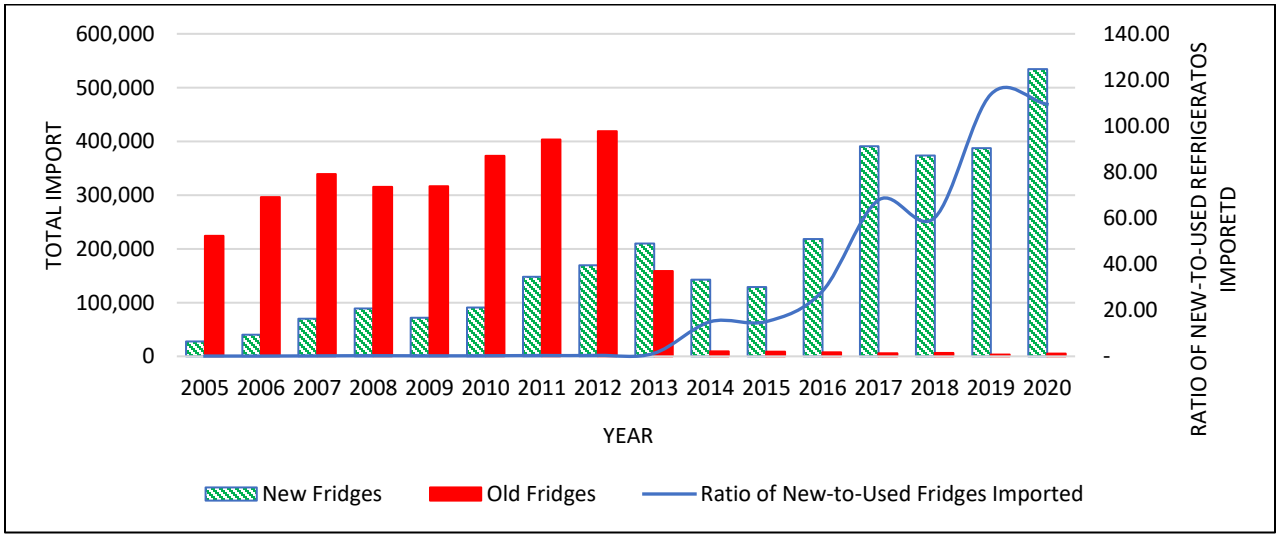


Figure 1.2: Trends in New Versus Used Refrigerators Imports (2005 – 2020)

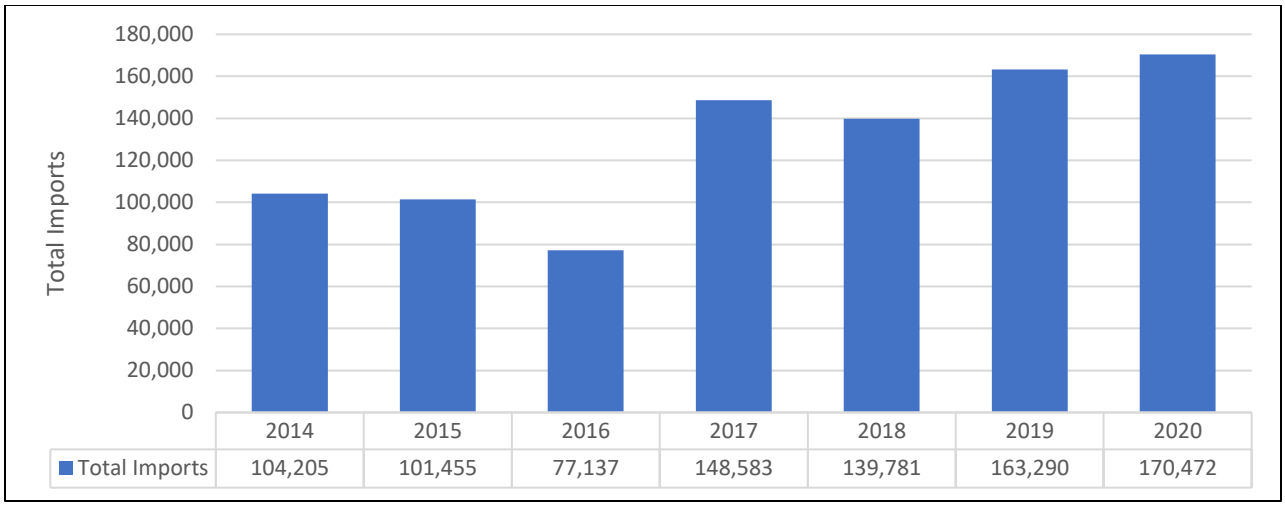


Figure 1.3: Yearly Trend in Air Conditioner Imports (2014 – 2020)

The average annual energy consumption of the new and efficient refrigerators has dropped drastically over the years compared with the used refrigerators. For instance, consumption values dropped from about 1,400 kWh to 760 kWh per unit for **combined used and new fridges** between 2005 and 2013 and from 760 kWh to 340 kWh per unit for the **new and efficient fridges** due to **stringent enforcement, market** surveillance **and public awareness** between 2013 and 2020. Figure 6 shows the trend in the average annual energy consumption patterns of refrigerating appliances over the years.

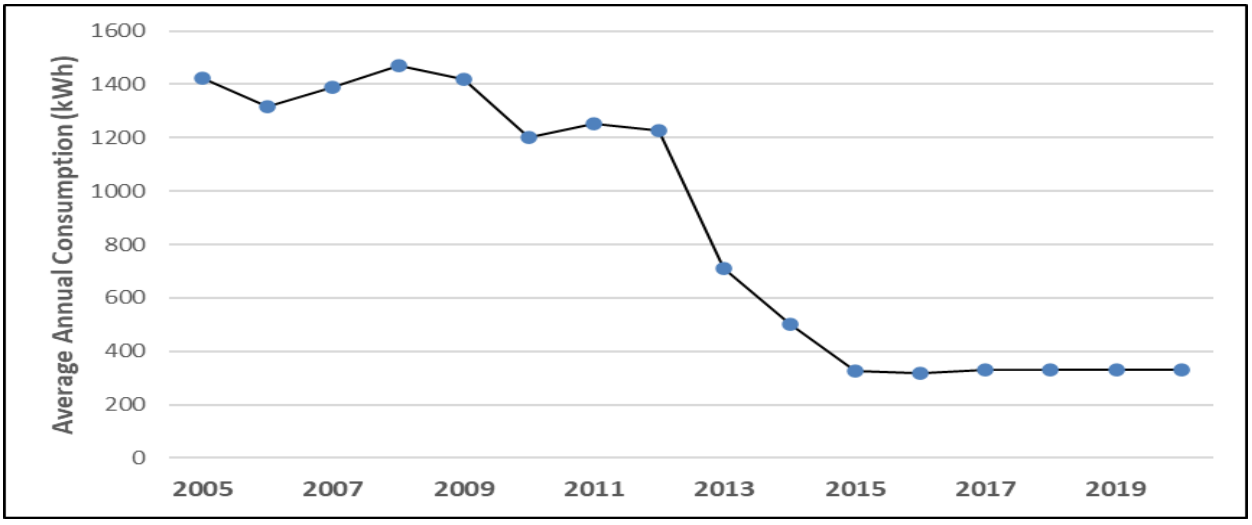


Figure 1.4: Average Annual Energy Consumption Patterns for Fridges over the period

CHAPTER TWO: METHODOLOGY OVERVIEW

This chapter presents the methodology adopted for the evaluation of the impact of the energy efficiency policy measures for household refrigerators and air conditioners as a result of MEPS implementation in Ghana.

2.1 Impact Model Review

Three appliance energy efficiency impact evaluation models were reviewed, as they can be used to evaluate the energy, financial and greenhouse gas (GHG) impacts of improvements in market product energy efficiency levels. They include the Product Policy Analysis Tool (PPAT), Bottom-Up Energy Analysis System (BUENAS) and Mepsy. Table 2.1 summarizes the main primary uses and key characteristics of each of these models.

Table 2.1: Primary Uses and Key Characteristics of Three Appliance Energy Efficiency Policy Impact Evaluation Models.

Parameter	PPAT	BUENAS	MEPSY
Primary Use	Compare and contrast energy savings potential-across various products in a single economy.	Sum energy savings potential across various products and 13 major economies.	Supports analysis and prioritization for the most energy-intensive appliances and equipment.
Key Points of Differentiation	User friendly built-in data visualization tools. Can estimate peak demand impacts.	Already contains market and efficiency data for various products and countries.	Support national, regional and global analysis. Can conduct the economic analyses needed to support policy development in one or many countries for different products.

Apart from the key points of differentiation stated above, there are major differences among the four impact models in terms of inputs, outputs, fuels, product, country coverage and additional features as summarized in Table 2.2.

Table 2.2: Comparison of the Three Impact Models

Model Characteristics		**PPAT**	**BUENAS**	**MEPSY**
Purpose	Estimate Impacts (Energy and CO_2)	X	X	X
	Assess Ease of Policy Implementation	X		
	Compare Across economies		X	
	Design Cost-Effective Policies			X
Scope	Economies	India only; extensible	13 major economies	162 countries
	Sectors	R, C, I[6]	R, C, I	R
	Products	More than 30	More than 30	Refrigerators, Room AC, fan, lighting, motors, TV sets, water heaters, others.
Fuels		Electricity, Fuel Oil, Gasoline, Kerosene	Electricity, Natural Gas, Fuel Oil	Electricity
Key Scenarios/Assumptions		BAU[7], Multiple User-Defined	BAU, Cost Effective Savings, BAT	BAU, MEPS[8] (multiple levels)
Inputs	Sales or Stock Time Series	X	X	X
	Sales Growth Rate	X		
	Unit Energy Consumption	X	X	X
	Demand (Coincidence) Factor		X	
	Product Lifetime	X	X	X
	Product Prices		Optional	X
	Energy Prices		Optional	X
	Discount Rate			X
	Compliance Level/Rate			X
	Other Macroeconomic Variables	X		X
Outputs	Stock (Each Year)	X	X	X
	Sales (Each Year)	X	X	X

[6] R: Residential, C: Commercial, I: Industrial

[7] BAU: business as usual, BAT: best technology available

	Energy Demand (Consumption) Electric Peak Power Demand	X	Final Energy[8]	Primary Energy[10]
	CO_2 Emissions	X	X	X
	Economic Impacts (National)			X
	Economic Impacts (Consumer)			X
Time Dimension	Base Year for Market Data	2010*	2005	2010*
	Policy Implementation Year	Base Year	2015	2010*
	Time Horizon	2030*	2030	2030*
	Time Increment	5 years	1 year	1 year
Features	Open Spreadsheet			X
	Built-in Visualization Tool	X		X
	Can Assume Non-Zero Price Elasticity of Demand			X
	Can Assume Declining Product Prices (Learning)			X
	Multi Tie Analysis			X
	Can Assume Efficiency Improvement in BAU Case		X	X
Publicly Available				X

* The user can adjust this parameter as desired.

The Mepsy model presented features that were helpful in this evaluation exercise, mainly because:

i. Macroeconomic data for economies under analysis are already available. The data already refers to possible sources of information and can be updated as required if more recent data becomes available. This can greatly reduce the time an analyst needs to compile data for multiple economies.

ii. Built-in saturation functions to forecast appliance ownership levels for two of the appliances under analysis (refrigerators and air conditioners).

[8] This quantity is also sometimes called "site" or "delivered" energy

iii. It can conduct a cost-benefit analysis of potential policies.

iv. It uses the bottom-up stock accounting approach.

v. It can perform multi-tie analysis.

vi. Factors in grid losses, power plant emissions, and electricity tariffs.

calculates cost and CO2 impacts associated with a given policy scenario.

Mepsy, as an online digital tool, is designed to model the cost, energy, and carbon reduction impacts of efficiency policies. Pre-loaded with data from 162 countries, it supports the analysis and prioritization of the most energy-intensive appliances and equipment. The model is based on a bottom-up stock accounting method that incorporates country-specific data on appliance energy use, markets, economic indicators and other policy factors.

Mepsy's ability to allow for updates of parameters with real import data, macroeconomic indicators and other relevant data through the user input tab was considered a major advantage. It also provides usability, flexibility, transparency and integration across different data stages. Based on the above, the Mepsy model was therefore chosen for this impact evaluation exercise.

2.2 Assumptions and Computational Equations in Mepsy Models

Mepsy assumes that:

i. before standards are put in place, all products on the market operate at a well-defined *baseline* efficiency;

ii. unit electricity consumption (UEC) is constant from year to year; and

iii. residential electricity tariff (*P)* is constant from year to year[9], set at 10 USc/kWh.

Mepsy uses Equation (1) to calculate the Life-Cycle Cost (LCC) for two cases:

i. A baseline case where no improvements are made to the appliance; and

ii. A policy case where a specific efficiency improvement is made to the appliance.

[9] Energy prices are not constant over time. Energy price trends are difficult to predict. Therefore, MEPSY does not attempt to forecast energy prices.

$$LCC = EC + \sum_{n=1}^{L} \frac{OC}{(1+DR)^n} \quad \text{.....(1)}$$

where EC is equipment cost (retail price), n is the year since purchase and OC is the annual operating cost and DR is the discounted rate. Operating cost is summed over each year of the lifetime of the appliance L.

The operating cost is determined by multiplying the Unit Energy Cost (UEC, in kWh) by the price of energy (P, in dollars per kWh) as shown in Equation (2):

$$OC = UEC \times P \quad \text{.....(2)}$$

Mepsy also calculates National Energy Savings (NES) each year by comparing the national energy consumption (NEC) of the appliance under study in the base case to the policy case, according to Equation (3).

$$NES = NEC_{Base\ Case} - NEC_{Policy\ Case} \quad \text{.....(3)}$$

Finally, carbon dioxide emissions savings (CES) and the total electricity cost savings (TECS) from MEPS implementation are calculated from energy savings, by applying grid emission factors and residential electricity tariff to site energy savings according to Equations (4) and (5):

$$CES = \frac{NES}{1-TD} \times CF \quad \text{.....(4)}$$

$$\text{TECS} = NES \times ET_{residential} \quad \text{.....(5)}$$

where CF is the carbon factor, derived from fossil fuel generation fraction, assuming emissions of 1000 g/kWh for thermal generation, TD is the fraction of energy lost in transmission and distribution and $ET_{\text{residential}}$ [USD/kWh] is the average electricity tariff for the residential sector, set at 10¢/kWh. The residential sector tariff was used because MEPS regulations in Ghana is primarily targeted at the residential sector.

2.3 Data Collection and Sources

Three types of data were collected for this analysis; namely Country data, Product market data and Energy use data to produce reasonable estimates.

The country data include population, household size, urbanization, electrification rates, electricity prices, CO_2 emissions factors, transmission and distribution losses.

The product market data on refrigerators and air conditioners were collected from the import appliance database or import registry developed by the Energy Commission, using information such as annual energy consumption, appliance lifetime, fridge and frozen volumes, refrigerants, star ratings and model numbers, from the performance test report submitted by importers from 3rd party accredited laboratory on the performance standard.

Energy use data for the cooling appliances include baseline unit energy consumption (UEC) and policy case energy consumption due to standards and labelling. Table 2.3 summarizes the data inputs and assumptions for the Mepsy Model and potential data sources.

Table 2.3: Mepsy Data Inputs and Potential data Sources.

Policy Dates	
Standard Year	2010
Policy End Year	2020
Analysis Year	2020

Sales Data (2010 - 2020)
Assumed to be 95% of Import Data

Economic Growth
High Growth Rate
Moderate Growth Rate
Current Growth Rate (1990 - 2003)

Model Pre-loaded with Country Specific Data	
Population Data (1950 - 2030)	
Household Size	3.78
Urbanization Rate	58.50%
Other Enginering Data	

Appliance Data

Parameter/Variable	**Appliance**	**Base Case**	**Policy Case**	**Sources**
Price ($)	Refrigerator	336.00	511.00	EC
	Air Conditioner	437.00	758.00	
Unit Energy Consumption (kWh)	Refrigerator	1,200	340	
	Air Conditioner	4,200	2,958	
Appliance Lifetime (years)	Refrigerator	7	15	
	Air Conditioner	5	12	

Economic Data

			Source
Discount Rates	Consumer	14%	GSS
	National	12%	
Income Growth		2.5%	

Energy Sector Parameters

		Source
Electricity Cost	$0.106	PURC
Heat Rate	2.2	EC
T&D Loss Factor	22.9%	
CO_2 per kWh (kg)	0.530	
Electrification	85.0%	

Note:

1. Generation factor from TAPCO is 45% (most efficient Power Plant)
2. Heat Rate = 1/Generation Factor
3. Exchange rate in 2010: 1 USD = GHS 1.4865
4. Exchange rate in 2020: 1 USD = GHS 5.82
5. In 2020, the average price of 3- and 4-stars refrigerators were used
6. In 2020, 3-stars air conditioners of 1.5 to 2.5 hp were used.

The Mepsy model contains user inputs tap, which capability was used to capture product data (sales), economic data, equipment cost, energy sector data and compliance data to override default values contained in the model. The adjusted values, once pasted into the user inputs sheet, override the default values. Figure 2.1 shows a snapshot of a user inputs tab in Mepsy used to capture the refrigerator data.

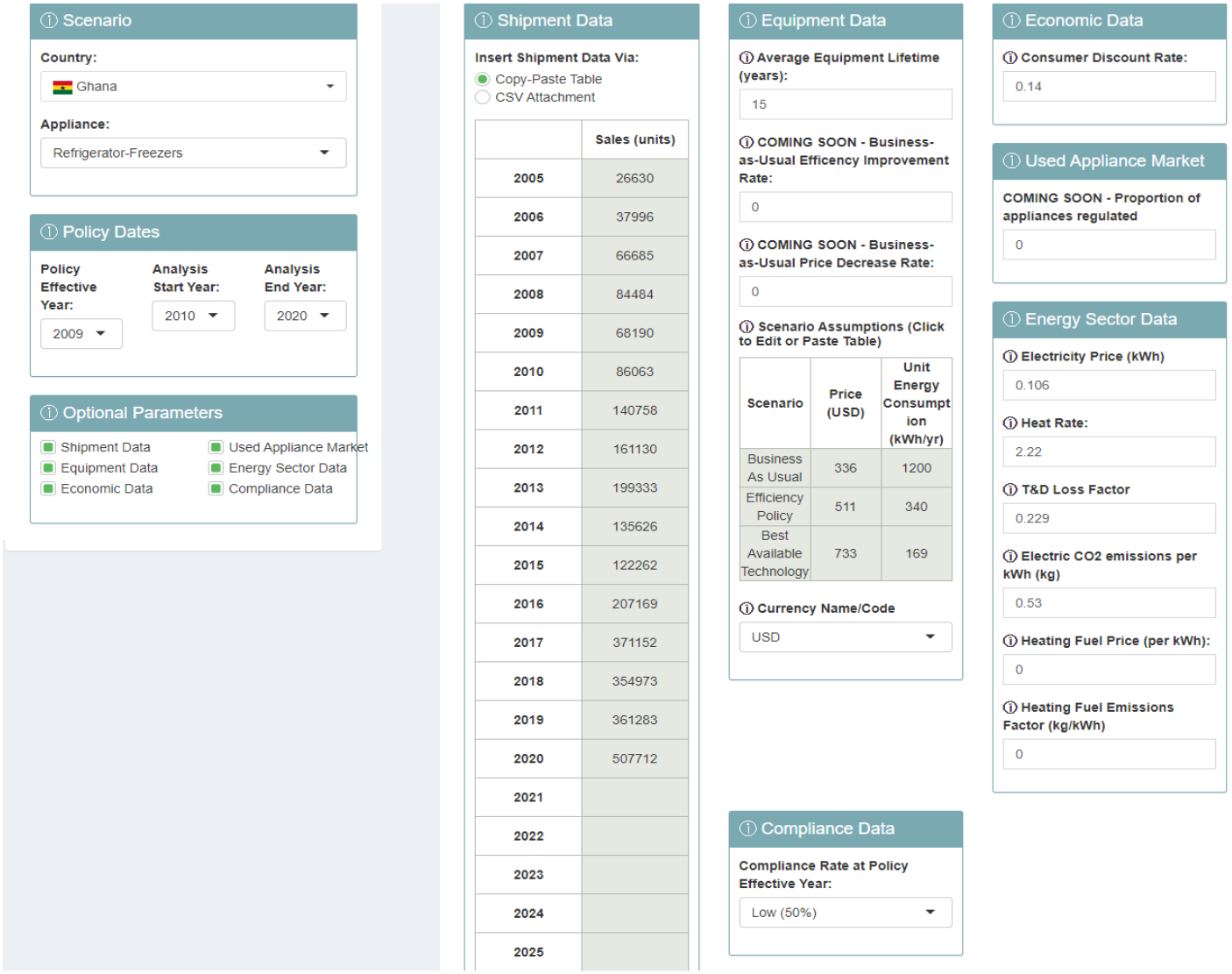


Figure 2.1: User Inputs Tab in Mepsy which is used to capture Refrigerator-Freezer Data.

CHAPTER THREE: KEY RESULTS

This chapter presents the **key results or impact** of the energy efficiency policy measures implemented for refrigerators and air conditioners in Ghana between 2010 and 2020.

3.1 Market Share

3.1.1 Refrigerating Appliances

Refrigerating appliances imported into Ghana are categorized into three: Fridge/Freezers (fresh and frozen volumes), Chest or Upright Freezers (frozen volume only) and Refrigerators (fresh volume only). For this report, each category was further divided into three sub-categories depending on the size or carrying capacity (net volume in litres) and will henceforth be referred to as "Small" (<= 340 litres), "Medium" (341 - 510 litres) and "Large" (> 510 litres). The market penetration of MEPS-compliant refrigerating appliances is summarized in Figure 3.1 by category.

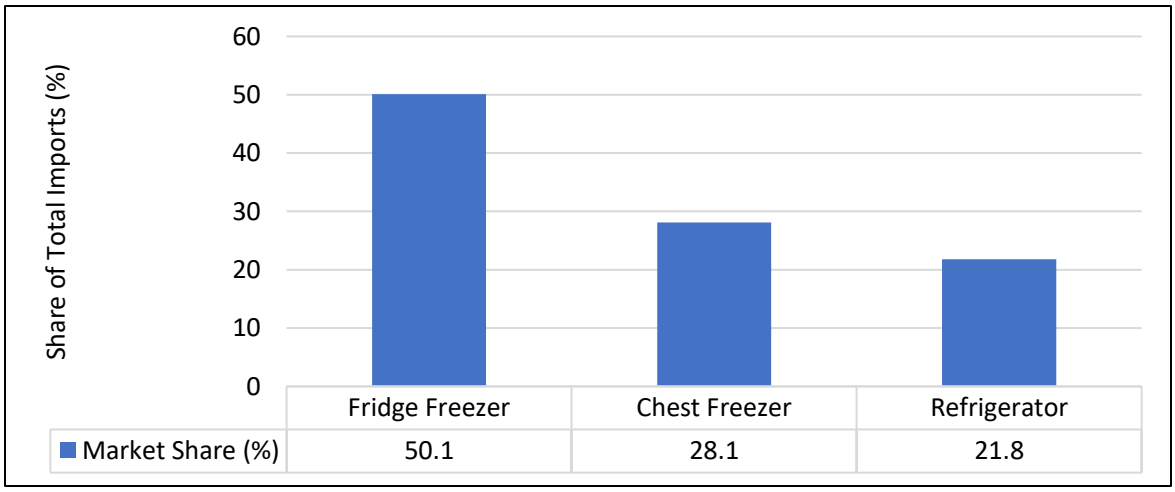


Figure 3.1: Market share of MEPS-compliant Refrigerators by category

In terms of market share, fridge/freezer has dominated the Ghanaian refrigerating appliance market, accounting for 50.1% of the total sales since 2013. Of this number, 95.7% are of small category, 3.1% are medium whilst 1.2% are large. Further details on the market share of MEPS-compliant refrigerating appliances by sub-category are indicated in Figure 3.2.

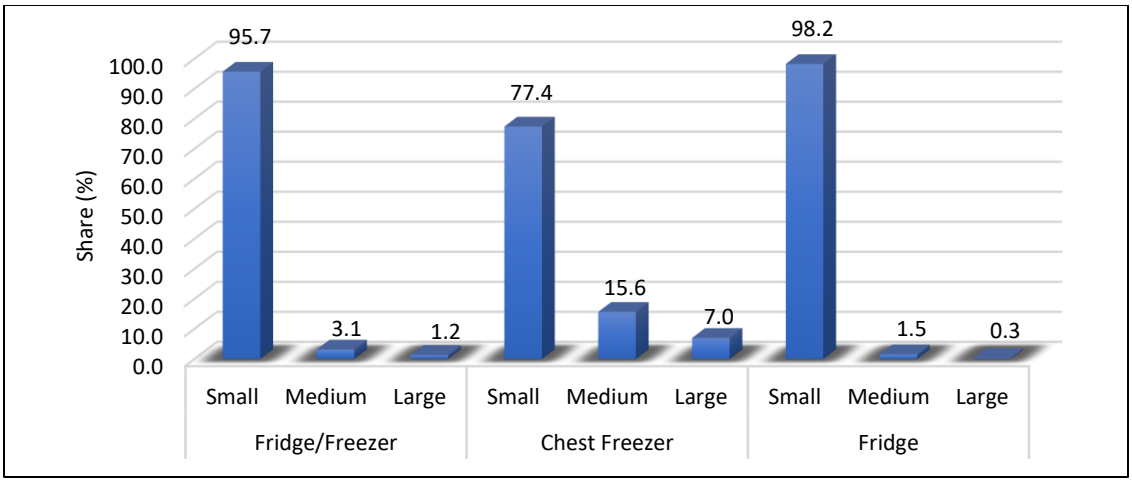


Figure 3.2: Market Share Of MEPS-Compliant Refrigerators by Sub-Category

In terms of overall energy efficiency star ratings, 38.2% of all categories of refrigerating appliances were 2-star rated, 33.6% (1-star rated), 14.3% (3-star rated), 12.9% (4-star rated) and the remaining 0.3% (5-star rated) as depicted in Figure 3.3. Nationally, over 66% (about 7 in 10) of the total refrigerators were 2- stars or more rated.

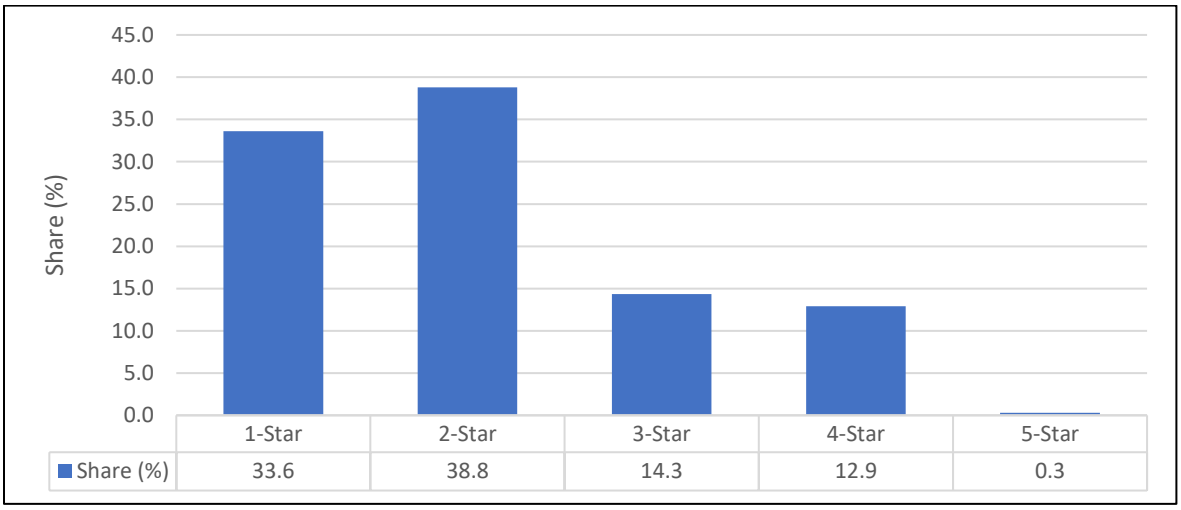


Figure 3.3: Overall Energy Efficiency Star Ratings of Refrigerators

Further details on the market share of MEPS-compliant refrigerating appliances by sub-category in terms of energy efficiency star ratings are shown in Figure 3.4.

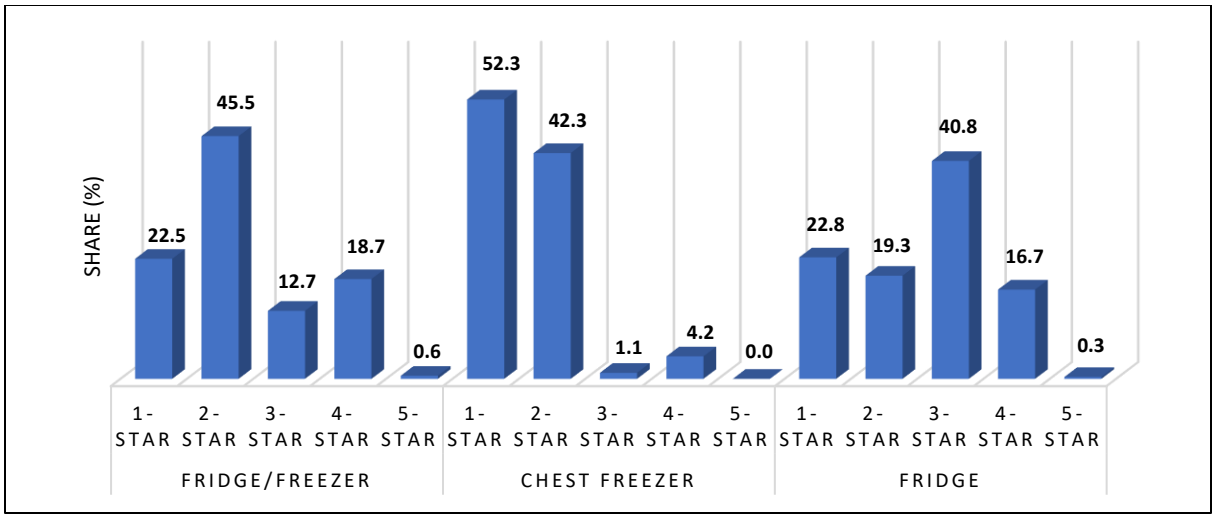


Figure 3.4: Energy Efficiency Star Rating of Each Refrigerator Category

3.1.2 Non-ducted Single Split Room Air Conditioners

In the case of the non-ducted single split room air conditioners, 55.4% of the total sales between 2014 and 2020 was 1-star rated; 21.1%, 2-star rated; 22.3%, 3-star rated and 1.2%, 4-star rated as indicated in Figure 3.5.

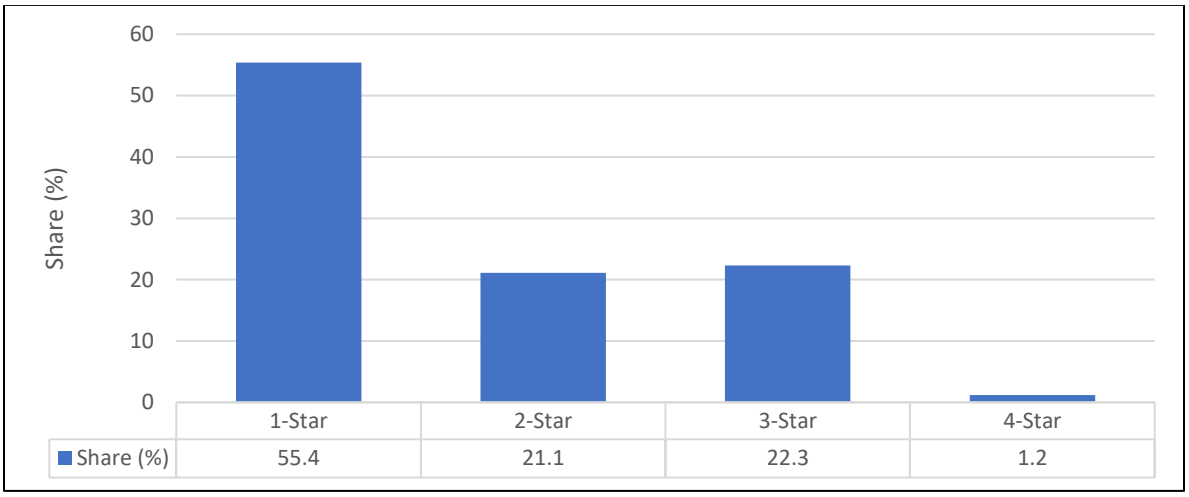


Figure 3.5: Energy Efficiency Star Rating of Air Conditioners

3.1.3 Refrigerants

For refrigerants, 89.9% of all refrigerating appliances run on R600a refrigerant, whilst 56.3% of the non-ducted single split room air conditioners also run on R410a refrigerant as shown in Figure 3.6. These refrigerants have both low global warming

potential (GWP), low ozone depletion potential (ODP) and are more energy-efficient, thereby resulting in the low energy consumption of these cooling appliances.[10]

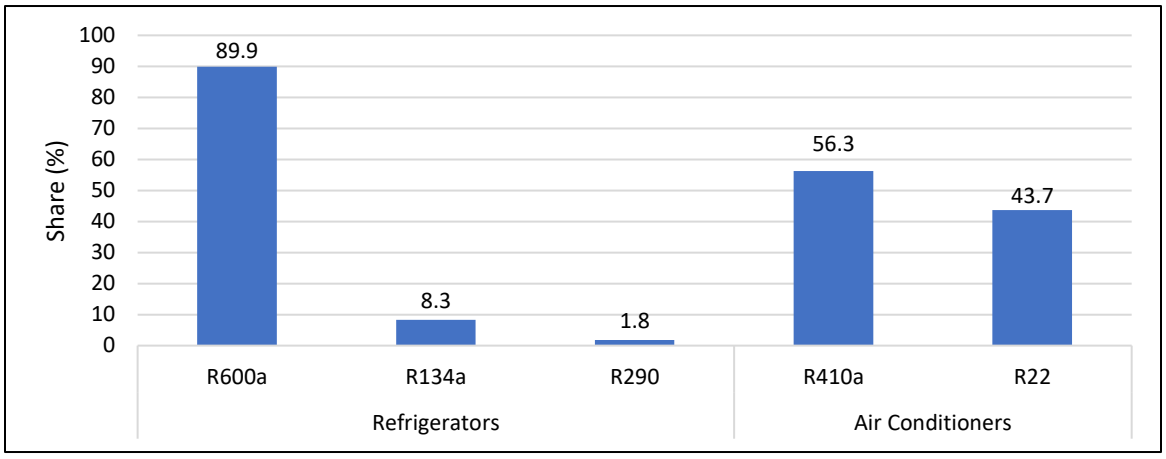


Figure 3.6: Shares of Refrigerants Used in Refrigerators and Air Conditioners

3.1.4 Compliance Level

The compliance levels of these cooling appliances have been on the rise over the years. Particularly, between 2017 and 2020, the compliance levels of air conditioners increased from 79.2% to 96.8% whilst that of refrigerators surged from 92.6% to 97.0%. Figure 3.7 displays the trends in the compliance levels of these cooling appliances between 2017 and 2020.

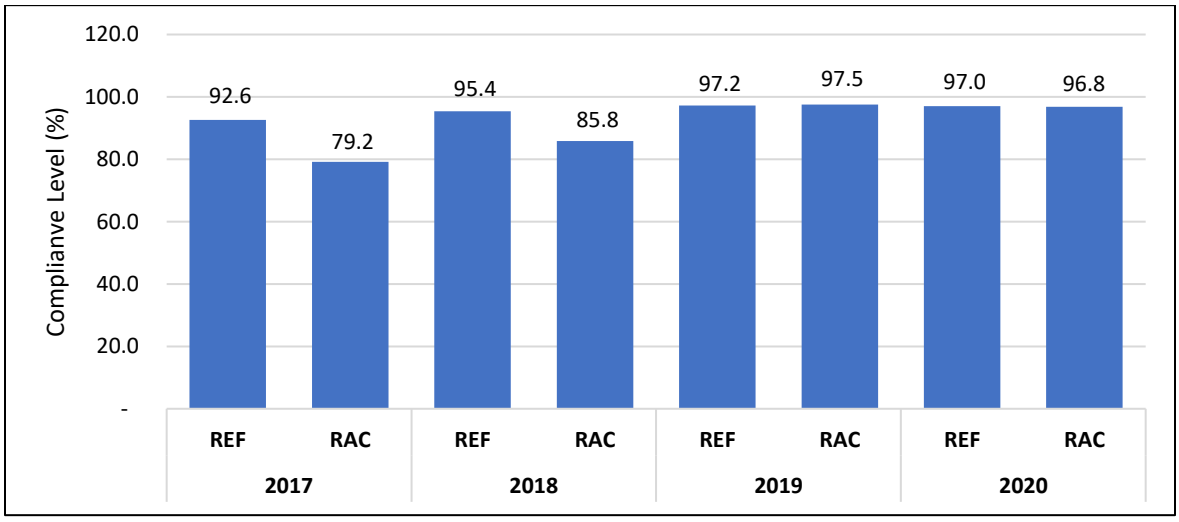


Figure 3.7: Trends in Compliance Levels of Cooling Appliances from 2017 - 2020

[10] CO_2 as a refrigerant in supermarket refrigeration systems.

The factors that have contributed to these high compliance levels include the following**:**

i. Submission of performance test report by importers from third-party accredited laboratories to the Ghana Energy Commission for evaluation and approval according to the Regulations;
ii. Establishment of import appliance database/register;
iii. Operationalization of the ICUMS digital portals for approving only appliances that meet MEPS;
iv. Rigorous physical examination procedures are being implemented at the ports of entry;
v. Regular and consistent market surveillance coupled with stringent compliance monitoring;
vi. Removal of non-compliant appliances from retail shops and showrooms for testing and re-labelling before displaying them for sale;
vii. Payment of enforcement fees for non-compliance by importers;
viii. Verification and challenge testing procedures; and
ix. Development and deployment of a Certified Appliances Mobile Application (APP), available on the google play store and Apple iOS. The APP contains all the approved appliances, nearby shops and tips on how to save energy. It also helps consumers to make an informed purchase decision.

3.1.5 Sales

In terms of sales, the assumption made was that 95% of total imports was sold between 2010 and 2020. Total refrigerators sold were estimated to be 2.72 million units between 2010 and 2020. Similarly, for air conditioners, the sales volume was estimated to reach about 870,000 units between 2014 and 2020.

3.2 Electricity, Carbon Dioxide and Financial Savings due to MEPS

This section presents the household unit savings and the national level impact.

3.2.1 Customer or Household Level Savings

3.2.1.1 Household Refrigerator Savings

The depreciation of the local currency during the implementation period has pushed up the average price of a refrigerator by about 52%, translating into USD 175, though prices have been decreasing globally due to market innovations, competition and economies of scale. In contrast, the annual electricity consumption goes down to 340 kWh/yr, a decrease of 860 kWh/yr for refrigerators. Correspondingly, the household's annual electricity bill contribution from the refrigerator has decreased by about USD 90. During the implementation period from 2010 to 2020, each household saved about 9,460 kWh, translating into financial savings of about USD 1,000 on the refrigerator. For example, a refrigerator that was bought in 2010 could have been replaced every 2 years from the savings over the period.

3.2.1.2 Customer or Household Air conditioner Savings

Similarly, the price of an air conditioner has increased by 73.6% or USD 321 due to the depreciation of the local currency, whilst the average annual electricity consumption goes down to 2,962 kWh/yr, a decrease of nearly 1,238 kWh/yr. Consequently, the household's annual electricity bill contribution from the air conditioner has decreased by about USD 131, resulting in a total electricity savings of 8,666 kWh with a financial savings of about USD 920. For example, an air conditioner that was bought in 2010 could have been replaced every 2 years from the savings over the period.

3.2.2 National Level Impact/Savings

3.2.2.1 Annual Electricity Savings

The Mepsy model uses Equation (3) to evaluate the annual electricity saving for the period under review. Results from the model indicate that the total annual electricity savings from the adoption of MEPS-compliant refrigerating appliances increased from 52.8 GWh in 2010 to 1,702 GWh in 2020, whilst that of room air conditioners increased from 0.11 GWh in 2014 to 744.12 GWh in 2020 as indicated in Figures 3.8

and Figure 3.9 respectively. The combined savings of 2,446 GWh in 2020 is reasonably close to 19% of the total thermal electricity (12,820 GWh) generated in 2020.[1]

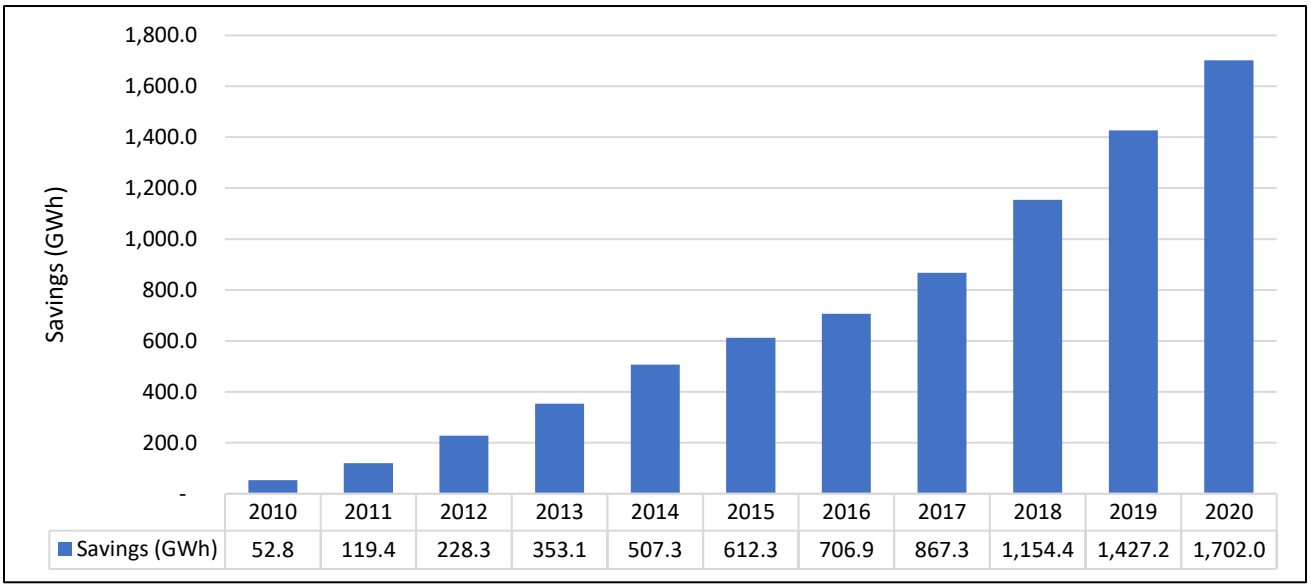


Figure 3.8: Electricity Savings for MEPS-compliant Refrigerators from 2010 – 2020

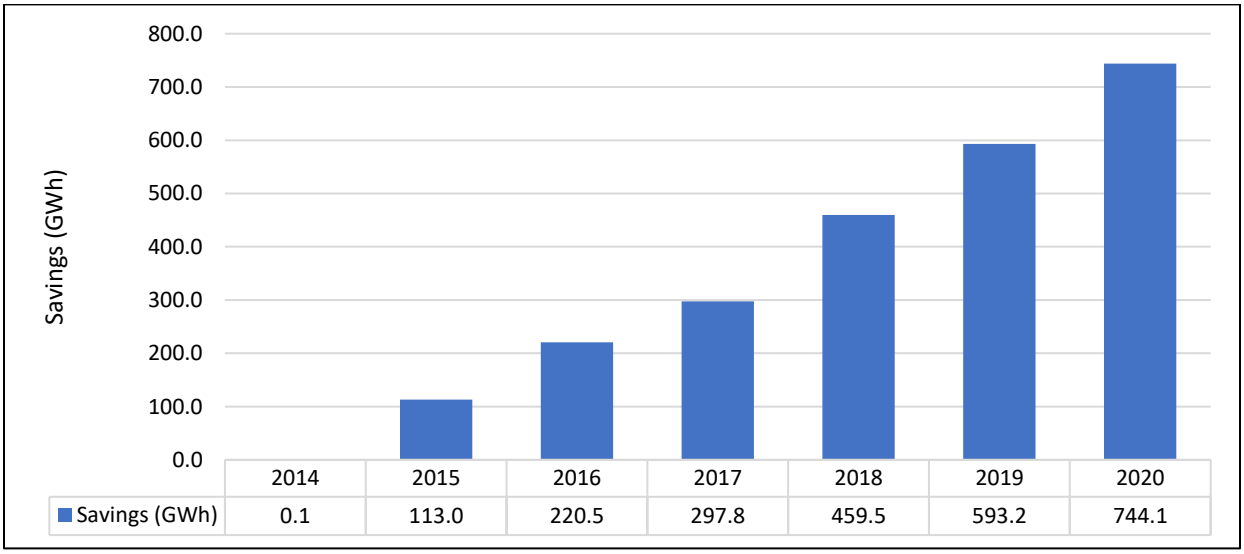


Figure 3.9: Electricity Savings for MEPS-compliant Air Conditioners from 2015 - 2020

3.2.2.2 Cumulative Electricity Saving

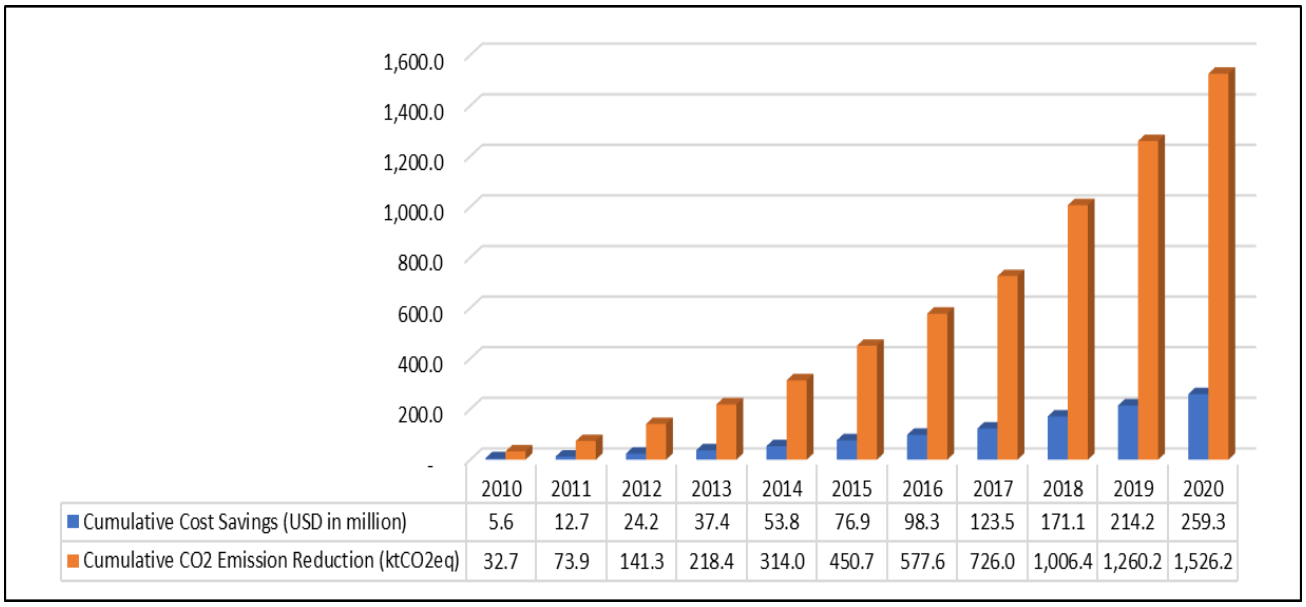
The Mepsy model uses Equation (3) to evaluate the cumulative electricity savings for the period under review. Results from the model indicate that the total cumulative amount of electricity savings due to MEPS implementation in 2020 was **10,159 GWh (10.16 TWh)** for both refrigerators and air conditioners. This is about half (50.4%) of the total electricity generated (20,170 GWh) in 2020[1], close to the total thermal electricity generated (10,195 GWh) in 2018[1] and constituting about 55.9% of the total electricity generation (18,188 GWh) in 2019[1]. This intervention **delayed** additional capacity expansion of **1,160 MW, equivalent to a third of the total Installed Thermal Generation Capacity (3,649 MW)[1]**.

The comparison with thermal power generation is important since the burning of the fuels (HFO, Natural Gas, LCO and Diesel) are responsible for emitting large amounts of carbon dioxide (CO_2) into the atmosphere. With 5,288 MW licensed capacity in Ghana in 2020, about 3,649 MW, representing 69% of the total generation capacity, are thermal power plants with capacities ranging from 87 MW to 470 MW.[1] The entire fleet of these thermal power plants generated a total of 12,819.3 GWh of electricity in 2020.[1] The Government of Ghana has initiated several flagship programmes such as the One District, One Factory (1D1F), One Village, One Dam and Planting Foods and Jobs aiming to revive Ghana's industrialisation drive. The 1D1F in particular, where Government seeks to establish medium-to-large scale factories that have the potential to affect the economic fortunes of the country, will require more power plants to be built to meet the expected increase in electricity demand of these industries under the 1D1F programme. However, MEPS savings have demonstrated that it is possible to save a substantial amount of electricity demand through **regulatory actions**, thus deferring the necessity to increase the generation capacity of carbon-intensive thermal power plants and the attendant environmental and economic implications.

3.2.2.3 Cumulative Energy Cost Savings and Carbon Emission Reductions

The cumulative energy cost-saving and carbon emissions reduction realized from MEPS-compliant cooling appliances from 2010 to 2020 is shown in Figure 3.10. Results from the model indicate that about USD 1 billion has been saved on electricity bills and 6.33 million tonnes of CO_2eq have been saved using Equations (5) and (4)

respectively. The huge financial saving and environmental benefits gained from deferred electricity consumption amplify the positive implication of the MEPS programme in Ghana.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cumulative Cost Savings (USD in million)	5.6	12.7	24.2	37.4	53.8	76.9	98.3	123.5	171.1	214.2	259.3
Cumulative CO2 Emission Reduction (ktCO2eq)	32.7	73.9	141.3	218.4	314.0	450.7	577.6	726.0	1,006.4	1,260.2	1,526.2

Figure 3.10: Cumulative Energy Cost Savings and Carbon Emission Reduction due to MEPS-Compliant Cooling Appliances.

3.3 Comparison of Current Results with Previous Projections

An ex-ante analysis, using the Policy Analysis Modeling System (PAMS) model, was conducted in 2006 to estimate baseline energy savings and CO2 emission reduction in 2020 due to energy efficiency measures being considered. The current analysis however considers ex-post using the Mepsy Model. It is, therefore, possible to compare these current estimates against the original projections made in 2006. Table 3.1 provides the estimates of the projections against the actual results from the current analysis.

Table 3.1: Comparison of Current Results with Previous Projections

Parameter	**PAMS 2006 Baseline Projections for 2020 From 2010 - 2020**	**MEPSY 2020 Actuals From 2010 - 2020**	**% Increase**
Total Energy Savings (GWh)	2,178	10,159	366
Total CO_2 Reduction ($MtCO_2eq$)	0.38	6.32	1,563

From Table 3.1, the current analysis delivered more savings than was initially projected in 2006, because actual import/sales data, real electricity tariff, the correct number of households and other real economic figures/data were used in 2020.

CHAPTER FOUR: CONCLUSIONS AND RECOMMENDATION

The implementation of MEPS for cooling appliances in Ghana during the period under review yielded 10,159 GWh (10.16 TWh) of electricity savings nationally. Carbon dioxide emissions was also reduced by 6.32 million tonnes within the same period. This is a major improvement in Ghana's carbon footprint (fulfilling SGDs 7 and 13) and thereby making the future net-zero pathway a reality. This figure roughly corresponds to the total thermal electricity generated (10,195 GWh) in 2018 and more than half the total electricity generated (20,170 GWh) in 2020. At USD 0.10/kWh, about USD 1.0 billion has been saved on electricity bills.

At the household level, about 18,306 kWh of electricity has been saved, resulting in a financial savings of about USD 1,920 on both refrigerators and air conditioners.

In conclusion, the implementation of energy efficiency programmes for these cooling appliances delayed additional capacity expansion of 1,160 MW.

It is therefore not out of place for the Commission to have considered expanding the scope of appliances under the Ghana appliance standards and labelling regime. ECOWAS in particular, and all African countries in general, should consider adopting MEPS and labeling. The adoption of MEPS and labelling by ECOWAS will give strength to Ghana's effort as the entire subregion will be insulated against the dumping of substandard appliances.