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Market Assessment Study of Commercial Beverage Coolers under Standards & Labeling Programs

MAY 2024

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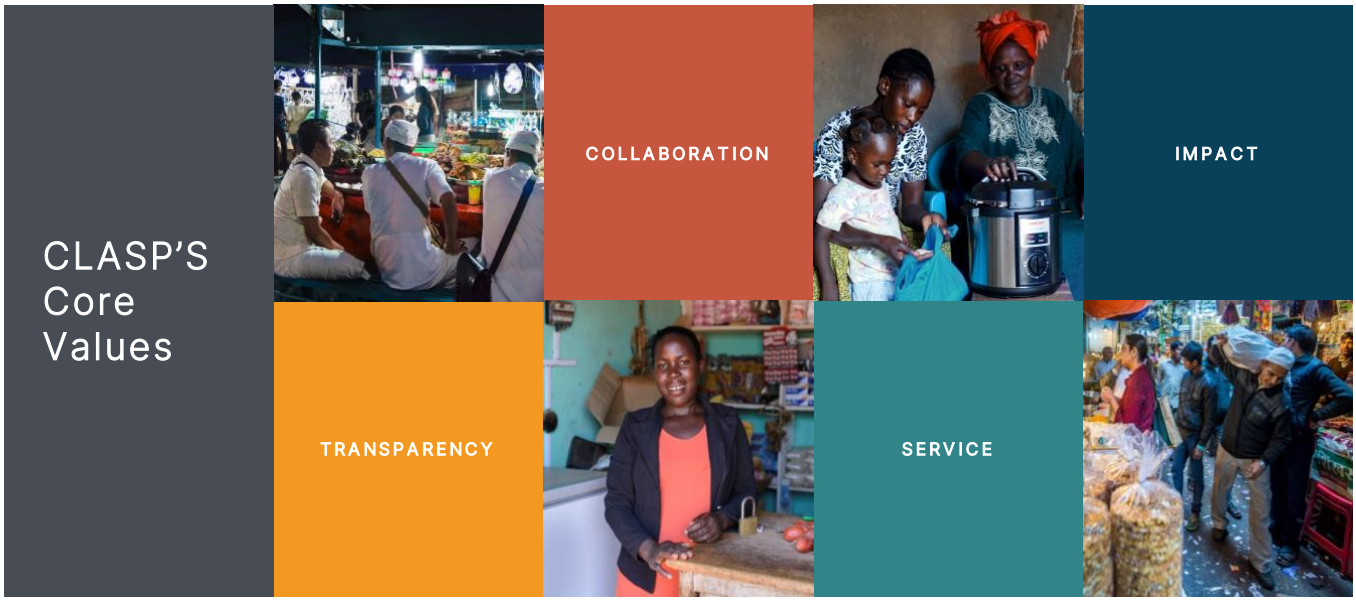

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ABBREVIATIONS

AEC	Annual energy consumption
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
B2B	Business-to-business
B2C	Business-to-consumer
CAGR	Compound annual growth rate
CBC	Commercial beverage cooler
CC	Climate class
CFR	Code of Federal Regulations
CRE	Commercial refrigeration equipment
DOE	Department of Energy
EEI	Energy Efficiency Index
EMD	Energy management device
EU	The European Union
FY	Financial year
HS CODE	Harmonized system code
ICAP	India Cooling Action Plan
IS	Indian Standards
ISO	International Organization for Standardization
kW	Kilowatt
MEPS	Minimum energy performance standards
MSME	Micro, small, and medium enterprises
$MtCO_2$	Million tons of CO_2
NABL	National Accreditation Board for Testing and Calibration Laboratories
NDC	Nationally determined contributions
OEM	Original equipment manufacturer
SAE	Standard annual energy
S&L	Standards and labeling
SEC	Specific energy consumption
TDA	Total display area
TEC	Total energy consumption
TWh	Terawatt hours
Veq	Equivalent volume

Executive Summary

A commercial beverage cooler, also known as a visi cooler, is a self-contained bottle cooler with a transparent glass front door that is used to store bottled or canned beverages for sale in retail outlets. These coolers are refrigerating appliances that differ from domestic refrigerators in several ways – they do not have a freezer, are meant to cool all contents uniformly to the same specified temperature range, store only packaged beverages and not edible items, and their transparent doors allow consumers to see what is available for sale. Commercial beverage coolers are used by various businesses, such as grocery stores, restaurants, and supermarkets that sell packaged beverages. In India, these coolers are either provided by specific beverage brands, such as PepsiCo India, or purchased directly from manufacturers.

In 2017, the refrigeration sector consumed 67 terawatt hours (TWh) of energy and generated 57 million tons of CO_2 ($MtCO_2$) of carbon emissions. Of this, 24% and 25%, respectively, can be attributed to commercial refrigeration.[1] While energy consumption of domestic refrigeration in India is already well regulated, various commercial refrigeration products[2] are yet to be brought into the ambit of the Bureau of Energy Efficiency's (BEE) Standards and Labeling (S&L) program. It is estimated that a concerted effort to reduce energy consumption in the commercial refrigeration sector could potentially reduce energy consumption by 19% by 2027 than in the business-as-usual scenario.

Commercial beverage coolers are part of the growing commercial refrigeration sector in India. The India Cooling Action Plan (ICAP) states that the commercial refrigeration sector, including commercial beverage coolers, is "poised to grow 2-fold in the next decade and 6-fold in the subsequent decade with energy implications in the range of 2.2-times and 6-times increase". The report also states that commercial beverage coolers had a market size of 0.3 million units in 2017–2018.[3]

Anticipating the growth of commercial beverage coolers, the Bureau of Energy Efficiency (BEE), the statutory body under the Ministry of Power, has decided to develop energy efficiency labeling programs to enable the transition to efficient visi coolers. CLASP is assisting BEE by conducting a

1 Demand Analysis for Cooling by Sector in India in 2027.
2 The deep freezer, a commercial refrigeration appliance, is under the mandatory phase of the BEE star labeling program.
3 India Cooling Action Plan, 2019

market assessment of visi coolers and developing an energy efficiency standards and labeling program.

Through this project, BEE will regulate the energy consumption of visi coolers through a combination of minimum energy performance standards (MEPS) and comparative energy use labeling through star labels. The criteria for labeling is annual energy consumption (AEC in kWh/year), a derivative of total energy consumption (TEC in kWh/24 hours (h)) that has been tested in accordance with ISO 22044:2019 / IS 2167:2023.

Proposed Star Rating Table for Commercial Beverage Coolers

Star Rating Band – Annual Energy Consumption (kWh/year) with 20% Bandwidth			
1 star	(2.75*Veq) + 496.13	< AEC ≤	(3.30*Veq) + 496.13
2 star	(2.29*Veq) + 496.13	< AEC ≤	(2.75*Veq) + 496.13
3 star	(1.83*Veq) + 496.13	< AEC ≤	(2.29*Veq) + 496.13
4 star	(1.46*Veq) + 496.13	< AEC ≤	(1.83*Veq) + 496.13
5 star		AEC ≤	(1.46*Veq) + 496.13

The introduction of the star label is expected to potentially reduce energy expenditure by 11.67 billion kWh from 2024–2034, while also reducing CO_2 emissions by 8.35 $MtCO_2$. In addition, these labels will aid the removal of inefficient products from the market, ensuring that commercial consumers have energy-efficient commercial beverage coolers. This, in turn, will reduce their monthly electricity costs.

1. Introduction

A commercial beverage cooler is a refrigerated cabinet used for the sale or display of pre-packaged, non-perishable beverage products. These coolers are designed to chill products that can be stored per a specific storage temperature class. Commercial beverage coolers are also known as visible coolers or visi coolers.

Visi coolers are quite similar to normal refrigerators, but they have a few distinctions. One notable difference is the presence of glass doors on the coolers, which allow customers to view products and make immediate purchase decisions. This attribute is more conducive to increasing sales vis-à-vis solid, closed-door refrigerators. Visi coolers come in various types, alignments, door numbers, and placements, and are used in different kinds of stores – these are the factors that impact their usage.

The India Cooling Action Plan (ICAP) requires energy regulation of the commercial refrigeration sector to address increasing energy consumption. In 2017–2018, the refrigeration sector accounted for 67 terawatt hours (TWh) of electricity consumption,[14] with commercial refrigeration contributing 24%. A stock of 3.21 million commercial beverage coolers was already in the market (as of 2023), and it is anticipated that sales will experience a 5% compound annual growth rate (CAGR) until 2030. The anticipated expansion of the Indian retail sector, particularly the carbonated and non-carbonated beverage market segments, will further boost sales.

As per the ICAP, the Bureau of Energy Efficiency (BEE) aims to regulate the commercial beverage cooler sector through the implementation of minimum energy performance standards (MEPS) and bring this product under the ambit of a comparative star labeling program. While the MEPS will establish a minimum energy consumption threshold for commercial beverage coolers in India, the comparative star labeling will allow consumers to compare energy efficiency based on a five-star rating scale, wherein more stars indicate greater efficiency. The standards and labeling (S&L)

[4] Demand Analysis for Cooling by Sector in India in 2027.

program will initially be voluntary and transition to a mandatory framework once the market achieves a high penetration of labeled commercial beverage coolers.

In this report, we present our primary and secondary research along with a detailed analysis to develop an energy efficiency policy for visi coolers manufactured and imported in India. This report encompasses the methodology for market assessment, market survey findings, the standards utilized for testing, examination of international labeling systems, analysis of test results, methodologies employed in devising the MEPS and star rating table, and the anticipated reduction in CO_2 emissions within the first 10 years following implementation.

The proposal to implement a star labeling program for visi coolers aligns with the International Organization for Standardization (ISO) 22044:2021, as the current standard, Indian Standards (IS) 2167:2019, has not been updated to match the testing methodology required to develop the star labeling program. The Bureau of Indian Standards (BIS) is scheduled to introduce a revised version of IS 2167:2019, which will incorporate ISO 22044. This revised standard will serve as the reference for the BEE's future star labeling program.

2. Market Assessment

2.1. RESEARCH METHODOLOGY

The market assessment encompasses a comprehensive understanding of the visi cooler market in India. This includes a detailed preliminary market assessment of the product models marketed by key players, which offers insights into the diversity and scope of available offerings. To gather valuable end-use information, we also conducted national-level secondary research, during which we collected responses from a broad spectrum of participants. Our primary research involved extracting insights from partially completed responses from the four major players, who collectively hold a substantial 70% share of the Indian visi cooler market. The data and perspectives come from market research conducted by an independent research firm[5] and our subsequent analysis. Consultations with industry associations added another layer of expertise, ultimately enhancing the overall depth and accuracy of the market assessment.

2.2. PRELIMINARY MARKET RESEARCH

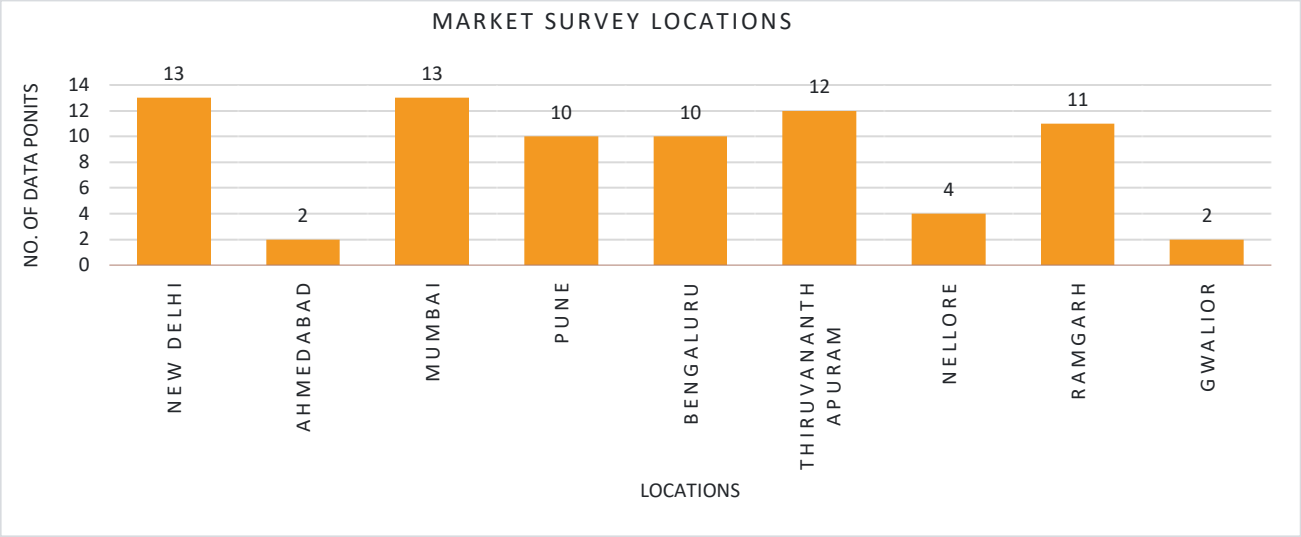
We conducted a comprehensive assessment of a total of 113 models from 11 manufacturers to obtain insights regarding the diversity and market scope of available models. Our analysis revealed that the majority of models in the market had single-door designs, capacities ranging 200–500 liters, and refrigerants utilizing R134a.

2.3. SECONDARY RESEARCH

We conducted exhaustive, nationwide secondary research to understand the brands and types of products that most retailers in India use. This survey covered the following regions of India: north zone (Delhi), west zone (Gujarat and Maharashtra), south zone (Karnataka, Kerala, and Andhra Pradesh), east zone (Jharkhand), and central zone (Madhya Pradesh). We studied nine cities across eight states and examined a total of 77 commercial beverage cooler models (see Figure 1).

[5] Insights on market sales data for 2016–2024 were collected by the independent research firm, Industry ARC.

FIGURE 1: SURVEY LOCATIONS AND SAMPLE SIZE



Out of the 77 visi coolers surveyed, a significant majority, 75%, were single-door models, all floor-standing and vertical in design, with swing doors. Nearly 45% of the visi coolers had five shelves, while some even featured up to ten. R134a emerged as the predominant refrigerant in these visi coolers and a notable 42% of them operated continuously without shutting off. In addition, 38% of the surveyed visi coolers fell within the age range of 2–7 years.

2.4. PRIMARY RESEARCH

In this section, we discuss the findings of the survey conducted on major visi cooler manufacturers in the Indian market. The survey questionnaire was divided into two sections: one focused on manufacturer/original equipment manufacturer (OEM)–specific information, while the other focused on general country-level information. The questionnaire covered key aspects, such as annual sales figures, market segmentation based on storage capacity, alignment, door type, and other parameters, the supply chain of components, and details of test facilities.

We received responses from four key players in the Indian market. The following is a summary of the manufacturer-specific information obtained from the primary survey.

M1 is a leading manufacturer of vertical, floor-standing visi coolers in India. Its product line comprises swing-type single and double-door models, and they have sold 3,20,000 units in the last 5 years. M1 outsources all components to local Indian manufacturers – except for compressors, which it imports primarily from China and Slovakia. M1 exports approximately 20% of its visi coolers to Africa. It has an in-house test facility in Gurugram, Haryana, and estimates the predicted life of the average visi cooler that it manufactures/sells to be approximately 7–9 years.

M2 has sold 73,240 units of visi coolers in the last 5 years. M2 manufactures vertical, floor-standing visi coolers with swing-type doors. M2's product line comprises 86% single-door models and 75% models with a storage capacity of 200–500 liters. M2 outsources refrigerants, condensers, shelves, evaporators, capillary tubes, and insulation materials to local Indian manufacturers and imports primarily compressors, fan assembly, lighting accessories, display panels and control boards, sensors, and doors from China. Indeed, about 80% of M2's visi cooler imports are from China, and it does not have any in-house or third-party test facilities. M2 estimates the predicted life of the average visi cooler it manufactures/sells to be approximately 5 years.

M3 has sold 1,13,000 units of visi coolers in the last 5 years. Its product line comprises floor-standing visi coolers, 90% of which have vertical alignment, with a swing-type door and a storage capacity of 200–500 liters. Approximately 80% of models that M3 sells are single-door visi coolers. M3 outsources refrigerants, fan assembly, lighting accessories, and doors to local Indian manufacturers and mostly imports compressors, condensers, display panels and control boards, shelves, sensors, evaporators, capillary tubes, and insulation materials from China, South Korea, and Thailand. M3 has in-house test facilities located in Pantnagar, Uttarakhand, and Faridabad, Haryana. It estimates the predicted life of the average visi cooler that it manufactures/sells to be approximately 6–8 years.

M4 is a major player in the visi cooler market, with 10,37,430 units sold in the last 5 years. Notably, 95% of models that M4 sells are of the single-door swing type, 99% of their models are vertically aligned, and 96% are floor-standing. Almost half the models sold have a storage capacity of 200–500 liters. When it comes to production, M4 manufactures condensers and doors in-house while outsourcing refrigerants, shelves, capillary tubes, and insulation materials to local Indian manufacturers. The company imports fan assemblies, lighting accessories, display panels and control boards, sensors, and evaporators from China. However, most of its compressors come from Brazil, Slovakia, and China. M4 exports approximately 10–15% of its visi coolers to the Middle East and Africa. It has an in-house test facility located in Sanjan, Gujarat, to ensure the quality of its products. The company estimates that the predicted life expectancy of the average visi cooler that it manufactures/sells is approximately 7 years, which is on par with the industry average.

M2 estimates that the current stock of visi coolers being used by consumers in India in 2022 amounts to approximately 5,00,000 units. Meanwhile, M3 estimates a higher figure of 2,500,000 units. It is important to note that these are only estimates provided by the companies; there may be variations in the actual figures. This disparity in data between the two sources suggests a variation in the estimated number of visi coolers installed across all commercial premises in India. Such variations in data can be attributed to differences in data collection methodologies, sample sizes, or other factors that may affect the accuracy and reliability of the findings.

S. No.	Aspect	M1	M2	M3	M4
1	**Units sold (FY 2021–2022)**	90,000	21,411	26,000	3,21,783
2	**Product line**	Swing-type single and double-door models	Mostly single-door models	Mostly single-door models	Mostly single-door models
3	**Product type**	Floor-standing vertical visi coolers	Floor-standing vertical visi coolers	Floor-standing vertical visi coolers	Floor-standing vertical visi coolers
4	**Storage capacity**	Various capacities	Mostly 200–500 liters	Mostly 200–500 liters	Mostly 200–500 liters
5	**Imports**	Compressors from China and Slovakia	Various components from China	Various components from China, South Korea, and Thailand	Fan assemblies, lighting, display panels, sensors, and evaporators from China
6	**Exports**	20% to Africa	Not specified	Not specified	10–15% to Southeast Asia, Middle East, and Africa
7	**In-house test facility**	Gurugram, Haryana	N/A	Pantnagar, Uttarakhand, and Faridabad, Haryana	Sanjan, Gujarat
8	**Predicted life**	7–9 years	5 years	6–8 years	7 years

2.5. MARKET CHARACTERISTICS IN INDIA

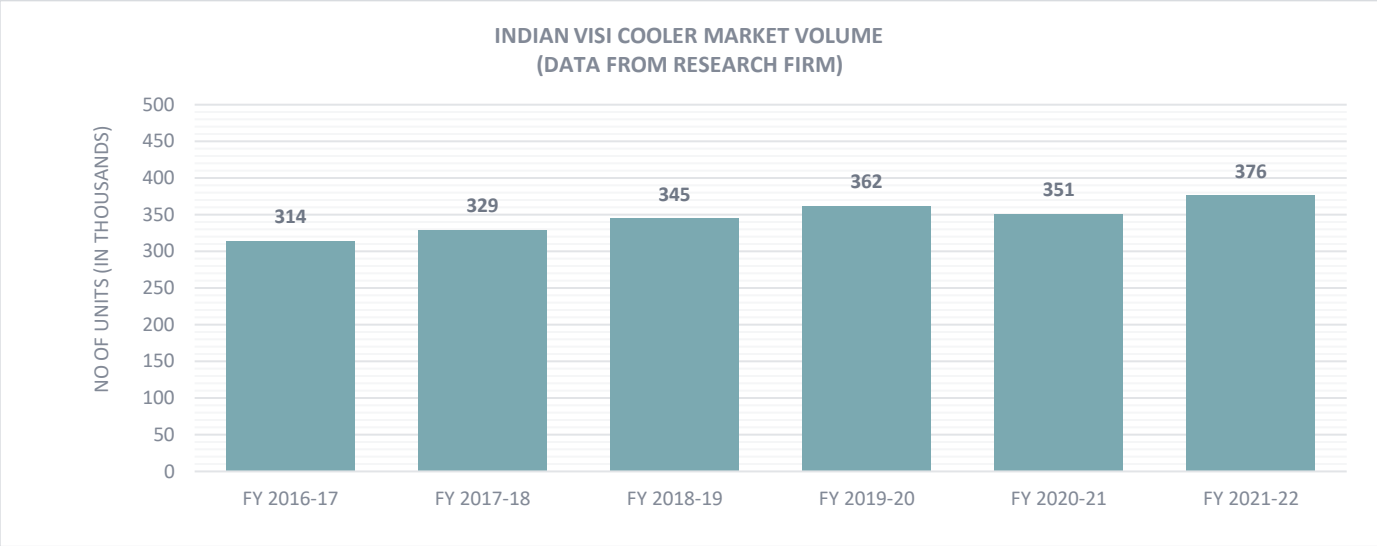
In this section, we present an extensive market evaluation that encompasses the total market volume for visi coolers in India, incorporating data obtained from a research firm.[6] The assessment is anchored in the year 2022 as the baseline and provides a forecast up to 2050.

[6] Industry ARC.

2.5.1 TOTAL SALE

The total visi cooler market volume in India was 0.31 million units in FY 2016–2017 and reached 0.37 million units by FY 2021–2022.

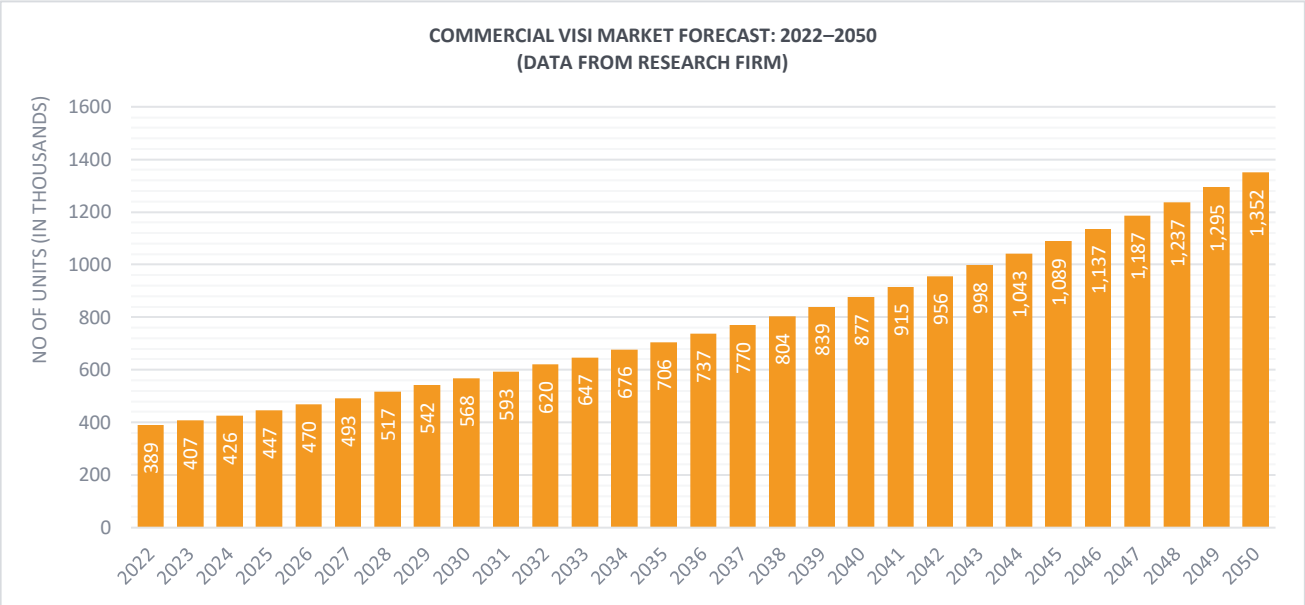
FIGURE 2: INDIAN VISI COOLER MARKET (VOLUME)



2.5.2 MARKET FORECAST TILL FY 2050

The volume of the Indian visi cooler market is expected to reach 0.56 million units by 2030 and 1.35 million units by 2050, with a projected CAGR of 4.23% in 2022–2030 and 4.43% in 2030–2050.

FIGURE 3: INDIAN VISI COOLER MARKET FORECAST: 2022–2050



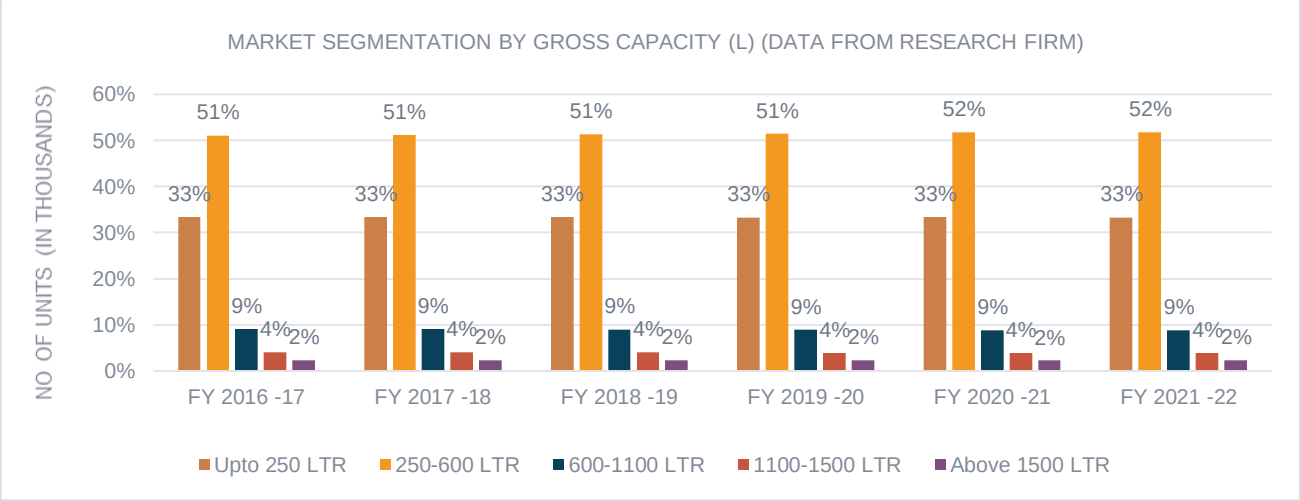
2.6. TYPE-WISE MARKET TREND

Visi coolers in the Indian market can be segmented based on various factors, such as their gross storage capacity, number of doors, and alignment (floor-standing or tabletop). Initially, we analyzed the market sales data provided by the independent research firm[7] to determine the percentage of sales in each category. Subsequently, we validated this data against the results obtained from the preliminary market survey to draw inferences from the findings.

2.7. MARKET BY GROSS CAPACITY

When segmented by gross capacity, the 250–600 L range was the most popular in FY 2016, accounting for around 0.16 million units or 51.11% of the total market volume. At the time, the segment including up to 250 L represented approximately 0.10 million units or 33.33% of the total market volume; the 600–1,100 L segment was around 0.03 million units or 9.14%; the 1,100–1,500 L segment was around 0.01 million units or 4.12%; and the above-1,500 L segment was approximately 0.007 million units or 2.38%. However, in FY 2021, the 250–600 L segment had increased its share to around 0.19 million units or 51.87% while the other segments remained relatively stable.

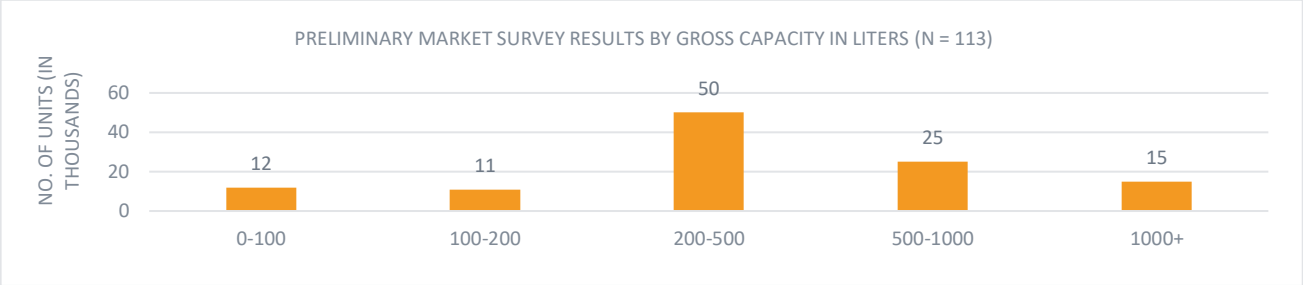
FIGURE 4: INDIAN VISI COOLER MARKET VOLUME BY GROSS CAPACITY



[7] Industry ARC.

The preliminary market survey and pan-India study show that a large portion of visi coolers in the market have a capacity of 200–500 liters. This confirms the market segmentation based on gross capacity, highlighting that the majority of available visi coolers fall within the 500-liter category.

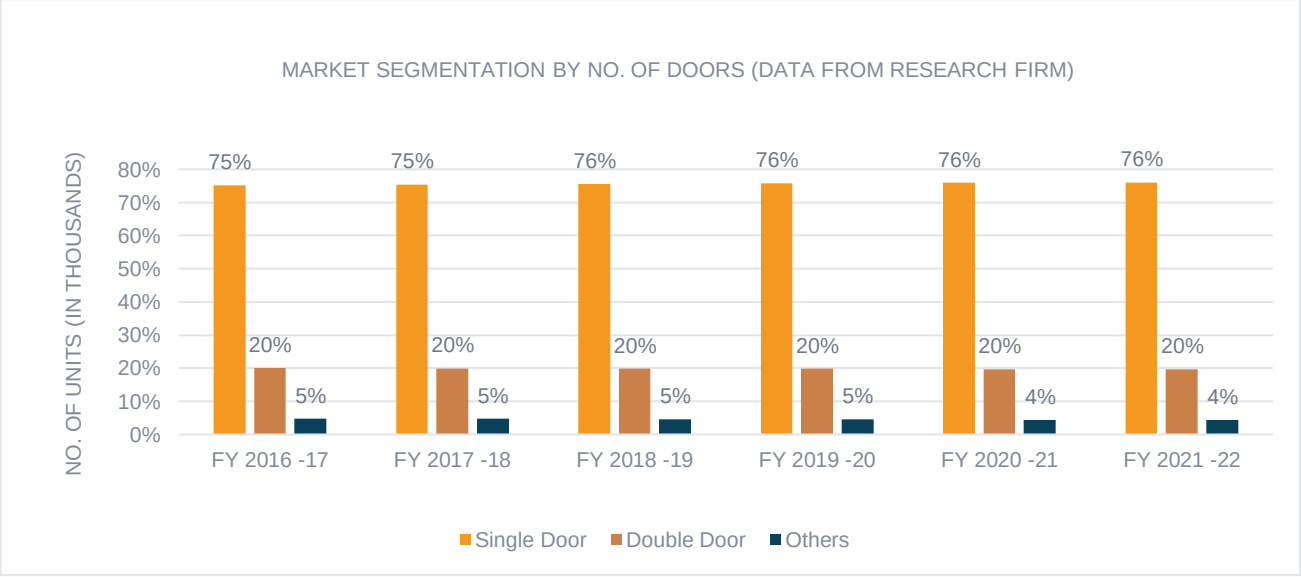
FIGURE 5: MARKET SURVEY RESULTS BY GROSS VOLUME IN LITERS



2.8. MARKET BY NUMBER OF DOORS

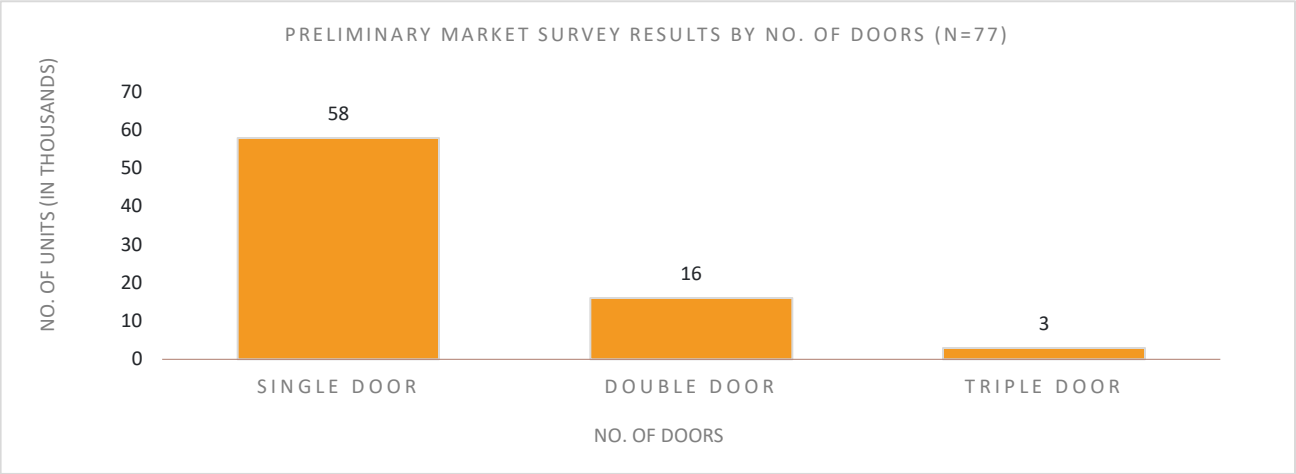
Segmentation by the number of doors shows that single-door visi coolers were the most popular, accounting for around 0.24 million units or 75.29% of the total market volume in both FY 2016 and FY 2021. Double-door visi coolers represented approximately 0.06 million units or 20.01% of the market in FY 2016 and increased to around 0.07 million units or 20.55% in FY 2021, while triple-door visi coolers accounted for less than 0.02 million units or 4.16% of the market volume in both years.

FIGURE 1: INDIAN VISI COOLER MARKET VOLUME BY NO. OF DOORS



The preliminary market survey also revealed that single-door visi coolers continue to be the most prevalent among the visi coolers surveyed, with 58 out of 77 models being single door. Among the remaining 19 units, 16 had double doors, while three featured triple doors. This data aligns with the market segmentation based on the number of doors presented in Figure 7.

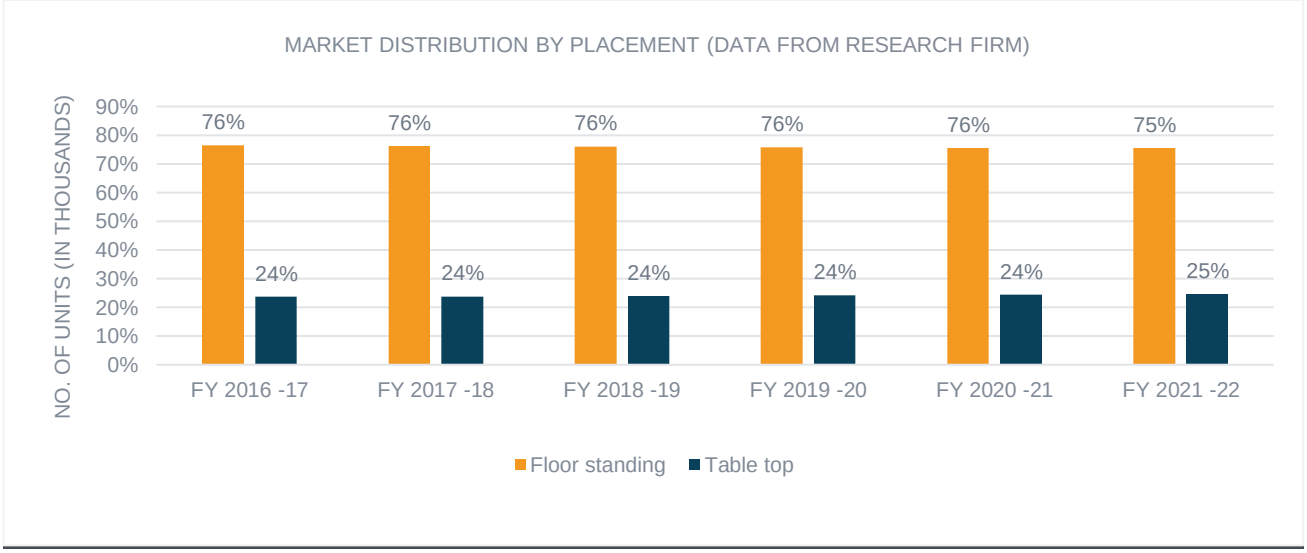
FIGURE 7: MARKET SURVEY RESULTS BY NO. OF DOORS



2.9. MARKET BY PLACEMENT

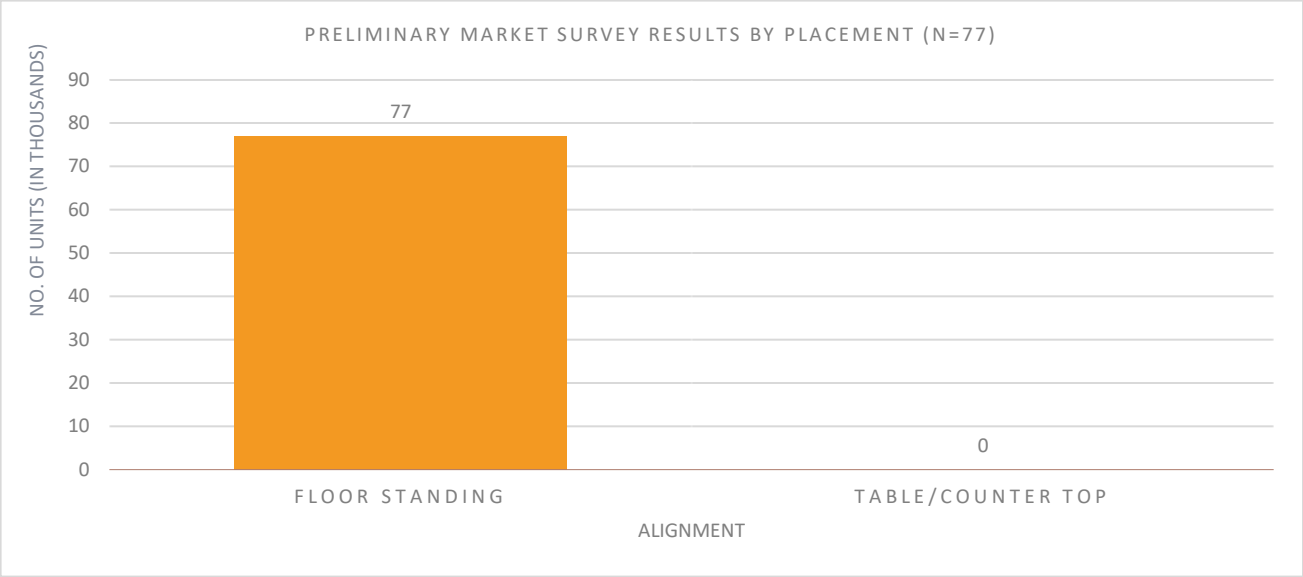
When segmented by placement, floor-standing visi coolers were more popular than tabletop visi coolers between FY 2016 and FY 2021, with floor-standing units representing approximately 0.24 million units or 76.06% of the total market volume in FY 2021.

FIGURE 8: INDIAN VISI COOLER MARKET VOLUME BY PLACEMENT



The preliminary market survey exercise also reveals that all visi coolers examined were floor-standing units. This information significantly correlates with the market segmentation data based on the placement, as we present in Figure 9.

FIGURE 9: MARKET SURVEY RESULTS BY PLACEMENT



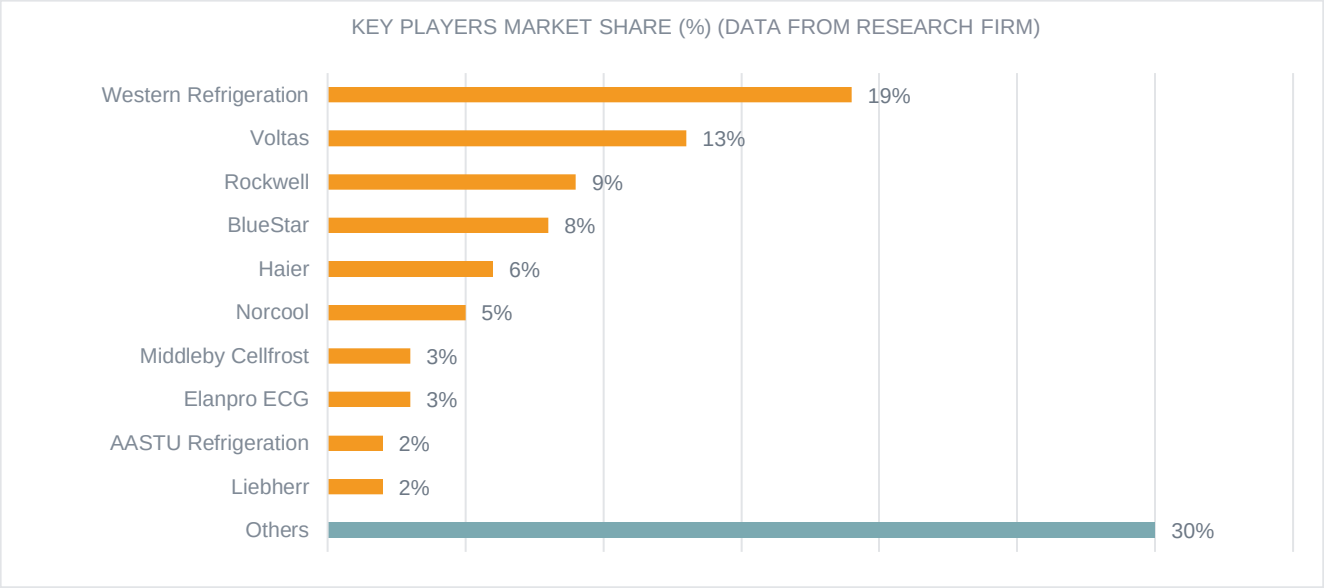
2.10. KEY PLAYERS

The key players in the commercial beverage cooler market in India are Voltas, Rockwell Industries, Bluestar, Haier, and Western Refrigeration Pvt. Ltd. Other companies collectively account for approximately 30% of the overall market share. We outline data from the independent research firm as follows:[8] Western Refrigeration Pvt. Ltd. holds the highest market share at 19%, Voltas follows closely with a share of 13%, while Rockwell and Blue Star hold 9% and 8% respectively. Other notable players in the market include Norcool with 5%, Haier with 6%, Middle by Celfrost and Elanpro ECG with 3% each, and AASTU Refrigeration and Liebherr with 2% each.

Moreover, based on the information provided by the independent research firm, it is interesting to examine each company's market share in different visi cooler segments. For instance, in the floor-standing segment, Western Refrigeration Pvt. Ltd. holds the highest market share at 22%, followed by Voltas at 17% and Bluestar at 11%. In the tabletop segment, Haier leads with a market share of 21%, followed by Elanpro at 16% and Blue Star at 13%. It is worth noting that these market shares may change over time as market dynamics and consumer preferences evolve.

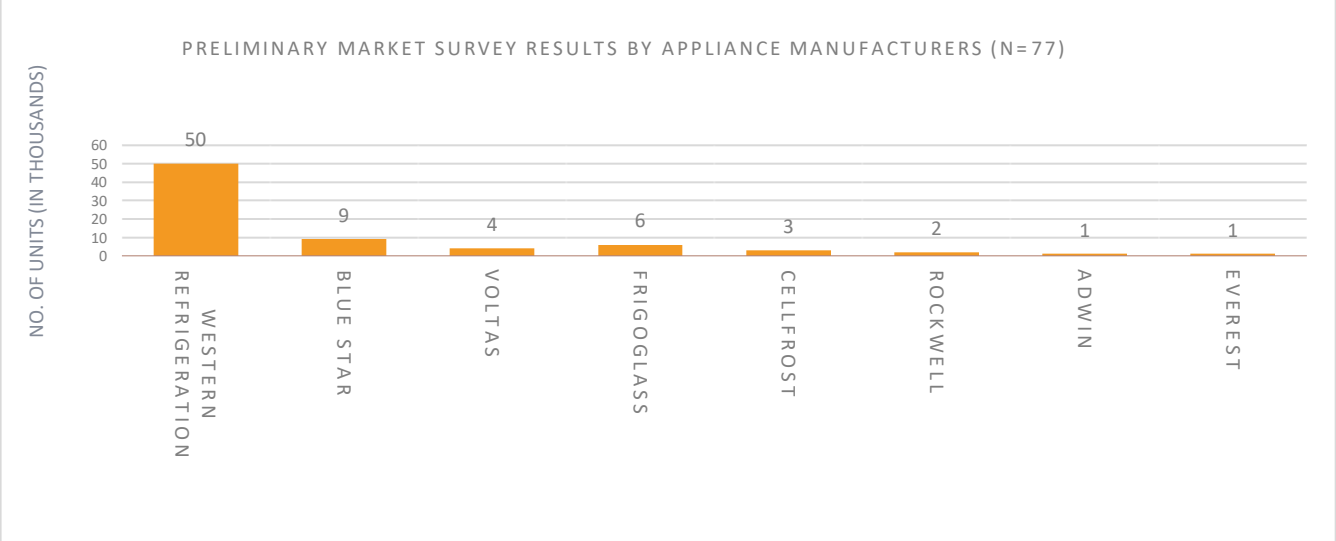
FIGURE 10: KEY PLAYERS IN THE INDIAN COMMERCIAL BEVERAGE COOLER MARKET

[8] Industry ARC.



The preliminary market survey provided implicit support to the findings about the market shares of the top industry players. Specifically, Figure 11 illustrates that out of the 76 visi cooler installations surveyed, 50 were produced by Western Refrigeration Pvt. Ltd., indicating that this brand has more extensive market usage than its competitors.

FIGURE 2: MARKET SURVEY RESULTS BY APPLIANCE MANUFACTURERS



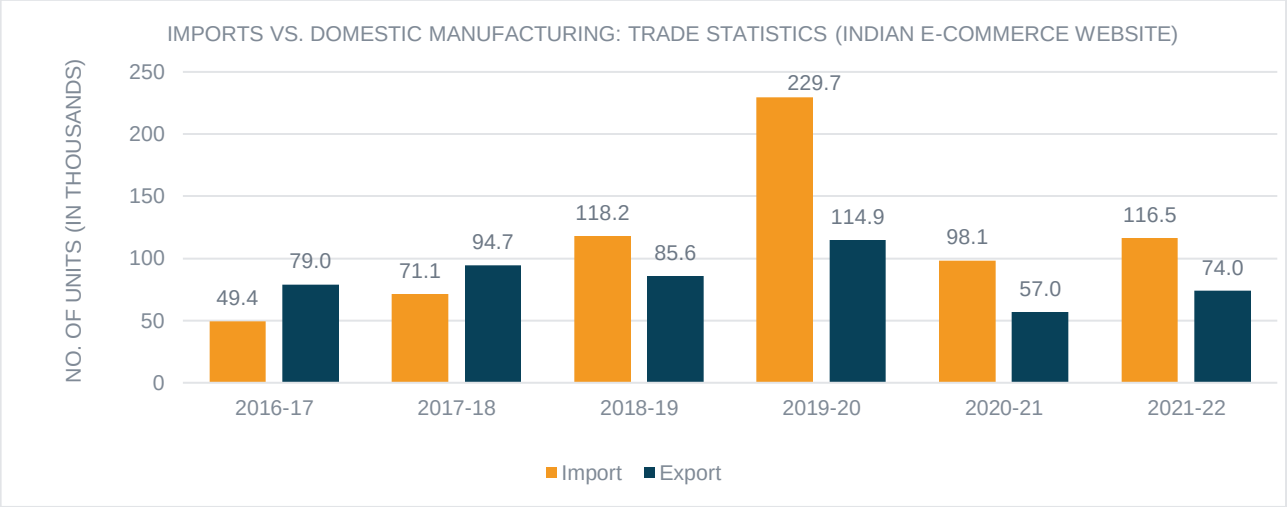
2.11. IMPORT AND EXPORT SCENARIO

India both imports and exports commercial beverage coolers, with a higher quantity of imports than exports. The primary countries from which India imports visi coolers include China, Thailand, and Malaysia.

Over the past decade, there has been an overall increase in both import and export numbers, but imports have grown at a faster rate, resulting in a widening gap between the two. The import and

export of visi coolers experienced significant growth until 2020, but since then, there has been a decline in both figures, likely due to the impact of COVID-19. However, these numbers are gradually recovering. In 2016–2017, exports amounted to 79,000, while imports reached 49,400. Approximately 30% of the total estimated sales for the period spanning 2021–2022 are of imported models.

FIGURE 12: IMPORT–EXPORT SCENARIO 2016–2021



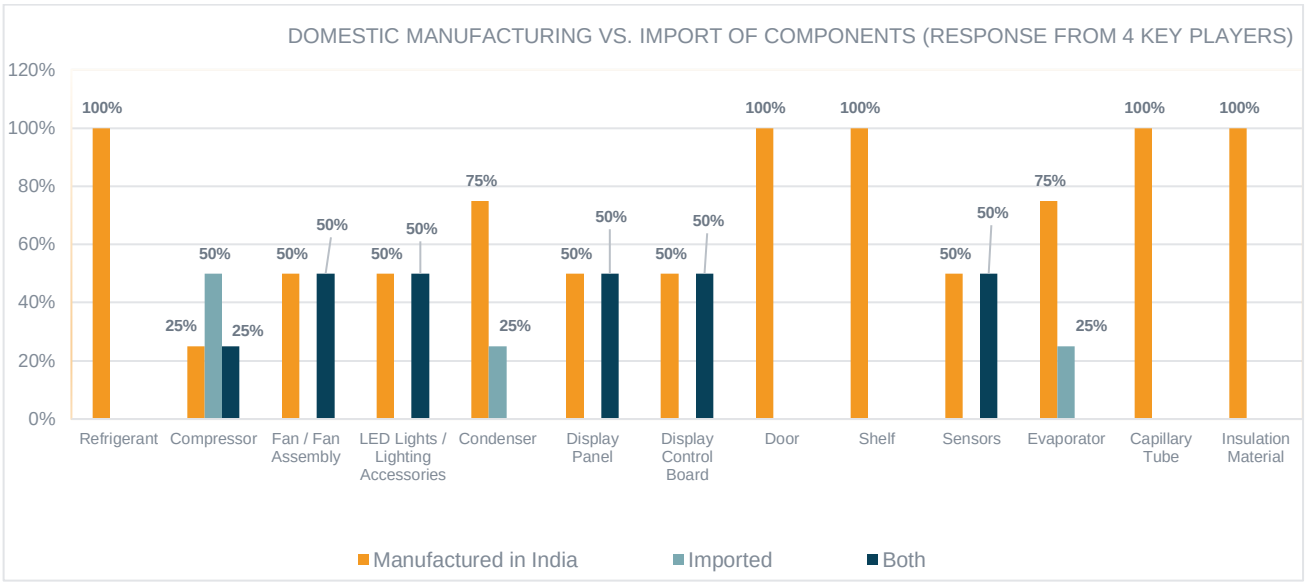
2.12. SUPPLY CHAIN ANALYSIS

In the supply-chain assessment, we comprehensively analyzed visi cooler components, including refrigerants, compressors, fans/assembly, lights, condensers, capillary tubes, insulation material, display panels, display control boards, doors, shelves, sensors, and evaporators.

We gathered responses from the four key players through a questionnaire. Our analysis focused on two primary categories: whether products were made in India or imported. A deeper level of scrutiny then determined the source of components for domestically manufactured visi coolers, distinguishing between in-house and outsourced procurement. This approach provided valuable insights into visi cooler industry supply-chain dynamics.

The graph in Figure 13 illustrates the proportion of domestically manufactured visi cooler components compared to imports in India. Our analysis indicates a strong domestic manufacturing presence for refrigerants, doors, shelves, capillary tubes, and insulation materials, while critical components are primarily imported to meet market demands. Fan assemblies and LED lights exhibit a balanced scenario, with 50% produced domestically and 50% imported. Conversely, India relies heavily on imports for components such as condensers, display panels and control boards, sensors, and evaporators.

FIGURE 13: DOMESTIC MANUFACTURING VS. IMPORT OF COMPONENTS



2.13. KEY TAKEAWAYS

Our secondary and primary research efforts allowed the project team to reach a number of conclusions about important aspects of the market that will help develop an evidence-based star rating table considering the Indian market conditions. We enumerate these in this section.

- A variety of visi coolers are available for sale and purchase in India. However, not all types available in the market are equal in demand or popularity.
- Notably, nearly 75% of manufacturers specialize in producing visi coolers with a capacity ranging 200–500 liters, with an average predicted service life of approximately 7 years.
- Visi coolers are widely used in different stores in India. The type of store influences the use of the cooler. For instance, dairy shops use them to keep milk and milk products cold, while small kiosks or grocery stores may turn them off when their products are already cool.[9]
- Some visi coolers have been on the market for more than 7 years. This indicates that they have a considerably long life; once sold and not require to be replaced for many years.

[9] Based on discussions with shopkeepers.

- Many visi coolers in the market have five or more shelves, which often leads to overloading with various foods and drinks, making the machine less efficient. Frequent opening and unloading also affect cooling and increase energy usage.
- The prevalence of single-door visi coolers can largely be attributed to the limited floor space available in most stores. For instance, stores with constrained floor space might choose a larger single-door unit to maximize vertical space and minimize the floor area used.
- We also highlight the dominant role of international suppliers, with a significant portion (30%) of parts being imported from China, South Korea, Thailand, and Slovakia. Furthermore, single-door models are prevalent among manufacturers, constituting almost 90% of production, while nearly 100% of respondents manufacture floor-standing vertical visi coolers.

3. Test Standards and Facilities

3.1. BIS – IS 2167:2019

In 1962, the BIS published specifications for bottle coolers, IS 2167, which they later revised in 1983 and 2019. This standard's scope specifies the general requirements for constructing and testing dry-type, self-contained, close-type bottle coolers powered by electrically driven vapor-compression refrigeration machines with air-cooled condensers. This standard only applies to bottle coolers that use air, not water, to cool. Manufacturers can certify products that meet this standard's requirements under the Bureau of Indian Standards Act, 2016 and its accompanying rules and regulations, and label them with the standard mark to inform consumers of their conformity to the prescribed standard.

The standard sets out guidelines for constructing bottle coolers, including their overall design, materials, thermal insulation, refrigeration system, electrical components, and more. It also outlines the calculation of various measurements, such as gross and net machine volume. The standard provides detailed procedures for several tests, such as:

- **Type tests:** Thermal insulation test, insulation resistance test, high-voltage test, no-load performance test, power consumption test, percentage running time test, capacity rating test, and maximum operating condition test
- **Production routine tests** (done after production is complete): Insulation resistance test, performance test, and high-voltage test

3.2. ISO 22044:2021

The BIS is currently revising IS 2167 in alignment with the ISO 22044 standard; its publication is scheduled for the end of 2023. Following the release of this standard, the BEE is set to adopt IS 2167:2023/ISO 22044:2021 for the star labeling program.

ISO 22044:2021 outlines the classification, requirements, and testing procedures for commercial beverage coolers. This standard is designed for integral refrigeration systems and does not apply to remote or secondary system cabinets. However, it details test procedures and requirements for the measurement of volume, performance, and energy consumption.

The standard specifies testing for dimensions, area, and volume, seals for doors and lids, durability, temperature, half-reload recovery (also covering energy consumption), water vapor condensation, calculation for specific energy consumption, lighting, and more. It also specifies various test requirements, including the test room setup, product types and classification, material and construction, capacity, performance, and energy consumption, as follows:

3.2.1. MACHINE TYPES

- **Vertical commercial beverage coolers:** These are beverage coolers with an overall height ranging 0.5–2.2 m.
- **Semi-vertical commercial beverage coolers:** These are vertical beverage coolers, with an overall height of no more than 1.5 m, that feature a vertical or inclined display opening.
- **Horizontal commercial beverage coolers:** These are beverage coolers with a horizontal display opening accessible from above.
- **Open commercial beverage coolers:** These can be horizontal, vertical, or semi-vertical, with no barriers to accessing the displayed products. Night covers are not considered barriers to access.
- **Closed commercial beverage coolers:** These are horizontal, vertical, or semi-vertical beverage coolers that require opening a door or lid (transparent or solid) to access the displayed product.

3.2.2. MACHINE CLASSIFICATION

- **Classification according to temperature:** All beverage coolers must comply with one of the temperature classifications defined in the standard, which mentions five temperature classes: K1, K2, K3, K4, and a special classification called ‘S’.
- **Classification according to test room climate class:** The standard recognizes three climate classes (CC) – CC1, CC2, and CC3. Each classification has a different temperature and humidity requirement.

3.2.3. MATERIAL AND CONSTRUCTION

- **Construction:** All beverage coolers must meet the standard for strength and rigidity in their pipes and connections, condensate drainage, and joints and seams.
- **Material:** This section mentions the required wear resistance, corrosion resistance, and other similar aspects.
- **Insulation:** This section specifies standards for the efficiency of thermal insulation, vapor barrier, and containment and insulation of the material.
- **Refrigerating system:** The standard prescribes the design and construction of all parts of the system, condensation, system protection, and the refrigerant used.
- **Electrical safety:** The standard prescribes compliance as per IEC 60335-2-89.

3.2.4. PERFORMANCE AND ENERGY EFFICIENCY

- **Dimensions and volume:** The test requires an assessment of dimensions and net, gross, and equivalent volume.
- **Seal test for doors and lids:** This test measures the effectiveness of doors and lids in maintaining a seal.
- **Absence of odor and taste test:** This test is voluntary. The standard describes the method for conducting this test, including the ambient temperature and the cleaning, thermostat settings, sampling, and test period requirements.
- **Durability of door and lid test:** This test aims to check the durability of the hinges and handles of doors or lids.
- **Temperature test:** This is a 24-hour test with the lighting on and the night cover of the beverage cooler open to find how well the products are cooled. It notes the warmest, the coldest, and the average temperature of the products in the visi cooler.
- **Water vapor condensation test:** This test is meant to understand how well the visi cooler manages water vapor and condensation. The test results are considered satisfactory if there is no evidence of condensed water vapor having been in direct contact with or dripped onto any test M-cans, among other requirements. The standard also requires mention of fog, droplets, or running water that may develop on external surface areas during the test period.
- **Energy consumption test:** The standard provides separate testing methods for machines that are fitted with an energy management device (EMD) and those that are not. These tests are prescribed to be conducted only at CC1 and no other class.
- **Half-reload recovery test:** This test measures the capability of the beverage cooler to lower all product temperatures to the desired temperature within a specified time after half the products are removed and the cooler is reloaded with products at ambient temperature.

3.2.5. PERFORMANCE AND ENERGY RATING

The standard also specifies standard rating conditions and instructions for calculating both the total and specific energy consumption for beverage coolers as follows:

Total energy consumption during 24 h (kWh/24h) is **TEC = Energy consumption during light ON (12 h) + energy consumption during light OFF (12 h)**.

Equivalent volume (V_{eq}) is $\mathbf{V_{eq}}$ **= Gross volume x (25-** $\mathbf{\mathit{Tc}}$**)/20 x** $\mathbf{\mathit{Cc}}$.

Tc is the average compartment classification temperature: +3.5°C for K1 beverage coolers; +2.5°C for K2 beverage coolers; –1.0°C for K3 beverage coolers; and +5.0°C for K4 beverage coolers.

The temperature class details for K1, K2, K3, and K4 are specified in Table 2 of ISO 22044:2021.

TABLE 2: TEMPERATURE CLASS FOR K1, K2, K3, AND K4

S. No.	Class	Highest Temperature [°C]	Lowest Temperature [°C]	Average Temperature [°C]
1	K1	7	0	3.5
2	K2	6	–1.0	2.5
3	K3	1	–3.5	–1
4	K4	9	1	5

Cc is the climate class factor: 1 for CC1; 1.05 for CC2; and 1.1 for CC3.

Specific energy consumption (SEC) is $SEC = TEC/V_{eq}$.

3.3. CODE OF FEDERAL REGULATION: 10 CFR IN THE UNITED STATES

In the United States, Title 10 (Energy), subchapter D (Energy Conservation), part 431 (Energy Efficiency Program for Certain Commercial and Industrial Equipment), subpart C of the Code of Federal Regulations (CFR)[10] governs commercial refrigerators, freezers, and refrigerator-freezers. This section includes energy conservation mandates for these types of commercial equipment.

The definition of commercial refrigerators includes refrigeration machines that satisfy the following criteria:

- exclusion from classification as a consumer product under part 430
- absence of exclusive design and marketing for medical, scientific, or research purposes
- operation at chilled, frozen, combination chilled and frozen, or variable temperatures

[10] Energy Star Program | USAGov

- utilization for horizontal, semi-vertical, or vertical display or storage of perishable materials
- incorporation of transparent or solid doors, with options for sliding or hinged doors or no doors
- intended functionality for either pull-down temperature applications or maintaining temperature

3.3.1. TEST REQUIREMENTS

This regulation establishes the criteria for determining whether a commercial beverage cooler is eligible for the 'Energy Star' label and provides guidelines for testing procedures to determine the daily energy consumption in kWh/day for different categories and sizes of commercial refrigerators, freezers, and refrigerator-freezers in accordance with the Energy Policy Conservation Act. The testing involves conducting appropriate test procedures outlined in various subpart appendices and calculating each covered product's daily energy consumption based on raw measured values. The final results of the test are to be reported in increments of 0.01 kWh/day.

3.3.2. TEST PROCEDURE

The regulation requires that the daily energy consumption of each type of commercial refrigerator must be tested using the test procedure outlined in the AHRI Standard 1200 (I-P)-2010.

3.3.3. TEST CONDITIONS

The code outlines the methods for assessing the doors' transparency and describes relevant procedures for measuring the energy usage of the commercial beverage cooler.

TABLE 3: TEST CONDITIONS AS PER THE CODE OF FEDERAL REGULATION

S. No.	Category	Integrated Average Temperature
1	Refrigerator with transparent door(s)	38 °F (±2 °F)
2	Commercial refrigerator with a self-contained condensing unit designed for pull-down temperature applications and with transparent doors	38 °F (±2 °F)
3	Commercial refrigerator, freezer, and refrigerator-freezer with a self-contained	0 °F (±2 °F) for low-temperature applications

	condensing unit and without doors	38 °F (±2 °F) for medium-temperature applications
4	**Commercial refrigerator, freezer, and refrigerator-freezer with a remote condensing unit**	0 °F (±2 °F) for low-temperature applications 38 °F (±2 °F) for medium-temperature applications

The lowest application product temperature (LAPT), which is the lowest temperature setting on the thermostat for units equipped with one, is used for testing. For remote condensing equipment without a thermostat or temperature control, the LAPT is achieved by setting the dew point temperature (as defined in AHRI Standard 1200 (I-P)-2010) to 5°F below the manufacturer's LAPT.

3.3.4. VOLUME AND TOTAL DISPLAY AREA

The volume is determined using the method set forth in HRF-1-2008. To calculate the total display area (TDA) of the commercial refrigeration equipment (CRE) model, the AHRI Standard 1200-2006 is to be followed, excluding Appendix D's requirement for transparent material. The visible product's projected areas that are viewable from a perpendicular angle to the transparent area are added using square feet. The interior length (L) of the CRE model is determined by measuring the transparent area's length. If the non-transparent area is ≤ 5 inches, the interior length is the measured length. If it is > 5 inches, 5 inches are added to the visible product's linear dimension(s) for the interior measurement.

3.4. OEM STANDARD

While the OEM standard is similar to the ISO standard in many ways, there are some differences. The primary difference is that the OEM standard considers the preference for PET bottles over M-cans in India. Therefore, beverage cooling tests are conducted on 500 ml PET bottles rather than the M-cans used for the ISO standard. M-cans are reference cans with dimensions of 115 mm (H) x 66 mm (diameter) that contain 330 milliliters of a mix of 33% propylene glycol and water by weight and are used to simulate popular canned beverages in other regions.

The following is a brief description of the OEM standard used in India:

- **Half-reload pull-down test:** Half the cooled contents of a fully loaded commercial beverage cooler are removed and the machine is loaded with room-temperature items. The tests measure the time taken for the newly loaded items to reach the desired temperature. The 'pull-down' is the time required to bring down (or pull down) the temperature of items being tested to the desired temperature.

- **Target temperature:** The temperature targeted for the items being cooled is required to be in the 0.0–7.2°C range for the test to be successful.
- **Target time:** The maximum time by which the target temperature must be achieved is ≤ 17 h for single-door visi coolers and ≤ 19 h for double-door visi coolers.
- **Condensation test:** For a commercial beverage cooler to successfully pass the condensation test, there must be < 5% condensation on the glass.
- **Thermal overload allowed:** A thermal overload relay is an electrical protection mechanism that disconnects a machine, appliance, or installation from its power source in the event of damage or overload. The OEM test allows a thermal overload of 1.
- **Condenser blockage test:** Condensers cool hot, vaporized refrigerant into its liquid form. Blocked condensers have a reduced capacity to condense the refrigerant. This test checks for functionality at 50% blockage. At 50% condenser blockage, a compressor should not trip, and the product temperature should be within the specified target temperature range (0.0–7.2°C).
- **Evaporators freeze-up test:** Evaporators remove heat and moisture from the air passing over them. In case low cooling temperatures are required, they can sometimes freeze. The test checks for this under prescribed conditions, which are:
  - Door opening: 90°C
  - Duration: 6 seconds
  - Openings: 6/h
  - Total duration: 8 h
  - Requirement: The temperature should be within the target temperature range (0.0–7.2°C)

The key differences and similarities between the OEM and ISO 22044:2021 standards are summarized in Table 4.

TABLE 4: DIFFERENCES AND SIMILARITIES BETWEEN THE OEM AND ISO 22044:2021 STANDARDS

S. No.	Test	OEM Standard	ISO 22044:2021
1	**Half reload**	41°C ambient; 75% RH	40.6°C DBT; 75% RH Max half-reload recovery time: ≤ 20 h
2	**Target temperature**	0.0–7.2°C; tested on 500 ml PET bottles	0.0–7.0°C; tested on M-cans
3	**Target time**	Single-door model: ≤ 17 h Double-door model: ≤ 19 h	Vertical, semi-vertical, and horizontal: ≤ 20 h
4	**Condensation test**	Condensation on the glass < 5%	Can be free from moisture; glass condensation should not run
5	**Thermal overload allowed**	1	N/A
6	**Condenser blockage test**	At 50% condenser blockage, the compressor should not trip, and the product temperature should be within the specified range (0–7.2°C)	N/A
7	**Evaporator freeze-up test**	Door opening: 90°C Duration: 6 seconds, 6 openings/h Total duration: 8 h Requirement: The temperature should be within 0–7.2°C	N/A
8	**Energy consumption test**	N/A	25°C DBT; 60% RH Maximum half-reload recovery time: ≤ 13 h
9	**Door seal test**	N/A	Insert a strip of paper 50 mm wide and 0.08 mm thick of a suitable length into the closed door; it should not slide freely

S. No.	Test	OEM Standard	ISO 22044:2021
10	**Door durability test**	N/A	Open and close doors 25 times a minute for a minimum of 100,000 cycles without any deterioration that could be prejudicial to the airtightness of the door

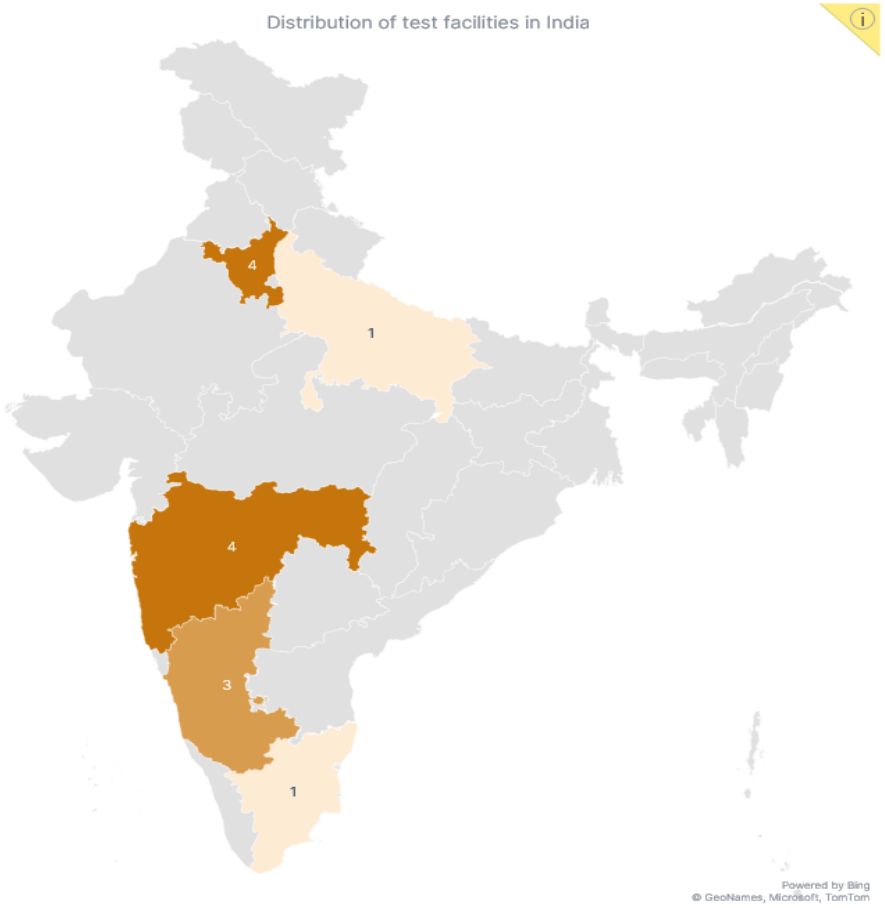
3.5. TEST FACILITIES

Ten third-party test facilities in India, as listed in Table 5, claim to have the capability to test the energy consumption of visi coolers. Currently, discussions are underway with these facilities to establish the requirements for testing commercial beverage coolers for energy consumption according to ISO 22044:2021.

TABLE 5: THIRD-PARTY TEST FACILITIES

S. No.	Laboratory Name	Location
1	Bharat Test House	Haryana
2	Central Electrical Testing Laboratory (CETL)	Tamil Nadu
3	Central Power Research Institute (CPRI)	Karnataka
4	Classic Calibration & Testing Laboratories	Uttar Pradesh
5	Intertek	Maharashtra
6	Electrical Research And Development Association (ERDA)	Maharashtra
7	Institute For Testing & Certification (QVC Certification Services)	Haryana
8	Institute For Testing & Certification (Zenith Quality Assessors)	Maharashtra
9	Institute of Testing & Certification India Pvt. Ltd.	Maharashtra
10	UL	Haryana

FIGURE 14: TEST FACILITIES AVAILABLE IN INDIA



4. International Labeling Programs

4.1. ENERGY STAR IN THE UNITED STATES

4.1.1. SCOPE

- Product types that are eligible for certification include convertible temperature equipment, reach-in, roll-in, or pass-through units; merchandisers; under-counters; worktops; hybrid units; milk coolers; back bar coolers; bottle coolers; deep well units; beer-dispensing or direct draw units; and bunker freezers.

4.1.2. OVERVIEW

- ENERGY STAR® is the government-backed symbol for energy efficiency. The blue ENERGY STAR label provides simple, credible, and unbiased information that consumers and businesses rely on to make well-informed decisions. It is administered by the US Environmental Protection Agency.[11]

- Commercial refrigerators and freezers that carry the ENERGY STAR label are, on average, 20% more energy-efficient than regular models.[12] [13] This increased efficiency is due to their incorporation of features such as ECM evaporators and condenser fan motors, effective hot gas anti-sweat heaters, and high-efficiency compressors. These enhancements play a significant role in decreasing energy consumption and subsequently cutting down utility expenses.

4.1.3. ELIGIBILITY CRITERIA

To be eligible for ENERGY STAR certification, the products must:

- meet the definitions of a commercial refrigerator, freezer and refrigerator-freezer, commercial hybrid, or convertible temperature equipment
- fall under the eligible equipment class designations or a combination of equipment classes mentioned in the program
- be commercial-grade and third-party certified to the applicable requirements set forth in the following quality and safety standards:

  (1) ANSI/NSF International Standard for Food Equipment – Commercial Refrigerators and Freezers (ANSI/NSF 7-2019).

[11] Energy Star Program | USAGov
[12] "Commercial Refrigerators & Freezers"
[13] "UL 471"

(2) UL Standard for Commercial Refrigerators and Freezers (UL-471) and/or (UL/CAS 60335-2-89).

4.1.4. TEST STANDARD

UL/CSA 60335-2-89 may be used to satisfy the UL-471 requirement for ENERGY STAR certification. The UL Standard for Safety Commercial Refrigerators and Freezers (UL-471) covers commercial refrigerators and freezers intended for connection to alternating-current circuits rated not greater than 600 volts.[14] These requirements do not apply to refrigeration systems that are fabricated in the field, such as those used in cold storage rooms, walk-in coolers, and similar places. Requirements for the installation of commercial refrigerators and freezers are included in the National Electrical Code, ANSI/NFPA 70, and the Safety Standard for Refrigeration Systems, ASHRAE.[15]

4.1.5. EVALUATION

The program for commercial refrigerators and freezers endorses products that meet its daily energy consumption (DEC), refrigerated volume (V), and total display area (TDA) requirements as per the Code of Federal Regulations, as described in 10 CFR Part 431, subpart C, Appendix B.[15] As of 22 December 2022, all commercial refrigerator and freezer products need to be certified to Version 5.0. of ENERGY STAR® program requirements.

The refrigerated volume (V) and the total display area (TDA) of a refrigerator or freezer are calculated in accordance with the DOE test procedure at 10 CFR Part 431, Subpart C, Appendix B. The maximum daily energy consumption (MDEC) of hybrid equipment is the sum of all individual compartment MDEC values.

For example,[16] consider a vertical closed refrigerator with a total volume of 50 cubic feet (cu. ft.), with one 25 cu. ft. compartment having a transparent door and the other 25 cu. ft. compartment having a solid door. The MDEC of the equipment would be the sum of the MDEC for the two compartments. The requirement used to calculate the MDEC for each compartment is based on the compartment's volume and door type:

- Transparent door MDEC: (25 cu. ft. X 0.05) + 1.12 = 2.37 kWh/day
- Solid door MDEC: (25 cu. ft. X 0.05) + 0.45 = 1.70 kWh/day
- MDEC for entire cabinet: 2.37 kWh/day + 1.70 kWh/day = 4.07 kWh/day

[14] "UL 471"
[15] Commercial Refrigerators and Freezers Specification Version 5.0.
[16] ENERGY STAR® Program Requirements for Commercial Refrigerators and Freezers.

FIGURE 15: THE ENERGY STAR CERTIFICATION LABEL[17]

4.2. EUROPEAN ECO-DESIGN AND ENERGY LABELING REGULATION

The European Union (EU) has comprehensive eco-design and labeling programs for various appliances, including commercial beverage coolers. Both regulations are described in this section.

4.2.1. EUROPEAN ECO-DESIGN: COMMISSION REGULATION (EU) 2019/2024

Scope and Definition

This regulation establishes eco-design requirements for electric refrigeration devices that are connected to the main power supply. This includes appliances intended for refrigerating items beyond just food products. It was enforced in October 2019.

This regulation describes a 'beverage cooler' as a fridge-like machine meant for quickly cooling packaged drinks (excluding wine) that start at room temperature and are sold at temperatures lower than room temperature. Beverages may be accessed through open sides, doors, drawers, or a mix of these. To save energy, the cooler's temperature might go up when not in use, since drinks do not spoil easily.

[17] ENERGY STAR Brand Book | ENERGY STAR

Parameters

The regulation uses the Energy Efficiency Index (EEI) as the parameter to regulate energy consumption. EEI is defined as an index number for the relative energy efficiency of a refrigeration appliance with a direct sales function expressed in percentage, calculated in accordance with the formulae and methodologies prescribed in the regulation.

From 1 March 2021, the maximum EEI for refrigerating appliances with a direct sales function, expressed as a percentage for all appliances other than ice-cream freezers, is 100. Since 1 September 2023, the maximum EEI of refrigerating appliances with a direct sales function – except for refrigerated drum vending machines and ice-cream freezers – expressed as a percentage has been 80.

Determination of EEI

- For all refrigerating appliances with a direct sales function, the EEI, expressed as a percentage and rounded to the first decimal place, is the ratio of the annual energy (AE) consumption (in kWh/a) and the reference standard annual energy consumption (SAE) (in kWh/a):

$$EEI = AE/SAE$$

- The AE, expressed in kWh/a, and rounded to two decimal places, is calculated as follows:

$$AE = 365 \times E_{daily}$$

- E_{daily} is the energy consumption of the refrigerating appliance with a direct sales function over 24 h, expressed in kWh/24h and rounded to three decimal places.

- The SAE is expressed in kWh/a and rounded to two decimal places. For refrigerating appliances with a direct sales function with all compartments having the same temperature class and for refrigerated vending machines, the SAE is calculated as follows:

$$SAE = 365 \times P \times (M + N \times Y) \times Cc$$

- For refrigerating appliances with a direct sales function with more than one compartment having different temperature classes, with the exception of refrigerated vending machines, the SAE is calculated as follows:

$$SAE = 365 \times P \times \sum_{c=1}^{n} (M + N \times Yc) \times Cc$$

where

- P is the daily energy consumption (kWh/day).

- *Cc* is the index number for a compartment type ranging from 1 to *n*, with *n* being the total number of compartment types. For beverage coolers, this value is 1.
- *M* and *N* are cabinet constants and values for beverage coolers are 2.1 and 0.006, respectively.
- Y, *Yc* is the equivalent volume of the compartments of the beverage cooler.

Coefficient Y_c

Y_c is the equivalent volume of the compartments of the beverage cooler with target temperature T_c and $V_{eq\,c}$; it is calculated as:

$$Y_c = V_{eq\,c} = \text{gross volume c} \times ((25 - T_c)/20) \times Cc$$

where T_c is the average compartment temperature and CC is the climate class factor. The values for T_c and Cc are presented in Tables 6 and 7.

TABLE 6: TEMPERATURE CLASSES AND AVERAGE COMPARTMENT TEMPERATURES (T_c)

S. No.	Temperature Class (*)	Tc (°C)
1	**K1**	+3.5
2	**K2**	+2.5
3	**K3**	−1.0
4	**K4**	+5.0

TABLE 7: EUROPEAN COMMISSION REGULATION: OPERATING CONDITIONS AND C_c VALUES

S. No.	Warmest Ambient Temperature (°C)	Ambient Relative Humidity (%)	C_c
1	+25	60	1.00
2	+32	65	1.05
3	+40	75	1.10

TABLE 8: EUROPEAN COMMISSION REGULATION: VERIFICATION TOLERANCES

S. No.	Parameters	Verification Tolerances
1	**Net volume and net compartment volume where applicable**	The determined value () shall not be more than 3% or 1 L lower – whichever is the greater value than the declared value.

S. No.	Parameters	Verification Tolerances
2	**Gross volume and gross compartment volume where applicable**	The determined value () shall not be more than 3% or 1 L lower – whichever is the greater value than the declared value
3	**TDA and compartment TDA where applicable**	The determined value () shall not be more than 3% than the declared value
4	**E_{daily}**	The determined value () shall not be more than 10% higher than the declared value
5	**AE**	The determined value () shall not be more than 10% higher than the declared value
6	**In the case of three additional units tested as prescribed in point 4, the determined value means the arithmetical mean of the values determined for these three additional units.**	

EEI for the Best Available Technology

At the time that this regulation was put into force, the best available technology on the market for beverage cooler EEI was identified as presented in Table 9.

TABLE 9: European Commission Regulation: EEI for the Best Available Technology

	TDA (m2), Net Volume (L) or Gross Volume (L) as Applicable	AE (kWh/a)
Beverage cooler	506	475 (= 1.3 kWh/24h)

4.2.2. EUROPEAN ENERGY LABEL: COMMISSION REGULATION (EU) 2019/2018

Scope and Definition

This regulation sets labeling requirements and additional product information guidelines for electric refrigerating appliances that run on main power and are used to sell items directly to consumers. It covers appliances used for cooling items other than just food. In this context, 'foodstuffs' refers to food, ingredients, beverages (including wine), and other items meant for consumption that need specific refrigeration temperatures. The regulation was implemented in March 2019.

It defines 'beverage coolers' as refrigerating appliances with a direct sales purpose. They rapidly cool non-perishable beverages (excluding wine) from room temperature to a

temperature below room temperature, allowing access through open sides, doors, or drawers. The cooler's temperature may increase when not in use to save energy, considering that beverages do not spoil easily.

NOTE: The steps to calculate EEI and eligibility criteria use the same process outlined in the European eco-design regulation, Commission Regulation (EU) 2019/2024, dated 1 October 2019. The only addition is in the star labeling, whose criteria we provide in Table 10.

TABLE 10: Energy Efficiency Classes of Refrigerating Appliances

Energy Efficiency Class	EEI
A	EEI < 10
B	10 ≤ EEI < 20
C	20 ≤ EEI < 35
D	35 ≤ EEI < 50
E	50 ≤ EEI < 65
F	65 ≤ EEI < 80
G	EEI ≥ 80

FIGURE 16: EU ENERGY LABEL FOR COMMERCIAL BEVERAGE Coolers

(I) QR code

(II) Supplier's name or trademark

(III) Supplier's model identifier

(IV) Scale of energy efficiency classes from A to G

(V) The energy efficiency class

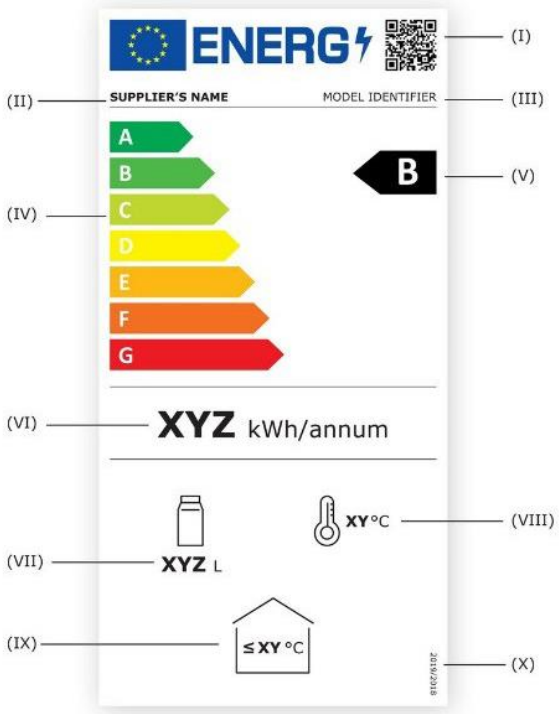
(VI) AE in kWh per year and rounded to the nearest integer

(VII) The sum of the gross volumes of all compartments, expressed in liters (L) and rounded to the nearest integer

(VIII) The highest average compartment temperature of all compartments with chilled operating temperatures (°C)

(IX) The warmest ambient temperature (°C)

(X) The number of this regulation: 2019/2018



5. Technical Assessment and Potential Star Rating Table

5.1. TECHNICAL ASSESSMENT

In this chapter, we discuss the methodology adopted to define the star labeling criteria and assess the potential star band options. Due to the absence of market data regarding the energy consumption of visi cooler models, which forms the foundation for creating the star rating table, we acquired a total of ten samples from five different brands and subjected them to testing in accordance with the ISO 22044 procedure. These models included a wide range of dynamic gross volumes, refrigerants, and costs, effectively representing the majority of models available in the market. All the models underwent testing at CC2 (32.2°C), which better mirrors Indian conditions. Additionally, two of the samples were subjected to testing at CC1 (25°C) to observe variations in TEC results. Notably, due to the unavailability of testing facilities that conduct samples in horizontal airflow, all the samples were tested with vertical airflow. Nevertheless, one sample was tested using horizontal airflow to gain insights into the dynamics of TEC results.

5.1.1. TESTING OF COMMERCIAL BEVERAGE COOLER SAMPLES

The technical analysis involved testing a representative sample of commercial beverage coolers for their energy consumption. We chose the sample size of ten units after consultation with the industry, CEAMA, and the CLASP team and numbered them from 1 to 10. These samples were selected based on their popularity, market demand, availability, and market representativeness. The list of models and their specifications can be found in Annexure 1.

5.1.2. TEST CONDITIONS

The energy consumption testing was conducted at a third-party test facility as per the test conditions and procedure outlined in ISO 22044.

NOTE: The proposal for a star labeling program for commercial beverage coolers is in accordance with ISO 22044:2021 because the existing IS 2167:2019 guideline does not meet the necessary testing methods for creating the star labeling program. The BIS will introduce a revised edition of IS 2167:2019, which directly adopts ISO 22044; this will be the reference standard for the BEE's star labeling program in the future.

5.1.3. ASSESSMENT OF AEC

We measured the total energy consumption and equivalent volume for each commercial beverage cooler model with the following formula:

$$\text{AEC (kWh/year)} = \text{TEC (kWh/24h)} \times 365 \text{ days}$$

$$\text{Equivalent volume } (V_{eq}) = \text{Measured gross volume} \times (25\text{-}Tc)/20 \times Cc$$

where

- *Tc* is the average compartment classification temperature (+5.0°C for K4 beverage coolers)

- *Cc* is the climate class factor (1.05 for CC2 (32.2°C/ 65% RH) beverage coolers)

The test results for the ten models are tabulated in Table 11.

TABLE 11: TEST RESULTS FOR THE SAMPLE MODELS

Sample #	Nameplate Gross Volume (L)	Measured Gross Volume (L)	No. of Doors	Refrigerant	TEC (kWh/24h)	Estimated AEC (kWh)	Calculated Equivalent Volume (L)	Specific Energy Consumption (kWh/24h * m3)
3	220	188.3	1	R-134a	3.44	1,255.60	212.54	16.19
4	358	309.4	1	R-134a	2.97	1,084.10	349.23	8.51
2	340	322.1	1	R-290	3.17	1,157.10	363.57	8.71
1	425	389.7	1	R-134a	5.03	1,835.90	439.87	11.44
5	570	540.5	1	R-290	4.46	1,627.90	610.09	7.31
6	530^	565.9	2	R-290	5.16	1,883.40	638.76	8.08
6*	530^	565.9	2	R-290	4.16	1,518.40	608.34	6.84
8	700	600.3	1	R-134a	6.04	2,204.60	677.59	8.91
7	807	737.4	2	R-290	5.58	2,036.70	832.34	6.71
7*	807	737.4	2	R-290	4.58	1,671.70	792.71	6.21
7**	807	737.4	2	R-290	5.34	1,949.10	832.34	6.42

Sample #	Nameplate Gross Volume (L)	Measured Gross Volume (L)	No. of Doors	Refrigerant	TEC (kWh/24h)	Estimated AEC (kWh)	Calculated Equivalent Volume (L)	Specific Energy Consumption (kWh/24h * m3)
10	905	835.2	2	R-290	5.74	2,095.10	942.70	6.09
9	947	862	2	R-134a	9.94	3,628.10	972.98	10.21

Arranged in increasing order of measured gross volume:

* (6*,7*) represent the assessment done at 25°C (CC1) with vertical airflow. The rest of the samples (1–10) were tested at vertical airflow at 32.2°C (CC2).

^ The gross volume for S#6 is as per the brochure. However, this value is expected to be the net volume.

(7) represents the assessment done at horizontal flow testing at 32.2°C.

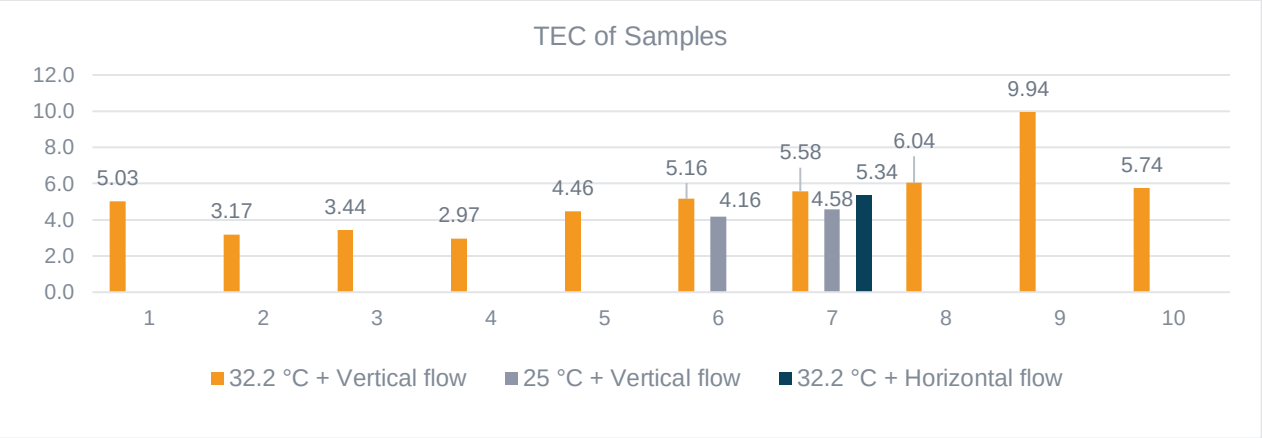
Equivalent volume, which is needed for SEC assessment, is calculated for each sample based on K1 conditions (Tc = 3.5).

5.1.4. TEC ANALYSIS

The graph displays TEC data for the ten samples tested at two temperatures (CC1 = 25°C and CC2 = 32.2°C) with both horizontal and vertical airflow directions.

In sample 6, comparing 32.2°C with vertical flow with 25°C with vertical flow showed a substantial increase of 24% in TEC at 32.2°C. Similarly, in sample 7, the comparison between 32.2°C with vertical flow and 25°C with vertical flow revealed a 22% TEC increase at 32.2°C. When analyzing sample 7, comparing 32.2°C with vertical flow versus 32.2°C with horizontal flow conditions showed that the TEC was 4.5% higher in the vertical flow setup. These findings highlight the influence of temperature and airflow direction on TEC variations among the different samples.

FIGURE 17: TEC OF SAMPLES

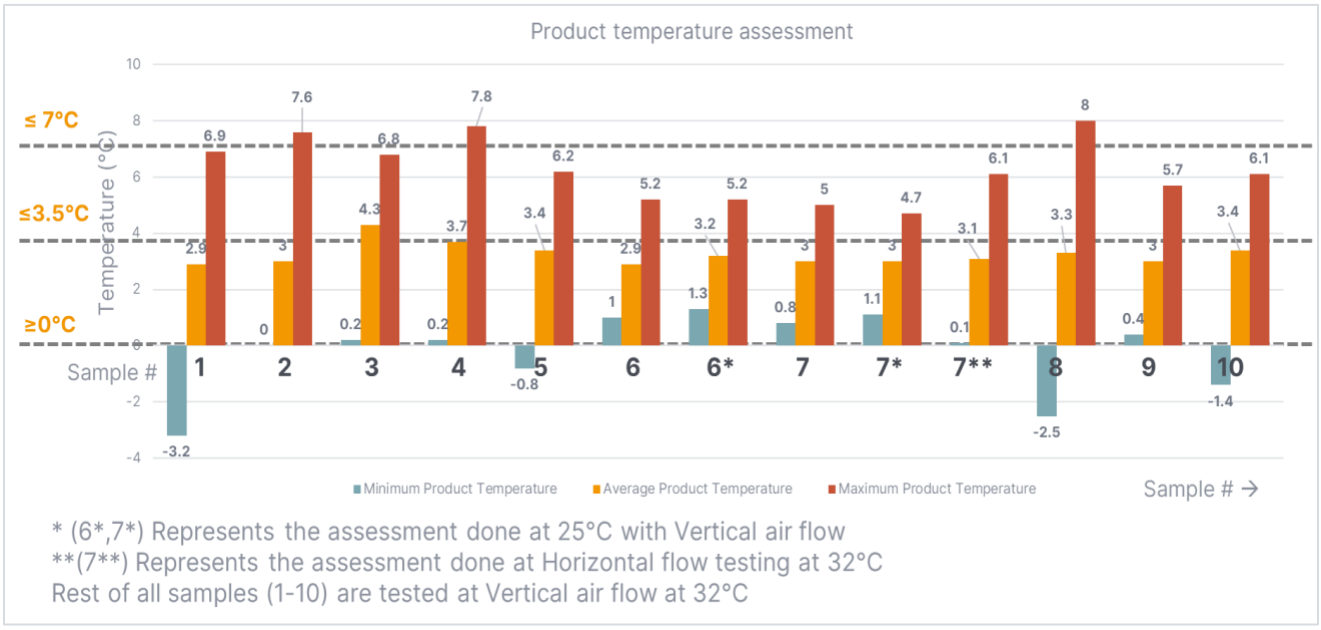


5.1.5. PRODUCT TEMPERATURE ASSESSMENT

We observed the minimum, average, and maximum product temperatures on all ten samples. The stabilized average product temperature was assigned as ≤ 3.5°C, indicating favorable temperature control, while the stabilized minimum product temperature was assigned as ≥ 0°C, which ensured that the products did not fall below freezing temperatures. Additionally, the stabilized maximum product temperature was assigned as ≤ 7.0°C.

We observed that two of the samples had their minimum product temperature fall below 0°C (samples 1 and 5). Two samples exhibited average product temperatures exceeding 3.5°C (samples 3 and 4) and three samples showed maximum product temperatures above 7°C (samples 2, 5, and 8).

FIGURE 18: PRODUCT TEMPERATURE ASSESSMENT OF SAMPLES



5.2. DEVELOPMENT OF STAR RATING TABLE

In this section, we discuss the methodology adopted for developing a star rating table for commercial beverage coolers.

5.2.1. STAR LABELING CRITERIA

AEC has been adopted as a labeling criterion in order to maintain consistency with existing BEE programs for other refrigeration appliances and to notify consumers of the estimated AEC under test conditions.

5.2.2. EVALUATION

We conducted a regression analysis of the ten samples using V_{eq} and AEC to derive the regression coefficient and slope. We then utilized these values to formulate the star band equations for each star criterion through a linear equation with a regression coefficient set at 3 stars and a 20% bandwidth before and after the succeeding star equations. In the linear regression graph (Figure 19), the linear regression lines were generated by applying equivalent volume values ranging from 100–2,000 liters in the star rating band equation for each star band. Subsequently, the AEC values of the tested samples were overlaid to determine which models fell within each star band.

FIGURE 3: REGRESSION ANALYSIS AEC AND V_{EQ}

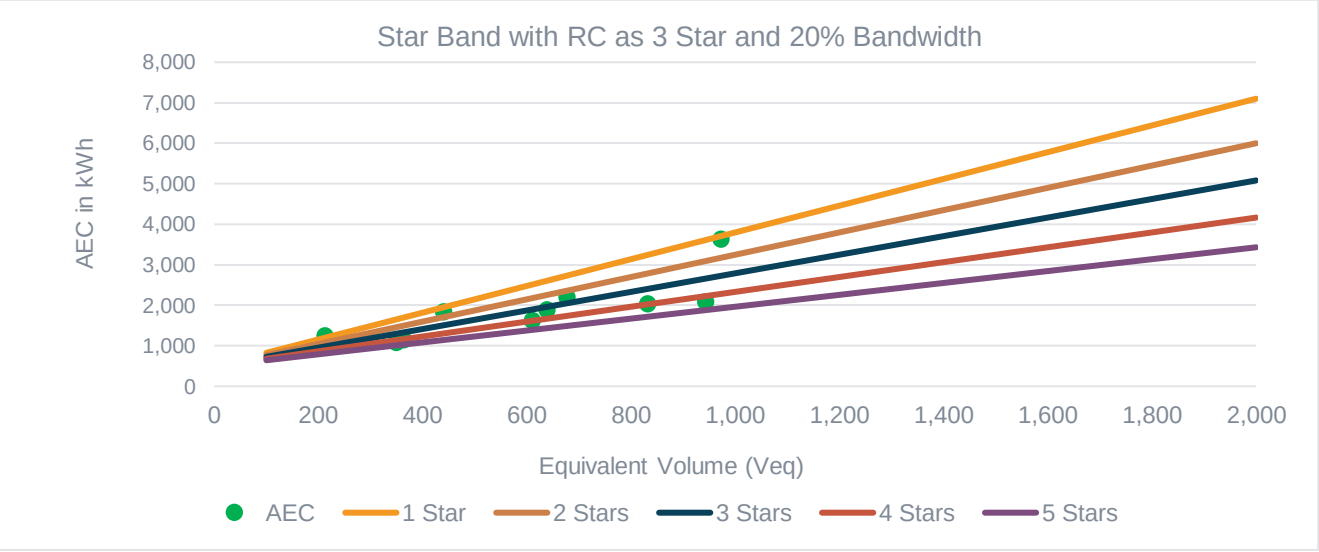


Table 12 shows a star rating band based on this analysis with the 3-star rating as the regression coefficient and 20% bandwidth.

TABLE 12: Star Rating Band Based on AEC and V_{eq}

Star Rating Band – Annual Energy Consumption (kWh/Year) with 20% Bandwidth			
1 star	(2.75*Veq) + 496.13	< AEC ≤	(3.30*Veq) + 496.13
2 star	(2.29*Veq) + 496.13	< AEC ≤	(2.75*Veq) + 496.13
3 star	(1.83*Veq) + 496.13	< AEC ≤	(2.29*Veq) + 496.13
4 star	(1.46*Veq) + 496.13	< AEC ≤	(1.83*Veq) + 496.13
5 star		AEC ≤	(1.46*Veq) + 496.13

6. Energy Savings and CO_2 Emission Reduction Potential

6.1. ASSUMPTIONS

Estimating energy savings requires a set of assumptions regarding the energy performance and sales of commercial beverage coolers during the assessment period. Consequently, we make the following assumptions:

1. The assessment period is from 2024–2025 (Y1) to 2034–2035 (Y11).
2. Sales are assumed to occur at the beginning of the financial year for simplicity of calculations.
3. The labeling scheme for commercial beverage coolers will commence from FY 2024–2025 on a voluntary basis.
4. The scheme will be made mandatory at the start of FY 2027–2028.
5. A visi cooler once sold remains in operation throughout the year.
6. The service life of a visi cooler is 7 years.
7. A product model with 400 liters of equivalent volume (V_{eq}) is the market representative.
8. We consider the star rating band with the TEC approach for the assessment of potential energy savings.

6.2. APPROACH

For each year in the assessment period, annual savings attributable to visi coolers sold are calculated as the product of the parameters in Table 13.

TABLE 13: ENERGY SAVINGS ASSESSMENT APPROACH

Parameter	Description
A = Difference in TEC	Difference in TEC between baseline and actual product model for the year
B = Operating duration (days in a year)	The number of days of operation/year (considering a total of 365 days)
C = Sales resulting in stock	Annual sales of the commercial beverage coolers; from annual sales, total running stock is arrived (the running labeled models will offer energy savings during their service life within the assessment period of 11 years – that is, till 2034–2035). The market forecast is based on CAGR of 4.23% for 2022–2030 and 4.43% for 2030–2035.

For baseline TEC, the TEC values prevalent in the absence of a labeling program would remain constant throughout the assessment period. For the actual TEC, we consider an overall distribution of sales among the 1–5-star bands and less-than-1-star (disqualification). Based on

the distribution, the sales-weighted representative TEC for each financial year during the assessment period is calculated.

TABLE 14: YEAR-WISE ENERGY SAVINGS ASSESSMENT

Energy Savings Assessment	2024–2025	2025–2026	2026–2027	2027–2028	2028–2029	2029–2030	2030–2031	2031–2032	2032–2033	2033–2034	2034–2035
Baseline energy consumption (kWh)	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89	4.89
Actual energy consumption (kWh)	4.87	4.42	4.30	3.80	3.80	3.67	3.67	3.67	3.45	3.45	3.45
Total stock (million)	0.42	0.86	1.31	1.76	2.19	2.59	2.93	3.21	3.44	3.65	3.83
Total energy savings (million kWh)	3.00	148.48	286.09	703.36	874.83	1,156.75	1,308.74	1,435.40	1,815.32	1,922.17	2,020.18
Cumulative energy savings (million kWh)	3.00	151.48	437.57	1140.93	2015.76	3172.51	4481.25	5916.65	7731.97	9654.14	11,674.32

6.3. ENERGY SAVINGS AND CO_2 EMISSION REDUCTION POTENTIAL

TABLE 15: Energy Savings and CO_2 Emission Reduction Potential

Energy Savings During Assessment Period 2024–2025 (Y1) to 2034–2035 (Y11)		
Total energy savings	***Billion kWh***	**11.674**
	MWh	**11,674,324**
GHG Emission Reduction During Assessment Period 2024–2025 (Y1) to 2034–2035 (Y11)		
Grid emission factor	*tCO_2/MWh*	0.715
Total energy savings	*MWh*	11,674,324
Total GHG emission reduction	***tCO_2***	**8,347,142**
	$MtCO_2$	**8.347**

7. Annexure

7.1. ANNEXURE 1: LIST OF COMMERCIAL BEVERAGE COOLER SAMPLES TESTED

TABLE 1: TEST SAMPLES AND THEIR SPECIFICATIONS

S. No.	Orientation	Opening	Gross Volume (L)	Refrigerant	No. of Doors	Temp. Range (°C)
1	Vertical	Closed/Transparent	340	R-290	1	2–8
2	Vertical	Closed/Transparent	585	R-290	1	2–8
3	Vertical	Closed/Transparent	805	R-290	2	2– 8
4	Vertical	Closed/Transparent	910	R-290	2	2–8
5	Semi-vertical	Closed/Transparent	220	R-134a	1	0–7
6	Vertical	Closed/Transparent	425	R-134a	1	0–7
7	Vertical	Closed/Transparent	947	R-134a	2	2–8
8	Vertical	Closed/Transparent	369	R-134a	1	2–8
9	Vertical	Closed/Transparent	530	R-290	2	2–8
10	Vertical	Closed/ Transparent	700	R-134a	2	1–10

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