Technical Appendix

Beverage Cooler

1. Introduction

This appendix offers a detailed explanation of the specific assumptions used in the beverage cooler module of Mepsy. For information on outputs and data sources for the parameters, please refer to the comprehensive Mepsy Methodology document.

Mepsy's model for beverage coolers (BCs), a subgroup of refrigerated display cabinets (RDC), includes commercial refrigeration equipment used in the food services and retail sector to cool and preserve non-perishable beverages, making them more accessible and enjoyable for consumers, especially in hot weather.

Beverage cooling units maintain a storage temperature below room temperature, at a range that ensures optimal cooling and food safety. The units are assumed to be switched off at night or during low usage periods without risk. Beverage coolers that are specified and procured by major soft drink manufacturers usually have higher cooling capacity than typical display and storage cabinets. They can rapidly cool beverages from ambient temperature to serving temperature, as specified in most test methods. Non-perishable beverages are usually delivered via an ambient temperature supply chain and are first cooled when displayed for sale.

ISO 22044[1] defines commercial beverage coolers as follows: "Commercial beverage cooler refrigerated cabinets to sell and/or display pre-packaged beverage products that are non-perishable, designed to chill products loaded at ambient temperature to the defined storage temperature class within a specified time and for which the customer is allowed direct access to the products".

2. Shipments and Stock

To obtain annual country-level sales of BCs, CLASP utilizes the global market intelligence data published by Grand View Research, which provides regional revenue and sales volumes for Asia Pacific, Europe, Latin America, Middle East & Africa, and North America. It also provides country-level datasets for beverage refrigeration for 20 major economies, namely Brazil, Canada, China,

[1] "ISO 22044:2021," ISO, accessed January 8, 2025, https://www.iso.org/standard/72395.html.

Egypt, France, Germany, Ghana, India, Indonesia, Italy, Japan, Kenya, Malaysia, Mexico, Russia, South Africa, South Korea, Thailand, United Kingdom, and United States.

To obtain shipment data for all 162 countries featured on Mepsy , CLASP developed a method to disaggregate the regional shipments for the remaining economies for all relevant years (2015-2027).

REGIONAL SHIPMENT DISAGGREGATION FOR THE REMAINING 142 COUNTRIES

We obtained a linear regression function fitted to the best estimates of stock for 20 economies, based on the 2022 Gross Domestic Product (GDP) per capita, adjusted for purchasing power (PPP), and expressed in constant 2017 US Dollar, sourced from the World Bank[2], to calculate the best estimate of country-level stock for 2023.[3]

$$\begin{aligned} &Global\ North: Stock\ of\ cabinets\ in\ an\ economy\ (thousands) \\ &\qquad = 0.327\ x\ GDP_{ppp}\ (thousand\ International\ USD, constant\ 2017) \end{aligned}$$

$$\begin{aligned} &Global\ South: Stock\ of\ cabinets\ in\ an\ economy\ (thousands) \\ &\qquad = 0.1237\ x\ GDP\ _{ppp}\ (thousand\ International\ USD, constant\ 2017) \end{aligned}$$

In consultation with experts, we developed ‘guardrails’ as a sense-check for the estimated stock of cabinets:

- **Cabinets per thousand people:** An automated check flag is triggered if the number is above 25 for a Global North economy, above 10 for Global South, or less than 0.1 for any economy. Any flagged number is individually reviewed for errors.

  Estimate average numbers of cabinets per thousand people:
  - Overall average for the countries analyzed: 6
  - Global North average: 13 with a high of 24 in the US and a low of 7 in Italy
  - Global South average: 3 with high of 7 in South Africa and lows of less than 5 in India, Kenya, Russia, and Brazil

- **Volume of chilled beverages sold per cabinet per working day in liters:** An automated check flag is triggered if the number is above 25 liters for Global North, above 40 liters for Global South, or less than 4 for any economy. Any flagged number is individually reviewed for errors. This requires data for soft drink and bottled water volume per

[2] "Glossary | DataBank," accessed December 10, 2024, https://databank.worldbank.org/metadataglossary/world-development-indicators/series/NY.GDP.PCAP.PP.KD.

[3] We choose to use Purchasing Power Parity (PPP) so that we adjusted the GDP figures to account for differences in the cost of living between countries. Constant 2017 U.S. dollars means the values were adjusted to reflect the purchasing power of money in 2017, so we can compare them without inflation affecting the results.

country and can be spot-checked by screen-grabbing beverage sales numbers from the Statista website.[4]

Average estimates:

- Global North weighted average: 14 liters per cabinet per working day, with a high of 18 in Italy and a low of 6 in Japan and South Korea
- Global South weighted average: 21 liters, with a high of 35 in Indonesia and a low of 7 in Pakistan

▪ **Volume of beverages per person per year sold via cabinets**: An automated check flag is triggered if a Global North country is above 60 (except the USA) and if a Global South economy is above 30. Any flagged number is individually reviewed for errors. This requires data for soft drink and bottled water volume per country and can be spot-checked by screen-grabbing beverage sales from the Statista website.[4]

Average estimates:

- Global North weighted average: 69 liters per person per year (39 if the US is not included), with a high of 100 in the US and a low of 26 in Canada and Japan
- Global South weighted average: 17 liters per person, with a high of27 in Indonesia, Brazil, and Egypt and a low of 3 in India

▪ The percentage of electrification in a given economy that is accounted for by beverage cabinets.[5]

We obtained Initial stock estimates for the remaining 142 countries—outside of the 20 economies where country-level shipment data is available—by assigning the ratio of the country's GDP[5] in 2020 to the regional GDP to disaggregate the regional stock[6] for all relevant years (2015-2027).

$$\text{Initial Stock Estimate}_{i,\ y} = \frac{GDP_{i,\ y}}{Regional\ GDP_y} \times \text{Regional Stock}_{\ y}$$

Where:

$GDP_{i,y}$ is the GDP of country i in year (y);

$Regional\ GDP_{2020}$ is the total GDP of the region to which country i belongs in y;

Regional Stock_y is the total regional stock data for a year (y) from 2015 to 2027.

[4] "Beverages - Worldwide | Statista Market Forecast," Statista, accessed January 9, 2025, https://www.statista.com/outlook/emo/beverages/worldwide.

[5] "World Bank Open Data," World Bank Open Data, accessed December 11, 2024, https://data.worldbank.org.

[6] Regional stocks were calculated from the regional shipment provided by Grand View Research.

We then developed adjustment factors based on the ratio of the best stock estimate developed using the “guardrails” above and the initial stock estimates obtained from the aggregate regional shipments data provided in the Grand View Research dataset. The factors were then applied to adjust the initial stock estimates to the best stock estimate, as evaluated above.

The adjustment factor F_i for country i is:

$$F_i = \frac{\text{Best Stock Estimate}_i}{\text{Initial Stock Estimate}_i}$$

Where:

$\text{Best Stock Estimate}_{i,y}$ is the refined or best estimate in year (y) for the country i based on the "guardrails";

$\text{Best Stock Estimate}_{i,y}$ is the stock estimate derived from the first step.

Finally, the adjusted stock estimate for the country i is:

$$\text{Adjusted Stock Estimate}_{i,\ y} = \text{Initial Stock Estimate}_{i,y} \times F_i$$

Where:

$F_{i,y}$ is the adjustment factor derived in the previous step.

Figure 1The adjustment factor F_i for country i is:

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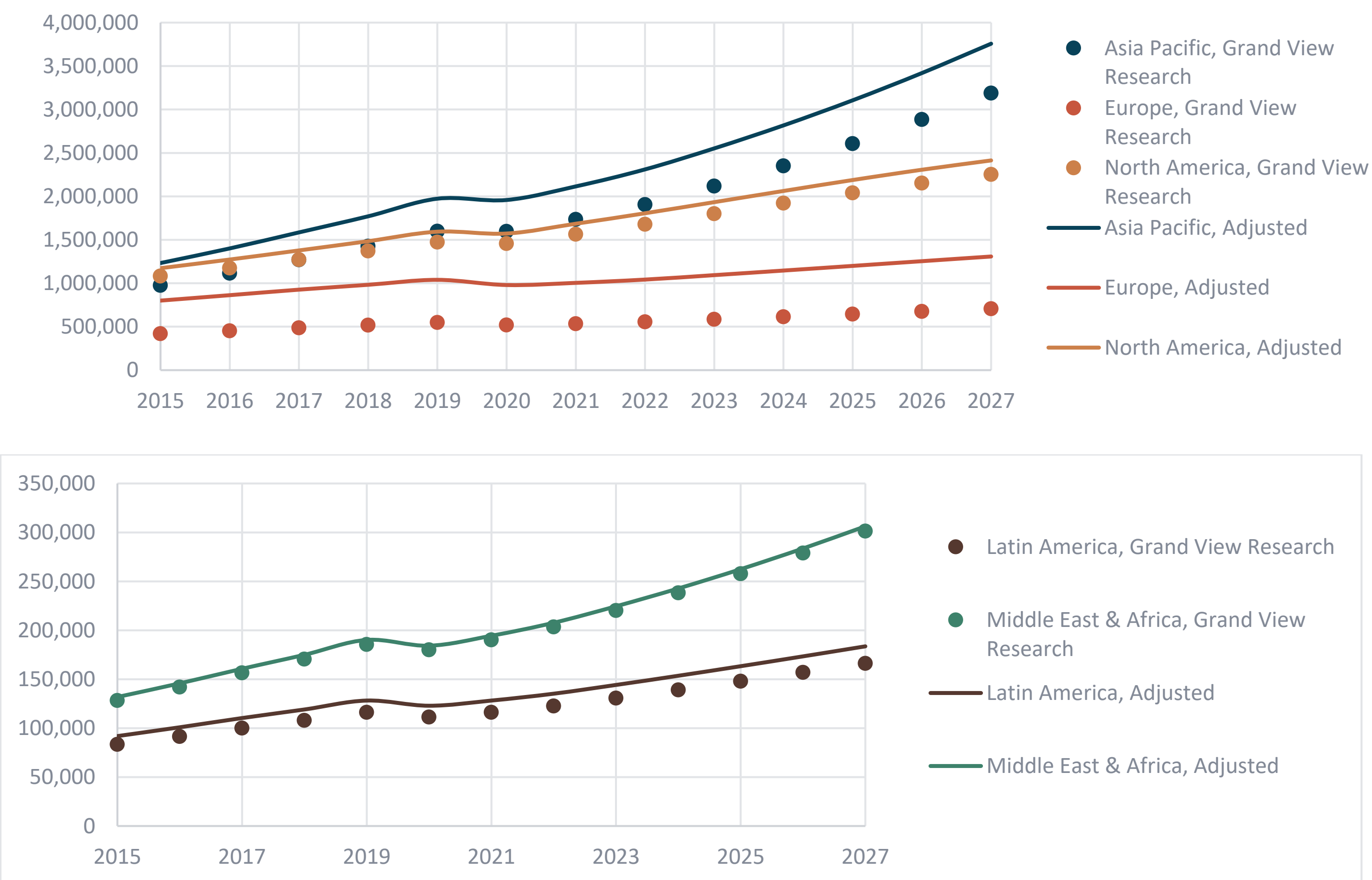
Where:

$F_{i,y}$ is the adjustment factor derived in the previous step.

illustrates the regional total from Grand View Research and the changes after the assignment of adjustment factors. As illustrated, minimal changes are applied to economies in North America, Middle East & Africa, and Latin America. Most adjustments apply to countries in the Asia Pacific region and Europe, where a close review of stock estimates in the respective regions indicates higher volumes of shipments required to support beverage refrigeration needs.

FIGURE 1. COMPARISON OF STOCK VALUES: GRAND VIEW RESEARCH DATA VS. RESULTS AFTER ADJUSTMENT



We calculated and applied the average compound annual growth rate (CAGR) values of the defined year ranges by developing the back-cast of shipments prior to 2015 and the forecast after 2027.

The general formula for calculating the future value using CAGR is:

$$Future\ Value = Initial\ Value\ \times (1 + CAGR)^n$$

Where:

$Future\ Value$ is the value of shipments in the forecast or back-cast year;

$Initial\ Value$ is the known value for the reference year;

$CAGR$ is the Compound Annual Growth Rate;

n is the number of years between the reference year and the forecast/back-cast year.

Maximum CAGR were set to a threshold of anticipated growth. The year ranges considered in the back- and fore-cast were as follows:

- For 1950-2014, referencing average CAGR between 2015-2019 and assigning 3.5% CAGR as maximum for the Global North countries and 5.0% CAGR for the Global South countries

$$Shipment_{1950-2014} = Initial\ Value\ \times (1 + \min(CAGR, 0.035\ for\ Global\ North, 0.50\ for\ Global\ South)^{n}$$

- For 2028-2035, referencing average CAGR between 2023-2027 and assigning 3.5% CAGR as maximum for the Global North countries and 5.0% CAGR for the Global South countries

$$\begin{aligned} Shipment_{2028-2035} \\ &= Initial\ Value_{2027}\ \times (1 \\ &+ \min(CAGR, 0.035\ for\ Global\ North, 0.50\ for\ Global\ South)^{n} \end{aligned}$$

- For 2036-2060, referencing average CAGR between 2023-2027 and assigning 2% CAGR as maximum for the Global North countries and 3% CAGR for the Global South countries

$$\begin{aligned} Shipment_{2036-2060} \\ &= Initial\ Value_{2027}\ \times (1 \\ &+ \min(CAGR, 0.02\ for\ Global\ North, 0.3\ for\ Global\ South)^{n} \end{aligned}$$

3. Unit Energy Consumption, Usage, and Standards Scenarios

The representative unit defined for RDC-BC is an integral (self-contained) vertical glass door cabinet, with 400 liters gross volume and a typical height between 0.5 and 2.2 m. The representative unit is assumed to be configured without energy management devices, requiring manual setting of target temperature and manual switch off. The typical lifetime is 8 years.

The relevant test method considered for the product group is ISO 23953[7] to provide Unit Energy Consumption (UEC) estimates under the following country-level assumptions:

- Storage temperature: K1 (3.5ºC) in all countries
- ‘Cool ambient’ country, ambient temperature class CC1 (25ºC / 60% Rh)
- ‘Warm ambient’ country, ambient temperature class CC2 (32ºC/ 65% Rh)

Proposed benchmarks are shown in Table 1 and described below:

- **Business-as-usual (BAU)** or typical performance of units currently sold in the market

[7] “ISO 23953-2:2023,” ISO, accessed January 9, 2025, https://www.iso.org/standard/80861.html.

- Global South: 7.21 kWh/day (K1 CC2), 2633 kWh/year with 365-day operation.
  - This level is in line with the recommendations made by U4E for Brazil, based on market research conducted by Procel in 2021.
- Global North: 6.32 kWh/day (K1 CC1), 2306 kWh/year with 365-day operation.
  - This level refers to the EU preparatory study by JRC.[8]

▪ **Efficiency Policy Scenario (MEPS)**

- Global South: 4.81 kWh/day (K1 CC2), 1755 kWh/year with 365-day operation.
  - This level is set at the currently enforced MEPS in the EU region.
- Global North: 3.28 kWh/day (K1 CC1), 1196 kWh/year with 365-day operation.
  - This level is slightly less ambitious than EU MEPS from Sep 2023, fully achievable in all Global North markets, and considered applicable up to 2026.

▪ **Best Available Technology (BAT)**

- Global South: 1.92 kWh/day (K1 CC2), 702 kWh/year with 365-day operation.
  - This level is set based on the average performance level of commercially available top-performing Beverage Coolers,[9] currently available in Global North markets, for the specified target storage temperature and ambient condition for the Global South.
- Global North: 1.87 kWh/day (K1 CC1), 683 kWh/year with 365-day operation.
  - This level is set based on the average performance level of commercially available top-performing Beverage Coolers, currently available in the Global North markets, for the specified target storage temperature and ambient condition for the Global North.

TABLE 1. SUMMARY OF PROPOSED MEPS AND BAT LEVELS, ALL IN EQUIVALENT KWH/DAY FOR NEW 400-LITRE CABINET UNITS AVAILABLE IN CURRENT MARKETS, TO BE OPERATED IN THE RESPECTIVE AMBIENT CONDITIONS SET FOR GLOBAL NORTH AND GLOBAL SOUTH

Scenario	Global North - index	Global North - K1CC1	Global South - index	Global South - K1CC2
Business-as-usual (BAU)	135	6.32	150	7.21
Efficiency Policy Scenario (MEPS)	70	3.28	100	4.81
Best Available Technology (BAT)	40	1.87	40	1.92

[8] For Global North stock, the 7 kWh/day figure is judged from the base case consumption of the EU preparatory study by JRC (Base case assumption (sales) was 7.3 kWh/day for a 500-litre cabinet in 2012). This is on the worse side of the EU MEPS (5.08) as not all countries have MEPS and dominance of legacy products existed before MEPS implemented in EU.

[9] “The Best Beverage Coolers on the European Market (2024) | Topten.Eu,” accessed December 11, 2024, https://www.topten.eu/private/products/beverage_coolers.

Glossary

Ambient Temperature: The temperature of the surrounding environment, typically referring to the temperature in the room or area where the appliance is located.

Business-as-Usual Performance: Refers to the typical performance of units currently sold in the market, representing no significant improvements in energy efficiency. It is used as a baseline scenario to compare other performance levels.

Best Available Technology (BAT): The most energy-efficient and commercially available technology currently on the market. In the context of Beverage Coolers, this represents the highest-performing units available in both the Global North and South markets.

CC1 and CC2 Ambient Temperature Classes: Classification for ambient conditions, where:

CC1 represents a cool ambient temperature class (25ºC, 60% RH),

CC2 represents a warm ambient temperature class (32ºC, 65% RH).

Cooling Capacity: The ability of a refrigeration unit, such as a Beverage Cooler, to lower the temperature of stored beverages. Typically, these units are designed to cool products quickly from ambient temperature to the desired storage temperature.

Compound Annual Growth Rate (CAGR): A measure of the mean annual growth rate of a value over a period of time, factoring in growth during the forecast period.

Disaggregation of Regional Shipments: The method used by CLASP to break down regional shipment data to obtain country-level estimates by using factors like GDP per capita.

Efficiency Policy Scenario (MEPS): A policy intervention scenario that assumes the phase-out of low-efficiency products due to Minimum Energy Performance Standards (MEPS), resulting in a reduction in annual energy consumption by a set percentage.

Energy Management Devices: Devices used to control and optimize the energy consumption of refrigeration units. These may include automatic temperature adjustments, energy-saving modes, or advanced controls.

GDP PPP (Gross Domestic Product: Purchasing Power Parity): A metric used to compare the economic output of different countries, accounting for differences in the cost of living. It is used in stock estimation and market disaggregation.

Global North: Refers to economically developed countries, typically located in the Northern Hemisphere, including regions like North America and Europe. These countries generally have higher GDP and energy consumption rates.

Global South: Refers to economically developing countries, typically located in the Southern Hemisphere. These countries have lower GDP per capita and energy consumption rates compared to the Global North.

Guard handrails: A “sense-check” method used to flag potential errors in stock estimates for refrigeration units based on thresholds for the number of cabinets per capita or other measures of consumption.

ISO 22044: A standard that defines the technical requirements for commercial beverage coolers, including their cooling capacities and energy performance.

ISO 23953: The test method used to evaluate the Unit Energy Consumption (UEC) of refrigerated display cabinets, including beverage coolers.

K1 Temperature Class: A classification for storage temperature of 3.5ºC, used as the target temperature for storing beverages in the cooling unit.

Linear Regression: A statistical method used to fit a line to data points in order to make predictions or estimates, such as estimating stock levels of refrigeration units based on GDP.

Manual Switch Off: A feature where the refrigeration unit must be manually turned off, typically during low-usage periods or at night, to save energy.

Market Disaggregation: The process of breaking down regional market data into specific country-level data using statistical methods and factors like GDP per capita.

MEPS (Minimum Energy Performance Standards): Regulations or guidelines that define the minimum energy efficiency levels for refrigeration units, such as Beverage Coolers, to be sold in specific markets.

Population Headcount: The total population of a given country, which is used in some estimates for the number of refrigeration units per capita or per thousand people.

Refrigerated Display Cabinet (RDC): Commercial refrigeration units used to store and display products like beverages in retail environments. Beverage coolers are a subset of RDCs that specialize in non-perishable beverages.

Regulation Adjustment Factors: Factors applied to initial stock estimates of refrigeration units based on population size, GDP, and other key metrics, to adjust for specific country and regional conditions.

Shipments: The annual sales volume or number of units of a product, such as Beverage Coolers, sold within a specified region or country.

Stock: The total number of refrigeration units, such as Beverage Coolers, in use within a given country or region.

Unit Energy Consumption (UEC): The energy consumed by a refrigeration unit, such as a Beverage Cooler, typically measured in kilowatt-hours (kWh) per day or year. This metric helps in evaluating the energy efficiency of the unit.

Vertical Glass Door Cabinet: A type of beverage cooler with a vertical design and glass doors, typically used in retail environments to display beverages to customers.

Weighted Average: A statistical method where different values are given different levels of importance based on their frequency or market share, to calculate an average that reflects real-world conditions.

Working Day: A typical business day, often considered as 8 hours of operation for refrigeration units, excluding weekends or public holidays.

CONTACT

CLASP

info@clasp.ngo

clasp.ngo