Brazil Case Study - Definition of Testing Standards for Assessing the Energy Efficiency of Commercial Refrigerators

INTRODUCTION

As part of its Nationally Determined Contribution (NDC), Brazil has committed to implement measures on energy-efficiency to achieve 10% efficiency gains and to reduce greenhouse gas emission by 43% below 2005 levels by 2030. The first government policies on energy efficiency were established in 1981 and since then, important steps have been taken including introduction of a an energy labelling programme in 1984, the creation of the National Electricity Conservation Program (PROCEL) in 1985, the creation of the Energy Efficiency Program (PEE) for electric utilities in 2000, and the implementation of Minimum Energy Performance Standards (MEPS) since 2001 including room air conditioners and domestic refrigerators (both enforced in 2020).

The Federal Government has now turned its attention to the commercial refrigeration sector and launched the *Leapfrogging to Energy-Efficient and Climate Friendly Commercial Refrigerating Appliances in Brazil* project in November 2021, enabled with funding from the Green Climate Fund Readiness Programme. The project is jointly implemented by Brazil's Ministry of Mines and Energy (MME)[1] as the federal focal authority and the United Nations Environment Programme United for Efficiency initiative[2] . The project aims to help Brazil tackle electricity waste by accelerating the transition to energy-efficient and climate friendly commercial refrigerators through MEPS and energy labels as well as implementation of effective monitoring, verification and enforcement (MVE) based on international testing standards and best practices, while enhancing national stakeholder capacity in these areas.

Brazil's commercial refrigeration sector is comprised mainly of wholesalers and retailers (supermarkets), hotels and restaurants. There is significant potential to improve energy efficiency – based on UNEP U4E analysis for commercial refrigerators in Brazil, it is estimated an energy consumption of 14.5 TWh annually (2022 values), and annual savings of 2,4 TWh (16%) are projected by 2035 with the implementation of MEPS and Labels[3].

Competent testing laboratories are fundamental to the successful implementation of regulatory programmes as they verify product performance in standard conditions. Test laboratories play a key role in conformity assessment and market surveillance by determining the declared performance of products before entering the market, and verifying their compliance of those already sold in the market. In Brazil, 95% of the commercial refrigeration market is supplied by local manufacturers. Third-party laboratories which are accredited and

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[1] *https://www.gov.br/mme/pt-br/assuntos/ee/refrigeradores-comerciais-eficientes-no-brasil/refrigeradores-comerciais-eficientes-no-brasil*

[2] *http://united4efficiency.org/*

[3] *"Recomendações para as métricas, normas de ensaio e níveis de MEPS e Etiquetas dos Refrigeradores Comerciais no Brasil", 2022 UNEP U4E.*

following appropriate protocols help enhance compliance with MEPS and labels and underpin confidence in Brazilian cooling market[4].

Several commercial refrigeration equipment manufactures already test their products though self-declaration system to inform clients about energy performance. However, given the lack of energy efficiency regulations for this segment in the country, varying test conditions and procedures are used by different manufacturers, making it impractical to compare energy use across brands. Implementation of MEPS and labels regulations in Brazil must involve setting and enforcing clear testing standards for all parties. To this end, the *Leapfrogging to Energy-Efficient and Climate Friendly Commercial Refrigerating Appliances in Brazil* project included a laboratory study tour training programme at an internationally accredited testing facility in preparation for the new testing regulations. The objective was to develop the capacity of Brazil's testing laboratory staff, regulatory officials and industry on *ISO 23953 – Refrigerated display cabinets*, *ISO 22043 – Ice-cream freezers* and *ISO 22044 – Beverage coolers* and to provide a platform to discuss potential adaptations of these international standards for Brazil's requirements.

The training programme included complementary activities in Brazil in collaboration with U4E after the study tour to support the successful development and enforcement of national test standards, including:
- Study on testing procedures was undertaken to determine what discrepancies exist when using the different chamber types and the airflow direction – a key aspect raised by manufactures during the study tour.
- The Brazilian Association for Standardization (ABNT) adapted the international ISO 22044 and ISO 22043 to the Brazilian context for national test standards.
- Definition and implementation of MEPS and labelling scheme for commercial refrigerators which was included in the regulatory agenda[5] with expected publication in 2025.

COMMERCIAL REFRIGERATOR STUDY TOUR ACTIVITIES

In coordination with MME and U4E, the study tour took place from 25-27 January 2023 at the Re/gent laboratory in Helmond, The Netherlands. Re/gent is ISO 17025 accredited for testing the energy consumption and performance under the abovementioned standards for commercial refrigerators. Furthermore, Re/gent participates actively in the elaboration process of European regulations and standards, as well as other European projects related to energy efficiency regulations for commercial refrigerators and other products.

The study tour had attendees from the public sphere, such as the MME and the local implementing authority of the GCF project, as well as from third party national laboratories including CEPEL (*Centro de Pesquisas de Energia Eléctrica*), LABELO (*Laboratórios Especializados em Eletroeletrônica, Calibração e Ensaios*) and SGS (Société Génerale de Surveillance), and stakeholders from the private sector including local commercial refrigerator and compressor manufacturers such as FRICON, ARTICO, METALFRIO and TECUMSEH.

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[4] *More information on compliance of MEPS and Labels available at: https://united4efficiency.org/resources/ensuring-compliance-with-meps-and-energy-labels/*

[5] *RESOLUÇÃO CGIEE Nº 1, DE 1º DE FEVEREIRO DE 2024 - RESOLUÇÃO CGIEE Nº 1, DE 1º DE FEVEREIRO DE 2024 - DOU - Imprensa Nacional (in.gov.br). Available at: https://www.in.gov.br/web/dou/-/resolucao-cgiee-n-1-de-1-de-fevereiro-de-2024-541217170*

Picture 1. Brazil delegation, U4E team and Re/gent testing experts at Re/gent facilities, The Netherlands

The study tour consisted of a three-day training programme, where participants took part in activities related to:

- Introduction to test procedures according to international standards for energy consumption, volume and display area calculation, climate class, temperature class, half reload test, and cabinet preparation for the three main international commercial refrigeration standards mentioned above.
- Laboratory tour and familiarization with measurement equipment, such as climate rooms, sensors and control equipment.
- In-house calibration of laboratory equipment and uncertainty calculation.
- Practical sessions for conducting various test methods for measurement of commercial refrigerators, including loading package plan preparation, volume and total display area measurement.
- Climate room design.
- Classification of the different types and sub-types of commercial refrigerators.

On the first day of training, participants were welcomed to the Re/genT Laboratory with presentations from Martien Janssen (Re/genT Laboratory Director), Patrick Beks (Manager, Standard Testing) and Randolph van Kasteren (Research Engineer and Quality Manager).

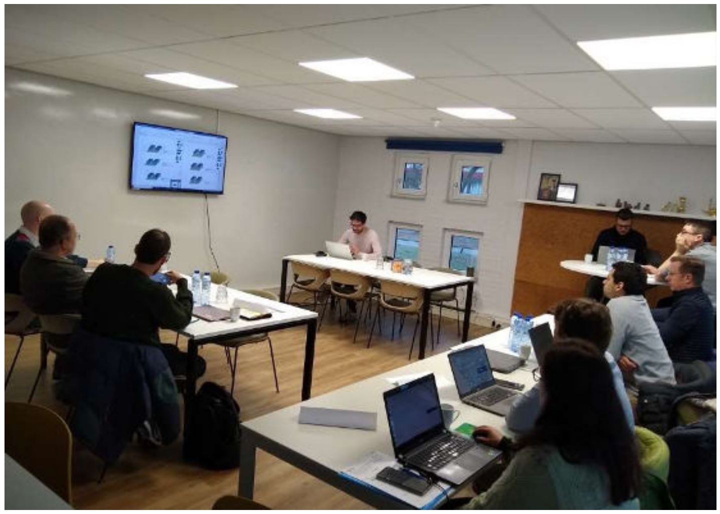
Following the presentations, the participants were given a tour of Re/gent's facilities to familiarize them with the required equipment and space requirement for conducting testing in laboratory conditions. Additionally, participants were shown other test rigs of interest for investigating specific components of commercial refrigerators, such as the compressor calorimeter (Picture 2) which maps compressor performance under varying conditions by controlling evaporating and condensing temperatures.

Picture 2. Compressor calorimeter

The climate room (Picture 3) contains the laboratory setup for testing the overall energy efficiency of commercial refrigerators and was of particular interest to participants. This facility can simulate specific ambient conditions, such as ambient temperature, humidity, and air flux around the cabinet within the allowed tolerances of the standards. Commercial refrigerators are placed in the climate room in line with the requirements of the standard and, once they reach the point of stability, energy consumption and internal cabinet temperatures are measured for 24 hours. For certain types of commercial refrigerators, such as supermarket display cabinets (ISO 23953-2), a door opening sequence is applied to simulate real conditions (an automatic arm will open and close the cabinet door according to the test standard). Additional tests required for compliance conducted within the climate room include the climate class test which indicates the maximum temperature and humidity combination at which the refrigerator can maintain compartments at the target temperature, and the half reload recovery test for beverage coolers which indicates the speed of pull-down temperature when half of the load (cans) is replaced by beverages at ambient temperature.

Picture 3. Climate room

The first day continued with a theoretical session on the three main test standards for commercial refrigerators. This included a detailed explanation of each of the commercial refrigerator categories and the main differences and properties of the equipment, namely: refrigerated display cabinets, professional storage cabinets, ice-cream freezers, beverage coolers, gelato scooping cabinets and vending machines. For each of the test standards, the session presented a detailed overview of the test procedures, such as the scope, the energy consumption test procedures, the volume and total display area calculation, climate class test, temperature class test, half reload test, and cabinet preparation.

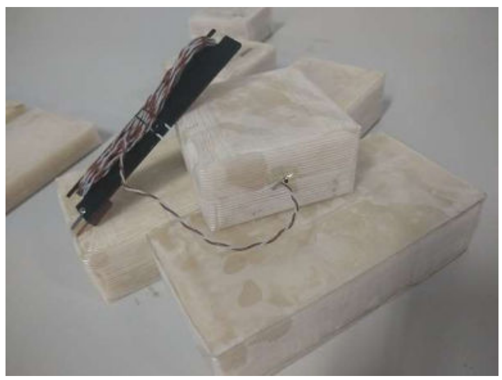


Picture 4. Theory session providing a detailed explanation of the test standards

After the theory, the attendees divided into two groups for practical sessions conducting the loading process (Picture 5) for a vertical refrigerated display cabinet (ISO 23953) and for a horizontal ice-cream freezer (ISO 22043). Each group carried out both exercises which continued the second day.

During these tests, load packages are used to simulate the food that would be stored in the refrigerators. Proper loading is essential, as the standards indicate specific loading procedures and the placement of temperature sensor packages (known as M-packages). Accurate compliance with the standards ensures fewer interpretation errors, leading to greater repeatability of test results. As this was a training exercise, aluminium packages were used for ease of handling instead of standardized ones which are usually stored at frozen temperatures. Picture 6 shows the standardized packages, including an M-package with an embedded temperature sensor.

Picture 5. Practical session: Loading exercise of a vertical refrigerated display cabinet (left) and ice-cream freezer (right)



Picture 6. Standardized load packages, including an M-package with an embedded temperature sensor

The ice-cream freezers exercise focused on volume and total display area measurements (Picture 7) as these can be challenging due to the varying shapes these cabinets are available. To ensure repeatability, testing standards strive for precision, but some interpretation points may arise. In such cases, Re/genT advised engaging in discussions among experts, recording observations in an "interpretation" notebook for future reference, and documenting the approach in the test report observations section, facilitating accurate repetition if needed.

On the second day, the participants carried out a beverage cooler loading exercise (ISO 22044). For this test, the load comprises 330 cl cans. The cans, which contain the temperature sensors, are filled with a mixture of water and glycol to prevent freezing. Soda cans are not recommended, as they may freeze at specific temperature classes.

Picture 7. Practical session: Volume and total display area measurement exercise on ice-cream freezers

On the third day, theory and practical sessions continued providing experience on:

- Climate room design, looking at the airflow control and room design for airflow homogeneity, as well as temperature and relative humidity controls (Pictures 8 and 9).
- Required equipment to regulate the operation of the test laboratory, such as the temperature sensors, the power meter, data acquisition system, and the calibration equipment to perform in-house calibration (Picture 10)
- Measurement evaluation software (ColApp), which reads the data from the data acquisition system and performs the calculations to present it in a standardized format for analysis.

Picture 8: Theory session on climate room controls and design

Picture 9. Climate room design (practical visit to installation)

Picture 10. Presentation of various equipment, including power meter, data adquisition system and in house calibration equipment

COMPLEMENTARY ACTIVITIES IN BRAZIL

In addition to the capacity building at Re/Gent, the project undertook the following related activities:

A. Policy Working Group meetings:
The core team of local stakeholders of the project held regular meetings to discuss key aspects and share findings from various studies to guide decision-making and project deployment. The group focused on the definition and implementation of MEPS and labelling scheme for commercial refrigerators. This included deliberations on test standards, including topics such as temperature conditions for measuring energy efficiency, reference test standards, and the definition of airflow direction in test chambers among others. The group met regularly online, with a final in-person meeting held towards the end of the project (Picture 11), with a strong foundation for further convening in due course depending on future activities which may be pursued as part of follow-on projects.

B. Nationalization of Test Standards:
The ABNT convened a dedicated working group to translate into Portuguese and adapt the international ISO 22044 for beverage coolers and ISO 22043 for ice-cream freezers test standards to the Brazilian context. The working group was open to participants from any organization or institution with a relevant and genuine interest, meeting once every month to discuss the translation and any specific additional requirement. Although the project officially concluded in June 2023, the ABNT working group has continued its efforts and in July 2024, the nationalization of the ISO 22044 was completed and ABNT ISO 22044 published. ABNT ISO 22043 is finalized and going through public consultation (expected finalization and publication in Q2 2025). Furthermore, in August 2024, work began on updating ABNT ISO 22953:2018 following the release of a new version by ISO in 2023.

C. Airflow Direction in Test Chambers comparison:
Most of the installed capacity of testing rooms in Brazil are vertical airflow chambers, which are typically used for residential refrigerators. However, international test standards for commercial refrigerator specify the use of test rooms with horizontal airflow which is more critical for open display cabinets, and since, it has been extended to other types of commercial refrigerators. Most manufacturers already have laboratories equipped with vertical airflow chambers, which might imply investments to convert their facilities to the horizontal airflow configuration to implement the international standards. Thus, it has been requested to consider accepting tests conducted in vertical airflow chambers. However, there are no studies available comparing the impact on the results between the use of vertical or horizontal airflow chambers.

In response, UNEP U4E undertook a study to obtain preliminary test results and determine what, if any, discrepancies exist when using the different chamber types and the airflow direction. This task was entrusted to CEPEL, a third-party laboratory of reference in Brazil, who has the capability to run test in both vertical and horizontal airflow chambers.

The study was done in a vertical beverage cooler with transparent door, donated by a local manufacturer. This type of refrigerator was selected as it dominates the market, and beverage coolers have fewer subtypes compared to supermarket refrigeration equipment. Thus, the results of this investigation could potentially inform decisions across the entire ISO 22044 testing process. However, it is important to note that these results cannot be extrapolated to commercial refrigerators tested under different standards, (such as ISO 23953, which is used for supermarket display cabinets).

The following tests and conclusions were obtained during the study:

1. *Temperature Test:* The test verifies the appliance's ability to maintain the compartment temperature within the declared temperature and climate classes. Conclusion: No significant differences were observed between vertical and horizontal airflow chambers.
2. *Energy Consumption Test*: The test measures the energy consumption under the specified climate class conditions (ambient temperature and humidity) and temperature class (target compartment temperatures). Conclusion: On average, daily energy consumption was 17% higher in the horizontal airflow chamber compared to the vertical airflow chamber.
3. *Half-Reload Test*: The test calculates the time required for the appliance to return to the target temperature class after replacing half of the load (cold beverage cans) with cans at ambient temperature (climate class). Conclusion: In this case, the differences in compartment temperature stabilization make it challenging to perform a precise quantitative comparison between the two types of test rooms. However, an analysis of the temperature trends indicates that both test types exhibit similar behaviors. This observation suggests that the differences in reload recovery times are likely not substantial.

All tests were conducted under consistent conditions: Temperature Class K3 (target temperature between +1°C and -3.5°C) and Climate Class CC2 (32.2°C and 65% relative humidity). Each test was repeated five times in both types of test chambers, totaling 30 tests (15 in each chamber type).

These results indicate that energy consumption measurements differ depending on whether horizontal or vertical airflow chambers are used. The outcomes of this comparison provide valuable information for decision-making by the Brazilian government on whether to accept tests from both vertical airflow and horizontal airflow chambers for beverage coolers.

D. Introduction of a New Temperature Class for Beverage Coolers:

Another concern raised by the manufacturers was that the most common temperature classes (temperature in the compartment) for beers used in Brazil is not specified in ISO 22044. However, the standard includes provision for a special temperature class, which allows countries to specify different conditions to the four stipulated in the standard. Manufacturers proposed a special temperature class, K5 (minimum/maximum/average temperature = -6.0°C/ +1.0°C/ -2.4°C) to harmonize the testing carried out in Brazil and measure the energy consumption plus other performance capabilities at the real temperature at which the beverage cooler will be working in the field. An additional concerned was raised of whether cans could withstand the special low temperature class without damage (as glass bottles are used at these low temperatures in the field, while cans are used in laboratory test according to ISO 22044). Thus, at the end of the sequence of tests carried out by CEPEL to study the influence of airflow direction, which was conducted at temperature class K3 (minimum/maximum/average temperature = -3.5°C/ +1.0°C/ -1.0°C), a study on the impact of using the special temperature class K5 was undertaken.

After reaching stabilization within the temperature range at K5, the refrigerator was kept in operation for at least 24 hours. After this period, the refrigerator was emptied, and the cans inspected for any signs of deformation or damage caused by freezing. The inspection focused on identifying the types of imperfections, the number of cans affected, and their respective locations within the refrigerator. The results showed that none of the cans were damaged during the test at the K5 temperature class, indicating that this test can be safely conducted at this specific temperature setting. It is important to note that the beer used in this test had an alcohol content of 4.8%. Using beer cans with lower alcohol content could potentially lead to damage, as the freezing point of beer is influenced by the presence of alcohol.

Picture 11: Policy Working Group, Rio de Janeiro meeting, June 2023

ACKNOWLEDGEMENTS

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ABOUT UNITED FOR EFFICIENCY

United for Efficiency (U4E) is a global initiative led by the United Nations Environment Programme (UNEP), funded by the Global Environment Facility (GEF), and supported by an array of leading companies, expert organizations, and public entities with a shared interest in transforming global markets for lighting, appliances and equipment to more energy efficiency alternatives saving all electricity consumers, including government, $ billions at the same time.

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