

Market Baseline Performance Testing for Off-Grid & Weak-Grid Refrigerators

May 2018



ideas to impact.

SUMMARY of RESULTS & ANALYSIS

Refrigerators hold unique potential to unlock economic and social progress for billions of un- and under-electrified people globally. Yet the nascent market for highly energy-efficient, appropriately-designed off- and weak-grid refrigerators remains supply constrained. Refrigerators must be smaller, cheaper, and run on far less energy than conventional products to be viable for off- and weak-grid customers.

Negligible data currently exists regarding off- and weak-grid refrigerator cost and performance. To help fill this gap, with support from UK DFID's Ideas to Impact Initiative, CLASP procured and tested commercially available refrigerators in 2016 to establish a performance baseline. While not exhaustive, these test results constitute the most extensive available set of energy performance and service delivery metrics for commercially available off-grid refrigerators at an early stage of a market's development.

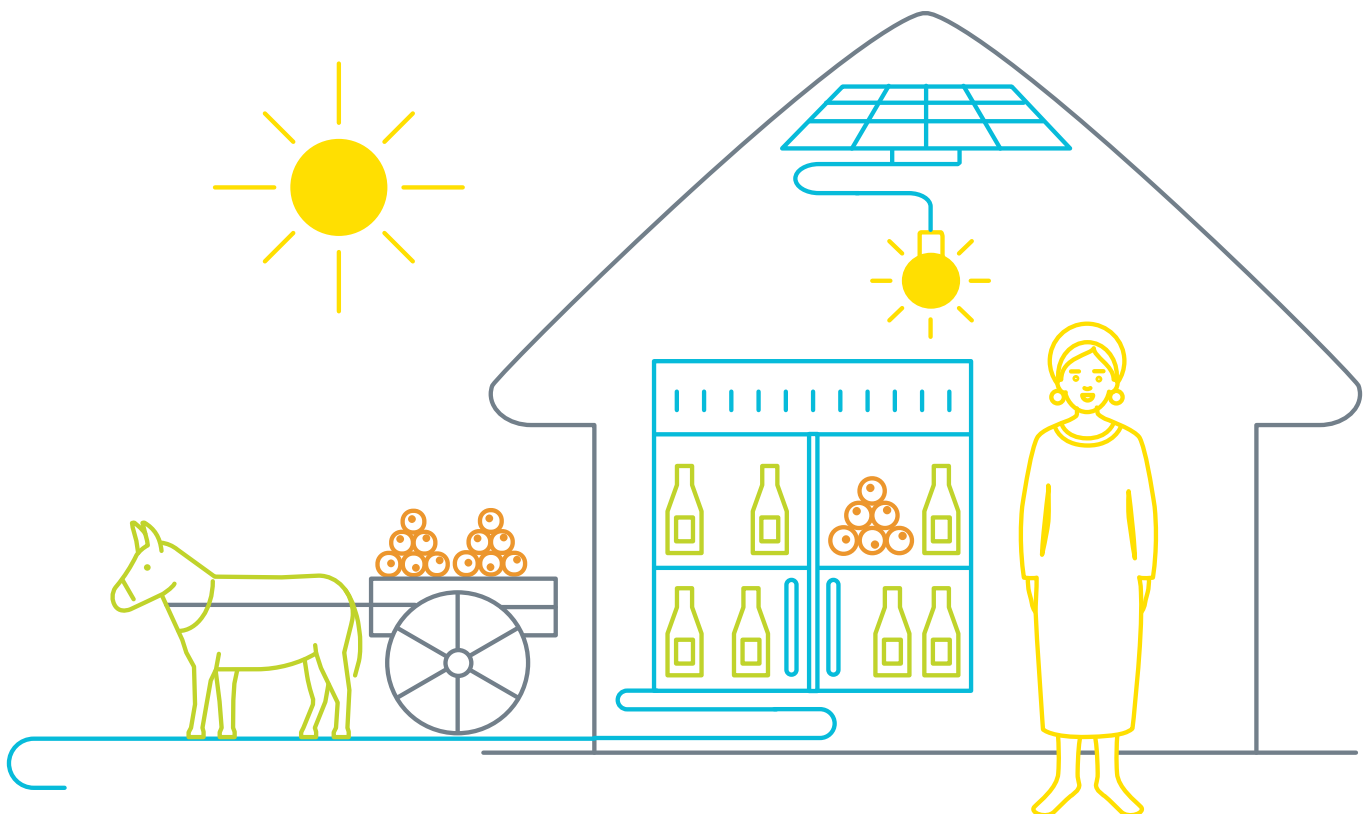
This summary contains a snapshot of some key findings from the test results, with the goal of enhancing the marketplace's knowledge about off- and weak-grid refrigerator efficiency and performance to inform continued innovations in the sector. Please contact info@efficiencyforaccess.org for more details or to see the full report.

METHODOLOGY

Testing focused primarily on two common types of commercially available refrigerators. CLASP procured a total of 36 products online, direct from manufacturers, and through field agents in off-grid areas. Among the 36 test samples, 24 were refrigerator-freezer combination units (67%), and 12 were refrigerators only (33%).

These products underwent testing in accredited laboratories according to the Global LEAP Off-Grid Refrigerator Test Method to evaluate their energy performance, service delivery, durability, and off-grid appropriateness.

You can find the Global LEAP Off-Grid Refrigerator Test Methods here: <https://bit.ly/2LwTy0u>



DAILY ENERGY CONSUMPTION

Ambient air temperature is a key driver of energy consumption of refrigerators, but limited data exists comparing off-grid refrigerators' performance at various ambient temperatures. To demonstrate its impact on refrigerator performance, we conducted testing to measure the average daily energy consumption of refrigerators, in kWh per day, at four ambient temperatures – 10°C, 16°C, 32°C, and 43°C.

Notably, the degree that energy consumption increased with changes to ambient temperature varied widely across products.

For each product, daily energy consumption increased as ambient temperature increased. The average daily energy consumption at 32°C was 0.902 kWh/day, while the average daily energy consumption at 43°C was 1.505 kWh/day – a 67% increase.

Figure 1. Steady State Energy Consumption Overview

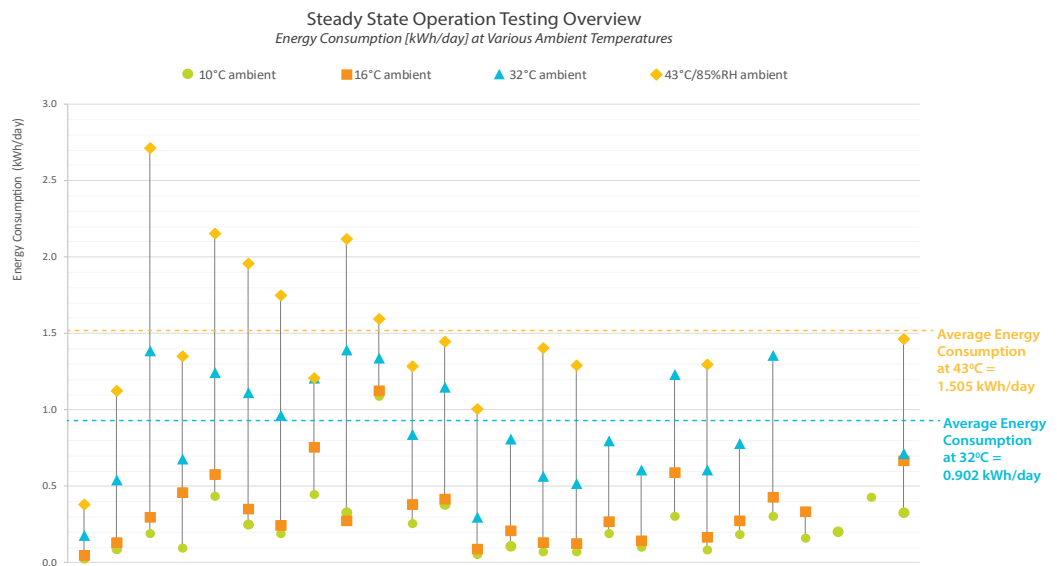
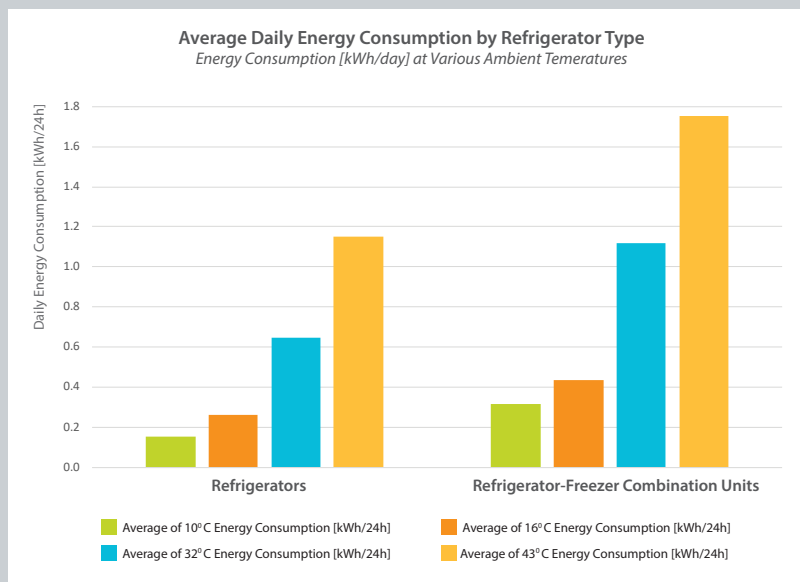


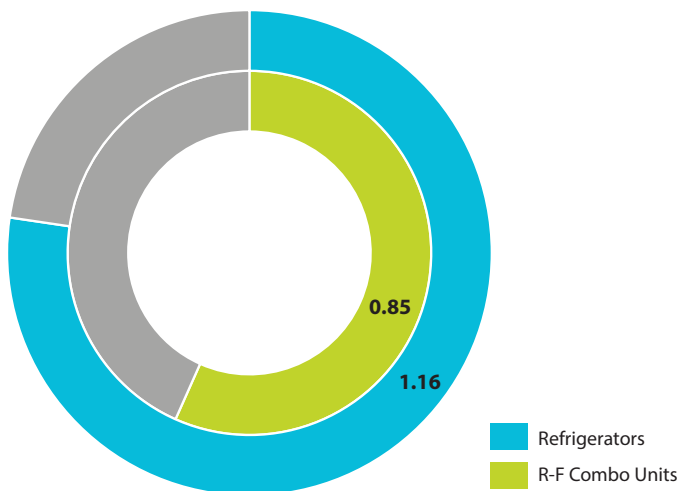
Figure 2. Average Daily Energy Consumption by Refrigerator Type



Refrigerator-freezer combination units on average consume 34-51% more energy than refrigerators, depending on the ambient temperature.

AUTONOMY

Figure 3. Autonomy by Refrigerator Type (hours)



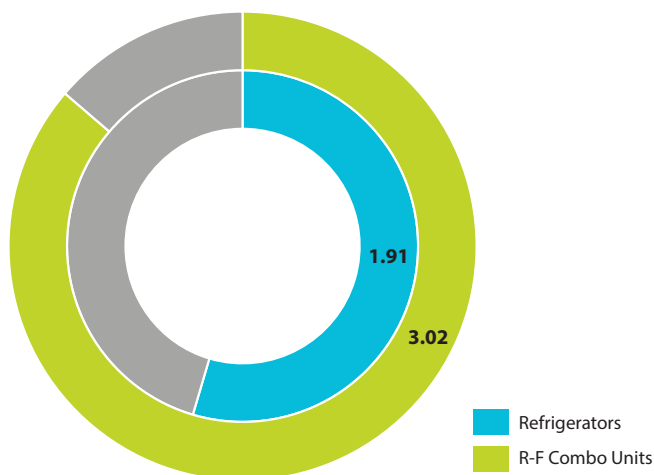
Autonomy — **the ability to keep a sealed refrigerator compartment cool without input of power** — is one of the most valued characteristics by consumers who live in off- and weak-grid environments and have highly constrained and/or intermittent electricity supply. The autonomy testing measured the number of hours it took a product’s internal compartment temperature to rise from 4°C to 12°C with no external power supply.

For all products tested, **autonomy hours range from 0.6 hours to 2.6 hours**, with the average value of autonomy being approximately 1 hour.

On average autonomy measures, refrigerators outperformed refrigerator-freezer combination units. The average refrigerator autonomy performance (hours) was 1.36 times longer than combination units.

PULL-DOWN TIME

Figure 4. Pull-Down Time by Refrigerator Type (hours)



Pull-down testing measured **the time required to lower the temperature of a refrigerator compartment from ambient temperature (32°C) to a desired cooling temperature (4°C)**. A shorter pull-down time means a refrigerator can cool a compartment to a target temperature faster.

Pull-down performance of tested refrigerators varied significantly. On average, the refrigerators took 2.67 hours to cool down to 4°C, with the lowest at 0.3 hours and the highest at 9.7 hours.

Refrigerators performed better than refrigerator-freezer combination units. On average, refrigerator-freezers required 1.21 more hours than refrigerators to pull down the compartment temperature and reach the targeted temperature.

