Lab Grade Refrigerators and Freezers Measure Package Development

Final Report

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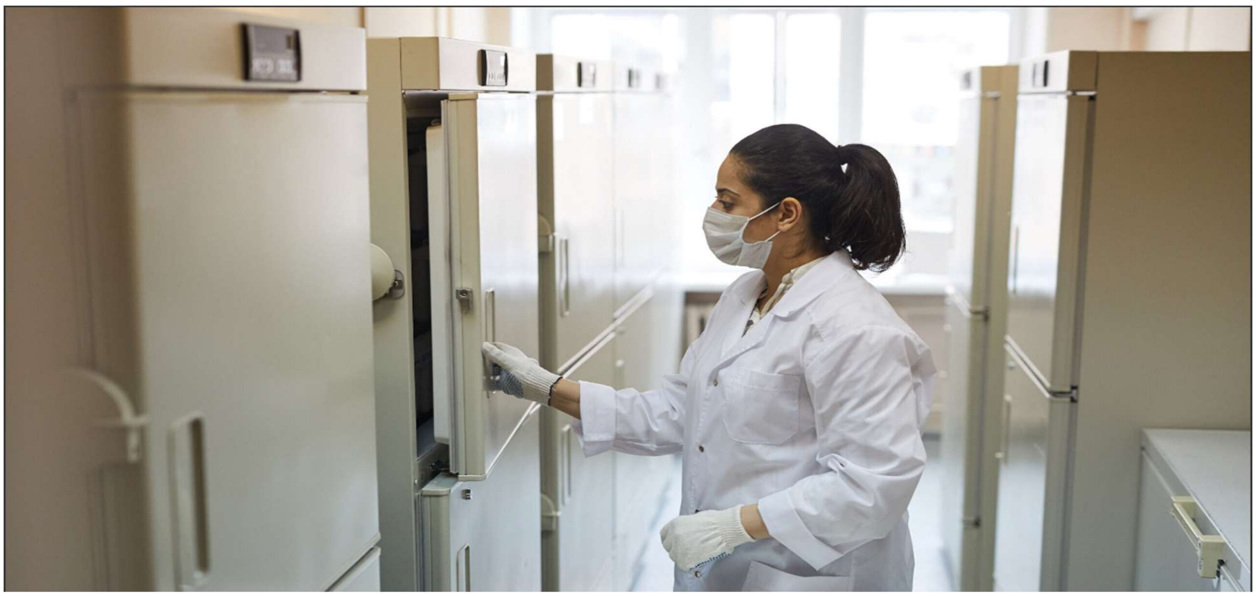

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Disclaimer

Executive Summary

The Lab Grade Refrigerators and Freezers Measure Package Development project aims to establish a new California (CA) electronic Technical Reference Manual (eTRM) Measure Package for the high-performance subset of the equipment defined by ENERGY STAR's® Laboratory Grade Refrigerators and Freezers Specification Version 2.0. The project included capturing baseline energy consumption data through onsite field equipment metering, conducting a market assessment, developing incremental measure cost values for the measure package, and submitting a measure package to the California Technical Forum (Cal TF) for affirmation.

Abbreviations and Acronyms

Acronym	Meaning
CA eTRM	California Electronic Technical Reference Manual
Cal TF	California Technical Forum
CPUC	California Public Utilities Commission
Ft^3	Cubic Feet
HVAC	Heating, Ventilation, and Air Conditioning
IOU	Investor-Owned Utility
kWh	Kilowatt-hour
LGE	Laboratory Grade Equipment
LGF	Laboratory Grade Freezer
LGR	Laboratory Grade Refrigerator
PG&E	Pacific Gas & Electric
SCE	Southern California Edison

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Introduction

Laboratory grade refrigerators (LGRs) and laboratory grade freezers (LGFs), together known as laboratory grade equipment (LGE), are critical for biotechnology, pharmaceutical, university, and healthcare research facilities, where they preserve valuable reagents and irreplaceable biological material. Once stocked with samples, they are rarely shut off, running 24 hours a day, 365 days a year with compressor duty cycles of 70 percent or greater, making them large energy consumers. This project focused on high-performance LGRs and LGFs, which are a subset of LGE designed for laboratory applications that require tighter temperature tolerances than general purpose LGRs and LGFs and offer more savings opportunities than general purpose units.

The COVID pandemic increased the visibility of ENERGY STAR® certified LGE equipment as an energy-saving measure, but ever-present research needs and growing biotech manufacturing and biobanking industries continue to expand the market. Advanced compressor technology, better insulation, use of hydrocarbon refrigerants, and thoughtful design have increased the energy efficiency of LGEs, providing an opportunity to influence the market through energy efficiency portfolio incentives. There is strong interest and support from lab equipment suppliers in being able to offer incentives for high-efficiency LGE to their customers. Adding a LGE measures to the existing ultra-low temperature (ULT) freezers measure offered through the investor-owned utility (IOU) incentive programs would provide a more comprehensive energy efficiency offering in the growing life science market.

Background

LGRs are used for storing non-volatile reagents and biological specimens at setpoint temperatures between 2 and 8 °C (35.6 and 46.4 °F) and are typically marketed through laboratory equipment supply stores for laboratory or medical use. The United States (U.S.) Environmental Protection Agency (EPA) ENERGY STAR Version 2.0 standard defines high-performance LGRs as units designed to support a maximum peak variation in temperature no greater than 6 °C.

LGFs are used for storing volatile reagents and biological specimens at setpoint temperatures between -50 and -15 °C (-58 and 5 °F) and are typically marketed through laboratory equipment supply stores for laboratory or medical use. The EPA ENERGY STAR Version 2.0 standard defines high-performance LGFs as units designed to support a maximum peak variation in temperature no greater than 10 °C.

There are no federal or state minimum energy efficiency standards for LGR or LGFs. ENERGY STAR certifies LGRs and LGFs based on a defined energy consumption metric performance test (kWh/day), compared with a maximum daily energy consumption (MDEC) threshold in kilowatt-hours per 24-hour period. There are prescriptive incentives available for LGRs and LGFs in six states — Michigan, New York, Massachusetts, Wisconsin, Rhode Island, and New Hampshire — with an estimated gross annual kWh per unit savings ranging from 1,403 to 2,552 kWh for LGRs and 1,608 to 2,596 kWh for LGFs, depending on size.

Objectives

The project's overall objective is to support the inclusion of LGRs and LGFs in California utility rebate programs. The project assessed the market opportunity and used the ENERGY STAR Laboratory Grade Refrigerators and Freezers Specification Version 2.0 as guidance for equipment efficiency qualification and size categories to develop a measure package for the California electronic Technical Reference Manual (eTRM). The project estimated the market size of LGRs and LGFs in California, calculated the per-unit energy savings for each measure, collected baseline energy consumption data through field monitoring or data collection from existing monitoring systems, conducted incremental measure cost analysis to understand the cost differential between standard and high-efficiency equipment, assessed the effect of new refrigerant regulations, and submitted a deemed measure package to the California Technical Forum (Cal TF).

Methodology and Approach

Energy Solutions developed and submitted a California eTRM measure package to Cal TF, based on the data and analysis conducted in this scope. The project team recommends aligning LGE categories and efficiency requirements with the final draft specification that EPA ENERGY STAR released for high-performance LGRs and LGFs on August 29, 2024. This Version 2.0 Laboratory Grade Refrigeration and Freezers Specification has an effective date of June 30, 2025.[1]

1. **Market Size Estimates of LGE:** Energy Solutions interviewed LGE equipment manufacturers and distributors to gather sales and cost data that supported the market characterization and incremental measure cost studies. This analysis considered the growing needs of key sectors, such as biotechnology, pharmaceutical, healthcare, government, retail healthcare, and academic research laboratories, all of which require reliable and energy-efficient cold storage solutions. Refrigerant regulations and their effects on LGE development were also discussed. Findings support the market characterization and incremental measure cost studies.
2. **Site Recruitment:** Energy Solutions leveraged both local and national relationships in the life sciences industry to help recruit sites to meter the energy consumption and operational parameters of LGE in California. The project team reached out to LGE equipment operators, such as facilities engineers, to gain access to their facilities to monitor their LGE or access data from existing monitoring equipment. The project's goal was to install data loggers on at least eight LGRs and LGFs. This activity provided data to determine a working baseline of energy usage and efficiency and enable energy savings analysis and comparison to efficient equipment.
3. **Baseline equipment monitoring:** The project team employed two energy monitoring methods in the study. The first involves using a plug-load meter, which is installed by temporarily unplugging the refrigeration unit and then plugging the unit in through the plug-load meter.

[1] For details, see EPA ENERGY STAR Final Draft Version 2.0 Laboratory Grade Refrigeration and Freezers specification.

The second method uses individual energy loggers installed in the electrical panel that do not require unplugging units. This option was developed after feedback from the market showed that some customers are hesitant to interrupt the power supply to their units. Specifically, the project team was informed by multiple potential monitoring partners that the initial metering method (i.e., momentarily shutting off power supply to attach meters) would be unacceptable, due to the sensitivity of high-value specimens to slight temperature changes and concerns that compressors on older equipment would not restart. With both monitoring options, additional loggers were installed in the facilities and equipment to capture temperatures and events such as door openings.

In some cases, existing monitoring data exists or can be captured from the participant site's remote monitoring subscription service. These services utilize the same technology, which consists of Wi-Fi modules (motes), sensors, and software used by the third party contracted to do the baseline energy consumption monitoring on this project and capture the same data points. Participant-provided data that met the monitoring scope requirements was curated and included in the analysis. Monitoring data points include:

- Power (amperage and voltage)
- Ambient temperature
- Internal unit temperature
- Door openings

Remote monitoring services have long been prevalent in the research industry, primarily for temperature tracking. As energy consumption becomes another common metric for monitoring, it is worthwhile to note the opportunities for future long-term studies that existing data can provide. Gathering existing data would circumvent the hurdles of onsite metering, and further research into its efficiencies and cost-savings potential is recommended.

4. **Energy Savings Analysis**: Considering the upcoming ENERGY STAR Laboratory Grade Refrigerators and Freezers Standard Version 2.0, the project team is using the size of the qualifications from the new standards, and a blended baseline to calculate energy performance. This methodology blends standard efficiency data collected for this project with performance test data from units that meet the current ENERGY STAR Laboratory Grade Refrigerators and Freezers Standard Version 1.1 qualifications but do not meet the Version 2.0 standards. This presents a more accurate comparison for baseline high-performance LGE. The savings analysis was used to provide deemed savings values for measure package development.
5. **Incremental Measure Cost Analysis:** The project team has compiled and reviewed incremental measure costs for the proposed LGF and LGR measure offerings to ensure accurate cost-effectiveness evaluations.
6. **Measure Package Plan Development and Submission for IOU consideration:**

The project followed the Cal TF process for submitting and approving measure packages. The Cal TF website provides details on each step of the process.[1] An overview of the process is listed below:

1. Submit measure package plan to Pacific Gas and Electric (PG&E) for submittal to the California Public Utilities Commission (CPUC) — Energy Solutions
2. Submit measure proposal to Cal TF — Energy Solutions
3. Measure proposal approval — Cal TF
4. Complete draft measure package — Energy Solutions
5. Measure review — Cal TF
6. Measure affirmation — Cal TF
7. Submit measure for CPUC approval — PG&E

Once the Cal TF approves the measure for development, they will generate a blank measure packet shell in the eTRM. Energy Solutions will update the packet with the necessary measure package data. When complete, the Cal TF will review the measure packet for completeness and adherence to eTRM standards. Energy Solutions will resolve any requested edits from the Cal TF. Once the review and affirmation are complete, PG&E, the lead IOU for this measure, will take assignment of the measure packet in the eTRM and submit it to the CPUC for the last step in the measure development process.

PG&E will manage responses to comments, edit requests, or questions from the CPUC review committee. Once the measure package is approved by the CPUC, the measure will be published and publicly accessible in the eTRM.

Findings

Market Characterization

LGRs and LGFs share the same market space as ULT freezers, but their function in biopharma, university research, and healthcare environments is for short-term temperature stability of samples, reagents, biological products, and medicines during experimental or clinical work, rather than long-term storage. Differentiated by their temperature ranges, LGRs are designed to contain non-volatile materials between 2 and 8 °C; LGFs maintain temperatures from −50 to −15 °C for volatile materials, according to ENERGY STAR Version 2.0, which then divides LGFs and LGRs into 'high performance' or 'general purpose' categories. They are also categorized by application or safety needs, such as blood bank, chromatography, vaccine, pharmacy, standard, explosion proof, and flammable materials. Each manufacturer uses different marketing terminology to describe their tiered product offerings, from no-frills units to models with touchscreen displays and Wi-Fi (e.g., basic, premiere, performance). As a result, energy efficiency has not been a defining feature in the market.

Market Actors and Supply Chain

Approximately 41 LGE manufacturers produce more than 760 LGR models, and 29 LGE manufacturers produce more than 200 LGF models, both ranging in size from three cubic foot undercounter models to large free-standing units over 78 cubic feet in size.

There are two very large laboratory equipment and supplies distributors that sell LGE to customers nationwide: Fisher Scientific, which is owned by Thermo Fisher Scientific, and VWR, which is owned by Avantor. In addition to VWR and Fisher Scientific, there are many national, independently owned distributors such as Thomas Scientific and MIDSCI, and local dealers such as Lab Equipment Company and Discovery Scientific.

LGE is rarely stocked in distributor warehouses, due to logistics concerns and shipping expenses. Rather, the equipment is configured to spec by the manufacturer or pulled from a manufacturer warehouse, then drop-shipped directly to customers or delivered via white-glove services that install the units directly into customer facilities.

Sales and Shipment Data

The project team estimates the California market for LGRs and LGFs was approximately $136 million in 2023.[2] According to industry sources, the San Francisco and San Diego markets represent 60 to 70 percent of the California LGE market. The values in Table 1 provide the estimated numbers of units in the field and the annual sales estimates in California. The market penetration rate for ENERGY STAR units is currently unknown, but estimates suggest as much as 55 percent of units sold under the Version 1.1 specifications are certified units. The new Version 2.0 specifications, which go into effect in June 2025, will remove about 55 percent of the high-performance units on the qualified products list today.

[2] U.S. Biomedical Refrigerators and Freezers Market Report, 2032 (gminsights.com)

Table 1: California Laboratory Grade Equipment Inventory and Annual Sales*

Category	Size Category	Fielded Market (Units)	Est. 2024 Unit Sales
Lab Grade Refrigerators	0 < V < 20	6,650	1,040
	20 ≤ V < 44	14,300	2,230
	44 ≤ V	18,200	2,840
Lab Grade Freezers	0 < V < 15	920	140
	15 ≤ V < 30	24,100	3,770
	30 ≤ V	2,460	380

Source: Market intelligence

*Please note: LGR size category is for solid door units whose small- and medium-size buckets are 0 < V < 20 and 20 ≤ V < 44. Transparent door size buckets are 0 < V < 10 and 10 ≤ V < 44, respectively, but market intelligence provided inventory and sales numbers for both solid and transparent door units in the 0 < V < 20 and 20 ≤ V < 44 ranges.

Standard Efficiency Laboratory Grade Refrigerators and Freezers: While conducting market research for this report, the project team identified a number of factors hindering the adoption of energy-efficient, high-performance LGE, including:

- The prevalence of commercial grade and consumer grade cold storage for non-critical applications.
- All manufacturers producing energy-efficient models continue to offer standard-efficiency LGE because there is still a market for low-upfront cost equipment.
- There are six manufacturers that do not offer energy-efficient models competing for market share against generally more expensive ENERGY STAR-certified units.
- The number of distributors selling standard-efficiency LGE is higher than expected, with three based in California and 21 more as online retailers.

Refrigerants Overview

Refrigerants are an important consideration for laboratory cold storage equipment. After the phase out of chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants,[3] hydrofluorocarbons (HFCs) were the dominant refrigerant used in ULT freezers, LGFs, and LGRs.

In response to the American Innovation and Manufacturing Act of 2020, LGE manufacturers adopted natural and low-global warming potential (GWP) refrigerants in their product lines with GWP ratings

[3] See Phasedown of Hydrofluorocarbons: Management of Certain Hydrofluorocarbons and Substitutes Under the American Innovation and Manufacturing Act of 2020.

well below the phase-in requirements issued by the EPA in 2023. These requirements specify refrigeration and cooling units with final effective dates depending on equipment type, such as industrial process cooling, stand-alone refrigeration for retail food, and cold warehouses.[4] While LGRs are not specifically addressed in the regulations, the EPA issued guidance to LGE manufactures to select a "best fit" equipment category, meet the associated regulations by the specified effective date, and be prepared to defend their response.

Most LGE manufacturers currently employ hydrocarbon (HC) gas mixtures, typically ethane and propane, which have with very low GWP ratings. This technology has improved efficiency by up to 30 percent over the conventional CFC- or HFC-gassed freezers. Table 2 provides a list of refrigerants commonly used in ENERGY STAR LGRs and LGFs.

Table 2: ENERGY STAR Refrigerant Listings — Sept 9, 2024

High-Performance Lab Refrigerators	High-Performance Lab Freezers
R-290 (GWP:3)	R-290 (GWP:3)
R-600a (GWP:3)	R-600a (GWP:3)
R-744 (CO2)	R-404A (GWP:3920)
R-513A (GWP:630)	
R-404A (GWP:3920)	

Source: ENERGY STAR qualified products list

Baseline Equipment Monitoring

Identification of sites for equipment monitoring overlapped with a similar concurrent CalNEXT project, "Large Ultra-Low Temperature Freezer Measure Offering," which monitored equipment in the ULT freezer category. Temperature differentiates LGE equipment from ULT freezers, but the same sites use each type of equipment, so the effort of selecting sites was consolidated.

Energy Solutions leveraged local and national relationships with manufacturers and distributors in the life sciences industry to assist with the recruitment of sites to monitor LGE energy consumption. This engagement helped to create interest and support for the add a new measure offering and laid the groundwork for some eventual data collection, but local distributors and manufacturers' representatives ultimately did not have the motivation to assist with site recruitment.

The project team determined that a participation incentive would have been beneficial for site recruitment. Allies from all areas of the supply chain volunteered large amounts of time considering

[4] See for example, https://www.cityfm.us/blog/new-epa-refrigerant-regulations/#b.

the team's requests, making introductions, going through data, and meeting with the project team. A stipend or other immediate incentive would have influenced LGE distributors or monitoring service representatives to participate in locating sites for monitoring. Manufacturers were more amenable because they can model how a potential utility rebate program would aid sales of energy- efficient LGE's in the future. However, an incentive would likely have resulted in faster turnaround times and increased interest. Direct outreach to potential monitoring sites was the most effective tactic, as many participants were able to easily provide energy usage data from their existing monitoring systems. They also saw value in having an outside engineering firm perform the metering, as they did not have the internal bandwidth to perform.

Identifying and selecting equipment for monitoring faced several hurdles. Equipment nominated for metering was limited by its physical location at each site. Some units that fit project parameters were inaccessible because they are being used in clean rooms, restricted manufacturing labs, or high-level biosafety facilities. Additionally, the sensitivity and values of the materials housed in the LGRs and LGFs created difficulties in monitoring the equipment. In some cases, internal temperature logging was prohibited because outside materials or equipment were not allowed inside the LGEs, which can house product worth $500,000 or more. Facilities were also concerned with unplugging the power supply to their units due to the sensitivity of high-value specimens to slight temperature changes and concerns that compressors on older equipment would not restart. The materials are of such value that, in one facility, four operational but empty units are used as immediate emergency backup to the nine stocked units storing millions of dollars' worth of samples. Ultimately, units were selected that could be unplugged, but this issue highlighted the difficulty of metering LGE.

One facility allowed the project team access to their buildings to meter equipment. The monitoring location is a biopharma research facility located in Southern California where three LGF units were monitored. Another facility considered monitoring but ultimately could not get the monitoring agreement filled out by management within the project timeline. Data captured from the monitoring site includes:

- Energy consumption
- Ambient temperature
- Door openings

When internal temperature cannot be captured with external equipment due to the sensitivity of the materials inside, data from the site's temperature monitoring systems were aggregated with the other data points collected by loggers.

The following list summarizes potential participants Energy Solutions engaged that were unable to comply with the fast-track timeline for metering:

- A San Diego hospital system's medical lab.
- An Oakland-based integrated managed care consortium.
- A large biotech company with a sustainable science focus.

- A sustainability director from a multi-campus university system attempted to recruit participation from the campus research labs and various stakeholders but noted a lack of bandwidth to continue following up.
- Two international laboratory sustainability organizations agreed to assist our efforts by introducing the project team and socializing our request to their local California membership. It did not generate any interest, unfortunately.
- A biotechnology company strongly considered our request for information but could not get a monitoring agreement signed by their management within the project timeline.

Existing Monitoring System Data

The project team's knowledge of the research market's usage of remote monitoring systems prompted their outreach requests to include both onsite equipment metering and sharing of data as an alternative to metering. Sharing data was a better alternative for potential participants that wanted to support the growth of energy-efficient equipment but viewed unplugging their LGE as a dealbreaker. The following list summarizes participants Energy Solutions engaged that generously shared existing data:

- A biopharmaceutical research facility shared a year's worth of data from their monitoring system.
- A large lab equipment manufacturer that also provides metering and monitoring services shared a large dataset of LGE energy consumption data from CA laboratory sites.

Energy Savings Analysis

ENERGY STAR Specification Update

During this project, new ENERGY STAR draft updates were released which include the final criteria for Lab Grade Refrigerators and Freezers Version 2.0. The final criteria contain new size categories and efficiency standards for LGRs and LGFs. This change in criteria caused the project team to reanalyze the measure package to evaluate aligning with ENERGY STAR on size offerings and qualifications, which also aligns with market preference. The project team analyzed the available data to assess the number of data points in each size category and their ability to calculate savings estimates for each grouping. Based on this analysis, there were several data gaps, but were able to fill most gaps with monitoring data and determined there was sufficient data to proceed with the ENERGY STAR size offerings. Appendix AError! Reference source not found. provides details on the ENERGY STAR Laboratory Grade Refrigerators and Freezers Version 2.0 Specification minimum efficiency requirements.

Data Collection and Analysis

The project team collected and consolidated data from four sources to provide sufficient data to calculate deemed savings values for the measure package. Data was collected from the ENERGY STAR data set used to develop the new standard, stakeholders' monitoring data noted in the Existing Monitoring System Data section above, energy monitoring at sites noted in the Baseline Equipment Monitoring section above, and the ENERGY STAR qualified products list.

Energy Savings Methodology

The formula for calculating annual unit savings is provided in Equation 1 below. The daily kilowatt hour (kWh) consumption figures were averaged from the available data set for input variables for baseline- and high-efficiency units in each size category. The difference between the baseline and measure case in each size category was then multiplied by the total number of assumed operational days to achieve kWh savings per year. General purpose refrigerators and freezers were not included in the measure, as savings are low for those equipment categories and there is less data available for general purpose laboratory grade refrigerators and freezers than for high performance units.

$$(AVG(ENERGY\ STAR\ v1.1\ ,Monitoring\ Data) - AVG(ENERGY\ STAR\ v2.0)) * 365\ Days = kWh\ Savings/\ Year$$

Equation 1: Annual Unit Savings Formula

Baseline Efficiency

The baseline efficiency is blended efficiency of the site monitoring data and units that qualify for ENERGY STAR Lab Grade Refrigerators and Freezers Specification v1.1 but do not meet the measure efficiency requirements. Table 3 provides baseline efficiency values for each measure category.

Table 3 Laboratory Grade Refrigerator and Freezer Baseline Efficiency

Product Category	Attributes	Size Category	Average Volume (ft³)	Baseline Average kWh/day
Laboratory Grade Refrigerators	High Performance — Solid Door	0 < V < 20	8.95	1.58
		20 ≤ V < 44	27.24	4.72
		44 ≤ V	57.42	9.29
	High Performance — Transparent Door	0 < V < 10	5.27	1.64
		10 ≤ V < 44	22.15	4.42
		44 ≤ V	52.91	8.15
Laboratory Grade Freezers	High Performance — Manual Defrost	0 < V < 15	7.23	2.23
		15 ≤ V < 30	23.65	5.14
		30 ≤ V	30.00	9.25
	High Performance — Automatic Defrost	0 < V < 15	6.44	4.39
		15 ≤ V < 30	22.89	11.88
		30 ≤ V	48.02	13.86

Measure Efficiency

The measure case efficiency is the average efficiency of current ENERGY STAR qualifying products that meet the Lab Grade Refrigerators and Freezers Specification v2.0. Table 4 provides baseline efficiency values for each measure category.

Table 4 Laboratory Grade Refrigerator and Freezer Measure Efficiency

Product Category	Attributes	Size Category	Average Volume (ft³)	Measure Average kWh/day
Laboratory Grade Refrigerators	High Performance — Solid Door	0 < V < 20	8.95	0.69
		20 ≤ V < 44	27.24	1.52
		44 ≤ V	57.42	3.26
	High Performance — Transparent Door	0 < V < 10	5.27	0.60
		10 ≤ V < 44	22.15	1.93
		44 ≤ V	52.91	3.78
Laboratory Grade Freezers	High Performance — Manual Defrost	0 < V < 15	7.23	1.15
		15 ≤ V < 30	23.65	2.89
		30 ≤ V	30.00	4.00
	High Performance — Automatic Defrost	0 < V < 15	6.44	2.16
		15 ≤ V < 30	22.89	5.53
		30 ≤ V	48.02	8.00

Measure Qualification

The qualification for this measure is defined by the Maximum Daily Energy Consumption Requirements of the ENERGY STAR Lab Grade Refrigerators and Freezers Specification v2.0. Table 5 provides the formula to calculate the qualifications for each measure category. In this formula, V equals the volume of the model being assessed in cubic feet. For example, a high-performance, solid-door lab grade refrigerator with a volume of 19 cubic feet must consume less than 1.14 kWh/day (0.01*19 +.95).

Table 5 Laboratory Grade Refrigerator and Freezer Minimum Qualifying Efficiency

Product Category	Attributes	Size Category (ft^3)	Maximum Daily Energy Consumption (kWh)
Laboratory Grade Refrigerators	High Performance — Solid Door	$0 < V < 20$	$\leq 0.01V + 0.95$
		$20 \leq V < 44$	$\leq 0.07V - 0.25$
		$44 \leq V$	$\leq 0.056V + 0.04$
	High Performance — Transparent Door	$0 < V < 10$	$\leq 0.1V + 0.55$
		$10 \leq V < 44$	$\leq 0.06V + 1.08$
		$44 \leq V$	$\leq 0.14V - 2.48$
Laboratory Grade Freezers	High Performance — Manual Defrost	$0 < V < 15$	$\leq 0.08V + 1.0$
		$15 \leq V < 30$	$\leq 0.12V + 0.4$
		$30 \leq V$	≤ 4.0
	High Performance — Automatic Defrost	$0 < V < 15$	$\leq 0.18V + 1.0$
		$15 \leq V < 30$	$\leq 0.28V - 0.5$
		$30 \leq V$	≤ 8.0

Source: ENERGY STAR Program Requirements Product Specification for Laboratory Grade Refrigerators and Freezers Eligibility Criteria Version 2.0

Savings Results

Table 6 provides annual savings estimates for high performance laboratory grade refrigerators and freezers using the ENERGY STAR Lab Grade Refrigerators and Freezers Specification v2.0 measure categories.

Table 6 Lab Grade Refrigerator and Freezer Annual Energy Savings per Unit

Product Category	Attributes	Size Category	Total Annual kWh Savings	Demand Savings (kW)
Laboratory Grade Refrigerators	High Performance – Solid Door	0 < V < 20	323	0.033
		20 ≤ V < 44	1,166	0.120
		44 ≤ V	2,202	0.226
	High Performance – Transparent Door	0 < V < 10	377	0.039
		10 ≤ V < 44	911	0.094
		44 ≤ V	1,596	0.164
Laboratory Grade Freezers	High Performance – Manual Defrost	0 < V < 15	375	0.038
		15 ≤ V < 30	820	0.084
		30 ≤ V	1,916	0.197
	High Performance – Automatic Defrost	0 < V < 15	816	0.084
		15 ≤ V < 30	2,317	0.238
		30 ≤ V	2,140	0.220

HVAC Interactivity Analysis

HVAC interactive effects were not calculated for this measure due to a few factors. Unlike ultra-low temperature freezers, there has not been a study done on the HVAC interactive effects from LGE. Additionally, the only other research on the effects of refrigeration on HVAC system involved residential units, which are not applicable to LGE or the commercial HVAC systems in the building in which they are housed. Finally, energy consumption and savings from installing high efficiency units, which is used in the ULT study are not as large with LGE as with ULTs. Small savings results in smaller interactive effects on HVAC systems to a point where the calculated HVAC savings are questionable whether the values could be distinguished as influencing the energy use of a commercial HVAC system. For instance, using the ULT study's modeling methodology, the <20 ft3 solid door refrigerator would save approximately 60 kWh/year on an HVAC system that was modeled to use nearly 300,000 kWh a year. Adding HVAC interactivity to the LGE savings estimates would add unnecessary permutations to the eTRM for values that cannot be validated.

Incremental Cost Study

LGR and LGF retail pricing data can be difficult to obtain due to the sales channel, which is primarily through distributors and limits publicly available pricing data for this equipment. Additionally, the pricing on an individual unit can vary greatly based on purchasing agreements and discount rates provided to distributors from the manufacturers, which is not apparent through online dealers. Data was collected on LGE in quarter three of 2024 via manufacturer outreach and retail pricing data from web scraping of laboratory equipment retailers. Additionally, data collected from Energy Solutions' existing LGE midstream programs on ENERGY STAR qualified models was used to provide real world pricing and to help understand discount factors to calculate retail prices from manufacturer list pricing, including baseline equipment. Costs were not normalized per cubic foot because there is not a strong correlation between size and unit price. The data was aggregated and grouped by size offering to calculate an average retail cost for baseline and measure case LGEs. The difference between measure case and baseline cost is the incremental measure cost.

To represent actual incremental measure costs accurately, a sufficient number of unit prices is needed for each of the 12 individual types of lab grade refrigerators and freezers. Energy Solutions reviewed pricing on nearly 300 units to encompass all configurations of LGRs and LGFs for efficiency, size, door type, and freezer defrost type.

Table 7 and

Table 8 provide the incremental measure cost for lab grade refrigerators and freezers.

Table 7 Lab Grade Refrigerator Incremental Measure Costs

Refrigerator Type	Size (ft³)	Baseline Average Cost	Measure Average Cost	IMC
Solid Door Refrigerator	0 < V < 20	$2,246	$2,512	$266
	20 ≤ V < 44	$7,038	$7,510	$471
	44 ≤ V	$8,329	$9,137	$807
Transparent Door Refrigerator	0 < V < 10	$2,430	$2,683	$253
	10 ≤ V < 44	$6,418	$6,854	$436
	44 ≤ V	$10,393	$11,007	$614

Table 8 Lab Grade Freezer Incremental Measure Costs

Freezer Defrost Type	Size (ft^3)	Baseline Average Cost	Measure Average Cost	IMC
Manual Defrost Freezer	0 < V < 15	$1,771	$2,103	$332
	15 ≤ V < 30	$5,310	$6,042	$732
	30 ≤ V	$9,516	$10,396	$880
Automatic Defrost Freezer	0 < V < 15	$3,348	$3,695	$347
	15 ≤ V < 30	$7,857	$8,719	$862
	30 ≤ V	$9,516	$10,396	$880

Recommendations

- Data shared with the project team showed there is an aging population of LGE still plugged into the grid. Although this falls outside the scope of this project, this inventory offers an opportunity to analyze equipment lifecycle, the existing market inventory, and the potential of an early retirement program.
- LGE presents a unique opportunity, as a large number of units are currently connected to monitoring systems that collect energy use, temperature, and other data points. The IOUs should leverage data from stakeholders' connected monitoring systems to conduct additional and long-term research on LGE energy use, expected useful life, and deterioration of efficiency.
- The complexity and sensitivity of life sciences stakeholders requires that project engagement provide long lead times to coordinate and work within the bandwidth of their facilities and research teams. At least nine months should be planned for stakeholder outreach and engagement, followed by an additional nine months for project implementation in collaboration with stakeholders.

Appendix A: Supplemental Information

ENERGY STAR® Program Requirements