THERMAL ENERGY STORAGE AND PHASE CHANGE MATERIALS

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Partnering with Wisconsin utilities

Original Request

Thermal energy storage (TES), phase change materials. We're interested in applications for both larger scale refrigerated storage as well as smaller scale convenience stores/grocery stores. Given our service territory, there may be more applicability in smaller facilities.Trying to figure out if there are efficiency opportunities since this is a massively energy -intensive operation.

kWh savings come from operating the compressors fully loaded (more efficiently) for fewer hours vs. at partial load more continuously. From a customer/utility perspective, there can be opportunities for demand control to reduce peak demand and for more consistent temperatures throughout the storage space.

Points for Response

How can Focus Help?

- Load shifting projects are eligible for custom incentives under Focus on Energy, provided that they result in a net reduction in energy use (Custom Incentives Overview).

Incentive Rates

Energy Efficiency (1-10 year payback)	Incentive Limit per Project
$100 per peak kW*.	The lesser of $300,000, 50% of project cost, or capped at a one-year payback.
$0.05 per kWh saved.	
$0.95 per Therm saved.	

**Peak kW reduction is determined by the average kW load reduction or generation occurring between 2 p.m. and 6 p.m. on weekdays during June, July, August, and September.*

Response to Requests

Disclaimer: We want to be clear that we're presenting this information without making recommendations.

We're interested in applications for both larger scale refrigerated storage as well as smaller scale convenience stores/grocery stores.

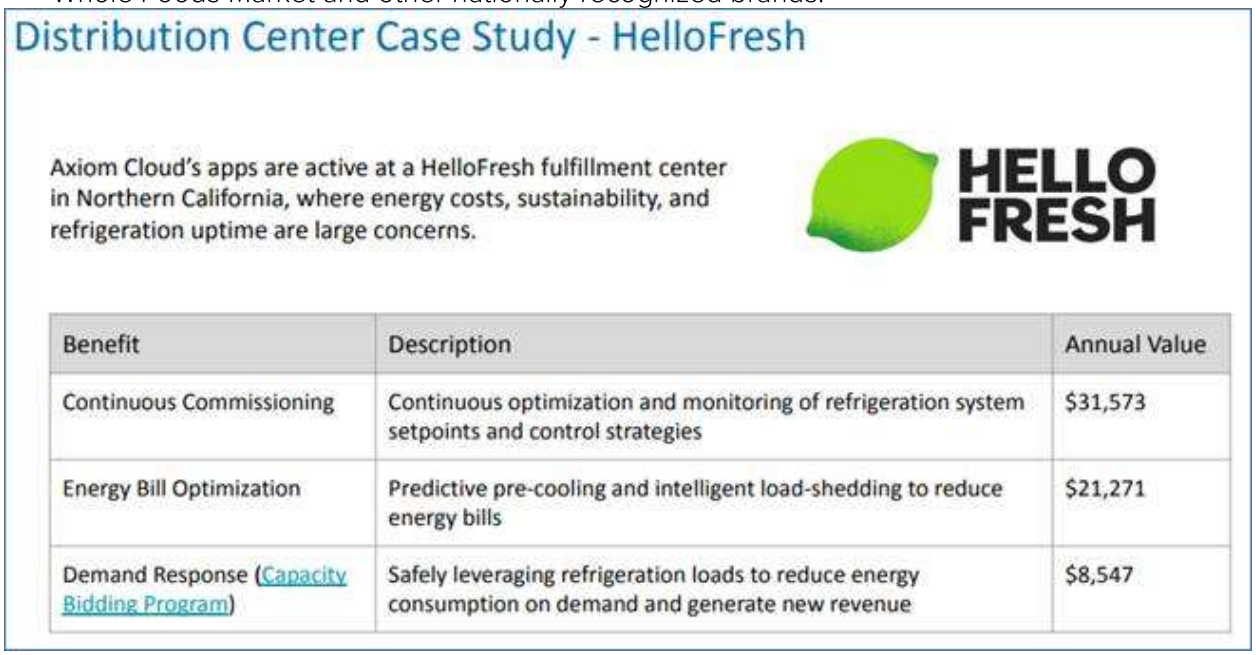
Here is a summary of the information that we could locate regarding refrigeration energy storage.

- Refrigeration Thermal Energy Storage Research (ComEd, MN Dept. of Commerce) - This joint research is supported by ComEd and MN Department of Commerce. *"Refrigeration thermal energy storage (RTES) is an emerging technology which presents an opportunity to save energy and reduce or shift peak demand in refrigerated facilities. This can lead to both energy savings and greater resilience. However, how much energy these technologies can save—and how they can be supported by energy efficiency programs—requires additional study, especially in cold climates."* Slipstream presented on the Phase I findings in July of 2022 (slides and video). Phase I found static thermal mass and phase change materials to be the most promising thermal storage technology (link). The linked presentation includes content from Axiom Cloud and Viking

- Cold Storage (mentioned later in this email). This research is currently in Phase II Field Testing & Demonstration phase in ComEd territory and Minnesota.

Strategy	Payback	Types of refrigeration	Ideal building type
Static thermal mass	Lowest simple payback	Freezers only	Large industrial cold storage facilities
Phase change material	Higher initial cost	Freezers + coolers	Smaller buildings (i.e. grocery stores)
External storage	Significant payback time	Freezers + coolers	Facilities that can afford high upfront installation costs

- Axiom Cloud's Virtual Battery Program Provides Static Thermal Mass ("flywheeling") in Grocery Applications - National Grid, the Rhode Island Office of Energy Resources, and Axiom Cloud are partnering to research the potential for precooling grocery store refrigeration systems (using frozen inventory as thermal mass), supported by EERE under the Buildings Technology Office Award Number DE-EE0009464. *'The concept is called load shifting. In this case, supermarkets will shift their high energy use to just before and after a peak demand event. "The idea is that when stores would be normally participating in a peak load event — a hot summer day when the energy supply of the grid might be driven more by fossil fuel generators — this platform would allow those stores to avoid consuming power," Halik said. "They could shift that load because they've pre-cooled their freezers in advance."'* This program helps customers participate in demand response programs.
    - This application has other programs that benefit its customers (continuous commissioning, energy bill optimization). See
    - Axiom Cloud is now in use at 80+ Grocery Outlet locations. Other Axiom Cloud customers include Existing customers include Sprouts Farmers Market, HelloFresh, Whole Foods Market and other nationally recognized brands.



- Phase Change Materials (PCMs) Thermal Storage in both Small and Large Applications – Viking Cold Solutions is the only provider of PCM thermal energy storage in refrigeration applications. In addition, to large refrigerated applications, they have a grocery freezer case study that

claimed an 85% (5 kW) reduction in demand over a 13-hr peak window (8:30a – 9:30p). There's some indication that they may have other installations, but I've not found any reports on their results.
    - While load shifting has generally increased energy usage, PCM thermal storage seem likely to lower energy usage through the following mechanisms: 1) operating at night during cooler ambient conditions (less compressor work), 2) operating the compressors at full-load capacity (best efficiency point) more often, and 3) there is no need to cool below normal temperatures like traditional ice storage systems. Viking Cold also requires that continuous commissioning type measures such as reducing defrost cycles, closing doors and other things found by monitoring space and plant conditions.
        - The technology appears to work. The mechanism of action doesn't disturb any laws of physics or chemistry.
        - The technology can optimize pure peak demand, load leveling, load shaving, demand response, or energy efficiency. It cannot maximize all of these at the same time. The specific application will dictate what energy features can or should be optimized to provide the best ROI and operational characteristics.
        - The technology is more likely to be cost-effective in larger installations. Costs per kW decrease as project size increases.
        - Viking Cold promotes a business model using operation leases as a key feature - "no money out-of-pocket." Focus on Energy can provide incentives for projects that involve capital leases but they require pre-approval prior to initiation or execution of the lease.
    - Field-Testing PCM in Cold Storage Applications - Southern California Edison (SCE) conducted field testing to evaluate the energy savings and Demand Response (DR) potential of passive PCMs and supplemental controls in cold storage freezer applications (full report). Conclusions:
        - adding PCM to the freezer reduced its energy consumption by 19%,
        - supplemental controls and a load-shape DR strategy increased annual energy savings to 25%.
        - results show benefits associated with installing PCMs and supplemental controls in freezers
        - Load-shed test results were not impacted by events on consecutive days
    - Xcel Energy (MN) Dynamic Thermal Storage Program – Xcel MN is encouraging PCM used for refrigeration load shifting. From website: "*Thermal energy storage involves cooling previously stored "phase change material" (PCM) that can then be used when needed. This allows stored energy to cool your facility or refrigeration system at peak times of the day when energy is the most expensive and has the most carbon emissions. The system will then recharge at off-peak times when energy is cleaner and less expensive.*"
        - Incentives = 10% of your project cost, plus you'll receive another 5% of the project cost annually as long as load shifting is performed.

- Traditional Ice Storage Systems – San Diego Gas & Electric (SDG&E) conducted field testing on ice storage in commercial grocery applications. (*Grocery Store Thermal Energy Storage Retrofit Study, 2021*) *"The goal of this Emerging Technologies study was to determine the load shifting potential of salt-water ice thermal energy storage systems installed as a retrofit on an existing grocery store refrigeration system. This report presents findings from the field test of a new refrigeration ice storage system at a 46,000 square foot grocery store. At this store, the ice storage system was installed as a retrofit on the existing medium temperature refrigeration system, which accounts for approximately 20% of the store's annual electric energy consumption. The store's medium temperature refrigeration system serves a combination of walk-in coolers, reach-in and coffin refrigerated cases, and a low temperature compressor rack sub-cooler."* Here is a summary of the conclusions:

- The vendor estimated a 75 kW demand reduction, while this installation showed ~20 kW demand reduction. This failure to meet expectations may be due to the smaller size of this grocery store.
- Chemical batteries may have a more attractive payback, smaller footprint, and less O&M.
- This technology is best suited for stores with a floor area of at least 100,000 ft^2.

There are number of vendors that provide thermal storage via ice production.

- CALMAC/Trane IceBank
- Baltimore Air Coil (BAC) Ice Storage Systems
- Nostromo IceBrick