TIP 307: Pilot Testing Demand Response for Retail Supermarkets

Context

Historically, the primary driver of supermarket refrigeration design has been to keep refrigerated display cases sufficiently cold to preserve perishable items. More recently, driven by energy costs and corporate sustainability initiatives, energy efficiency (EE) has become a key consideration.

Over the past 10 years, the implementation of advanced metering infrastructure and centralized building energy management and control systems has allowed automation of demand response (DR) in lighting and HVAC systems.

In the case of supermarket refrigeration, DR has lagged because refrigeration typically uses a separate measurement and control system with limited Web-enabled communication and visualization capabilities, and because of concern that DR strategies could jeopardize product safety and integrity.

Nevertheless, building information and control technologies have advanced to the point that they are adequate to enable DR in commercial refrigeration systems, a substantial load that utilities can use to provide extra capacity and balance system loads.

Description

The project demonstrated technologies and controls for DR and EE in supermarket refrigeration systems using numerical modeling at the National Renewable Energy Laboratory (NREL) and field testing in the Pacific Northwest (PNW).

The project encompassed the entire refrigeration system, including compressors, condensers, and refrigerated case equipment such as anti-condensate heaters, lighting, fans, and defrost equipment. It also included service water heating, which is closely related to refrigeration in supermarkets because refrigeration waste heat is often captured for service water heating. This provides a great deal of flexibility in shaping the overall system load shape— either increasing or decreasing loads—as required by BPA or the utility provider. The mix of loads also provides flexibility in terms of the DR time scale.

Numerical modeling assessed the feasibility of DR in supermarkets and to evaluate the potential DR and EE resources available in supermarkets.

The team pursued five objectives in this study:

1. Conduct pilot evaluation tests to understand stakeholder concerns and barriers to implementing DR in supermarket refrigeration systems.
2. In the course of these pilot tests, evaluate strategies that can provide 3- to 4-hour capacity reserves (identified as a key DR resource by the Bonneville Power Administration [BPA] for capacity management during critical demand peaks).
3. Conduct additional experiments in a real supermarket for the purpose of developing reliable models of the type needed to quantify DR potential.
4. Use these models to estimate the total aggregated supermarket refrigeration DR resource available to BPA.
5. Recommend future research and other work that must be done to maximize DR potential in supermarkets.

The results provided high-quality data needed to assess the business case for DR in supermarkets and identify key practices needed to achieve successful outcomes.

Benefits

The project provides compelling evidence that DR is feasible in supermarket refrigeration and represents a significant resource for BPA and utility providers. The successful pilot test lowers the risk of adoption for supermarket owners, supporting the broad application of the tested DR strategies.

Project results can be applied in supermarkets throughout BPA's grid wherever AMI has been installed. Supermarkets that have legacy control solutions will present a business opportunity to enable other controllers for automated DR. This technology development will lead to longer term application as DR in supermarkets diffuses throughout the market.

The project demonstrated the same type of capacity and grid balancing benefits as other existing types of DR and therefore can be integrated into existing utility programs for incentivizing DR.

Accomplishments

The project achieved its goal of demonstrating that substantial DR and energy savings are achievable in supermarket refrigeration systems and that the integrity and safety of refrigerated products will be maintained to minimize risks to supermarket owners and customers.

Accomplishments (continued)

- Quantified thermal response of reach-in and walk-in freezers
- Developed algorithm to determine baseline power consumption
- Used calibrated EnergyPlus model to predict upper DR bound
- Created thermal model of reach-in and walk-in cases that can be used to simulate DR events
- Demonstrated ~10kW load shed for 2 hours in most successful test despite being able to modify only 20% of system
- Calculated 15-20kW load shed available per store on hottest day of the year across BPA territory with low temperature, non-ice cream cases only**; possibly aggregating to ~20 megawatts over BPA's service territory.

**For ~1.5 hours with no pre-cooling and ~2.5 hours with pre-cooling

TIP 307: Pilot Testing Demand Response for Retail Supermarkets

Project Start Date: December 1, 2013

Project End Date: September 30, 2015

Total Project Cost

Total Project Cost: $892,000

Deliverables

Final Report: **Pilot Testing of Commercial Refrigeration-Based Demand Response**

A. Hirsch, J. Clark, M. Deru, K. Trenbath, I. Doebber, and D. Studer

This report was produced under direction of the Bonneville Power Administration by the National Renewable Energy Laboratory (NREL) under Interagency Agreement IAG-14-1921 and Task No WFGA.1000.

For More Information Contact:

Technology Innovation Project Management Officer:
TechnologyInnovation@bpa.gov

Links

This report is available from the National Renewable Energy Laboratory (NREL) www.nrel.gov/publications.

Participating Organizations

National Renewable Energy Laboratory
Whole Foods Market
Emerson Climate Technologies
Parasense
Source Refrigeration

BONNEVILLE POWER ADMINISTRATION