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Towards quantifying energy saving strategies in big-box retail stores: A case study in Ontario (Canada)

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ABSTRACT

This research focuses on energy-related initiatives implemented by one big-box retail chain in Canada. Through analysis of energy reduction strategies, the study compares the energy performance of two stores (an original store and its replacement store) adjacent to each other at the same location. One of which operated with conventional design features and the other operated with energy-reducing upgrades. The results of this research conclude that the store constructed with advanced technological solutions outperformed the original store in terms of energy-use intensity by 44%. The main energy reductions were achieved through alternative electrical strategies (primarily lighting) (39%) and alternative space heating strategies (61%). The research also reveals that premium costs related to the advanced technologies were effective choices.

1. Introduction

The North American retail landscape has changed dramatically over the past 50 years. Prior to World War II, retail stores were isolated to individual communities in the form of general stores and "mom-n-pop" shops (Smyyth, 2011). By the early 1960s, Walmart, K-Mart, and Target all opened their first large discount stores and the era of big-box retail was born (Welch, Burritt, & Coleman-Lochner, 2012).

Big-box retail development boomed in the 1990s and began to dominate suburban landscapes with the now familiar stand-alone big-box store (Hahn, 2000; Jones & Doucet, 2000; Welch et al., 2012). Fundamentally, these types of buildings are constructed with one main goal; to provide a facility where consumers can choose from a selection of goods and services that satisfy their needs profitably (Burke, 2005). While this remains a standard goal for any retail store, additional elements have become more prevalent in recent years with respect to the design and operation of these buildings. The reduction of energy consumption in big-box stores has become an important component for many retailers. Energy-efficient retail building design can add value in addition to direct expense reduction, including the ability to publicize a corporate commitment for sustainability, linking to a corporate sustainable mission, higher employee morale, and maintenance cost savings when properly implemented (ASHRAE, 2011).

The objective of this research is to identify and evaluate practical solutions regarding energy reduction for big-box retail stores. This research is presented in the form of a case study analysis of one newly constructed retail store in eastern Ontario (Canada). This store was constructed by a large Canadian retail organization and a number of non-traditional 'sustainable' technologies were incorporated into this building. The newly constructed store, Store B, replaced a traditional store in the same market located on an adjacent lot, Store A. Store A was constructed in 1999 using traditional building design strategies common in big-box retail design. Through analysis and comparison of performance data of Store B to the more traditional Store A, this research aims to quantify the energy impacts of these non-traditional technologies.

2. Background and prior related research

2.1. Background: big-box retail stores and retail sustainability

ASHRAE (2011) defines medium to big-box stores as having gross floor areas (GFA) between 3700 m^2 (40,000 ft^2) and 9300 m^2 (100,000 ft^2). Typical big-box architectural design has changed very little over time. The buildings themselves are ubiquitous and are largely indistinguishable from retailer to retailer. Retail organizations are frequently altering interior store designs and layouts, however the base-building design features of these facilities have remained largely unchanged. These buildings are frequently

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single-storey structures with large footprints. Floor-to-ceiling heights between 6 m and 7 m are common. The result is a large volume space that requires illumination, heating, cooling, and ventilation. Big-box stores are often constructed of similar materials, conditioned in similar ways, and illuminated using common lighting designs. They are most often individual buildings, and often part of larger shopping developments, or power centres.

In recent years, with increased competition in the marketplace and the amplified importance of maximizing share value, retailers have started to invest in operational cost-saving strategies. Such strategies are typically presented on many large retailer's corporate websites as achievements towards their sustainability targets (Costco, 2015; Target, 2015; Walmart, 2015). Overall, it has been shown that corporate social responsibility plans enhance customers' views and strengthen loyalty (Bolton & Matilla, 2015). Chen (2014) summarizes several studies showing a positive link between corporate sustainability, sales and loyalty. Given that many retailers operate hundreds of stores and millions of square metres of floor space globally, the opportunity to reduce energy consumption has become a significant source of investment both off the bottom line and with customers.

Energy costs are typically the second largest cost for retailers beyond labour (ASHRAE, 2011). Over the past few years, leading retailers have added sustainability leaders to their executive teams, established and publicly reported on energy-reduction targets, improved the energy performance of their stores and real estate assets, and actively managed the sustainability of their supply chains to ensure a lower impact on the environment (Jamieson & Hughes, 2013). One of the biggest impacts on energy use comes from finding efficiencies in the retail buildings themselves. In companies where big-box stores represent the overwhelming number of retail locations, finding improvements in the building's operations is critical to any energy reduction strategy.

A number of factors over the past several years have contributed to the industry's willingness to implement strategies for building and operating more efficient stores. Primarily, cost savings has been the driving factor, but a review of some large multi-national retail organization websites reveal that newly created corporate social responsibility (CSR) platforms have also played a role. Although barriers to sustainable product and purchasing have been identified (Ganesan, George, Jap, Palmatier, & Weitz, 2009; Gleim, Smit, Andrews, & Cronin, 2013), the chance to lead consumers by demonstrating corporate sustainability may break down such barriers. Leading retailers have added sustainability leaders to their executive leadership teams, established and publically reported on targets, improved the efficiency of their facilities, invested in renewable energy, improved product lifecycles, and actively managed the sustainability of their supply chains to ensure a lower impact on the environment (Jamieson & Hughes, 2013).

Many retail companies have produced case studies that identify successes with new technologies. In conjunction with the U.S. Department of Energy (DOE), one multi-national retailer constructed a new store in California that incorporated several new energy-efficient strategies (Klettke, 2013). Focusing on all areas of new store design, the retailer was looking to make improvements in their energy performance through the inclusion of improved lighting technology, efficient HVAC strategies, and building envelope improvements. The report listed all energy reduction strategies considered and presented the data to identify energy saved (kWh/a) and simple payback period in years.

In recent years, many large North American retailers have begun to collaborate as part of a DOE initiative in the United States called the Commercial Building Energy Alliance (CBEA) (Holuj, Nicholls, Sandahl, & Torcellini, 2010). A number of industries are represented and work in sub-groups specific to their building type. In the case of the retail group many of America's largest retailers are represented. Members of the CBEA collaborate with regularity and discuss energy savings initiatives and strategies. A review of CBEA annual reports indicate that this group has made significant progress in terms of developing energy reduction programs (DOE, 2012a). Through 2013, member organizations accounted for over 900 million square metres of floor area, and reported energy savings, on average, of 2% across their portfolios as a result of DOE-related initiatives. The DOE estimates that if the commercial building sector at-large were to implement the strategies developed through the relevant technology specifications and other energy-related campaigns, energy consumption would be reduced by 12% across the commercial portfolio of buildings in the U.S. (DOE, 2012b).

For the past several years one large multi-national corporation has been an active member of the DOE's CBEA program (Langer, Deru, Williams, & Hirsch, 2013). Through this collaboration, the corporation has developed a strategy whereby energy efficiency measures (EEMs) implemented in retrofit projects are measured and monitored for their energy-related performance. The corporation has evaluated such strategies as reducing lighting power density through lamp, ballast, and reflector retrofits, as well as ventilation strategies that result in significantly less ventilation being required in a store (Langer et al., 2013). The results of these initiatives are then studied and, where suitable, are implemented in future retrofit and new construction programmes.

2.2. Energy reduction strategies

2.2.1. Building envelope

Haves, Coffey, and Williams (2008) and Eley Associates (2004) both conclude that due to the large floor area of a typical big-box store, energy-use loads are very core dominant and are not greatly affected by building envelope performance. Haves et al. (2008) used energy modelling software to simulate performance and create an energy benchmark for a chain retailer across a number of climate zones. Subsequent energy modelling using various store locations showed minimal improvements in overall energy performance as a result of upgrading the thermal resistance in the respective building envelopes. The study concluded that the much smaller efficiency gains predicted for insulation improvements reflect both the core-dominated nature of the loads and the diminishing returns from insulation (Haves et al., 2008).

An additional report authored by Energy Design Resources (Eley Associates, 2004) also concluded that building envelope upgrades in big-box retail stores yielded insignificant results in terms of energy efficiency improvements.

To further illustrate this notion, a review of the DOE's report on emerging technologies with respect to building envelopes reveals that in terms of insulation upgrades, the payback period is heavily dependent on installed cost of the insulation as opposed to its energy performance. The analysis concludes that performance targets cannot be met unless new insulation materials are cost effective from a supply and installation perspective (EERE, 2014).

Areas that were identified as having energy reduction benefits were related to air leakage and thermal bridging within the envelope assembly. The ASHRAE Advanced Energy Design Guide (ASHRAE, 2011) identified a number of considerations with respect to thermal bridging and air leakage issues. The guide identified strategies across all climate zones and made recommendations on detailing the critical components and junction points within the envelope. The guide identifies ideal vestibule configurations, overhead door strategies, and other applicable areas within the envelope that typically result in air infiltration and/or thermal bridging (ASHRAE, 2011).

To further emphasize the importance of providing a thermally efficient, air-tight building envelope, Straube (2014) identified the