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Impact of an Energy Efficiency Regulation in Northern Canada

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ABSTRACT

Extreme cold climates and Canada's sparsely populated Northern regions have limited human and infrastructural capacity making it difficult to build energy-efficient homes. Despite such differences, homes are built based on codes and standards developed for Canada's South. In 2008, a by-law was passed in Yellowknife, Canada requiring a minimum EnerGuide Housing (EGH) rating of 80 for all new single-family and two-family residential buildings. The EnerGuide's Energy Rating Service (ERS) program is an energy assessment program for residential housing formerly known as the EnerGuide Rating for Houses (EGH). Homes are rated between 0 to 100; lower numbers represent homes that are less efficient and 100 represents an airtight and well-insulated house that is net-zero energy. 1002 homes from the City of Yellowknife evaluated since 1950s were studied from the ERS database, Performance metrics studied include energy intensity, EGH rating, ACH rating, window types, the thermal resistance of the building envelope, primary heating and hot water heating equipment's efficiencies, total electricity used, and total energy used. The analysis identified the current state of housing in Yellowknife, past and present housing trends, and determined the effect of the city of Yellowknife's new building by-law had on housing performance. The preliminary finding shows a pathway to significantly improve the energy efficiency of the housing stock in Yellowknife. This regulation shows other municipalities in Canada that legislations pushing energy efficient buildings can be very effective.

KEYWORDS

Remote Communities, Extreme Cold Climates, Energy Efficient Housing, Policy

INTRODUCTION

The Canadian northern region is remote with limited human and infrastructural capital, little demand for private housing and small incentives for suitable northern building products. Temperatures drop to -50°C for extended periods; homes must have high performing building envelope with minimized thermal bridges and air leakage. There are housing standards adopted in northern regions that were developed for Southern regions of Canada with warmer climates. With growing concerns about climate change and the region's desire to become less dependent on fossil fuels, governments have identified new housing standards as urgent (Government of Nunavut, 2007). As part of a research program, a protocol for low energy homes for northern Canadian regions was developed (Thirunavukarasu et al., 2016). This paper outlines a section of the research, which examined the impact of the city of Yellowknife's building by-law no. 4469 had on the energy performance of housing. The by-law, adopted in 2008, required a minimum EnerGuide Housing (EGH) rating of 80 for all low-rise residential buildings. This paper presents the impact of by-law no. 4469 on the housing performance to show methods that improve significantly the energy efficient of homes.

METHODS

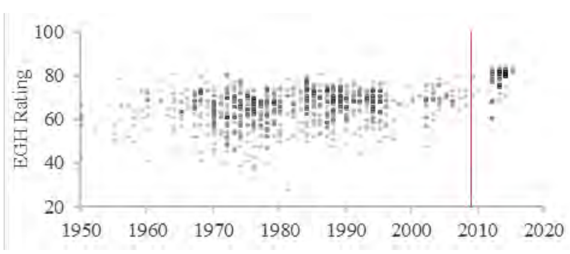
The EnerGuide's Energy Rating Service (ERS) or the EnerGuide Rating for Houses (EGH) program, developed by Natural Resource Canada (NRCan), is an energy assessment program for residential housing. The program evaluates the housing size, location, orientation of the home, building envelope (area, average insulations levels in walls, ceiling, floors,) window types, air leakage (measured), mechanical systems (heating, domestic hot water and ventilation), occupant behaviors, appliances, and lighting loads (Parekh et al., 2000). The total energy consumption is estimated based on the above inputs into HOT2000 software platform, validated by Natural Resource Canada (NRCAN). The program assumes, for single family homes, 2 adults and 2 children occupancy, 225 liters/day hot water load and an electric load of 24kWh/day.

The EGH rating is calculated as the ratio of estimated total energy consumption to benchmarked total energy consumption of the building. The benchmarked values are based on heating degree days for the location. Homes are rated between 0, indicating high energy consumption, and100 indicating a net-zero energy home. Homes rated EGH 80 represent home built to ENERGY STAR standards. The EGH rating allows a standardized energy labels for homes. Data collected through certified evaluators upload information into the ERS database. The database is a comprehensive tool to track and manage residential energy evaluations and allows for identification of trends over time and region. 1002 homes evaluated for EGH rating from the City of Yellowknife were data mined from the ERS database – the last evaluated home included in this study was built on July 1st, 2015.

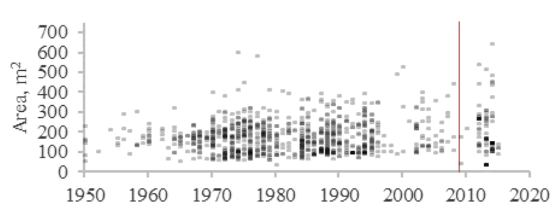
By-law no. 4469 required a minimum EGH rating of 80 for low-rise residential units. Pre-drywall blower door testing for air leakage and submission of construction plans to city for recommendations. The study compares performance metrics of 225 homes built from 1990 to 2009 to 102 homes built between 2010 and 2015. The parameters include ACH rates obtained through blower door testing, thermal resistance levels of building envelope, and mechanical systems efficiencies obtained through on-site verification, EGH rating, energy intensity (kWh/m^2), total annual electricity use (kWh/m^2), and total annual energy consumption (kWh/m^2) calculated using software.

RESULTS

102 homes evaluated are built after 2009 when by-law no. 4469 took effect. Figures 1a to 1g plot performance metrics based on construction dates from 1950 to 2015. There is a gradual improvement in the air leakage rate, thermal efficiency of the building envelope, and the annual energy consumption. Primary heating and hot water equipment's efficiencies remained constant 2009, then improved by 5 to 10%. After 2008, there is a 'clustering effect' as seen is Figure 1a, 1b, 1c, 1d, 1e and 1g.



a)



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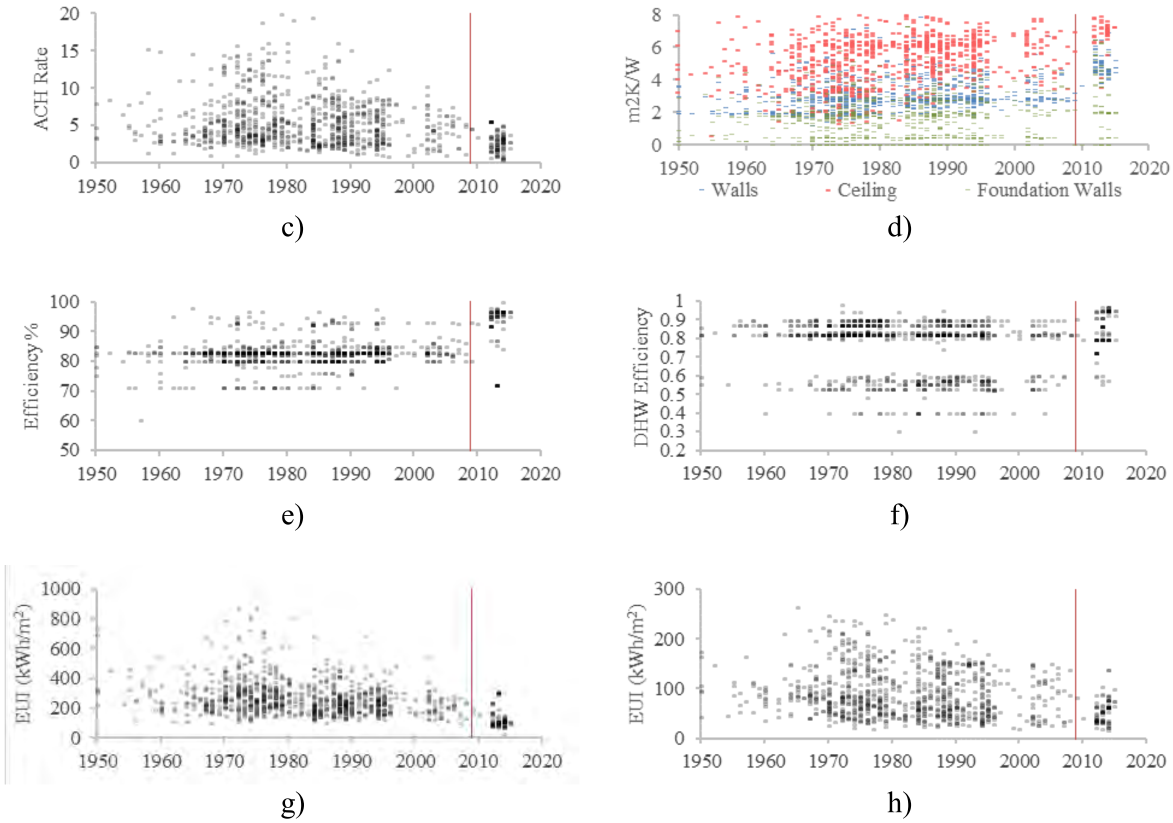

Figure 1. Performance metrics for homes since 1950 to 2015 (a) EGH rating, (b) home footprint (m^2), (c) ACH Rate @ 50 pa, (d) Thermal resistance for walls, ceiling and foundations, e). primary heating equipment efficiency, (f) primary DHW equipment efficiency, (g) annual energy use intensity, (h) Annual electricity use.

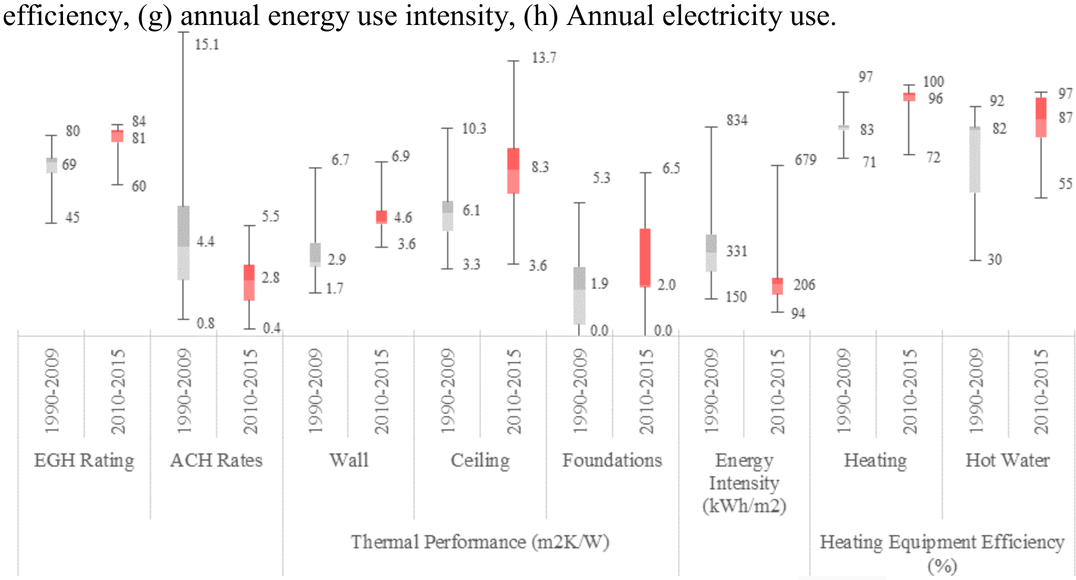

Figure 2. Percentage box plot shows minimum, 25% percentile, median, 75% percentile and maximum values for performance parameters between 1990 to 2015. Values for minimum, median and maximum are labelled on the graph.

Figure 2 presents the percentage box plot comparing 225 homes built in 1990 to 2009 and 103 homes built in 2010 to 2015. Impact of by-law no. 4469 is further evident in Figure 2. The median EGH rating rose from 69 to 81, the median ACH rate reduced by 36% from 4.4 to 2.8.

Primary heating and hot water equipment efficiency increased by 10% and 5% to 96% and 87%, respectively. Higher efficiencies were achieved by installing condensing boilers for heating and switching to instantaneous condensing hot water heaters from conventional storage-type water heaters. Thermal performance of the exterior walls increased from 2.9 m^2K/W to 4.6 m^2K/W. The mininum thermal performance of the exterior wall in homes built after 2009 was 3.6 m^2K/W, greater than the median for homes built between 1990 and 2010. Median thermal performance of the ceiling increase by 35% (2.2 m^2K/W). Median energy intensity is reduced by 37% after the by-law was adopted. Newer homes used 10% less total annual electricity than homes built between 1990 to 2009. EnerGuide's rating systems has a standard assumption for household lighting and plug loads – so, this research did not assess any energy efficiency steps to reduce lighting and plug loads.

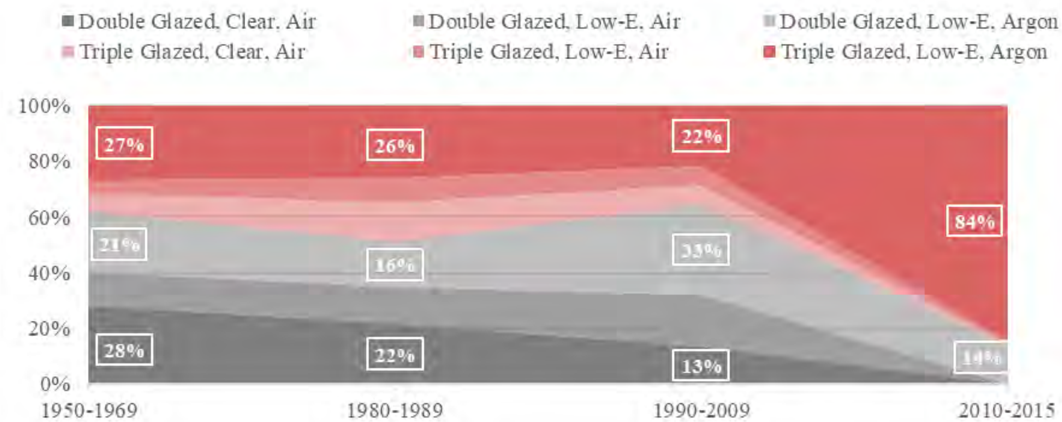

Figure 3. Distribution of window types as a percentage between 1950 to 2015

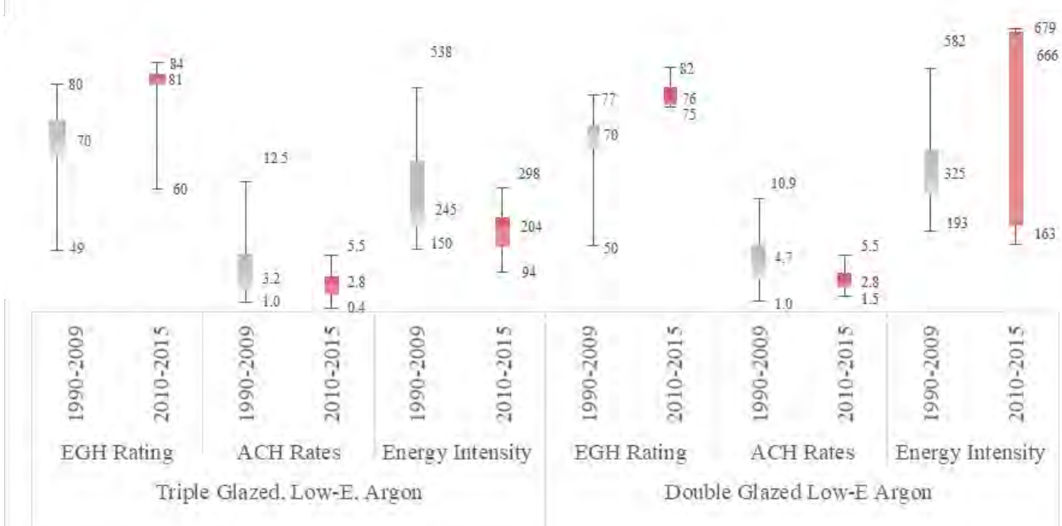

Figure 4. Percentage box plot shows minimum, 25% percentile, median, 75% percentile and maximum values for performance parameters between 1990 to 2015 comparing triple glazed to double glazed windows. Values for minimum, median and maximum are labelled on the graph.

After 2009, shares of triple-glazed, low-E, argon windows (TG) installed in homes increased from 22% to 84%. Between 1990 and 2009, double-glazed, low-E, argon windows (DG) were most common – although, notice a greater variation in windows install between 1950 to 2009. Between 2010 and 2015, 98% of all windows install were either DG or TG. Figure 4 evaluates

EGH, ACH rates, and energy intensity of homes using TG and DG for homes built from 1990 to 2009 and from 2010 to 2015. First, homes built after 2009 had higher EGH rating and lower ACH rating for both window types. Energy intensity reduced only for TG after 2009. 14 homes built after 2009 installed DG; which may explain the higher variance in energy intensity for DG. Homes built from 1990 to 2009 had similar EGH rating, ACH rating and energy intensity levels regardless of window type used.

DISCUSSION

The data shows a clear pathway to increase energy efficient homes for the North with 75% of homes built after 2010 reaching ENERGY STAR performance (Figure 2.) Although cost was not considered in this study, as fuel is imported in the northern regions of Canada, electricity cost per kilowatt-hour (kWh) can be up to 10 times as much as in southern cities (Northwest Territories Power Corporation, 2015). Significant energy savings can be achieved for little added cost by building high performing envelope systems, performing pre-drywall blower door testing and installing triple pane windows. Energy savings through the building envelope can reduce size of the mechanical systems and more efficient mechanical systems such as condensing boilers and instantaneous hot water heaters is chosen. Further optimization of solar design parameters (Thirunavukarasu et al., 2016) can further reduce energy consumption for little added cost.

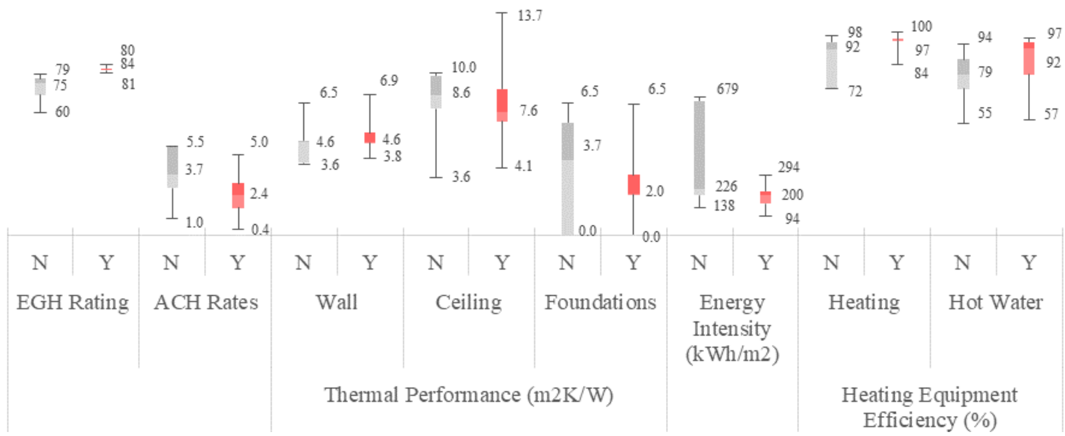

Figure 5. Percentage box plot showing performance of homes in non-compliance (N) and compliance (Y) with by-law.

This study shows that since by-law no. 4469 was passed, 84% of homes used triple glazed, low-e, argon windows, reduced air leakage, and increased thermal efficiency of the building envelope. Although the by-law faced resistances from local builders, general opinions of builders in 2015 were supportive (Thirunavukarasu et al., 2016). Of the 102 homes evaluated since 2010 to July 1st, 2015, 69 homes built met the by-law requirements.

Homes not in compliance with the by-law either had twice the average ACH rate of homes in compliance with the by-law (see Figure 5) and/or used less efficient conventional hot water heaters and/or had little to no insulation levels on foundation walls.

CONCLUSION

This paper presents the results analyzed for 1002 houses from the EnerGuide's Energy Rating Service (ERS) for Yellowknife, Northwest Territories and the impact of by-law no. 4469 by evaluating 225 homes built from 1990 to 2009 and comparing to 102 homes built between 2010 and 2015. By-law no. 4469 required a minimum EGH rating of 80 and city offered pre-drywall blower door testing for air leakage, and pre-construction submission of plans for recommendations from the city.

This by-law shows other municipalities in Canada that legislation for more energy efficient buildings can be very effective when combined with verification methods such as blower door testing.

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