



Article

An Incentives Planning Framework for Residential Energy Retrofits: A Life Cycle Thinking-Based Analysis under Uncertainty

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Abstract: Building energy retrofits can reduce emissions and increase cost savings. Some retrofits that can deliver higher emissions savings are not popular due to a lack of economic justifications. Financial incentives can be used to change buyer perception around such retrofits. This study proposes a framework to identify the best-performing retrofit strategies for a given building cluster and the optimal incentive amounts to promote the chosen strategies, accounting for uncertainties, stakeholder priorities, and budget constraints. The proposed framework was demonstrated using a case study complemented with policy insights. Life cycle cost savings and capital cost significantly impact retrofit purchase decisions. Case study results showed that retrofitting houses heated with electricity can produce significant cost savings. However, adopting energy-conscious behaviours in houses heated with natural gas and injecting renewable natural gas into the gas supply can produce two times more emissions savings achieved by any retrofit strategy applied to an electrically heated house. This indicates the need for adopting performance-based incentives over the prescriptive approach to reward occupant efforts in addition to asset performance. Despite potential life cycle cost savings, incentives must be complemented with low-interest loans to promote retrofit strategies carrying higher capital costs.

Keywords: building energy retrofits; financial incentives; life cycle assessment; fuzzy uncertainty; energy policy

1. Introduction

Climate change is not identified as a future crisis anymore. Leading scientific bodies such as NASA acknowledge that climate change's impacts are already affecting the world [1]. The inter-governmental panel on climate change (IPCC) indicates that the associated environmental impacts would be beyond repair if the global temperature increases 1.5 °C over pre-industrial temperatures [2]. IPCC advocates curbing anthropogenic greenhouse gas (GHG) emissions to avoid the predicted climate adversities and identifies the building sector as a key area that can support this as it accounts for 12% of anthropogenic GHGs and 40% of the energy use in the world [2–4].

In response to these rising challenges, climate leaders such as British Columbia (BC), Canada developed innovative policy tools such as BC Energy Step Code to reduce the environmental impacts of new constructions [2]. However, improving the performance of existing buildings constructed to less stringent energy efficiency standards remains a challenge [3].

Retrofits are commonly used to improve the energy performance of existing buildings. Energy retrofits lead to economic, environmental, and indoor environmental quality (IEQ) performance enhancements [4]. Occupants can benefit from operational cost savings and improved IEQ [5]. In addition, building owners can benefit from the property value increases. In the bigger picture, retrofitting projects can support national climate change



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Energy Policy Strategies For Uncertainty

DP Hallahan

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