BOSTON UNIVERSITY
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CAS EE 538

Deep diving into data with clear direction for Lexington, MA

Understanding the Value of All-Electric Housing

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Content

Introduction

Purpose

The significance of this study lies in its ability to convey important information in an easy-to-understand manner and provide data-driven recommendations for policymakers, builders, and homeowners in the pursuit of energy-efficient residential housing. My comprehensive approach takes into account various factors such as climate, utility rates, solar resources, and incentives, offering a holistic view of the potential for achieving all-electric housing.

Background

I chose to focus on this subject to provide accurate and comprehensive details to potentially guide Lexington Township's transition toward a more energy-efficient future with affordability and resiliency in mind, at the request of a Lexington Select Board Member.

What is the cost differential between conventional and all-electric residential construction, specifically in affordable housing development?

This data-driven research shows that all-electric housing is not only affordable for Lexington, MA, but also that such a transition can save homeowners money in the long-term.

Research Objectives

Research Objective #1

Compare Costs of Conventional and All-Electric Housing Development

Research Objective #2

Provide Evidence-Based Insights that Address Misconceptions and Inform Decision-Making

Research Objective #3

Explore Strategies, Incentives, and Policies that Support the Adoption of All-Electric Construction Methods

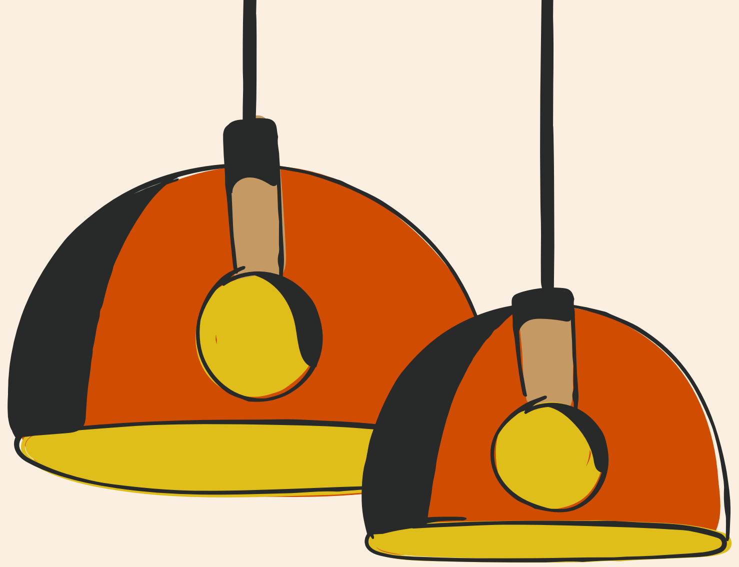
Research Scope

My study encompasses several key domains to provide a comprehensive understanding of the implications of adopting all-electric construction methods.

Cost Analysis	• The data gathered on construction costs, including materials and equipment, is systematically compared between conventional and all-electric building methods, highlighting the cost differential and its implications on affordable housing development.
Energy Efficiency	• The research leverages data on energy consumption, efficiency measures, and potential savings to evaluate the benefits of all-electric construction, demonstrating the long-term cost-effectiveness and environmental impact of these building methods.
Geographical Location	• The study focuses on Lexington, MA, which is located in Climate Zone 5.
Public Policy	• The study utilizes data on existing policies and regulations to analyze their effect on the adoption of all-electric construction and the promotion of energy-efficient housing, identifying gaps and areas for improvement.
Incentives and Financial Support	• The research assesses the data on available incentives, tax credits, and other financial support mechanisms to determine their effectiveness in encouraging the adoption of all-electric construction and fostering affordable housing development.
Education, Training, and Stakeholder Perspectives	• The research identifies the need for further investment in education and training. This is vital to enhance awareness and understanding of all-electric construction methods and their advantages among builders, developers, policymakers, homebuyers, and other stakeholders, while also addressing barriers to adoption and devising potential solutions for increasing its accessibility and affordability.

Scaling Cost

How to Scale All-Electric Housing Cost Results



Overview

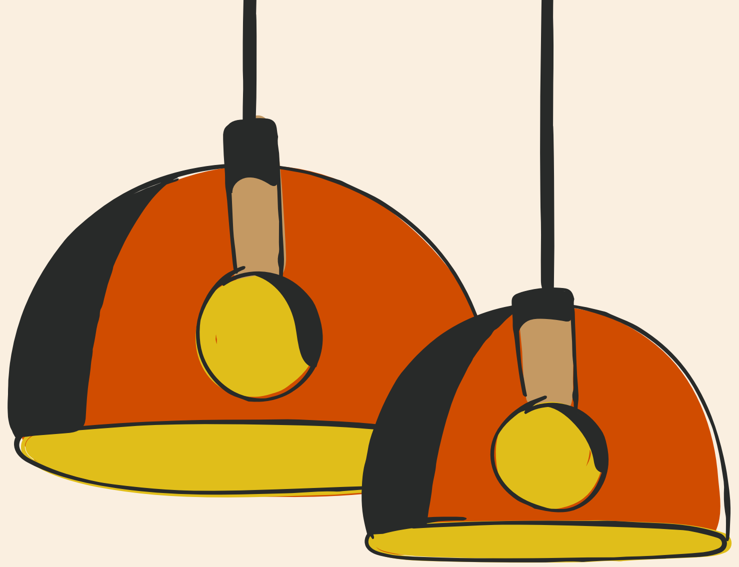
- Using an all-electric housing model, I scaled the results to model Lexington's climate zone and other local factors.
- This approach provides a rough approximation that can give policymakers and builders a sense of where costs currently stand in Lexington.

Approach: Factors that Influence Cost

- **Climate Zone**
  - The modeled home used IECC climate zones, specifically climate zone 5 for Lexington
- **Utility Rate (Residential)**
  - The DOE State and Local Energy Data was used to find electric utility rates by city.
- **Material Cost (Not Included in Scaled Model)**
  - RSMeans data was used in the study to supply material cost factors compared with the national average for many cities. Home Innovation Research Labs 2021 IECC Residential Cost Effectiveness Analysis was also used.
- **Baseline Code (Residential Energy Code)**
  - The baseline code affects the incremental cost to build all-electric homes as well as the estimated energy savings. My analysis used IECC 2009 through 2021 as the baseline codes. Construction cost and energy bill estimates come from PNNL's cost-effectiveness analysis for IECC 2012 and IECC 2015 in addition to Home Innovation Research Labs 2021 IECC Residential Cost Effectiveness Analysis
- **Incentives**
  - DSIRE and EnergySage were used to identify national and state incentives for renewables and efficiency.
- **Solar Cost and Resource**
  - Solar costs follow different material and location factors than energy efficiency measures. EnergySage is a good resource to determine how solar costs vary by state. Solar Resource: Solar PV electricity production is dependent on solar resources in the city, so cities with better solar resources won’t need to install as much solar to achieve. A city’s solar resource can be determined using PVWatts, a free resource developed by NREL.

Cost Analysis

Applying the Energy-Efficiency Cost Analysis to Lexington



Overview

- All-electric, single-family new construction is more economical to build and operate than a home with gas appliances and has lower lifetime emissions in all cities within climate zone 5.
- The all-electric home is more efficient and cheaper to install than a mixed-fuel home, resulting in lower utility bills and substantial carbon emissions savings. This leads to a net present cost savings of $2,300 in Lexington. Health benefits from avoiding gas stoves are not included in this estimate.

Applying Scaled Model Results

- **Climate Zone**: 5
- **Utility Rate (Residential)**: $0.26/kWh
    - Utility Rate Average for MA (FEB 2023): $0.3213/kWh
    - Utility Rate Average for US (FEB 2023): $0.1596/kWh
    - Utility Rate Average for MA (FEB 2022): $0.2568/kWh
    - Utility Rate Average for US (FEB 2022): $0.1383/kWh
- AVG Electric Bill/Month: $204/month, $2,448/year
    - 19% Higher than National AVG
- **Residential Energy Code**: 2021 IECC (CZ5)
    - HIRL 2021 IECC Residential Cost Effectiveness Analysis for NAHB
- **Incentives**: 59 Policies and Incentives were identified for Massachusetts
- **Solar Cost**: $3.54/W (AVG per Watt)
    - Gross Solar Panel Cost (6 kw system average): $21,240
    - Gross Solar Panel Cost (10 kw system average): $35,400
    - 2023 Federal Tax Credit Value (for 10 kw system): $10,820

Conclusion

Results

The results of the energy and economic analysis for this report show that all-electric and all-electric ready homes can be cost-effective even in some of the United States' coldest climates. This conclusion is supported by a growing body of evidence, including case studies and research projects sited as far north as the Arctic Circle. Stakeholders should prepare now for these super-efficient homes to enter the mainstream.

My Takeaways

While starting my research, I was unsure whether the data would support what I was hoping—that electric housing is more cost-effective than traditional housing. Thankfully, the data worked in my favor. I learned to be patient with the process and while it initially seemed that electric, or green energy alternatives, were costlier... the data proved me wrong. The green future looks brighter than ever and I'm excited to watch the transitions to renewables take place!

Thank you

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Cost Analysis Sources

Quantitative Methods

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). (2009). Economic Database in Support of ASHRAE 90.2. Retrieved from https://www.ashrae.org/

ASHRAE's 2009 report provides cost information specific to single-family and multifamily constructions. This data was used to update or verify costs associated with each ECM.

BEopt, National Renewable Energy Laboratory (NREL)

This free software tool was used to model various energy efficiency measure packages to find the optimal ZE package at the lowest cost, which enabled the analysis of ZE home costs.

DSIRE. “Database of State Incentives for Renewables & Efficiency®,” November 7, 2014. https://www.dsireusa.org.

Electric Power Research Institute (EPRI). (2016). Establishing Feasibility of Residential Zero Net Energy Community Development - Learnings from California’s First ZNE Neighborhood. Retrieved from https://www.epri.com/

The 2016 EPRI report, produced in collaboration with Meritage Homes Corporation, explores the cost and performance of ZE homes. The report was used to estimate the costs of ductless mini-split units. This data was also used to update or verify costs associated with each ECM.

EnergySage. “Solar Calculator.” Accessed May 1, 2023. https://www.energysage.com/solar/calculator-results/.

Home Innovation Research Labs Labs. “2021 IECC Residential Cost Effectiveness Analysis,” n.d. https://www.nahb.org/-/media/NAHB/advocacy/docs/top-priorities/codes/code-adoption/2021-iecc-cost-effectiveness-analysis-hirl.pdf.

National Renewable Energy Laboratory. “BEopt (Building Energy Optimization Tool) Software,” n.d. https://beopt.nrel.gov/home.

“PVWatts.” Accessed May 1, 2023. https://pvwatts.nrel.gov/pvwatts.php

National Institute of Standards and Technology (NIST). (2016). Net-Zero Energy Residential Building Component Cost Estimates and Comparisons. Retrieved from https://www.nist.gov/

NIST's 2016 report provides cost estimates for incremental components of a ZE test facility in Maryland, using seven data sources. The report was utilized to inform the costs of envelope, HVAC, and water heater measures. This data was also used to update or verify costs associated with each ECM.

National Residential Efficiency Measures Database (NREMD). (n.d.). [Database]. Retrieved from https://remdb.nrel.gov/

In this research, the NREMD serves as the primary source for cost estimates of various energy conservation measures (ECMs) within the BEopt modeling software. Costs associated with each energy conservation measure (ECM) were derived from this database, which was embedded in BEopt. The database relies on numerous cost studies and statistical analyses.

RSMeans. (2018). Residential Cost Data. Retrieved from https://www.rsmeans.com/

RSMeans. 2020. *Residential Cost Data*. RSMeans. https://www.rsmeans.com/

RSMeans. 2020. *Residential Repair and Remodeling Cost Data*. RSMeans. https://www.rsmeans.com/

RSMeans' 2018 and 2020 Residential Cost Data is a widely recognized and trusted cost resource in the construction community. This data was used to update or verify costs associated with each ECM, as well as deriving the baseline home cost and altering costs by location using city-specific location factors.

U.S. Energy Information Administration (EIA). “Electric Power Monthly.” Accessed May 1, 2023. https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_06_a.