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Energy efficiency in U.S. residential rental housing: Adoption rates and impact on rent

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HIGHLIGHTS

- Rental units listings collected and analyzed for 10 U.S. cities.
- Energy efficient features included in 5.3–21.6% of rental units in each city.
- The most common efficient features are lighting and appliance upgrades.
- Propensity score matching and conditional mean comparison methods used.
- Generally, energy efficient features increases the units' rent, overall from 6% to 14%.

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ABSTRACT

For 118 million residential housing units in the U.S., there is currently a gap between the potential energy savings that can be achieved through the use of existing energy efficiency technologies, and the actual level of energy savings realized, particularly for the 37% of housing units that are considered residential rental properties. Additional quantifiable benefits are needed beyond energy savings to help further motivate residential property owners to invest in energy efficiency upgrades. This research focuses on assessing the adoption of energy efficient upgrades in U.S. residential housing and the impact on rental prices. Ten U.S. cities are chosen for analysis; these cities vary in size across multiple climate zones, and represent a diverse set of housing market conditions. Data was collected for over 159,000 rental property listings, their characteristics, and their energy efficiency measures listed in rental housing postings across each city. Following an extensive data quality control process, over thirty different types energy efficient features were identified. The level of adoption was determined for each city, ranging from 5.3% to 21.6%. Efficient lighting and appliances were among the most common, with many features doubling as energy efficient and other desirable aesthetic or comfort improvements. Then using propensity score matching and conditional mean comparison methods, the relative impact on rent charged in each city was calculated, which ranged from a 6% to 14.1% increase in rent for properties with energy efficient features, demonstrating a positive economic impact of these features, particularly for property owners. This was further subdivided into five types of energy efficiency upgrade and three housing types. Single family homes generally demanded higher premiums with energy efficient features, however there was not a consistent pattern across the types of efficient upgrades. The results of this work demonstrate that investment in energy efficient technologies has quantifiable benefits for rental property owners in the U.S. beyond just energy savings. This methodology and results can also be used in other cities and by property owners, utility companies, or others, ultimately encouraging further investment and positive economic impact in residential energy efficiency and in turn improving energy and resource conservation in the building sector.

1. Introduction

In the United States, buildings consume approximately 40% of energy and 72% of electricity, over half of which can be attributed to the residential building sector [1]. Buildings thus have a significant impact on the environment, accounting for up to 36% of annual

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greenhouse gas (GHG) emissions, with the residential sector responsible for approximately 20–25% [2]. Thus over the life of a building, the environmental costs and resource consumption due to building operations are significant. As the world faces significant challenges and impending threats due to climate change [3], it is beneficial to determine ways to reduce the environmental impact of the U.S. building stock. This can be accomplished through energy efficiency upgrades to the existing residential buildings [4], which, compared to new energy-efficient construction, offers improved environmental sustainability and resource conservation benefits [5]. Among residential buildings, rental properties represent 43.7 million household units, approximately 37% of total residential buildings in the U.S, and more than 23% of residential energy consumption [6]. Thus the rental property market is a strong player in the energy consumed in the residential sector. It has also proven to be one of the most challenging sectors in which to successfully implement energy savings measures [7,8].

There are many residential energy efficiency programs in place, a large number of which are utility-sponsored programs that provide rebates or incentives to residential building owners who invest in more energy efficient systems and technology [9,10]. Other programs such as EnergyStar do not provide rebates, but promise lower operational costs over a product, system, or buildings lifetime [11]. Utility programs are targeted at correcting inefficiencies such as over-sized, old, and/or inefficient heating, ventilation and air conditioning (HVAC) systems, limited wall or attic insulation, and inefficient appliances, lighting, windows, and/or other electronics [12]. These programs aim to directly reduce the operating costs of buildings, saving money for the building owner through lower energy bills, reducing loads on the electric grid, and decreasing environmental impacts due to less natural resource consumption and emissions from power plants [13–15]. However, despite the clear benefits of energy efficiency programs, current literature is in general agreement that energy improvements in the U.S. fall short of the anticipated adoption of efficient technologies [16–18], often described as the “energy efficiency gap”, between potential and realized savings [19].

Energy benchmarking requirements for commercial buildings in some cities in the U.S. and in many countries throughout Europe, is one potential method to help overcome the issues of information asymmetry [20]. There have been some initial efforts in this area for residential buildings in the U.S., for example some cities such as Austin, TX has implemented mandatory energy audits be completed on all homes 10 years and older during home sales transactions [21]. However for residential buildings these efforts are not yet widespread.

This efficiency gap is particularly significant with residential rental properties, in part due to the “split-incentive” phenomenon, in which neither the homeowner nor the tenant have motivation or ability, respectively, to improve the building performance [22–24]. Banfi et al. [25] and Burfurd et al. [26] studied the willingness to pay (WTP) for energy efficiency improvements in rental property tenants. According to Banfi et al. [25], renters and homeowners are willing to pay 1–13% higher rent, depending on the type of feature, generally finding a lower WTP in the renters than the residential building owners. Owners of residential rental properties are thus a key component that enables the opportunities for energy efficiency to be implemented. At the same time, their lack of action can be the missing link between connecting an energy efficiency opportunity with a building in need. Therefore, additional efforts are needed to determine how to narrow this gap in the residential rental building market, in an effort to achieve additional environmental benefits in this market segment. Given that energy on average accounts for approximately 13% of total monthly housing costs and 4% of household income for the average renter, and up to 15% of total income for low-income families (2011 American Housing Survey), finding ways to motivate improvements in energy efficiency will also benefit renters in terms of lower energy bills.

Investigating how to better motivate the homeowner to invest in energy efficiency has been cited as a key research need by multiple recent reports [18,27–30]. Initial reports have concluded that the main motivational factor for residential property owners investing in energy efficiency is saving energy, followed closely by other non-energy benefits [28,31,32]. This indicates that when residential building owners need to replace or repair energy-related items, they will consider factors beyond just cost savings in their decision [28]. Non-energy benefits in particular have not been well studied in comparison to the energy benefits. One that has been less studied is the effects of energy efficiency investments on residential rental prices, particularly in the United States.

There have been a number of studies analyzing energy efficiency impacts on sales and rental rates in other countries, but not in the U.S. A majority of the literature is focused on the impact of EPC (Energy Performance Certificates), generally adopted in Europe, on the sales prices of residential units. Less focus has been placed on the impact of rent prices in rental housing. Ayala et al. [33] analyzed the price of energy efficiency in the Spanish housing market, finding that if a home has an EPC, the home demanded a 5.4–9.8% premium compared to others. Fuerst et al. [34–36] investigated energy efficiency premiums due to EPCs in Finland (2014, 2016), England (2015) and Wales (2016), and Hyland et al. [37] in Ireland, also generally finding a positive relationship between the EPC rating and sales prices in all locations, in particular, finding a higher premium for more quality housing. Premiums range from 1.3% to 3.3% in Finland, up to 5% in England, up to 4.5% in Whales, 5.4–9.8% in Spain, and 1.8–3.2% in Ireland. For lower quality housing, the percent premiums were lower and sometimes negative. In studies that compared rental and sales prices, it was found that advertising energy efficiency in rental property listings improves the rental price values (e.g. [38]), however, not as significantly as in the sales market (e.g. [37]). Feige et al. [39] found that some sustainability features has positive effects, and some had negative effects on apartment rental prices in Switzerland, and Popescu et al. [40] also assessed multiple benefits in Romania.

To date, to our knowledge there has not been a significant effort to study the impact of energy efficiency features in the U.S. residential rental property market segment. The sources and quality of rental unit data in the U.S. are highly unregulated as compared to the public record data of the buying and selling of residential buildings. This is similar in the commercial building rental market. Similarly, as compared to other countries, there are not currently country-wide standards or requirements for energy efficiency ratings or reporting requirements. These data consistency challenges are overcome in this work through developed custom data scraping codes to collect online rental property data, enabling the collection of a previously unavailable and unique dataset for this analysis. In addition no studies in the U.S. have consider multiple cities. Most studies in other countries have also been limited to one city. The broader dataset of data included in this work enables the comparison across a diversity of cities which vary in climatic region, political views, sizes, energy prices, and rental market pricing and level of demand. This comparison does not currently exist in the literature.

The goal of this research is to determine, for a diversity locations across the United States, (i) what are the adoption rates of energy efficiency features in rental properties, (ii) does having energy efficiency features in these residential buildings demand premiums in rental asking prices, and (iii) is there is a relationship between energy efficiency premiums and location-specific environmental conditions in which the building is located. Through the use of a large dataset of residential property rental data collected from online postings across a set of 10 cities in the United States, a statistical matching method is applied to answer these questions. This research is organized into several sections, including, first, a discussion of the collection methods, cleaning and quality control of the data, followed by the methodology, results and discussion, and overarching conclusions and future research needs.