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Poster Abstract: Economic Feasibility of IoT-Based Controls in Low-Income Residential Buildings

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Poster Abstract: Economic Feasibility of IoT-Based Controls in Low-Income Residential Buildings

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Abstract

Internet of Things (IoT) devices promise to reduce energy cost for residential buildings through data-driven methods like model-predictive control. However, most prior research assumes that data is "free" and does not factor in the cost of devices and required infrastructure. These are especially relevant for low-income households which stand to gain the most from reduced energy costs. In this poster, we present an empirical study of the economic feasibility of IoT devices through the lens of a real-world 28 residence deployment. We find that some IoT investments can be justified, when infrastructure costs are ignored or heavily discounted.

CCS Concepts: • **Social and professional topics** → **Systems analysis and design**; *Information system economics*; • **Hardware** → *Energy metering*.

Keywords: Economic Feasibility, Smart Home, Internet of Things

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1 Introduction

Commercial IoT devices such as smart thermostats and plugs promise energy savings through optimized control [2, 3]. While research shows IoT-based strategies can cut consumption, it often assumes free infrastructure, sensors, connectivity, and computing. In practice, deployment and maintenance entail significant upfront and ongoing costs [2, 4]. This is especially burdensome for low-income communities where affordability limits adoption. Hence payback period evaluation is essential for policy and deployment decisions. This study identifies conditions under which IoT analytics and smart control are economically viable in a small residential community, we focus on two applications: (1) load-shifting via smart plugs, and (2) simple smart thermostat control strategies.

2 Case Study

Our analysis combines detailed plug-load monitoring data with whole-building HVAC simulations. The community comprises 28 homes: 15 use electric heat pumps for both heating and cooling; 13 use natural gas furnaces with no cooling. Our dataset contains high-resolution smart plug measurements from 17 of these homes. Data span the 2024 calendar year and provide one-minute power consumption records for 68 individual plug-based appliances.

We evaluate two smart control strategies: plug load shifting and thermostat-based HVAC control. For plug load shifting, we use real data from 17 mobile homes. We estimate savings by simulating 10–100% shifting of plug loads from peak to off-peak hours. To quantify energy cost savings, we adopt Time-of-Use (TOU) electricity pricing ($ per kWh) from the local utility: June–Sept (Mon - Fri) has on-peak = $0.21277, off-peak = $0.07884 Oct–May (Mon - Fri) has on-peak = $0.18331, off-peak = $0.06792.

For HVAC control, we model 28 homes using `EnergyPlus`[1] to simulate three thermostat schedules: a fixed 72°F baseline, night-time setbacks (60°F 10PM-6AM), and daytime setbacks (60°F from 9AM-4PM on weekdays). We also evaluate hypothetical MPC savings at 10%, 30% and 50% energy reduction levels.

3 Results

We exclude internet costs to highlight direct financial and operational savings. We use a 3% interest rate to reflect electricity inflation rate of U.S. [6]. Our target payback period is

[1]https://energyplus.net/

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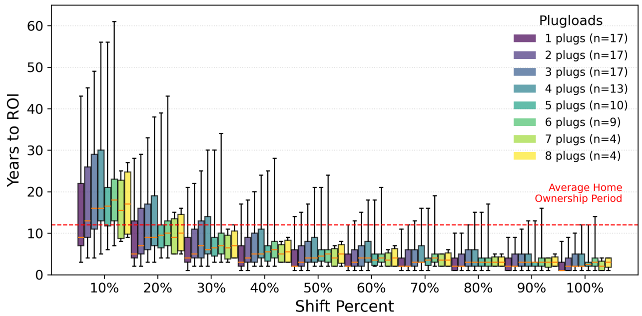

Figure 1. Return on investment period by number of plugloads(sorted in decreasing order).

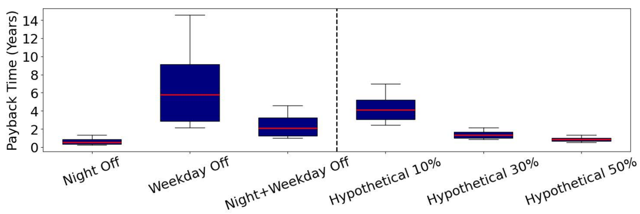

Figure 2. Expected payback period for thermostats under different savings assumptions.

12 years, which is the average length of home ownership in the US [1]. We assume an average cost of $8.79/plug .

Figure 1 shows that increasing the number of plug loads shifted leads to higher ROI. This suggests that smart plugs should be used strategically on the devices that will have the most significant impact.

We evaluate annual heating and cooling costs and the impact of various thermostat control strategies. Households spend an average of $530/year on heating ($300–$801). A nighttime setback saves $59/year (10.6%), a weekday setback saves $46 (8.1%), and combining both yields $108/year (19.5%). Figure 2 illustrates the expected payback periods for each strategy. Nighttime setbacks recoup costs quickly. Adding daytime setbacks can decrease the payback period further. Even a 10% reduction in heating bills can justify the cost of an expensive thermostat within a few years.

Our results show that smart thermostats and plugs can provide measurable energy savings, but their economic viability is limited, especially for low-income households.

A major barrier is reliance on home internet access. About 40% of low-income U.S. households lack reliable fixed internet, with 20% having none and 20% relying only on mobile data. [5]. For this study, we assume a $40/month Verizon wireless data plan, as some homes do not have cable-based service available. Only when the cost of internet is removed do the smart plugs and smart thermostats show a feasible RoI. More advanced controls like model-predictive control bring costs related to energy model engineering effort and controls tuning.But even with the most optimistic assumption (hypothetical-50%), we are not saving enough to justify connectivity costs.

4 Conclusion

Our results show that smart plug and thermostats can reduce energy costs and justify the investment. But only if infrastructure costs are ignored or heavily discounted. They are often not feasible or have payback periods that exceed typical home ownership durations under realistic conditions. Future work will explore lower-cost infrastructure solutions for residential buildings and quantify savings across different building types, HVAC systems, and geographic locations.

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