Energy Efficiency & Transportation

Building Energy Reduction in Transit-Oriented Development Areas

OBJECTIVE AND SIGNIFICANCE: The goal of this research project is to develop and demonstrate a building energy analysis process that can be used during early design phases at multiple transit-oriented development (TOD) sites located along Oʻahu's light rail line. This helps Hawaiʻi meet its clean energy goals through reduced energy use in buildings, increased energy security and resiliency, and a better quality of life for residents.

BACKGROUND: HNEI has worked closely over the years with the University of Hawaiʻi's School of Architecture's Environmental Research and Design Lab (ERDL) to conduct energy efficiency research. Under this project, ERDL is collaborating with the University of Hawaiʻi's Community Design Center (UHCDC), the developers of multi-family residential building conceptual designs for the State Office of Planning in a project called the "Waipahu Transit Oriented Development Collaboration: Proof of Concept Research, Planning, and Design Study."

At the start of this project, the Center's current TOD planning process did not include quantitative targets for building energy use or for on-site renewable energy generation. Design teams lacked specific guidance to design beyond the building energy code. ERDL is collaborating with the UHCDC to bridge these gaps by providing energy efficient design processes and natural daylighting strategies.

The results of this process are intended to inform designers, developers, and the State with specific guidance on which building features will provide the biggest impact on the energy performance, peak loads, energy cost, building operating emissions, and annual energy consumption.

The team set out to create a whole-building energy model representative of future development of five-story multi-family buildings in Waipahu, Hawaiʻi of approximately 20,000 ft².

In addition to the energy analysis, the team conducted detailed thermal comfort modeling to evaluate the applicability of passive cooling and/or mixed mode operation of the air conditioning systems in the residential units. The thermal comfort modeling considered both current and future weather predictions associated with various climate change projections.

Figure 1. TOD Site, Waipahu. (Photo Credit: UHCDC)

PROJECT STATUS/RESULTS:

Benchmarks: Based on existing benchmarks, new condo/multifamily projects designed and built to the current energy code (IECC 2015) perform similar to many existing condo/multifamily developments in Hawaiʻi. The energy simulations show that:

1. Designing to the IECC 2015 code can be achieved without additional effort and designers/building operators have the tools to achieve built performance; and
2. Driving building energy consumption down will take more than code minimum design.

The impact of combining various packages of energy conservation measures are described below. For additional detail, please refer to the final project report (linked on the following page).

Baseline Modeling: Using computer simulation and modeling, the team identified air conditioning (AC), domestic hot water, lighting, and equipment as the major energy end uses in a condo/multifamily residential building making them appropriate targets for advanced design.

The team demonstrated that building with air conditioning can be designed to reduce annual energy use by 29-61% compared to an IECC 2015 code minimum building.

The team modeled thousands of combinations of energy and design features that include building envelope and internal occupant loads. In addition to AC, domestic hot water and lighting, occupant plug loads, ventilation, window-to-wall ratio/glass, and glazing types were the biggest factors that influence energy performance.

Peak cooling demand can be reduced by providing minimum ventilation, effective building orientation, reduction of window area, increased exterior shading of windows, and use of high performance glass.

Peak electrical demand can be reduced by not installing AC or using high efficiency AC when installed, with lower window-to-wall ratio, higher shading ratio, and better window performance. Photovoltaic panels and on-site battery storage can shave the peak electrical demand.

Net Zero Energy (NZE) Targets: Buildings that are 2 stories or less can meet NZE targets. Taller buildings (over 3 or 4 stories) designed to IECC 2015 code minimum prescriptive requirements cannot achieve NZE due to insufficient roof area. In order for high density buildings to meet the NZE goal, off-site solar generation is needed.

Thermal Comfort: Historic climate data shows that comfort can be achieved without mechanical cooling. With ceiling fans and air movement, thermal comfort can be increased to 96.4% of the year (based on the ASHRAE 55 adaptive thermal comfort benchmark). For reference, a typical conditioned office space is considered properly designed when comfort targets are achieved 98% of the year.

Even under optimistic future weather scenarios where global temperature rise is muted (through reduction in global greenhouse gas emissions), the passively cooled space in Hawaiʻi will struggle to meet an acceptable level of comfort throughout the year (more than 90% comfortable). We would encourage developers and designers to design for passive cooling and provide provisions for future installation of AC. The findings may also encourage the State to consider more stringent energy targets which would mitigate climate change and decrease the need for future AC.

The final project report "**University of Hawai'i Whole-Building Energy Modeling for Future TOD Areas**" provides guidance to architects, engineers, and professional designers in sufficient detail to allow the methodologies be replicated when designing future buildings in Hawaiʻi.

This project has produced a number of works, including the two listed below:

- 2021, W. Meguro, E.J. Glassman, **Evaluating Energy Targets and Efficiency Measures in Multifamily Subtropical Buildings through Automated Simulation**, Technology Architecture + Design, Vol. 5, Issue 1, pp. 82-95. (Open Access: **PDF**)
- 2021, W. Meguro, E.J. Glassman, **Designing Zero Energy Multifamily Buildings Informed by Simulation and Policy**, Presented at the Design + Architecture Hawaiʻi Event, September 30 - October 1.

Funding Source: Energy Systems Development Special Fund

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Last Updated: November 2021