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ENERGY EFFICIENCY AND CONSERVATION PROGRAMS FOR LOW-INCOME AND MINORITY HOMES

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Energy conservation and efficiency at the household level are important measures to reduce inequitable energy burdens, promote climate resilience, and encourage an equitable transition to clean energy in the US. The Community Weatherization Coalition (CWC), a non-profit coalition, has provided free home energy and water surveys to improve energy efficiency since 2008, focusing on low-income residential homes of Alachua County, Florida. This paper discusses descriptive statistical results of the program in reduction of energy and water usage for 312 households in Alachua County that were served from 2016 to 2019. The findings indicate that the CWC program has provided an innovative and effective way to reduce the inequitable energy burden for low-income residential populations through volunteer-based home energy conservation services. The results highlight the importance of incorporating energy efficiency into efforts to promote the transition to clean energy and suggest how local government and utilities can leverage energy efficiency to increase the resilience of the community.

Keywords: Energy conservation, Energy equity, Energy burden, Community resilience.

1 INTRODUCTION

Energy conservation and efficiency at the household level play a crucial role in reducing inequitable energy burdens, fostering climate resilience, and supporting a fair transition to clean energy in the US (NRC 2010, Azevedo *et al.* 2013). Since 1980, energy efficiency investments have reduced US annual energy expenditures by nearly $800 billion and cut household consumption by 16% (ACEEE and BCSE 2022). The potential for cost-effective energy efficiency improvements is very large: it is "the largest, least expensive, and shortest-lead-time resource for balancing energy supply and demand" (NRC 2010). A long-term commitment to energy efficiency could produce over 20% savings in total national electrical demand and over 50% reduction in natural gas demand, making energy efficiency a high priority energy resource (EPA 2015).

Increased investments in energy efficiency programs are driven by rising fuel costs, as well as growing concerns over climate change due to greenhouse gas emissions from the burning of fossil fuels (ACEEE and BCSE 2022). Energy efficiency also has significant non-energy benefits for ratepayers, households, and especially to the broader society (Schweitzer and Tonn 2003). Health and safety benefits are especially important for residents with outdated appliances and poorly insulated homes (Brown *et al.* 2020, Drehobl *et al.* 2020).

Despite these potential benefits of energy efficiency programs, there are relatively few examples of actual projects and programs to achieve decarbonization for affordable housing (York *et al.* 2022). Multiple barriers historically have impeded access by low-income populations to

energy efficiency programs, including high upfront costs, uncertainty and lack of information, and split incentives for rental housing when landlords are not responsible for utility costs (Gilleo *et al.* 2017, York *et al.* 2022).

As a result, the inequitable energy burden – the percent of household income spent on utilities for heating, cooling, and other home energy services – has persisted as a nationwide challenge despite decades of home energy efficiency program investments (Brown *et al.* 2020). One-quarter of all US households face high (paying over 6% of their income on energy bills) or severe energy burdens (over 10% of income), especially among Black, Hispanic, Native American, rural and older adult households in the South, and those who live in multifamily complexes and manufactured buildings (Brown *et al.* 2020). Over 60% of low-income US households faced a high energy burden in 2021, some paying over 20% of their income (ACEEE and BCSE 2022).

A recent study in the state of Florida found that just a 1% increase in energy efficiency programs for low- and middle-income households could increase their disposable income by over $5 million, while just a 1% increase in adoption of electric vehicles would add $175 million in health and quality of life benefits (The Balmoral Group 2022). Yet low-income populations accounted for only 1.69% of actual participants in energy services programs in the state, compared to around 3% for the population as a whole (The Balmoral Group 2022).

Utility companies spend less on energy efficiency programs for low-income households compared to other groups, while community-based organizations and non-profits are often more able to reach these underserved populations (Brown *et al.* 2020). In this paper, we focus on the home energy and water efficiency services carried out by one such organization in the state of Florida, the Community Weatherization Coalition (CWC).

With two full-time paid staff persons and over fifty active volunteers, the CWC is a grassroots community coalition founded in 2008 that trains local volunteers to conduct free home energy/water tune-ups, emphasizing education of low-income residents. CWC volunteer energy coaches inspect the building envelope, major appliances, lighting, water consumption, and safety issues as well as installing more efficient light bulbs, shower heads and faucet aerators. Since 2008, CWC energy coaches have carried out home energy/water tune-ups in nearly 1,500 homes in Alachua County. Additionally, over 100 households have been reached with the Do it Yourself (DIY) home energy tune-up program launched during the COVID-19 pandemic. The CWC recruits and trains new groups of energy coach volunteers twice a year.

2 METHODS AND DATA

As shown in Table 1 below, the study utilized Alachua County Property Appraiser (ACPA), Gainesville Regional Utilities (GRU) Consumption Data, CWC Participant Data, and US Census American Community Survey (CENACS) data. ACPA provides data regarding physical characteristics of 61,766 single-family residential homes in Alachua County as of September 2022. GRU Consumption Data includes monthly electric, natural gas, and water consumption data for each residential and commercial customer from 2015 to 2021. Total monthly natural gas and electric consumption were quantified in equivalent kilowatt-hours (ekWh), and outlying units that consumed less than 2,000 ekWh per year or more than 30,000 ekWh per year were removed from the dataset. The study used houses with heated area between 500 to 2,200 square feet, less than five bedrooms, and effective year built between 1955 and 2006. The final cleaned data included 30,177 single-family residential homes in Alachua County utilized for the analysis.

CWC Participant Data included 1,034 residents served by the CWC from 2008 to 2020, of which this study analyzed 312 participants from 2016 to 2019. Figure 1 below shows locations of participating homes utilized in this study. CENACS data included social, economic, housing, and

demographic data for Alachua County. This study focused on participants from low income and minority areas of the county. Low-income participants included those from the areas that had a median household income lower than the Florida median household income of $57,703 (US Census 2022). Minority participants included those from census areas that had percentages of underrepresented groups larger than national population percentages. Specifically, these areas had the % Black > 13.2%, or % Native American > 1.3%, or Hawaiian > 3.1%, or Hispanic > 18.9% (US Census 2022).

Table 1. Original databases used to create full analysis dataset.

Database	Variables
ACPA	PARCELID, address, number of bedrooms and bathrooms, heated area, year built, rent/own
GRU Consumption Data	PREMISEID, address, day, month, year, natural gas, water, electric, consumption rate ($/kWh)
CWC Participant Data	Address, date of participation, rent/own
CENACS	Median household income, percentage of race/ethnicity of the census block group

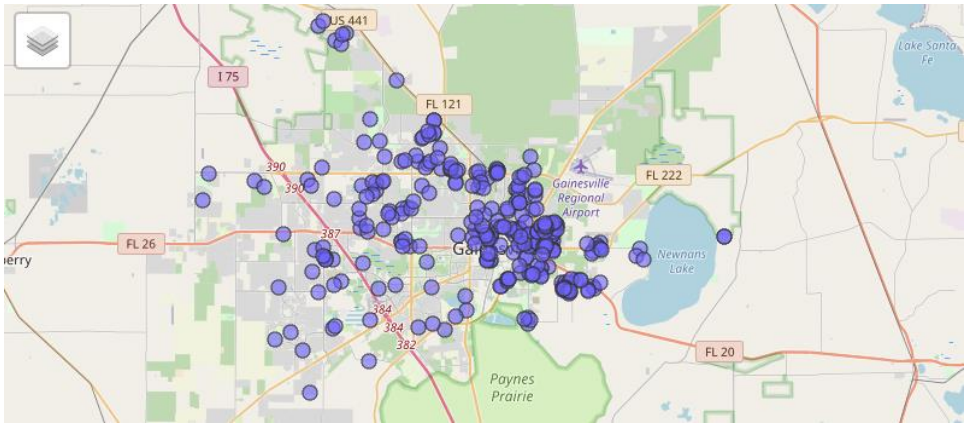

Figure 1. Location of selected CWC participants from 2016 to 2019.

This study utilized the annual community baseline (ACB) approach to estimate energy savings from participation in the CWC program while controlling for other factors such as variable weather (Jones *et al*. 2010). Analysis of this study was conducted in R with several supported library packages (e.g., dplyr, postmastr, tydycensus, ggmap, reshape2). As shown in Figure 2, residential units from low-income and minority communities in Alachua County had slightly lower energy consumption than high-income and majority communities.

Multiple regression analysis was conducted independently for each calendar year dataset. Electrical consumption (EC) of each residential unit in the census was estimated as Eq. (1) below:

$$EC_{year\ i} = \beta_0 + \beta_1 * bedroom + \beta_2 * bathroom + \beta_3 * htdarea + \beta_4 * year\text{-}build + \beta_5 * natural\text{-}gas_{year\ i} \quad (1)$$

Savings were estimated by taking the difference between post participation year and pre-participation year as shown in Eq. (2):

$$\text{Time series estimate} = \text{Post} - \text{Pre} \quad (2)$$

The ACB approach used multiple regression analysis to predict home energy use values for each home in the census and to compare homes that participated in CWC programs by taking the

difference between their adjusted predicted post-participation consumption and their actual post-participation consumption as shown in Eq. (3).

$$\text{ACB analysis} = \text{Actual Pre}/\text{Predicted Pre} * \text{Predicted Post} - \text{Actual Post} \quad (3)$$

where:

- Actual Pre: actual consumption one year before participation.
- Predicted Pre: predicted consumption one year before participation.
- Actual Post: actual consumption one year after participation.
- Predicted Post: predicted consumption one year after participation.

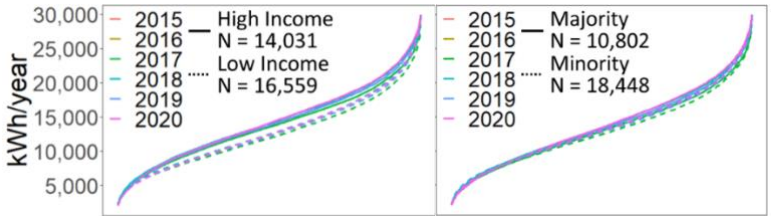

Figure 2. Annual community baseline of different groups in Alachua (ekWh/year).

3 RESULTS AND DISCUSSION

Figure 3 below shows the predicted and actual ekWh/year of each CWC participant household in 2016 to 2019. Each point in Figure 3 represents a CWC participant. Y-axis shows the predicted and actual ekWh/year while x-axis shows the heated area in square feet. Heated area was used for the x-axis as it was the biggest driver of energy use based on the result of regression analysis. Two fitted linear regression lines were built for the actual and predicted data. As shown in Figure 3, the fitted line for actual data had a smaller slope than the fitted line of predicted data. This result indicated that CWC participants used less energy than non-participants.

Table 2 shows the detailed energy savings that were computed for participants from low-income and minority households. Generally, all participants received energy savings; however, renters received more energy savings from the CWC programs than did owners. The last column shows the average portion of savings compared to median income for the census block group. In general, the CWC program helped save around .2% to .5% of each household's income in low income and minority communities. The same analysis was also computed for the aforementioned 30,177 single-family residential homes in Alachua County.

On average, the energy saving (i.e., energy differences) of the county was only around .01% to .03% of the household income. This implies that CWC participants from low-income and minority communities could have up to ten times the electrical bill savings from their household income compared to a typical family in the county. This result is especially important since Figure 2 indicated that residential units from low-income and minority communities use only slightly lower energy consumption than high-income and majority communities. Therefore, this study confirms the effectiveness of community coalition programs like the CWC to alleviate the energy burden for low-income and minority communities. Local government and utilities could consider leveraging such programs to improve energy efficiency of the communities.

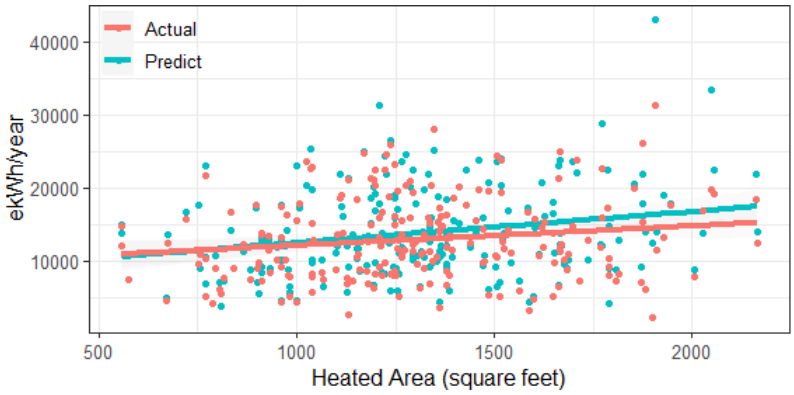

Figure 3. Predicted and actual ekWh of all participants in 2016 to 2019.

Table 2. Energy savings of participants from low-income and minority homes.

Year	CWC Participant	Average saving						% Savings compared to pre-participation		% Savings of household income	
		Low-income			Minority			Low-income	Minority	Low-income	Minority
		n	ekWh	$	n	ekWh	$				
	Total	47	657	67	47	433	42	4.7%	3.1%	.3%	.2%
2016	Owner	30	507	53	31	438	43	3.7%	3.1%	.1%	.1%
	Renter	17	921	94	16	424	40	6.6%	3.0%	.5%	.4%
	Total	35	389	53	35	376	48	3.8%	3.6%	.1%	.1%
2017	Owner	28	63	17	29	272	38	1.3%	2.8%	.0%	.1%
	Renter	7	1,696	193	6	878	98	14.8%	7.5%	.4%	.2%
	Total	31	1659	150*	28	1681	155*	9.3%	9.3%	.4%	.3%
2018	Owner	27	1,473	141*	23	1450	144*	9.1%	8.9%	.4%	.3%
	Renter	4	2,917	216	5	2745	214	10.9%	10.9%	.9%	.3%
	Total	62	913	65^{+}	51	603	33	4.3%	2.4%	.2%	.1%
2019	Owner	49	356	43	39	-174	-3	3.1%	-.3%	.1%	.0%
	Renter	13	3,014	156*	12	3131	163*	7.8%	8.6%	.5%	.4%

Paired t-test significant test: $^{+}$ p < .1, * p < .05, ** p < .01, ***

4 CONCLUSIONS

As the US faces the pressing need for a transition to renewable, low-carbon energy sources from fossil fuels, specific efforts are needed to ensure an equitable transition that does not leave behind the populations that have suffered for decades from persistent inequities in their energy burden, requiring attention to structural, distributional, procedural, and transgenerational justice (The Balmoral Group 2022). Non-profit organizations like the CWC can play an important role in helping to provide services and education to these underserved populations. The transition in Florida to a more resilient, renewable energy-based economy will have varied impacts across socioeconomic and demographic groups. An important consideration in energy policy will be energy equity, which recognizes that disadvantaged communities have been historically marginalized with overburdens in environmental hazards, lack of energy efficient housing and transportation, and underinvestment in the infrastructure for cleaner energy. A system designed with equity at the forefront ensures that the benefits of the transition are shared equally across society (The Balmoral Group 2022).

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