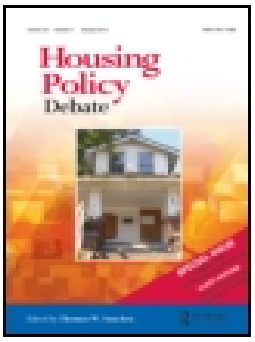

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Household Energy Costs and the Housing Choice Voucher Program: Do Utility Allowances Pay the Bills?

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ABSTRACT
Utility bills present a hidden threat to the affordability of a family's housing—unknown before a household moves into a unit, and unpredictable from one month to the next. In theory, tenants receiving Housing Choice Vouchers are shielded from energy cost burdens through utility allowances built into rent subsidies. However, tenants may face actual energy costs that far outstrip allowances, effectively rendering their housing unaffordable. This study compares utility allowances with electric bills for over 19,000 Housing Choice Voucher households in four Florida cities and identifies household and unit characteristics associated with excessive costs. Nearly half of tenants in the sample faced bills in excess of posted allowances, with households renting single-family homes particularly at risk. On the other hand, state-sponsored affordable housing developments, such as those subsidized by the Low Income Housing Tax Credit, offered voucher tenants the chance to live in modern units with lower energy use and a better fit between costs and the utility allowance. The findings have implications for housing authorities and tenants seeking to reduce energy cost burdens.

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Energy costs can place a heavy financial burden on low-income households. An evaluation by the Applied Public Policy Research Institute for Study and Evaluation (APPRISE) (2005) found that households with incomes below $10,000 spent a median of 16% of their income on energy, but households above $50,000 spent a median of 2%. Low-income households with high energy costs report financial strain, health problems from poor indoor temperature control, utility shut-offs, and frequent moves (Hernandez & Bird, 2010). Renters who pay their own utilities face an additional barrier that can raise their costs: a split-incentive problem that discourages landlords from investing in energy efficiency improvements, since it is the tenant who would realize the cost savings.

In theory, renters in subsidized housing are shielded from high energy burdens. U.S. federal housing subsidy programs generally are designed to limit tenants' housing costs to 30% of their income, with energy costs explicitly included in that gross housing cost. Under the U.S. Department of Housing and Urban Development's (HUD) Housing Choice Voucher (HCV) program, public housing authorities (PHAs) provide tenants with a rent supplement that includes an allowance for tenant-paid utility bills. In practice, tenants who live in inefficient units or otherwise consume more energy than expected may face bills that exceed their utility allowances. Tenants with low

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energy consumption may receive a modest income supplement if their allowances exceed their bills.

In a number of studies, particularly those documenting tenant moves from public housing to private units with vouchers, subsidized housing tenants have reported that high utility bills make it difficult for them to pay for rent and other household necessities and to maintain stable housing (Buron, Levy, & Gallagher, 2007; Hernandez & Bird, 2010). These studies have largely relied on tenants' self-reported experiences and energy costs. However, little research exists measuring actual energy bills and cost burdens for subsidized housing tenants.

This study addresses the research gap by examining energy costs and utility allowances for tenants participating in the HCV program between 2010 and 2013 in four Florida cities: Jacksonville, Gainesville, Tallahassee, and Orlando. The analysis focuses on voucher holders who are responsible for their own electric bills. It relies on a highly granular database matching two primary sources of household-level administrative data: (a) HUD tenant characteristics data, with voucher holders' locations, household characteristics, and income and rent payments; and (b) monthly electricity consumption records by address from utility companies. In all, energy costs were analyzed for 19,545 unique household–unit combinations.

The tenants used their vouchers in a diverse set of housing units, including single-family homes, duplexes and other small multifamily properties, and larger apartment complexes. In this study, we segment out voucher-occupied units in developments funded by the Florida Housing Finance Corporation (Florida Housing) through the Low-Income Housing Tax Credit (LIHTC) program, private activity bonds, and the state's housing trust fund. Florida Housing's portfolio is largely made up of new construction projects, built in the 1990s and later. Moreover, in recent years, Florida has offered incentives in its competitive funding process for properties incorporating energy-efficient construction practices (Florida Housing Finance Corporation, n.d.). Therefore, we hypothesize that these units offer voucher holders an energy-efficient alternative to market-rate housing.

The analysis addresses the following research questions:

(1) Do utility allowances cover electric bills for assisted households? Does that coverage vary by household and property characteristics?
(2) Which housing types provide more affordable energy options for voucher holders? Are there differences between Florida Housing-sponsored affordable developments and other multi-family housing?

To address these questions, we analyze two measures of households' energy cost and burden: electric bills and the differentials between billing amounts and utility allowances. Descriptive statistics examining these measures by household size and composition, income, and housing unit characteristics are followed by a multinomial logistic regression analysis to determine the characteristics associated with energy bills in excess of utility allowances.

This study adds to the existing literature in several ways. First, it employs detailed, household-level utility and housing administrative data to describe tenants' energy costs. Most previous studies have relied either on residents' self-reported costs or on aggregated data sets such as the U.S. Residential Energy Consumption Survey or the Census Bureau's American Community Survey. Second, most previous literature has focused on energy consumption and costs. This study adds the utility allowance side of the equation to give a fuller picture of the actual financial burden on tenants posed by energy costs. Third, studies of multifamily energy consumption typically use building-wide averages to assess energy use, which can mask differences among units and households in the same properties. The unit-level administrative data enable us to examine detailed household and unit characteristics. Fourth, whereas much recent interest in renters' energy consumption focuses on larger multifamily complexes, this study describes energy costs across the diverse housing types occupied by voucher holders. In particular, we focus on the higher energy costs associated with the use of vouchers in single-family homes, a common arrangement for families. We also distinguish between market-rate and subsidized multifamily developments to explore the potential to reduce tenants' energy costs by pairing vouchers with the modern multifamily units constructed under LIHTC and other state-administered programs.

Florida is used as a case study to take advantage of unit-level energy data available from municipally owned utilities in the four cities. Energy costs certainly vary across states because of differences in building systems, regulatory environments, and particularly climate. However, home energy use in Florida (which lacks extreme winter temperatures) is comparatively modest; Florida ranks 39th among states in residential energy use per capita (U.S. Energy Information Administration, 2016). Therefore, a finding of energy burden among voucher tenants in Florida has implications for other markets around the United States, where tenants may be even more vulnerable to excessive costs.

Background

Energy Cost Burden and Low-Income Households

Energy costs are an inherent part of the cost of shelter. U.S. Census estimates of gross housing costs include the cost of electricity, gas, and other fuels, and the housing literature generally has followed suit.[1]

Household energy is a necessity good. Demand for residential electricity is relatively inelastic to income, particularly for the lowest income households (Jamasb & Meier, 2010). In fact, low-income households pay more in energy per square foot than other households do. In part, this is because they are more likely to occupy smaller units than other households with the same number of members, and thus are spreading a similar intensity of energy use across a smaller number of square feet. However, the low-income households also are more likely to occupy units where the structure and household appliances are less efficient (Drehobl & Ross, 2016; Pivo, 2012). Also, higher-income households also are better able to afford one-time investments in energy efficiency measures that result in savings over the long term (Frederiks, Stenner, & Hobman, 2015).

Because low-income households cannot reduce the basic costs of heating, cooling, and lighting to be commensurate with their incomes, their energy cost burden—the ratio of household energy costs to income—is higher than that of other households. Hernandez, Aratani, and Jiang (2014, p. 3) define a high energy burden ("economic energy insecurity") as energy costs exceeding 10% of income. They found that in the United States, economic energy insecurity was more prevalent for households with income under 200% of the federal poverty level, as well as for households in the South, African American households, and renters. Energy cost burden falls in a linear fashion as income, the denominator of the energy cost/income ratio, increases.

Household energy consumption in warmer climates tends to be lower than the national average because of milder winters, but a warmer climate does not necessarily free households from onerous energy cost burdens. In the United States, when the cost of energy is also considered, average annual expenditures in Florida and the rest of the Southeast fall close to the national average. Expenditures are higher in the Northeast, but similar in the Midwest and lower in many Western states (U.S. EIA, 2012). Moreover, even in states with lower costs, energy burdens are not necessarily lower, since income levels also drive the energy cost burden calculation. Many Southeastern and Midwestern cities have high median energy burdens despite low energy costs, because of low household incomes (Drehobl & Ross, 2016).

The consequences of high energy costs for low-income households can extend well beyond immediate financial concerns. Hernández (2016) conceptualizes energy insecurity as including three dimensions: economic (high cost burden), physical (low-quality, energy efficient housing), and behavioral (coping strategies such as conserving energy or skimping on comfort). The financial impacts of energy insecurity include overhanging debts to utility companies, utility service shut-offs, frequent moves to try to reduce energy bills, and reliance on payday loans to cover energy bills (Drehobl & Ross, 2016; Hernandez & Bird, 2010). Health consequences can include exacerbation of illnesses such as asthma by poor temperature and humidity control, depression and anxiety triggered by chronic stress, and excess deaths in winter and during summer heat waves (Boardman, 2010; Hernández, 2016; Hernandez & Bird, 2010).

The Housing Choice Voucher Program

The HCV program presents a special case of the energy insecurity problem. It serves some of the lowest income tenants in the United States, who almost certainly would face severe energy cost burdens without assistance. The HCV program provides a utility allowance designed to limit tenants' gross housing costs, including energy, to a manageable share of income.

The HCV program was established in 1974 as an alternative to the traditional public housing program. Tenants rent units on the private market and receive a subsidy enabling them to devote a fixed portion of income to housing costs, typically 30%.[2] Specifically, HUD provides funds to local PHAs; the PHAs in turn provide supplemental payments to landlords to make up the difference between the voucher holder's payment and a contracted rent level. As public housing production waned in the 1980s, the federal government greatly expanded the HCV program. There are now more than 2.3 million voucher recipients in the United States (McClure & Johnson, 2015).

Voucher holders are free to choose a variety of housing types, including single-family homes, multifamily buildings, and mobile homes. Most vouchers are used in market-rate units, but some are used in properties subsidized by the federal LIHTC program. LIHTC was established in 1987 to provide capital subsidies for rehabilitation and new construction of affordable rental housing units. In return, the developments are subject to tenant income and rent limits, although generally not to the deep affordability levels afforded by the ongoing subsidies from the HCV program. Significantly, source of income discrimination is prohibited for owners of LIHTC-funded developments; that is, property managers cannot refuse to accept vouchers as rent payment. As a result, LIHTC developments provide an important source of available units for HCV holders. In Florida, for example, approximately one in seven voucher holders occupies an LIHTC-funded unit.[3]

Vouchers and Utility Allowances

The average annual tenant income for HCV recipients nationwide is just $13,800 per year, and 80% of participating households have incomes below $20,000 per year (HUD, 2015). An unassisted household at this income level would be extremely vulnerable to energy insecurity. However, the voucher program includes energy expenses as part of the housing costs covered by the tenant's 30% of income payment. If all utilities are landlord-paid, then the tenant's rent payment to the landlord simply equals the calculated family rent share. If the tenant pays any bills directly to a utility company, however, the PHA reduces the tenant's required payment to the landlord by a utility allowance based on the presumed amounts of the tenant's utility bills.

The utility allowance is figured directly into the tenant's payment calculation rather than being sent to the utility companies, and it is not adjusted for the tenant's actual bills. Each PHA publishes a detailed schedule listing allowance amounts based on the types of utilities that are tenant paid, such as electricity, gas, other types of household energy, water, sewer, trash collection, and provision of appliances such as stoves and refrigerators; the number of bedrooms in the unit; and the type of dwelling structure, such as single-family home or low-rise apartment building. HUD calls for these allowances to be based on typical consumption by an energy-conservative household (see Pazuniak, Reina, & Willis, 2015 for a detailed discussion of procedures for setting utility allowances and tenant payments in federal subsidy programs).

Tenants' actual energy costs can fall above or below the utility allowances, resulting in higher or lower than expected actual energy and rent burden. A General Accounting Office (1991) report found that utility expenses exceeded allowances for 70% of voucher households studied. The report noted that voucher holders have little residual income left for other expenses after paying their rent share ($380 per month on average, or $674 in 2016 dollars). Therefore, even small incremental costs from energy bills exceeding the utility allowance can present a severe hardship. More recently, tenant advocates have expressed concerns that PHAs' utility allowances are highly variable even within the same region and utility service area, and that the allowances do not keep pace with increases in energy costs (National Housing Law Project, 2009). Moreover, as household energy costs fluctuate from month to month, tenants may find that the utility allowance overestimates costs in some months and underestimates costs in others, resulting in a volatile actual rent burden. For example, residents using vouchers to exit public housing through the HOPE VI program reported difficulty paying utility bills, especially during hot summers and cold winters (Buron et al., 2007).

Recent data on energy use and costs for voucher-assisted tenants are scarce. Dastrup, McDonnell, and Reina (2012) use residents' self-reported energy costs from the American Housing Survey to find that voucher recipients pay statistically significantly higher electricity bills than unassisted tenants do. The analysis attributes this increase to "differences in characteristics of the units, buildings and households rather than in government assistance" (Dastrup et al., 2012, p. 144). More typically, however, the literature has focused on the potential to increase efficiency in project-based subsidized housing, such as public housing and HUD's project-based multifamily supply (Bamberger, 2010; Harak, 2010; Reina & Kontokosta, 2017).

Rental Housing and Energy: The Split Incentive Problem

Energy efficiency measures such as building retrofits and appliance upgrades can reduce both the physical and financial burdens of energy insecurity. However, most low-income households rent their homes, and renters face a well-documented split incentive problem that makes it difficult to reduce energy consumption in rental housing through efficiency measures (Bird & Hernández, 2012; Giraudet, 2018; Maruejols & Young, 2011; Melvin, 2018).

The split incentive problem works as follows. Fuel costs may be individually metered for the tenant's unit and billed directly to the tenant. Alternatively, fuel costs may be billed to the landlord, either individually for each unit or, for a multiunit property, based on a master meter for all units in the property. These costs are effectively passed on to the tenant through a gross lease that encompasses both use of the property and utility costs, but the rent amount does not change based on utility consumption. Gas heat is often included in tenants' rent, but electric bills are overwhelmingly tenant-paid. In 2015, 91% of U.S. renters paid their electric bills separately from rent, according to the Census Bureau's American Community Survey.

One version of the split incentive problem involves the minority of units where energy costs are landlord paid. In this case, tenants have little incentive to change their behavior to reduce energy use through measures such as changing thermostat settings or reducing the use of appliances. Using data on indoor temperatures from the Residential Energy Consumption Survey, for example, Levinson and Niemann (2004) estimate that energy use is higher in U.S. apartments with gross lease arrangements than in those with tenant-paid utilities. This inefficient arrangement leads to higher costs for landlords, tenants, or both, depending on the extent to which the additional utility cost is incorporated into the gross rent amount.

A more common version of the split incentive problem is associated with units where energy bills are tenant paid. In these cases, cost savings associated with energy efficiency measures will be realized by the bill-paying tenant. Therefore, landlords have little incentive to invest in efficiency measures such as weatherization and purchase of efficient appliances. Bird and Hernández (2012) place the split incentive and tenants' relative lack of control in this scenario in the context of principal–agent theory. The core of the principal–agent problem is that the agent as a supplier of services makes decisions that impact upon the principal (purchaser), but the agent's motivations are different and therefore may not serve the best interests of the principal. In this case, the landlord as agent supplies the physical components that greatly affect energy efficiency, such as the building envelope and major appliances. The tenant as principal is responsible for energy bills, but does not control energy efficiency components.

Moreover, even when landlords wish to implement energy efficiency measures and tenants wish to seek out efficient units, information gaps make it difficult to determine whether particular efficiency measures will result in real energy savings. Giraudet (2018) notes a number of these informational barriers to realizing the potential for energy savings through efficiency investments, including incomplete information (infrequent metering of energy use, difficulty interpreting product labels and audits) and imperfect information (e.g., utility bills can vary based on volatile energy prices and weather). A landlord who purchases purportedly efficient appliances or building materials has little information with which to evaluate potential or actual energy savings. Similarly, tenants may seek out green units with energy efficient features, but they also have little way of knowing to what extent these features will result in real energy savings.

HCVs and the Principal–Agent Problem: Introducing a Third Party

The HCV program introduces yet another level of complexity into the principal–agent relationship: the intervention of PHAs as another agent. PHAs are responsible for administering the voucher program and implementing federal policies. At several steps in the leasing process, the PHA is in a position to affect tenants' energy cost burden.

PHAs greatly influence tenants' choice of housing units. PHAs set rent payment standards based on Fair Market Rents published by HUD. These rent caps restrict the units that are available to the tenant to lower-cost units, which may be older and less likely to include modern energy efficiency features. Most PHAs further direct tenants' housing search by providing information such as rental listings, landlord contact information, and even housing search counseling. Once the tenant has selected a unit, the PHA conducts physical inspections to ensure that the unit meets federal Housing Quality Standards (HUD, 2001).

Most importantly for this analysis, PHAs set utility allowance schedules, thereby directly affecting tenants' ability to meet their energy costs without exceeding 30% of their income for total housing costs. PHAs have broad latitude in the data and methods they use to set the allowances. HUD instructs PHAs to use local data if possible to calculate typical energy costs, but PHAs may use a variety of local sources, and may use national data if local information is unavailable (Pazuniak et al., 2015).

The PHAs' roles in the housing search and setting allowances potentially provide them with means to mitigate the effects of the split incentive problem on low-income tenants. However, like other parties in the arrangement, PHAs face information constraints. PHAs are not directed to consider energy efficiency measures in voucher housing inspections, and they have limited information with which to set utility allowance levels based on average historic consumption. PHAs also are constrained financially. They issue vouchers to a limited set of tenants within a budget set by Congress and allocated by HUD; unlike similar programs in Great Britain and the Netherlands, the U.S. HCV program is not an entitlement for all income-qualified residents (Priemus, Kemp, & Varady, 2005). Therefore, rent supplements and utility allowances present a zero-sum game. Higher quality, more expensive units and higher utility allowances for individual tenants will mean that fewer tenants can be served.

To summarize, low-income renters are highly vulnerable to energy cost burdens. These burdens stem from the households' limited means to meet energy costs, combined with a split incentive problem that discourages energy efficiency improvements in rental homes. The HCV program and the intervention of housing authorities provide a potential solution: utility costs are considered part of a family's overall housing costs, which are intended to be limited to a manageable portion of income. This solution will only be effective, however, if utility allowances match actual costs—that is, if the costs are predictable and PHAs have sufficient information and resources to set allowances at levels that adequately reflect tenants' energy bills. In the analysis that follows, we examine the extent to which utility allowances meet costs in practice.

Data and Methodology

Utility-Household Data Set

This analysis relies on a large data set of matched utility customer and voucher household records. The data set includes the unit location of voucher holders in each month over the 2010–2013 study period, monthly electricity consumption in that unit transformed into an electric bill, the applicable utility allowance for electricity provided by the PHA, and household and unit characteristics. Table 1 summarizes the household-level variables and their data sources.

Customer records were provided by four municipally owned utilities that provide services within their city limits and in portions of the surrounding counties: Gainesville Regional Utilities (GRU), JEA (formerly Jacksonville Electric Authority), Orlando Utilities Commission (OUC), and the City of Tallahassee (TalGov). Records were available from all four companies for the years 2010–2013. HUD provided data on voucher households for these years from the Form 50058 database, which records actions by voucher tenants such as move-in and initial income certification, annual or interim income recertification, and, less consistently, move-out. We used data for tenants with vouchers issued by six PHAs corresponding to the utility service areas: Gainesville Housing Authority and Alachua County Housing Authority (GRU); Jacksonville Housing Authority (JEA); Orange County Housing and Community Development and Orlando Housing Authority (OUC); and the Tallahassee Housing Authority (TalGov).

Both sets of data have unique identifiers for each household: a household head ID for the voucher data and a customer ID for the utility data. Each data set also includes the house- or apartment-level address of the housing, referred to as the unit in the voucher data and the premises in the utility data. These addresses were matched between the utility and voucher records and then transformed into a longitudinal database with a monthly record of household characteristics and utility consumption for each household during its stay in a particular unit. Appendix A describes the procedure for creating the matched longitudinal voucher holder/utility customer data set. Addresses were also matched to a database of subsidized housing developments to identify tenants using vouchers in Florida Housing-sponsored developments.

The unit of analysis for the study is each unique customer–premises combination. These unique combinations are referred to as households for brevity's sake; however, if the same individuals or family moved to a new unit, as reflected by a change in the customer–premises match, they would have another record at the new premises in the data set. Premises were limited to electric-only

Table 1. Data sources.

Variable	Source
Public housing authority (PHA) issuing voucher	Department of Housing and Urban Development (HUD) 50058 database
Household composition	HUD 50058 database
Household size	HUD 50058 database
Housing type (single family, market-rate multifamily 2–9 units and 10+ unit, Florida Housing sponsored)	HUD 50058 database, Assisted Housing Inventory
Household income (% area median income)	HUD 50058 database, Florida Housing income limit schedules
No. of bedrooms in unit	HUD 50058 database
Year built	Florida Department of Revenue, Name-Address-Legal File
Estimated electric utility allowance ($)	PHA utility schedules
Monthly electricity consumption (kWh)	Gainesville Regional Utilities, City of Tallahassee, JEA, Orlando Utilities Commission customer records, based on meter readings
Estimated monthly electric bill ($)	Estimated from consumption (see Appendix A)

households with tenant-paid electric bills. Appendix A describes the method for excluding the small number of households with natural gas use or landlord-paid electric bills. The final longitudinal data set contained 19,545 unique customer–premises combinations, with lengths of stay ranging from a single month up to 48 months over the 2010–2013 study period.

Monthly records were assigned estimated electric utility allowances (EEUAs) from PHAs' annual published utility schedules based on the date of the household's entrance or income recertification, the number of bedrooms, and the structure type (e.g., single family, low rise).

For each monthly record, we calculated two related outcome variables. The *electric bill* is the billing amount in dollars estimated from consumption (see Appendix A for estimation method). The *bill–EEUA difference* is the amount of the estimated electric bill minus the amount of the estimated utility allowance for electricity. This increment could be positive or negative, depending on whether the bill exceeded or fell under the allowance amount.

The longitudinal data set included two sets of mean values for each unique customer–premises combination for the electric bill and the bill–EEUA difference. An overall mean was calculated using all months in the household's stay in the unit. A peak month mean was calculated using only values from any June, July, and August months included in the household's stay, to account for the impact of the peak air conditioning season on energy bills.

Finally, the overall bill–EEUA differences were transformed into a categorical variable with three possible values for each household: (a) greater EEUA (on average, EEUA exceeds real electric bill by at least $25 per month); (b) EEUA/bill parity (on average, EEUA and bills are within plus or minus $25); (c) greater bill (on average, the real electric bill exceeds EEUA by at least $25). The categorical approach and outcomes were chosen to respond most directly to the policy question, Do utility allowances roughly match costs, leave tenants with a deficit, or provide tenants with a surplus? The three categories correspond to three possible policy outcomes: allowances are excessive, indicating overuse of public resources (greater EEUA); allowance levels are sufficient but not excessive, indicating appropriate policy design (parity); or allowances are too low, indicating insufficient public resources dedicated to the problem (greater bill). The $25 margin was chosen as a buffer against trivial differences in bills and utility allowances, particularly given natural variation in electricity use throughout the year.

Regression Model

To identify the household and property characteristics associated with the three bill–EEUA difference categories, a multinomial logistic regression model was constructed. The equation of the model is specified below:

$$Pr(Y_i = k) = 1/\left(1 + e^{-(\alpha+\beta_{1i}x_{1i}+\beta_{2i}x_{2i}+\beta_{3i}x_{3i}+\beta_{4i}x_{4i}+\beta_{5i}x_{5i}+\beta_{6i}x_{6i})}\right) \text{ for k} = 1, 2, 3.$$

where the category probabilities $Pr(Y_i = k)$ are a function of six explanatory variables for customer–premises observation *i*: x_1—peak ratio (the ratio of June/July/August months counted in the household's stay to total months of stay, used to control for greater use of electricity for cooling during summer months); x_2—number of bedrooms (1 BR, 2 BR, 3 BR, and 4 BR); x_3—annual household income level (0–15% of area median income [AMI], 15.01–30% AMI, and 30.01% AMI or higher); x_4—household composition (elderly household, household with nonelderly adults, and household with children); x_5—PHA (Gainesville Housing Authority, Alachua County Housing Authority, Jacksonville Housing Authority, Orange County Housing Authority, Orlando Housing Authority, and Tallahassee Housing Authority); and x_6—household type (single family, market-rate development with 2–9 units, market-rate development with 10 units or more, and voucher household in Florida Housing-sponsored property). A seventh variable, number of household members, was removed because of multicollinearity with number of bedrooms.

In the characterization of k, category 1 is EEUA/bill parity, serving as the reference category for the odds. In addition, e is the base of the natural logarithm; α is the intercept parameter; and β_i is the coefficient of corresponding x_i for customer–premises observation i.

It must be noted that the explanatory variables included in the model by no means cover all determinants. For example, unobservable variables such as occupant behavior and structural quality likely explain a portion of bill–EEUA differences. Thus, results of this analysis cannot demonstrate a causal relationship.

Results

Voucher Data Set Characteristics

Table 2 shows the distribution of households in the data set by location, household composition, and housing unit characteristics. Most of the voucher households were families with children. The majority had incomes at or below 30% of area median income, including 28% with incomes at or below 15% of AMI. These households are referred to as deeply low-income (DLI) in this article (NLIHC, 2016).

Half of the households occupied single-family homes. The rest were divided among small market-rate multifamily (2–9 units), large market-rate multifamily (10 or more units), and multifamily developments subsidized by Florida Housing. Notably for the energy evaluation, the Florida Housing-sponsored units in the data set were built much later than the unsubsidized units were. The average year built for Florida Housing units was 1999, compared with 1965 for single-family homes, 1970 for small market-rate multifamily buildings, and 1977 for larger market-rate multifamily buildings.[4]

Table 2. Location, household, and unit characteristics for the voucher data set.

	n	% of households
All	19,545	100
Utility region/PHA		
Gainesville Regional Utilities (GRU)/Gainesville Housing Authority	1,414	7
GRU/Alachua County Housing Authority	895	5
JEA/Jacksonville Housing Authority	11,705	60
Orlando Utilities Commission (OUC)/Orange County Housing & Community Development	1,171	6
OUC/Orlando Housing Authority	1,797	9
City of Tallahassee/Tallahassee Housing Authority	2,563	13
Household composition		
Family with children	13,055	67
Elderly, no children	1,782	9
Nonelderly adults only	4,708	24
No. of bedrooms		
1	2,837	15
2	6,574	34
3	8,198	42
4	1,936	10
No. of household members		
1	4,693	24
2	3,977	20
3	4,419	23
4	3,396	17
5 or more	3,060	16
Housing type		
Single family (mean year built: 1965)	10,016	51
Multifamily 2–9 unit, market rate (mean year built: 1970)	1,503	8
Multifamily 10+ unit, market rate (mean year built: 1977)	4,818	25
Florida Housing Finance Corp. (mean year built: 1999)	3,208	16
Income (mean annual household income: $12,153)		
0–15% of area median income (AMI)	5,488	28
15.01–30% AMI	8,691	44
> 30% AMI	5,366	27

Electric Bills

Mean estimated electric bills ranged from $80 per month for one-bedroom units to $174 for four-bedroom units. These are the electric bills averaged across tenants' length of stay in the unit. Table 3 shows the distribution of mean electric bills across unit sizes (number of bedrooms) for various categories of households.

Average bills varied by utility service area because of different billing rates and structures and modest differences in climate. Not surprisingly, bills were generally higher for larger households in a given unit size. In the smaller units, expenditures were higher for families with children and lower for elderly households. Energy bills also varied by housing type. Average bills for each bedroom size category were lowest in Florida Housing-sponsored units, as hypothesized. Bills were higher in single-family homes and 3–4-bedroom units in small multifamily properties. Larger market-rate developments represented a middle ground.

One factor that did not appear to affect energy bills is household income. Average energy bills for DLI households were similar to those of households with higher incomes. That is, DLI households did not appear to seek out more efficient units or otherwise economize on energy costs, despite their lower disposable income.

Average energy bills were also calculated using only the peak cooling months (June, July, and August). Peak-month bills were on average 19% higher than the overall averages. This gap remained largely consistent (17–23%) for households and units stratified by number of bedrooms, housing type, household composition, PHA, and income, other than a slightly narrower gap for elderly households.

Table 3. Mean of households' average electric bill ($) by location, household, and unit characteristics.

	Number of bedrooms			
	1	2	3	4
All	80	116	152	174
Utility region/PHA				
Gainesville Regional Utilities (GRU)/Gainesville Housing Authority	93	125	175	223
GRU/Alachua County Housing Authority	84	124	165	202
JEA/Jacksonville Housing Authority	82	120	152	174
Orlando Utilities Commission (OUC)/Orange County Housing & Community Development	68	97	144	168
OUC/Orlando Housing Authority	68	97	144	168
City of Tallahassee/Tallahassee Housing Authority	82	115	149	166
Household composition				
Families with children	99	120	152	175
Elderly	73	105	148	175
Nonelderly adults	83	113	150	156
Household size (persons)				
1	79	105	135	138
2	93	116	144	151
3	124	125	145	167
4	None	131	156	166
5 or more	None	155	163	179
Housing type				
Single family	108	132	158	177
Multifamily 2–9 unit, market rate	96	121	166	214
Multifamily 10+ unit, market rate	80	110	139	155
Florida Housing Finance Corp.	69	96	125	146
Income (% area median income)				
0–15	85	119	152	176
15.01–30	79	114	152	176
> 30	80	116	152	171

Note. Values are means of households' average electric bills over their tenure in the unit.

Do Utility Allowances Cover Electric Bills?

Utility allowances vary by housing structure type and number of bedrooms. For example, Orlando Housing Authority's monthly electricity allowance for a four-bedroom single-family home was approximately double the amount allotted for a one-bedroom in a multifamily development. The allowances also can vary over time, particularly if the PHA undergoes a full recalculation of estimated utility costs.[5]

EEUAs for households in the sample varied widely across PHAs—much more than the actual electric bills varied. Table 4 shows average allowances by PHA and unit size over the study period.

To examine whether utility allowances meet actual costs, households were placed in three categories based on the average difference between bills and EEUAs. Households with *greater EEUA* were those where, on average over the household's stay, the EEUA exceeded the real electric bill by at least $25 per month. Households with a greater EEUA effectively receive an income supplement from the utility allowance. Households with *EEUA/bill parity* were those where the difference between allowances and bills was within $25 in either direction. Households with *greater bill* were those where the electric bill exceeded the allowance by an average of at least $25—that is, those whose utility allowances were inadequate to meet their actual costs. Table 5 shows the distribution of households into the three bill-allowance comparison categories by area, household, and housing characteristics.

As the top row (*All*) in Table 5 shows, households reached rough parity between electric bills and allowances (EEUA/bill parity) in 32% of cases. In nearly half of cases, however, utility allowances fell short of tenants' real costs (greater bill). Tenants whose electric bills were below their allowances (greater EEUA) made up the smallest category, at 23% of households.

The gaps between allowances and actual bills varied greatly depending on where the tenant lived. These differences stemmed from regional variation in utility bills but even more from the wide variation in utility allowances by housing authority. For example, Jacksonville, with mid-range electric bills but the lowest utility allowances, had the highest share of households with electric bills that exceeded EEUAs. Gainesville Housing Authority's very high utility allowances over a large portion of the study period outweighed the higher than average area electric bills to yield the largest group of households with allowances over actual costs. However, the GHA cases also show the effects of recalibrating utility allowances over time. Among households beginning utility service in May 2012 or later, after GHA adjusted utility allowances downward to more realistic levels, only 24% received an allowance in excess of bills.

Consistent with their larger household sizes and higher energy bills, families with children were more likely to experience a bill–allowance gap than other groups were. Bill–allowance gaps also varied depending on the type of housing. Electric bills in excess of utility allowances were more common for larger units and for single-family homes.

As Table 4 shows, the distribution of Florida Housing-sponsored units across bill–allowance categories was very similar to that of other large multifamily developments if all units were taken together. However, this masks differences within unit size categories, since Florida

Table 4. Average estimated electric utility allowances ($).

	1 BR	2 BR	3 BR	4 BR
Gainesville Housing Authority	108	134	158	183
Alachua County Housing Authority	84	97	111	125
Jacksonville Housing Authority	73	83	95	111
Orange County Housing & Community Development	86	108	129	162
Orlando Housing Authority	86	108	129	162
Tallahassee Housing Authority	105	127	162	199

Note. BR = bedroom.

Table 5. Summary of mean electric bill and utility allowance/bill comparison by household and unit characteristics.

	Mean electric bill ($)		EEUA/bill comparison, all months (% of households)		
	All months	Peak months	Greater EEUA	Parity	Greater bill
All	132	157	21	32	47
Utility region/PHA					
Gainesville Regional Utilities (GRU)/Gainesville Housing Authority	140	167	54	27	19
GRU/Alachua County Housing Authority	119	139	16	45	39
JEA/Jacksonville Housing Authority	135	161	11	27	62
Orlando Utilities Commission (OUC)/Orange County Housing & Community Development	119	144	33	40	27
OUC/Orlando Housing Authority	111	136	32	41	27
City of Tallahassee/Tallahassee Housing Authority	135	162	40	42	18
Household composition					
Family with children	146	176	19	26	54
Elderly, no children	95	109	30	44	26
Nonelderly adults only	107	128	24	42	35
No. bedrooms					
1	80	94	26	53	21
2	116	137	21	36	42
3	152	185	19	24	57
4	174	210	22	20	58
No. household members					
1	92	109	28	46	26
2	121	146	20	36	44
3	139	169	21	27	52
4	154	187	18	24	59
5 or more	170	206	18	19	63
Housing type					
Single family	155	188	19	22	60
Multifamily 2–9 unit, market rate	122	143	27	36	36
Multifamily 10+ unit, market rate	104	125	24	42	34
Florida Housing Finance Corp.	104	125	24	44	32
0–15% area median income (AMI)	138	164	18	30	52
15.01–30% AMI	125	148	22	34	44
> 30% AMI	136	165	23	30	47

Housing units were more likely than the other multifamily developments to have 3–4 bedrooms. Within unit size categories, a smaller share of Florida Housing units fell into the greater bill category for one-, two-, and three-bedroom units.

Although DLI households had the least disposable income to pay extra electric costs, a slightly higher proportion of these households fell into the greater bill category (52%) compared with all households. Conversely, DLI households were slightly less likely than other households to fall within the greater EEUA category, even though they were most in need of the modest increase in disposable income that accompanies a utility allowance in excess of actual costs. These results are consistent with the finding that most DLI households were families with children, which in turn were the household type that most commonly faced a bill–allowance gap.

Given the extra costs of cooling homes in the summer, peak-month bills can push more households into a bill–allowance gap. Of the households recording energy consumption during the summer months, 63% fell into the greater bill category considering only their June–August consumption, including 29% of households whose overall average allowances were adequate (i.e., who were in the greater EEUA or parity categories when all months were considered). Again, the hardest hit households were those in single-family homes and in 3–4-bedroom units, families with children, and DLI households (69%).

Multivariate Analysis

Multinomial logistic regression was used to examine the differences between household and unit characteristics among households in the greater bill, parity, and greater EEUA categories in more depth. Table 6 shows the results. For each group of independent variables, the odds ratios show the probability of the household falling in the greater bill (results on the left) or greater EEUA (results on the right) category compared with the reference category, parity, all other characteristics held equal. The reference category for each set of independent variables is listed in the note beneath the table. Results are considered significant if the *p* value is less than .01.

For example, an elderly household was 1.29 times more likely to fall in the greater EEUA category than the parity category compared with a household with children, the reference category. At the same time, an elderly household was 38% (1 − 0.62) less likely to have a greater bill over parity compared with a household with children.

As was seen in the descriptive statistics, the capacity of the utility allowance to cover electric bills varied widely by PHA, reflecting the PHAs' discretion to set allowances. Households receiving vouchers from the Jacksonville and Alachua County PHAs were most likely to face electric bills in excess of the utility allowance (greater bill), and least likely to receive allowances that exceeded their bills (greater EEUA). As the Gainesville Housing Authority results show, however, it is possible for a category to be associated more with both the greater EEUA and greater bill

Table 6. Multinomial logistic regression results for parity vs. greater bill vs. greater Greater Estimated Electric Utility Allowance (EEUA) groups.

	Greater bill[a]			Greater estimated electric utility allowance (EEUA)[a]		
Independent variables	Coefficient	*P*	Odds ratio (95% confidence interval)	Coefficient	*P*	Odds ratio (95% confidence interval)
Peak ratio	0.04	.71	1.04 (0.86–1.26)	− 0.76	.00	0.47 (0.37–0.60)
No. bedrooms[b]						
1	− 1.31	.00	0.27 (0.22–0.33)	− 0.72	.00	0.49 (0.39–0.60)
2	− 0.47	.00	0.62 (0.54–0.72)	− 0.64	.00	0.53 (0.44–0.63)
3	− 0.01	.86	0.99 (0.86–1.13)	− 0.31	.00	0.74 (0.63–0.86)
Income[c]						
0–15% area median income (AMI)	− 0.09	.06	0.91 (0.83–1.01)	− 0.21	.00	0.81 (0.73–0.91)
15.01–30% AMI	− 0.03	.53	0.97 (0.89–1.06)	− 0.27	.60	0.97 (0.88–1.08)
Household composition[d]						
Elderly	− 0.48	.00	0.62 (0.54–0.72)	0.26	.00	1.29 (1.11–1.51)
Nonelderly adults	− 0.21	.00	0.81 (0.73–0.90)	0.06	.29	1.07 (0.95–1.20)
Public housing authority[e]						
Gainesville	0.92	.00	2.51 (2.05–3.06)	0.93	.00	2.52 (2.16–2.96)
Alachua County	1.57	.00	4.82 (3.95–5.87)	− 0.74	.00	0.48 (0.39–0.60)
Jacksonville	2.15	.00	8.60 (7.60–9.74)	− 0.72	.00	0.49 (0.43–0.54)
Orange County	0.99	.00	2.68 (2.22–3.24)	− 0.06	.50	0.94 (0.80–1.12)
Orlando	1.19	.00	3.28 (2.77–3.89)	− 0.08	.29	0.92 (0.80–1.07)
Housing type[f]						
Single family	1.21	.00	3.34 (3.01–3.72)	0.17	.01	1.19 (1.05–1.35)
Market-rate 10+ units	0.98	.00	2.66 (2.26–3.13)	− 0.04	.64	0.96 (0.81–1.14)
Market-rate 2–9 units	0.55	.00	1.73 (1.55–1.94)	− 0.01	.88	0.99 (0.88–1.12)

Note. [a]Parity is the reference category.
[b]Four-bedroom unit is the reference category.
[c]Over 30% AMI is the reference category.
[d]Household with children is the reference category.
[e]Tallahassee Housing Authority is the reference category.
[f]Voucher household in Florida Housing-sponsored property is the reference category.

categories compared with the reference category (Tallahassee)—that is, households receiving vouchers from Gainesville are more likely to have bills that deviate from their utility allowance in *either* direction. This is unsurprising given that GHA greatly reduced its utility allowances midway through the study period.

Housing type also was an important factor associated with the allowance–bill gap. Households in single-family homes were 3.34 times more likely to fall in the greater bill category than were those using their voucher in a Florida Housing-sponsored unit. Those in both large and small market-rate multifamily properties were also more likely to face greater bills than those in state-sponsored affordable housing units. Most of the results for the greater EEUA analysis were not significant, other than slightly higher odds for single-family homes to be in the greater EEUA category.

Elderly households were less likely to fall in the greater bill category and more likely to fall in the greater EEUA category than were those with children. In addition, households made up only of adults were slightly less likely to fall in the greater bill category than were those with children.

Not surprisingly, greater peak-month to all-month ratio—a measure to capture extra costs of cooling homes in the summer—is negatively associated with the greater EEUA category. However, peak ratio is not significantly associated with the greater bill category compared with the parity category.

Results for the number of bedrooms were more mixed. The results suggest that utility allowances for one-bedroom units were closer to actual billing amounts than for larger units, in either direction. One-bedrooms were 27% as likely to fall into the greater bill category and half as likely to fall in the greater EEUA category compared with the reference category, four-bedroom units. Units with 2–3 bedrooms were also less likely to fall in the greater EEUA category than four-bedroom units were.

Finally, households with incomes below 15% of AMI were less likely to fall in either the greater bill or greater EEUA category than were households with incomes above 30% of AMI. However, the differences were slight: a 9% decrease in the odds of a greater bill and a 21% decrease in the odds of a greater EEUA. The results from the regression differed from those in the descriptive analysis, which found a slightly higher concentration of DLI households with bills in excess of the allowance and a slightly lower concentration with allowances in excess of bills. Given the small differences in results across income categories in both analyses, however, the overall conclusion is that DLI households were roughly as likely as other households to experience bills in excess of their utility allowances, despite their more limited resources to address the excess costs.

Discussion and Conclusion

Our first task in this analysis was to determine how energy costs for HCV households varied by household and property characteristics. In comparing average monthly electric bills, many of the results were as expected. Electric bills were higher for larger households and those renting single-family homes, and lower for residents of Florida Housing-sponsored units. Surprisingly, bills varied little by tenant income. DLI households paid as much on average as other households. The similarities across income groups suggest that the households with the least income to spare are not finding ways to economize on energy costs, either positively (by finding more efficient units) or negatively (by skimping on comfort and energy needs).

Energy bills are only half of the affordability equation for voucher holders. If utility allowances align with real energy costs, tenants are shielded from high energy cost burden. This analysis shows that voucher holders' energy bills often differ from the assumptions that underlie their utility allowances and, therefore, the calculations intended to fix gross rent costs at 30% of income. Nearly half of the tenants in the data set experienced energy costs in excess of their utility allowances, whereas fewer than one fourth received a surplus allowance.

Here, the role of the PHA as the agent that sets utility allowances was key. Allowances varied widely from one housing authority to another and over time for individual authorities. This means that tenants with units of the same size, in cities with similar climates or even within the same city, might have very different experiences trying to meet their utility costs with their allowances. Tenants' choice of housing type was also important. Residents of market-rate units were more vulnerable to bill–allowance gaps than were residents of Florida Housing-sponsored affordable units. Single-family home renters were particularly vulnerable, even though most utility schedules include a modest extra energy allowance for single-family units.

HUD should continue its work with PHAs to improve the information underlying utility calculations. This will ensure that allowance schedules estimate actual costs more accurately, provide consistent allowances across areas with similar climates and costs, and account realistically for differences between multifamily and single-family housing. Since 2002, HUD has provided a Utility Schedule Model (HUSM) to help PHAs calculate consistent utility allowance schedules based on a regression model developed from the Department of Energy's Residential Energy Consumption Survey (https://www.huduser.gov/portal/resources/utilallowance.html), as an alternative to PHAs' traditional reliance on past consumption to estimate allowances. Pazuniak et al. (2015) recommend improving the accuracy of utility allowances by calculating them at the tenant level, based on a more refined regression model that takes into account granular characteristics such as household size.

Among the households studied, utility allowances more frequently underestimated costs than overestimated them, so improving accuracy in utility allowance schedules would reduce tenant payments in many cases. However, higher allowances shift costs to the PHAs, which in turn reduces the number of households they can serve with a given HCV budget. A more comprehensive strategy will require improving the energy efficiency of voucher holders' units. As noted earlier, PHAs can play a key role as an intermediary to mitigate the natural disincentives for energy efficiency in rented housing, both by aiding tenants in their search strategies and by promoting physical efficiency measures.

It can be difficult for any party—tenant, landlord, or housing authority—to evaluate potential energy savings from various efficiency measures. Our findings suggest a simple place to start: with households renting single-family homes, particularly larger households. At minimum, heads of larger households should receive information about the gap in energy costs between single-family and multifamily units as they undertake their housing searches. Parents in particular may seek out single-family homes because they view them as more family friendly, but they should be aware that doing so may impose additional energy costs compared with multifamily buildings. PHAs can provide guides to the differences in energy costs by housing type based on local information collected from utility companies or tenant surveys.

Even with this information, many families are likely to continue to seek out single-family homes. A more far-reaching solution is to improve the efficiency of these homes. PHAs can work with nonprofits, government agencies, and utility companies to adapt established energy conservation programs for homeowners to serve voucher-occupied single-family homes. Multifamily developments historically have been underserved by conservation programs, but single-family conservation initiatives for homeowners are long established (Benningfield Group, I, 2009; Johnson & Mackres, 2013). In Florida, for example, utility-sponsored conservation programs for single-family homes have included home energy inspections and self-audit tools; weatherization assistance and rebates for customer purchases to reduce heating and cooling energy use, such as improved insulation, duct sealing, and heating/air conditioning equipment; and providing free shallow efficiency tools to customers such as compact fluorescent light bulbs, weather stripping and caulking, and air conditioner filters (Florida Public Service Commission, 2013). Targeting these same techniques toward landlords with a history of renting single-family homes to voucher holders can quickly leverage conservation program providers' experience with the single-family building type.

On the other hand, the analysis highlights the benefits of a different type of search strategy: pairing vouchers with modern subsidized units funded by LIHTC and other state-administered affordable housing programs. The Florida Housing-sponsored units generally offered lower energy bills and fewer instances of bills in excess of utility allowances when compared with other multi-family developments. As noted earlier, in states such as Florida where the LIHTC program is used predominantly for new construction, the pairing of vouchers with state-sponsored units offers voucher holders more opportunity to live in post-1990 units, implying more modern energy efficiency features and overall better housing quality compared with older units. Moreover, state housing finance agencies may offer explicit incentives for the construction of energy efficient units in their funding competitions, as Florida does.

The LIHTC–voucher pairing is particularly useful in tight rental markets where voucher holders have trouble finding units, as source of income discrimination is prohibited in LIHTC-funded developments. In these markets, the LIHTC units can act as a safety valve to ensure that voucher holders have modern alternatives to older, less energy efficient homes. Here too, PHAs can act as intermediaries by forming partnerships with state housing finance agencies to ensure that housing seekers with vouchers receive up-to-date information about the availability of units in LIHTC-funded developments.

Finally, we note that the Florida test case has implications for markets beyond the state. Given its mild winters and relatively low residential energy consumption, Florida represents a middle-range to best case for voucher holders' ability to meet their energy costs. Yet even in Florida, many households faced an energy bill gap. The effect of peak-month consumption on the energy cost–utility allowance gap is likely even more serious in areas with high winter heating costs, unless utility allowances reflect this full cost. Additional research is needed comparing actual bills and utility allowances in areas with more extreme weather conditions to determine the full impact of household energy costs on tenants participating in the federal voucher program.

Notes

1. The American Community Survey and earlier decennial census data sets define "gross rent" as "the contract rent plus the estimated average monthly cost of utilities (electricity, gas, and water and sewer) and fuels (oil, coal, kerosene, wood, etc.) if these are paid by the renter (or paid for the renter by someone else)" (U.S. Census Bureau, 2015).
2. In most cases, the family share is approximately 30% of household income. In two main cases, however, the tenant's share may exceed 30% of income. First, PHAs are allowed to charge a $50 minimum gross rent for voucher holders, with waivers available in some cases of financial hardship (24 CFR 5.630). Households reporting annual incomes below $2,000 ($167 per month) will face cost burdens above 30% if the $50 minimum rent is in place. Second, if the rent for a selected unit exceeds the PHA's payment standard for that unit type and number of bedrooms, the voucher holder may choose to pay the difference between the payment standard and the unit rent, as long as the resulting tenant payment does not exceed 40% of income.
3. Based on an analysis of 2016 income certification data submitted to Florida Housing by managers of LIHTC-funded developments.
4. County property appraiser data were provided by the Florida Department of Revenue, Name-Address-Legal File.
5. Most dramatically, the Gainesville Housing Authority used very high allowances before mid-2012, averaging $250 per month across structure types and number of bedrooms. GHA's subsequent allowance schedule, put into place in April 2012, reduced the average allowance to $101.
6. The year 2015 is outside of the 2010–2013 study period for this analysis, but billing structures and rates changed little over the entire 2010–2015 period in the four utility areas. In fact, the largest change, between 2011 and 2015 in the rate structure for Gainesville Regional Utilities, may result in a slightly *underestimated* bills for GRU customers in 2011 when the 2015 rate structure is applied.

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Appendix A. Matched Household-Utility Records Data Set

The first step in creating the data set was to match addresses between the utility and voucher records. We assigned utility premises IDs to voucher records using text-string matching on the respective address fields from the utility and voucher data sets. In the four areas, we were able to match utility premises IDs to 83% of voucher addresses. In most cases, the remaining voucher addresses could not be matched either because they were missing apartment unit numbers or because they fell outside of the service areas for the utility companies.

We transformed the voucher data set from point-in-time actions to monthly records with utility customer information, using a modified version of the person-period method outlined by Schultheis, Russ, and Lucey (2012). We filled in monthly records between voucher action records matched to the same premises IDs. Where a new premises ID appeared, we used that premises for subsequent months. We then used utility meter reading and billing records with premises ID–customer ID matches by date to assign a utility customer to each monthly record.

If a household had a record indicating end of participation in the voucher program, we terminated the household record using the exit date. If, as in most cases, there was no end-of-participation record, we assumed that households had left the program if no action record was filed for a period longer than 12 months. For each of the 12 months following the last income certification or similar action, we continued to assign the same premises to the voucher address if there was no change in the customer ID for the appropriate premises, thus implying that the same household continued to occupy the unit. If the customer ID for the premises changed without the tenant filing a voucher action showing an address change, we assumed that participation in the voucher program had ended. After 12 months with no voucher action field, we assumed end of participation in the voucher program (see Schultheis et al., 2012, pp. 199–201).

Next, we added energy consumption, household, and unit information to each monthly record:

- Energy consumption: electricity consumption in kWh associated with the customer ID for each premises from the utility records. In the utility data, consumption is measured in the time between meter readings, which occur roughly monthly but do not necessarily coincide with the beginning and end of the calendar month. Therefore, average daily consumption was calculated between each pair of meter readings, and then the daily values were aggregated into calendar months. For example, if meter reading periods ran from July 11 to August 10 and August 11 to September 10 for a particular household, then consumption for the calendar month of August would be estimated at (10 days × average daily consumption 7/11–8/10) + (21 days × average daily consumption 8/11–9/10).
- For the Tallahassee and Gainesville utility companies, natural gas consumption in therms was also recorded, so natural gas users could be excluded from the final data set. The Jacksonville and Orlando municipal utilities do not offer natural gas. Private companies do provide some natural gas service in these areas, but its use is rare in residential properties.
- Household characteristics: number of members, household composition (families with children, elderly, nonelderly adults), income, and tenant rent payment from voucher action records. Income was transformed to a percentage of area median income using annual county income limit schedules from the Florida Housing Finance Corporation.
- Housing unit characteristics: number of bedrooms and structure type from voucher action records; residential land-use type and year built from county property appraiser parcel-level data. The online Assisted Housing Inventory database was used to identify voucher locations in developments with financing from Florida Housing Finance Corporation through the Low-Income Housing Tax Credit program, Florida's housing trust fund, and private activity bonds.

Next, we assigned estimated electric bills and electric utility allowances in dollars to each monthly record. Both estimates required a series of assumptions. For bills, actual amounts were not available from all utilities, so monthly bills were estimated from electricity consumption data using the rate structure formula for each utility company, including base rates for basic consumption, any higher tiered rates for consumption over the base threshold, and additional flat customer surcharges and taxes. To take advantage of available data and simplify the analysis, we applied the 2015 rate structures to all years' data.[6]

For allowances, the voucher data from the U.S. Department of Housing and Urban Development included a total utility allowance amount for each household but not separate amounts for each type of service (electricity, water, gas, etc.). Therefore, we estimated utility allowance amounts for the electricity portion of the household allowance based on the six public housing authorities (PHAs)' annual published utility allowance schedules. Monthly records were assigned estimated electric utility allowances from the schedules based on the PHA, the date of the household's entrance or income recertification, the number of bedrooms, and the structure type (e.g., single family, low rise).

Longitudinal Database

Finally, we aggregated monthly records into a longitudinal record for each household during its stay in a particular unit, using all of the monthly records for each unique combination of utility customer and premises IDs. The final longitudinal data set contained 19,545 unique customer–premises combinations. The data set was limited by these exclusions:

- Only units with tenant-paid electric bills were included, based on utility customer information. Customers were identified as landlords if their customer IDs were associated with multiple premises. Monthly records with utility consumption exceeding 2,500 kWh were also excluded to further identify landlords with large master-metered properties.

- Households with bills showing natural gas consumption were excluded to limit the study to electricity-only households.
- Monthly records with less than 100 kWh were assumed to be vacant-unit periods and were excluded.
- Addresses outside of the four municipal utility companies' service areas were excluded.
- A small number of households were excluded because their vouchers were administered by an agency other than the six main PHAs in the study areas.
- Only units with 1–4 bedrooms were included. Units with five or more bedrooms made up only a small portion of the data set, and utility allowances were not available for studios or efficiencies for all PHAs.
- Voucher holders in mobile homes, a very small portion of the data set, were excluded.

Households reporting adjusted incomes below $1,000 per year, including zero-income households, were excluded. This will allow for further study of energy and gross rent cost burden ratios among households in the data set. The cost burdens are defined as energy or gross rent amounts divided by household income; using a very small number or zero for this denominator results in very high or incalculable ratios.