Pathways for Reducing Energy Burdens in Harris County

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ABSTRACT

Distributed Energy Resources (DERs) can offer financial, environmental, and resiliency benefits to our society. Vulnerable communities, for whom these benefits can be most impactful, often face barriers to access, including awareness, financial limitations, and housing conditions.

The Texas Energy Poverty Research Institute (TEPRI) leads the *Pathways for DERs to Reduce Energy Burdens* initiative to develop a roadmap for cost-efficient, inclusive, and effective pathways for rooftop solar and energy efficiency deployment in residential buildings located in low-income census tracks — with the goal of reducing the energy burden of residents. This analysis and stakeholder engagement initiative is initially focused on Harris County (Houston), Texas, (with 600,000 low-income households, 65% of whom are people of color) with the intent of expanding to other Texas regions.

The project involves a synthesis and analysis of existing literature and data, that includes both publicly available and proprietary datasets, to develop a clear understanding of the Energy Affordability Gap (EAG) and the energy efficiency and rooftop solar potential of the existing affordable housing stock. This project also involves stakeholder meetings in Houston with local community organizations, researchers, energy providers, and local leadership to identify barriers and co-develop solutions specific to Harris County, opportunities to leverage funding sources, and alignment with the City of Houston Climate Action Plan.

The most immediate action to reduce the EAG is to target energy efficiency measures in single family homes in geographical areas with high concentrations of low-income households. Furthermore, we encourage the development of community relationships to improve the implementation of weatherization programs among low-income communities.

Introduction

Energy affects every part of a household by providing power to the appliances needed to keep a house warm or cool, refrigerators to keep food and medicine fresh, and the multitude of devices like phones and internet routers that make modern life possible. “Energy poverty” describes a condition faced by many Americans in which the personal cost of consumption needed to maintain a healthy lifestyle creates a significant or unnecessary economic burden (Harmon, Haley, and Funkhouser 2017). Energy burden is defined as the portion of the total household income that is used for residential energy costs, expressed as a percentage. A household is said to have a high energy burden if the annual costs of energy exceeds 6% of the household’s income (Hernández and Bird 2011). Energy burden is useful as an indicator of household financial stress when comparing a geographically confined region, which would tend to have similar costs-of-living. While a high energy burden is a reliable indicator for risk of energy poverty, having a low energy burden may obfuscate someone who is experiencing energy poverty and making difficult trade-offs (Harmon and Moss 2019).

The Energy Affordability Gap (EAG) is the annual cost of home energy for a household above 6% of that household's annual income. In Harris County, the county seat of Houston, the EAG is $190 million despite a relatively low $0.1099 per kWh average cost of energy, which corresponds to 1.7 TWh of energy. Of the 605,000 households that fall below 80% of the area median income (AMI), 215,000 are in the bottom 30% of household earnings in Harris County and earn less than $17,575 per year. These 215,000 households spend an average of 13% of their household income on residential energy; this contrasts with the approximately 690,000 households who earn at least the median income and have an energy burden of only 1% (Figure 1). Our study aims to determine the factors that contribute to the EAG, how it affects the quality of life of households with high energy burdens, and what energy efficiency and rooftop solar programs and technologies may do to help.

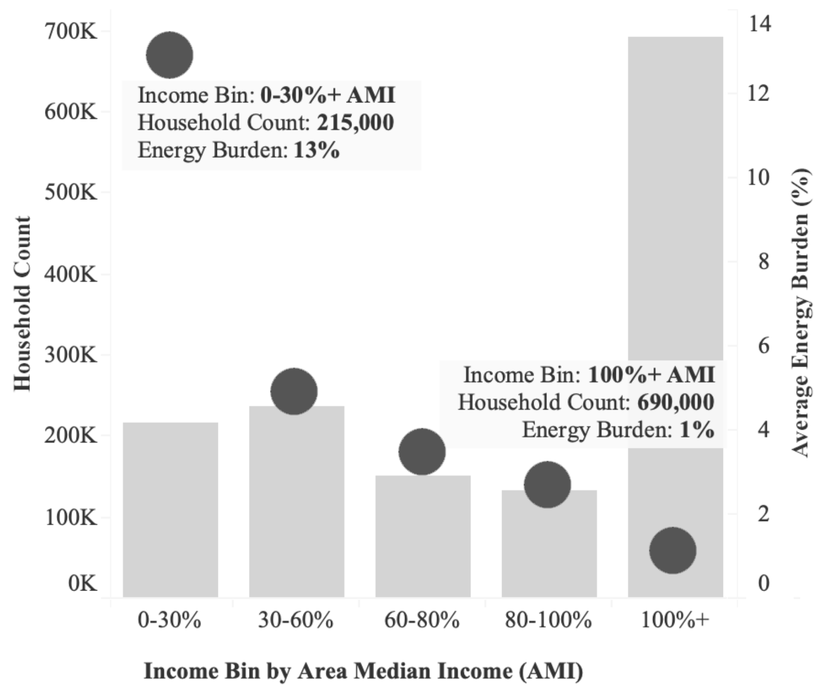

Figure 1. Organized by household income as a percentage of Area Median Income (AMI), the left axis uses bars to show the household count for each income category. The right axis uses dots to show the average energy burden (percent of household income on residential energy). Households who earn 0-30% of AMI total 215,000 in Harris County and have an average energy burden of 13%. By contrast, households earning at or above median income (100%+) have an average energy burden of 1% and account for approximately 690,000 households. *Source*: Ma et al. 2019.

Distributed energy resources (DERs), which include energy-efficiency improvements, rooftop solar, and various other technologies, can help reduce the EAG through consumption reduction and self-generation. While DERs include a variety of technologies, this study focuses on rooftop solar and energy-efficiency improvements when referencing DERs. The potential for each solution is divided into three areas: technical potential, the maximum potential without any financial constraints; economic potential, the subset of technical potential that would yield a net financial benefit over time; and achievable potential, the subset of economic potential that is realistically achievable within the next five years under current paradigms. Nonetheless, achievable potential is difficult to calculate and verify empirically so this paper focuses on technical and economic potential.

In this report, we investigate the different factors that contribute to the EAG, calculate the potential of DERs to reduce the EAG, and provide a roadmap for the deployment of these solutions based on insights gathered from stakeholders and our own analysis. By analyzing data from the various publicly available and stakeholder shared datasets, we investigate if the differences in geography, building types, or residential tenure affect the EAG. With our insights into the causes of the EAG, we determine how DERs can be applied economically. And finally, with the insights gathered from a series of key stakeholder meetings, similar projects and reports, and our own analysis, we develop a roadmap for the deployment of the highest impact solutions most likely for adoption.

While other studies investigate the energy burdens of different areas (Holmes and Mullen-Trento 2017; Housing 2017; Pigg, Cautley, and Francisco 2018; Allison, Napoleon, and Kallay 2019) energy burden investigations into Harris County, which houses Houston, the 4th largest city in the US, are surprisingly sparse. TEPRI is committed to filling in the knowledge gap related to energy poverty in Texas. Addressing the energy burden in the largest county in the state advances that goal.

Our results show that income is the biggest driver of the EAG, but there are other factors that can help to target solutions. We found that rooftop solar has the potential to erase the entire EAG just not yet economically, and energy-efficiency can overcome the entire EAG both technically and economically. However, DERs are not being deployed to their full potential because of knowledge and resource barriers which, with help from our stakeholder group, we offer a roadmap to overcome.

Background and Methodology

The project involved a synthesis and analysis of existing literature and data, that included both publicly available and proprietary datasets, to develop a clear understanding of the energy efficiency and rooftop solar potential of the existing affordable housing stock in Harris County. The analysis was balanced by four stakeholder meetings in Houston with local community organizations, researchers, energy providers, and local leadership to quantify energy efficiency and rooftop solar potential, identify barriers to adoption, and co-develop recommendations specific to Harris County, and highlight opportunities to leverage funding sources that can be used to implement these solutions.

Efficiency Programs

The Weatherization Assistance Program (WAP) is a federal program that improves energy efficiency in low-income homes and reduces annual energy costs by an average of $283 per household a year (DOE 2019). In Texas, the Texas Department of Housing and Community Affairs (TDHCA) administers the Department of Energy (DOE) WAP and the Low-Income Home Energy Assistance Program (LIHEAP) WAP (TDHCA 2018). In 2018, 2,916 low-income households across all of Texas benefited from these programs with almost $24 million total expended with approximately $8,000 per house. Through Baker Ripley, Houston’s WAP administrator, 277 Harris County households benefited from the program (95 through the DOE WAP and 182 through the LIHEAP WAP) (TDHCA 2018).

At the state-level, the Public Utility Commission of Texas (PUCT) addresses energy efficiency through various goals. 20,827 low-income Texas households participated in their utility's hard-to-reach energy efficiency programs in 2018, at a total cost of almost $23 million. Harris County is in the service territory of CenterPoint Energy Houston Electric, the Investor Owned Utility (IOU) that manages and owns the transmission and distribution infrastructure in Harris County and the surrounding area. The PUCT requires that IOUs in competitive retail areas of the Electric Reliability Council of Texas (ERCOT) "acquire a 30% reduction in its annual growth in demand of residential and commercial customers." For low-income customers, PUCT says: "savings achieved through programs for hard-to-reach customers shall be no less than 5.0% of the utility's total demand reduction goal." 'Hard-to-Reach' customers are defined as households whose incomes are 200% or less of the Federal Poverty Line (FPL) (PUCT). In Harris County, 200% FPL accounts for 462,592 households compared to 604,573 using the 0-80% AMI range. CenterPoint has three low-income energy efficiency programs as described in Table 1.

Table 1. CenterPoint Low-Income Energy Efficiency Programs

CenterPoint Program	Customer Reach (2018)	Spent Per Unit (2018)
Hard-to-Reach Standard Offer Program (SOP)	755	$ 1,570
Hard-to-Reach Multifamily Market Transformation Program (MTP HTR)	2,624	$ 123
Targeted Low-Income Market Transformation Program (MTP)	1,521	$ 2,460

CenterPoint Energy Houston Electric serves Harris County and the surrounding counties of Brazoria, Fort Bend, and Galveston. *Source*: TDHCA 2018

Estimating Economic Potential

According to a National Renewable Energy Laboratory (NREL) study (Wilson et al. 2017) that examined energy efficiency potential in single-family homes, 80% of the technical potential in the state of Texas was deemed economical. Therefore, we assume that the economic potential is 80% of the technical potential. Greater precision in energy efficiency is possible with physics-based simulations such as those developed by NREL (Cutler et al. 2013); however, the method used in this study provides similar accuracy and is much easier to calculate when used to determine optimal pathways for energy efficiency in low-income communities.

The cost-effective, or economic potential, of rooftop solar for low-income households in Harris County is significantly lower than the technical potential. In the NREL study, Estimating *Renewable Energy Economic Potential in the United States* (Wilson et al. 2017) economic potential is defined as the subset of technical potential: "where the cost required to generate the electricity … is below the revenue available in terms of displaced energy and displaced capacity." Using this metric, the economic potential of solar in Harris County is negligible because at current prices the payback period for rooftop solar is well over 10 years, too high for low-income households.

Drivers of the Energy Affordability Gap

Distribution of Energy Burden

As a baseline to understand where the greatest need is for DERs to reduce energy burdens, we mapped American Community Survey data from the LEAD tool as shown below. Figure 2 shows the areas in Harris County that have higher numbers of low-income households, defined as 0-80% AMI.

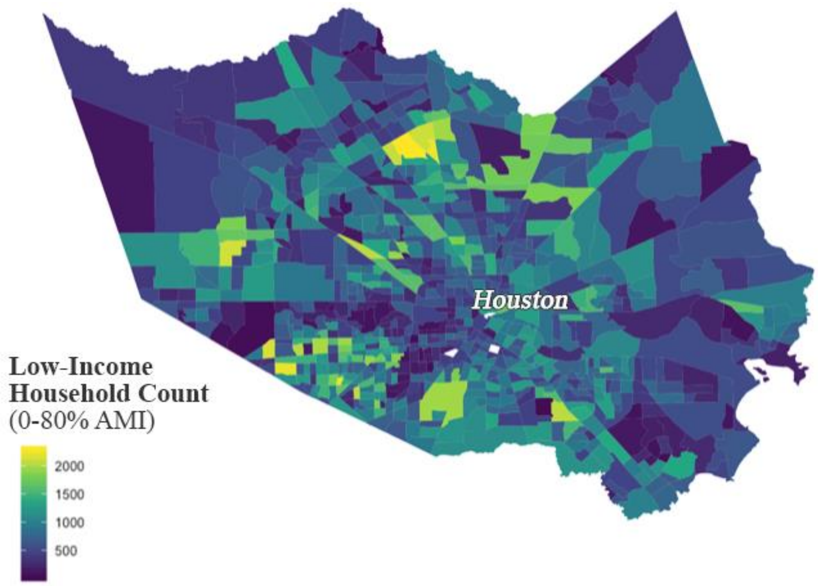

Figure 2. The number of low-income households in Harris County by census tract.
Source: Ma et al. 2019.

Furthermore, for households that rent (the majority of low-income households in Harris County) incentives are split between renters and landlords, which decreases the likelihood that energy efficiency measures or rooftop solar will be installed, because in most cases, the renter, not the landlord, pays the energy bills (McKibbin 2015; Hernández and Bird 2011). Finding ways to align existing programs with the needs of low-income households and their landlords is crucial to addressing the EAG.

Despite the split incentive, owners have significantly higher energy burdens than renters. As shown in Figure 3, one unit detached residences have by far the highest energy burdens of any building type. As the number of units decreases, the energy burdens tend to decrease for renter occupied units. The pattern does not seem to be true for owner-occupied multi-unit buildings, although the small number of owner-occupied multi-unit properties may skew the results. As shown in Figure 4, the energy burden, as a function of building age, is relatively constant for owner-occupied properties built since 1960 but experiences a sharp increase in renter occupied buildings starting in 2000.

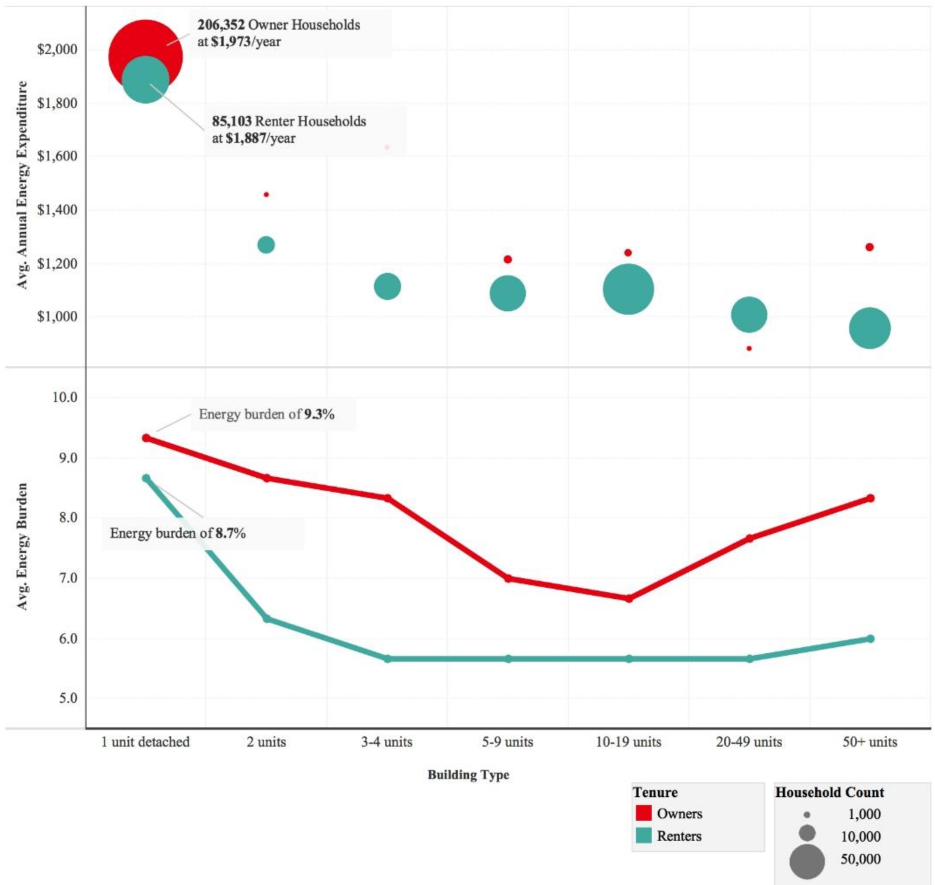

Figure 3. Average energy expense and energy burden by building type and tenure for low-income households (0-80% AMI) in Harris County. *Source*: Ma et al. 2019.

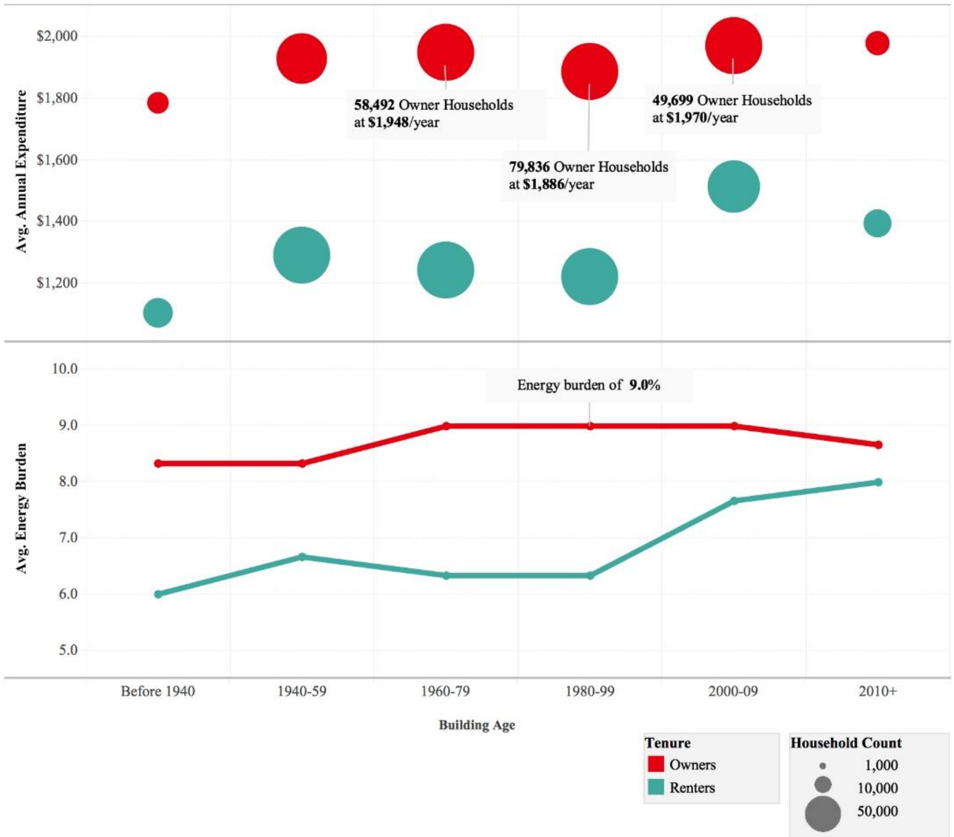

Figure 4. Average energy expense and energy burden by building age and tenure for low-income households (0-80% AMI) in Harris County. *Source*: Ma et al. 2019.

Potential for DERs to Reduce the Energy Affordability Gap

In this section, we explore the impacts of DERs on the EAG. Figure 5 shows the potential of DERs to address energy consumption and the EAG. We mainly focus on energy efficiency upgrades, which we break into two groups: shallow and deep retrofits. We also look at other measures, such as self-generation with solar.

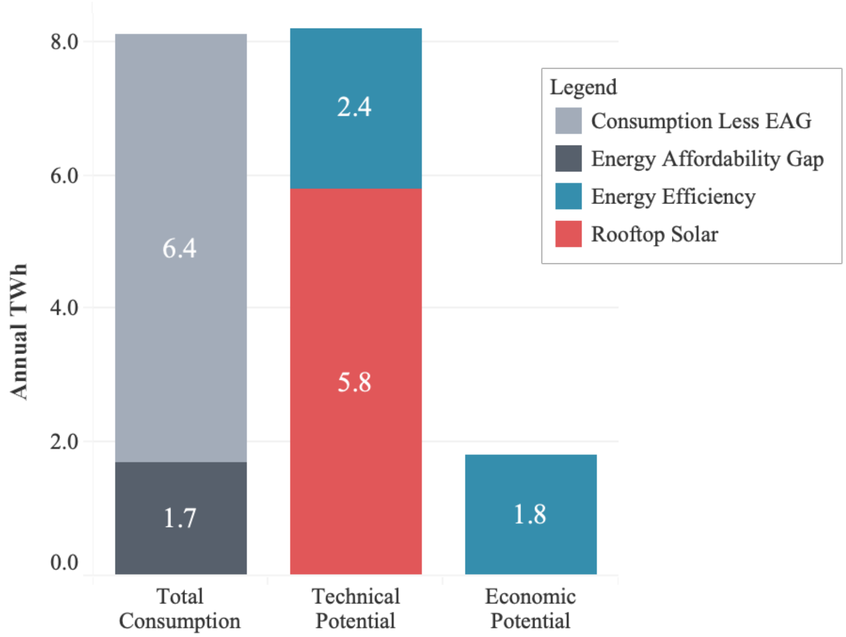

Figure 5. Harris County's energy consumption, energy affordability gap, and the potentials for DERs to reduce the gap. *Sources*: Sigrin and Mooney 2018; Wilson et al. 2017.

Technical and Economic Potential of DERs

To determine the economic energy efficiency potential, this project employs a proxy using Wilson et al. 2017 which examined energy efficiency potential in single-family homes of all incomes. In that study, 80% of the technical potential that was calculated for Texas was deemed economic. This ratio is employed for this study to calculate the economic potential.

Harris County low-income households have significant opportunities for energy efficiency improvements. As shown in Figure 5, we calculated a technical potential of 2.4 TWh and an economic potential of 1.8 TWh. The economic potential of energy efficiency improvements could eliminate the entire EAG of 1.7 TWh in Harris County.

Technical and Economic Rooftop Solar Potential. The cost-effective potential for rooftop solar generation in Texas is between 0.9-3.8 TWh annually (Sigrin and Mooney 2018). The State of Texas has an overall population of almost 29 million and Harris County has a population exceeding 4.7 million people (US Census Bureau 2019). Approximately 40% of Harris County residents are low-income, representing 6.5% of the total Texas population. This population share equates to a simple proportional range of 0.06-0.25 TWh of annual economic generation potential.

We justify that this range is accurate for the following reasons: Harris County is on the eastern side of the state which receives lower solar irradiance than the median for Texas; the eastern side of the state is heavily forested which reduces the number of single-family houses that are suitable for rooftop solar because of shade; and finally, low-income households typically have lower roof square footage that can be used for rooftop solar. We use the mean of the calculated range for an economic potential for rooftop solar of 0.155 TWh in Harris County.

Rooftop solar could provide up to 5.8 TWh of annual generation of local, clean, and renewable energy to low-income communities in Harris County. Figure 6 shows the technical potential by census track in Harris County. However, because of low electricity prices and other barriers like high installation costs, despite rooftop solar's high technical potential, the current economic potential of rooftop solar is too low to have a beneficial impact on low-income households in Harris County. Finding ways to improve the economics of solar, for example with improved financing, or by developing models beyond rooftop solar like community solar may have meaningful potential to reduce energy burdens. While these investigations are beyond the scope of this study, we cannot overstate their value and recommend that they be taken in future studies.

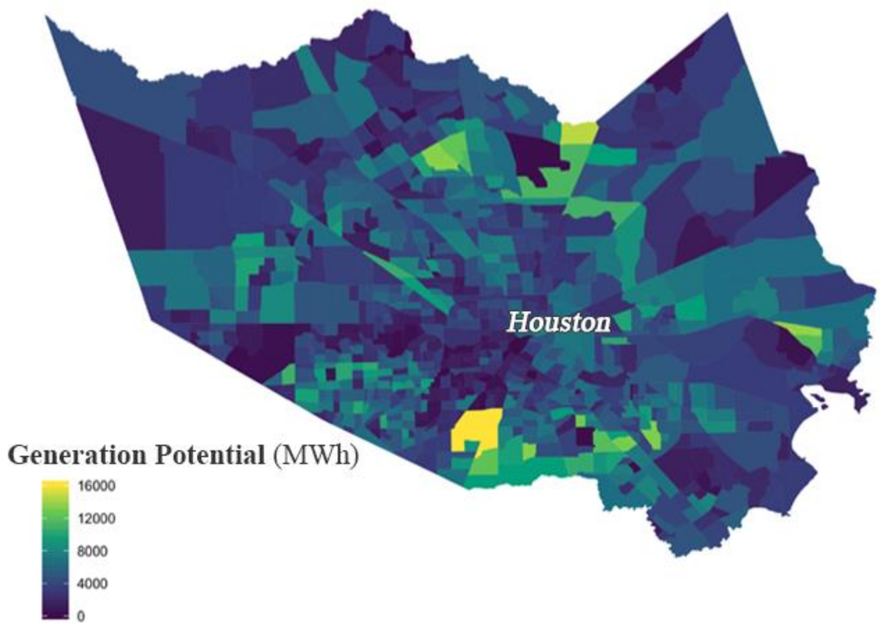

Figure 6. Low-income single-family home rooftop solar generation technical potential by census tract in Harris County, Texas. *Source*: Sigrin and Mooney 2018.

Pathways for Reducing the Energy Burdens in Harris County with Energy-Efficiency Improvements

Shallow Retrofits

Shallow retrofits are the retrofits that would have a low to moderate impact but are typically less expensive than other measures. Low-income households may have the capital to invest in these interventions without assistance. Furthermore, programs exist that target these low-cost upgrades. Our definition of shallow retrofits mirrors the energy efficiency upgrade definitions from Florida Power and Light (FPL) (Parker et al. 2014a). They upgraded energy efficiency using the following technologies.

Shallow Retrofits:

- Hot water tank and pipe insulation wrap

- Change-out of all eligible light fixtures to compact fluorescent lamp (CFL) or light-emitting diode (LED) equivalents
- Cleaning of refrigerator coils
- Replacement of eligible, homeowner-selected showerheads with low-flow showerheads
- Reduction of pool pump hours
- Advanced power strips (APSs) for home offices, gaming consoles, and entertainment centers.

This shallow retrofit list provided a framework for further exploration and discussion during stakeholder meetings to further detail solutions that would likely have significant impact potential for Harris County households as described below.

Full LED Adoption. Lighting upgrades are a common, low-cost, and easy-to-upgrade energy-efficiency improvement. However, while many commercial and higher income residential households have already made the upgrade away from incandescent bulbs, LICP survey data for the Houston area indicates that low-income households are delayed in making these upgrades (Harmon and Moss 2019).

If households realized the full technical potential of LED adoption, the total avoided annual costs for LMI residents in Harris County would reach ***$84.7 million per year***. Stated another way, if the full technical potential was reached for energy-efficient lighting alone, it would reduce the EAG by over 16%. Lighting is an easy change that does not rely on behavior change and also has a simple payback period of less than one year in most situations, at current pricing. Furthermore, our stakeholders both the utilities and the installers believe this is a realistic improvement that can be implemented in numerous households. It should be investigated as a potential immediate strategy for energy efficiency improvements for Harris County low-income households.

Other Shallow Retrofits. Other shallow retrofits (everything except LEDs) are not being implemented at a significant scale in Harris County. Nonetheless, according to Florida Power and Light these retrofits have the potential to save 8-10% of energy usage (Parker et al. 2014a). This is a significant potential that should be explored further.

Deep Retrofits

Deep retrofits are retrofits that would have a high impact but are typically more expensive than other measures. Low-income households would typically not have the capital to invest in these interventions. However, programs exist that target these more expensive upgrades. Again, we mirror the FPL's definitions for deep retrofits (Parker et al. 2014b) and highlight solutions stakeholders have identified that would have a high impact in Harris County.

Deep Retrofits:

- Supplemental mini-split heat pump (MSHP) / Variable Speed Heat Pumps (VSHP)
- Ducted and space coupled heat pump water heater
- Exterior insulation finish system (EIFS)
- Window retrofit
- Smart thermostat

- Heat pump clothes dryer (HPCD)
- Variable speed pool pump

This deep retrofit list provided a framework for further exploration and discussion during stakeholder meetings to further detail solutions that would likely have significant impact potential for Harris County households as described below.

Variable Speed Heat Pumps (VSHP). A significant number of low-income households have electric resistance heating, which is an antiquated heating technology that contributes to high winter energy burdens. On the other hand, VSHPs move heat from outside of the home to inside through vapor-compression. VSHPs also provide benefits in the summer for air conditioning as they are also more efficient than static speed heat pumps. Furthermore, according to our stakeholders a HVAC retrofits are effective, popular, and the institutional knowledge is there. IOUs and municipal utilities could expedite VSHP adoption in low-income communities through incentives and educational outreach.

Weatherization. Based on the high economic potential of weatherization and information from our stakeholder discussions, weatherization of low-income homes is perhaps the most effective method for reducing energy consumption through energy efficiency. Weatherization includes window retrofits, interior insulation, and EIFS. In the stakeholder meetings, participants identified the opportunity to build trust between implementers and low-income communities as a way to improve implementation of energy-efficiency improvements in low-income communities. A program that focuses on a targeted community that intends to reach many households paired with a dedicated educational outreach through community centers or places of worship would help WAP implementors build trust with the community and more efficiently weatherize more houses.

Other Deep Retrofits. Harris County programs do not perform any deep retrofits not listed above at a significant scale and most of the remaining technologies that we identified might not be applicable for low-income households. However, installing smart thermostats is an easy to implement solution that can save up to 7% of energy usage (Parker et al. 2014a).

Conclusion

To have the biggest impact on the largest number of low-income households, there is value in deeper investigation into efficiency for one unit detached residences of both owner- and renter-occupied households — with an emphasis on owner-occupied structures built between 1960-2009 and renter-occupied structures built since 2000 — as illustrated in Figures 3 and 4 based on data gathered from the LEAD Tool.

The EAG gap can be economically eliminated with targeted energy-efficiency improvements. Rooftop solar has the technical potential to eliminate the EAG, but it is currently not economical to do so. Energy-efficiency can be deployed as shallow retrofits or as deep retrofits that are more expensive but still appear to be cost-effective. Shallow retrofits are relatively easy to implement, while the larger, more impactful solutions deep retrofits require more effort to implement including coordinated community cooperation.

Although rooftop solar is currently not cost-effective for low-income households for large scale deployment, community solar solutions are expanding across the US and Texas, including a new project in Harris County called Sunnyside. The community solar model could be a pathway to decrease energy burdens and increase low-income DER adoption by reducing the investment costs of solar and outsourcing the maintenance and installation responsibilities. However, while the community solar model shows strong potential it still needs further development for scalable deployment in the competitive market. While this study only investigated rooftop solar, we recommend analysis of other solar solutions, such as community solar, in future studies.

In order to start eliminating the EAG, we recommend first targeting single family homes in geographical areas with high concentrations of low-income households. Then, we suggest immediately implementing shallow retrofits like LEDs in as many areas as possible. Finally, we encourage the development of community relationships to improve the implementation of weatherization programs in low-income communities.

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