JUST ENERGY PAPERS

Addressing Energy Burden: Estimate of funds for low- and moderate-income households during the transition to a clean, regenerative, and just energy system

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October 2021

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1. This paper was prepared for the Just Solutions Collective and the Equity Fund. General background references on an equitable energy transition include Cervas et al. 2020 and Bolon et al. 2021. The author would like to thank Subin DeVar, Jillian Du, Elena Krieger, Sonum Nerurkar, and Aiko Schaefer for reviews of drafts of this paper.

1. Summary

As climate impacts rapidly and dramatically increase and the discussion of possible action grows, any policy to transition our energy system will likely mean increased costs for low- and moderate-income (LMI) households, unless explicit action is taken to prevent that outcome. Energy burdens for LMI households are already very high, often exceeding 30 percent of annual income at the lowest income levels (50 percent of the federal poverty level or below). High energy burdens are a principal cause of financial distress, including conflicts in paying food, medicine, rent, or utility bills. The consequences include evictions and mortgage foreclosures. Extreme weather events exacerbated by climate change—such as more intense heat waves and longer, more severe fire seasons—are already causing increases in electricity bills and energy burdens. Moreover, without preventive action, an energy transition would also exacerbate the affordability problem. Thus, the prospect that climate change and the necessary energy transition might further aggravate energy burdens and their consequences, such as homelessness and ill-health, calls for preventive action. Indeed, the transition to a decarbonized electricity sector provides an opportunity to invest in reducing energy burdens to systematically ensure an equitable and inclusive future.

High energy burdens are a principal cause of financial distress, including conflicts in paying food, medicine, rent, or utility bills. Consequences include evictions and mortgage foreclosures.

Six percent of gross household income is generally considered the benchmark for a maximum affordable residential energy burden, derived from the federal guide for an affordable burden of 30 percent for housing plus utilities. Limiting burdens to this level would have a direct positive impact on households by providing the reliable energy supply necessary for health and adequate household functioning. There would also be major positive impacts on the rest of society. For instance, making energy affordable will drastically reduce energy bill conflicts with rent and mortgage payments, medical expenses, etc., potentially reducing some insurance company, hospital, and federal expenditures, such as costs of added emergency room visits that typically accompany homelessness. Limiting bills to an affordable level as a percentage of income is the surest way of making and keeping

household energy accessible across the spectrum of families that are part of the low- and moderate-income group and keeping these households resilient through worsening climate extremes and the energy transition.

Approximately 31 million households are energy burdened under the definition that an affordable burden is 6 percent of income (the median residential energy burden for all households is about 3 percent). This paper estimates the additional federal funds needed for states to implement Percentage of Income Payment Plans (PIPPs) to limit energy burdens to affordable levels. Based on the estimated level of need and number of qualifying households, the following federal funds are needed above current federal and state assistance amounts:

- About $29 billion per year would be required to limit LMI household energy bills for all fuels, including electricity bills, to 6 percent of gross income.
- About $20 billion per year would be required to supplement existing assistance programs to limit the electricity bills of LMI households to affordable levels (6 percent of gross income for electrically heated households and 3 percent of gross income for non-electrically heated households). The total requirement over the 2022-2030 period (inclusive) would be approximately $190 billion.
- About $2 billion per year would be required for states to administer the program, increase participation, and evaluate and report on its effectiveness in reducing energy burdens to affordable levels. The evaluation should also include assessments of various non-energy benefits both for the recipient individuals and society as a whole, such as improved health and reduced homelessness.

The income threshold used in estimating these amounts was 200 percent of the federal poverty level. This standard corresponds approximately to the criteria used by the federal Low-Income Home Energy Assistance Program (LIHEAP) as well as several states implementing this program: 150 percent of the federal poverty level or 60 percent of median income.[2]

[2] States set eligibility, with the federal limit being applied to state economic data. States can set eligibility criteria that are more stringent (i.e., with smaller maximum income for eligibility) than the federal criteria allow.

Administratively, the federal funds could be directed to LMI household utility accounts in a number of ways. The options include:

1. Block grants to states via the Department of Energy;
2. Block grants to states via the Low-Income Home Energy Assistance Program (LIHEAP), which is in the Department of Health and Human Services; and
3. Block grants via the Department of the Treasury, similar to the block grants for rental assistance in the American Rescue Plan.

The application processes and documentation requirements for assistance programs often present considerable obstacles for people who are elderly or ill or who may not have broadband, among others. Such obstacles can and do significantly reduce the number of people who apply and the fraction who actually get assistance once they have applied. Implementation of expanded assistance so that it reaches the vast majority of eligible households will also mean reducing these barriers and increasing both the application rate and the success rate for applicants.

It is important to note that affordable household energy also benefits society at large in many ways, such as lower costs due to better health and reduced homelessness because food-fuel-rent-medicine conflicts in family budgets are reduced. In the specific instance of the energy transition, many needed changes in the business model for electricity—such as integration of distributed generation, extensive demand response, and real-time electricity rates—could be implemented without the risk that large numbers of already economically vulnerable families would be adversely affected by the transition to a decarbonized electricity system.

2. High energy burdens in an era of climate disruption

The amount of income a household pays for energy, known as energy burden, is among the critical problems that contribute to financial insecurity in low- and moderate-income (LMI) families.[3] Energy burdens for millions of families are already very high. Potential increases in energy demand due to the increasing frequency and intensity of extreme weather events will add to that burden. And some of the changes to the electricity system that will be needed for a successful transition to a clean energy system are likely to further exacerbate energy burdens for LMI families, unless corrective action is taken to prevent such an outcome.

Existing energy burdens and their consequences

Low-income families are often forced to choose between paying utility bills or keeping up with the rent and their needs for medicine and food. Such conflicts are so frequent that there are sometimes tragic and predictable seasonal patterns. Families often resolve financial demands due to lower incomes by paying rent in the winter when they are more protected from utility shut-offs due to state or local regulations, opting to hold off on utility bills. The debt owed, or arrears, of unpaid utility bills begin to be paid off in the spring when terminations can resume, causing these stressed families to fall behind on rent. By the summer many families are evicted.[4]

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[3] The calculations here are based on LMI households being defined as less than 200 percent of federal poverty level because detailed affordability gap data are available on that basis. The LIHEAP eligibility standard for assistance is 150 percent of the federal poverty level or 60 percent of the median household income in a specific state, whichever is greater (LIHEAP 2018, p. i, footnote 2). This creates different levels for each state, since median incomes vary considerably. At the national level, 60 percent of median household income is approximately equal to 200 percent of federal poverty level.

[4] Matthew Desmond provides such an example in the case of Milwaukee in this book *Evicted* (Desmond 2016, pp. 15-16).

A 2018 survey of families who had received energy bill assistance at least once in the previous five years found serious housing difficulties:

"Many LIHEAP recipients had problems paying for housing in the past five years, due at least partly to their energy bills [and as a result]

- "17 percent moved in with friends or family; [and]
- "6 percent moved into a shelter or were homeless."[5]

These data indicate that a total of 23 percent of LIHEAP recipients experienced displacement from their homes over five years—amounting to an average of almost 5 percent every year. Nearly three-fourths of unhoused LIHEAP recipients moved in with friends and family. The rest—6 percent over five years, or 1.2 percent every year—actually became homeless or had to move into a public shelter. Even when shelter is available with family or friends, significant disruption in people's lives is implicit, for instance due to greater difficulties in accessing jobs and schools. The Covid-19 pandemic has also called attention to the health risks of crowding in homes.

Nearly 5 percent of LIHEAP recipient families lose their homes each year, a significant rate of displacement that causes severe distress to the displaced families as well as large costs to society.

Energy burden impacts on low-income families due to climate change

There are a number of reasons to anticipate that energy burdens for LMI families are likely to increase due to climate change:

- The increasing frequency and intensity of extreme weather events—such as fires, heat waves, and floods—requires investments by utilities in resilience and adaptation that are usually reflected in increasing electricity rates. For example, California's major investor-owned utility, PG&E, has proposed substantial rate increases to reduce wildfire risks and improve safety that would increase typical monthly residential

[5] NEADA 2018, p. ii (pdf p. 7).

electric and gas utility bills by about $30 per month; for low-income customers, the amount would be about $24 per month.[6]

More-intense heat waves and other extreme weather events are likely to increase energy burdens and financial distress, especially for the majority of low-income families who are renters.

- Extreme heat waves are becoming more common, thus increasing the use of air conditioning, which results in higher electricity bills. For example, the Environmental Resilience Institute of Indiana University estimates that the number of days with a high temperature above 95°F will increase from a historical average of seven per year to between 38 and 51 days per year in the coming decades.[7] Higher temperatures also mean that the atmosphere can hold more moisture, a factor that compounds the need for air conditioning on hot days. As a result, there is a greater need for investment in air conditioning for those households that do not have it. In areas such as the Pacific Northwest where residential air conditioning is not installed as a matter of course, this will mean a shift in the norms of housing construction. The money for such investments is often not available to LMI households, with consequent adverse impacts on health and productivity.[8]
- On average, LMI customers live in less-efficient homes;[9] climate extremes are therefore likely to impact their energy bills more than the average household.

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[6] PG&E Press Release 2021.

[7] Vilfranc 2021.

[8] For instance, the California Energy Commission estimated in 2018 that "[m]any counties in the San Joaquin Valley […] are expected to see more than 1,000 additional cooling degree days per year on average, a measure used to estimate energy demand needed to cool a building." CEC 2018, pdf p. 2. Increases in the number of very hot days are generally expected; see, for example, Vilfranc 2021.

[9] ACEEE 2016, p. 19. For details on one specific state, Maryland, see Makhijani, Mills, and Makhijani 2015, Table III-4, p. 43. This study found that the average energy use per square foot (known as energy use intensity) for heating in households receiving energy assistance was about one-and-a-half times the average for all households in the state—that is, the low-income households used about 50 percent more energy per square foot to heat their homes. A more fine-grained recent study examined disparities in energy use intensity in two cities, Tallahassee, Florida, and Knoxville, Tennessee. It

- Renters will be at a special disadvantage since many upgrades, such as improving building envelope insulation and equipment upgrades depend on landlords' willingness to invest, leaving the matter largely out of the control of the LMI families themselves.
- Extreme heat waves increase health emergencies, increasing financial stresses and conflicts between paying medical costs and utility bills.

Impact of the energy transition on low-income households

So far as the energy transition is concerned, costs are likely to go up for LMI households in the short and medium term, even as average costs go down:

- Demand response will become much more important to a future economical and resilient electricity system that has large proportions of solar and wind. The ability of consumers to participate fully and benefit economically will require smart appliances, access to information to respond to real-time rates, and access to credit and reasonable credit terms.
- The majority of low-income families are renters, giving them far less control or opportunity to participate in the emerging distributed energy market place; the same is true of a majority of Black and Latinx families of all income groups.[10]
- While average costs may decline, costs are likely to be transferred from those who can participate in distributed energy markets to those who cannot. For instance, access to rooftop solar and related incentives and bill savings is currently highly inequitable.[11] If that continues, adverse cost shifts will also continue.
- As fossil gas use declines due to conversions to efficient electric heating systems, the costs of maintaining the fossil gas distribution system will be borne by the dwindling number of customers who will increasingly consist of low-income and renter households that are likely to lag in electrification.

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found that households in the lowest income quintile had heating- and cooling-related electricity use that was between 66 percent and 167 percent greater per unit area than households in the highest income quintile (Tong et al. 2021, Table 1). This study also found disparities by race.

[10] HUD 2012, Figure 1. USA Facts 2020. According to the U.S. Census Bureau, Latinx homeownership rose just above 50 percent during 2020 but then fell back below this mark (U.S. Census 2020).

[11] For instance, in 2018, 15 percent of residential solar adopters had incomes below $50,000 (LBNL 2020, p. 5), but 40 percent of the households belonged in the $0 to $50,000 annual income range in the same year (Tax Policy Center 2020).

A recent report from Vibrant Clean Energy estimated that a mix of distributed clean energy resources would be more economical overall than a transition that focused mainly on centralized resources. However, the same report also estimated that costs of a distributed system would be higher in the initial years on average and lower in the out-years.[12] In addition, as noted, the impact on LMI households is likely to be disproportionately greater. In February 2021, the California Public Utilities Commission (CPUC) published a report on electricity affordability that provided further evidence for the view that inequities could increase if the transition is not well managed:

> The policy goals and regulatory requirements that create upward cost pressures appear manageable over a longer time horizon, *but if not managed correctly could trigger equity and affordability concerns for vulnerable customer populations over the short- to mid-term horizon*. There is the potential for a growing divide in the cost of service between customers participating in behind-the-meter (BTM) or distributed energy resources (DER) and those who are less likely to do so. Moderate- to higher-income customers are more likely to invest in DERs such as solar photovoltaic (PV) systems, electric vehicles (EV), and storage technologies, and the advanced rate offerings that support them. This enables them to shift load and take advantage of potential structural billing benefits that follow, which *often results in a cost shift toward the lower-income and otherwise vulnerable customers*. Without the prudent management of IOU revenue requirements, rate base, rate structures, and DER incentives, California's continued progress *toward the optimized grid of the future may widen this chasm between participants and non-participants*.[13]

Unless specific action is taken to prevent it, the energy transition could exacerbate energy burdens for low-income families, especially renters, even as average energy costs go down.

It is clear that, without preventive action, more families are likely to become homeless and more people will face food, rent, medicine, and utility bill conflicts due to the combined impacts of climate change and an inequitable energy

[12] Vibrant Clean Energy 2021, Figure ES-1. The report came to the same conclusion when comparing a distributed clean energy system to a "business-as-usual system."

[13] CPUC 2021, pp. 6-7; emphasis added.

transition. Any effort for a clean energy transition should therefore aim to forestall negative cost impacts *in advance*. Preemptively reducing costs will make the energy system more just for LMI families as well as for Black, Indigenous, People of Color (BIPOC) and frontline communities that are also often disproportionately economically vulnerable. Lowering energy burdens *is an essential investment in an emissions-free electricity system.*

3. Existing energy assistance programs

Eliminating high energy burdens for LMI households is essential for families and especially for BIPOC families that are disproportionately disadvantaged by being renters and that earn, on average, lower incomes than other groups. It is important to note that limiting energy burden is but one essential aspect of an equitable energy transition. Other facets include equitable access to solar energy and storage, efficient electrification of heating, and increased opportunities for individuals and BIPOC communities to own and control local energy systems.

> *Federal and state energy bill assistance programs help reduce energy burdens significantly, yet all too often, they still remain very high.*

Energy burdens are currently reduced in a number of ways. The Low Income Home Energy Assistance Program (LIHEAP) is a federal program that provides funds to states for heating and cooling bill assistance as well as support for weatherization of homes. There are a variety of state programs including electricity bill assistance, lower rates for the first block of energy consumed, and assistance to clear arrearages.

Typically, these programs reach only a fraction of those who are eligible. The obstacles to getting assistance are varied and substantial. They include lack of broadband access, onerous documentation requirements, lack of application materials or explanations in languages other than English, and health-related issues that may make it difficult to go through the application process.

Furthermore, even when people do get assistance, it is often insufficient to reduce energy burdens to an affordable level. In Maryland, for instance, pre-assistance burden for those who got help averaged about 14.8 percent, the post-

assistance burden averaged about 10.7 percent,[14] which is nearly 80 percent above the affordability norm of 6 percent. Only about a quarter of the eligible population in Maryland was helped.

Limiting energy burden to affordable levels is done in some states, including New Jersey and Colorado, by using Percentage of Income Payment Plans (PIPPs). PIPPs are typically enacted at the state level.[15] PIPPs may also have other features, like limitations on clearing arrearages or caps on amounts of assistance.

Comparing approaches to reducing energy burdens

In the United States, there are generally three approaches to reduce energy burdens as complements to the federal LIHEAP program:

1. Direct bill payment assistance, which reduces the amount payable by the customer;
2. Reduced rates for LMI customers up to a certain maximum consumption level; and
3. Percentage of Income Payment Plans (PIPPs).

A brief comparison of three options shows that there are clear advantages for Percentage of Income Payment Plans, especially in the context of climate change and the energy transition.

All three types of programs reduce energy burdens significantly. However, the first two do not guarantee that all LMI participant households will have an affordable energy bill, much less that affordability will be maintained through worsening climate extremes and through the energy transition. In other words, in the first two programs, many families are still left with energy burdens that result in significant utility bill, medicine, rent, and food budget conflicts, even as some energy burdens are reduced below the affordable 6 percent of income.

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[14] OHEP 2019, Table 11; data are for Maryland fiscal year 2019.

[15] Colton 2021, pp. 97-99.

The consequences of high burdens are severe for the families themselves and also imply significant costs for non-low-income households. For the same participation levels, the costs of Percentage of Income Payment Plans could be expected to be higher but the socioeconomic benefits for both low-income and non-low-income households are also higher (see Section 5, *Transitioning to electric heating*, below).

Direct bill payment assistance

The example of direct bill payment assistance in Maryland is illustrative. As noted, on average, energy assistance (state plus LIHEAP) reduced the average energy burden for participating households from about 14.8 percent to about 10.7 percent for all heating fuel types, well above the affordable amount. But there was significant variation *among* heating types. Specifically, assistance reduced the energy burden of fossil-gas-heated households to about 6 percent on average (the affordability threshold). However, the post-assistance burden for electrically heated households was 8.5 percent and almost 12 percent for fuel-oil-heated households. Furthermore, there is significant variation around these averages.[16] The Maryland program does provide higher assistance to very-low-income households, thereby reducing their energy burdens in percentage terms far more than at the upper levels of the income range of eligible households. For example, the average electric bill assistance for households at 75 percent or below of the poverty level was $687, providing an 80-percent reduction in the electricity bill. This amount corresponds to roughly a 3- to 6-percent income boost (depending on where in the income range the specific family might be). The corresponding average assistance for households in the 150 to 175 percent of poverty-level income range was $370, which reduces bills in this income group by 52 percent on average, boosting overall income by roughly 1 percent.[17]

[16] OHEP 2019, Table 11; data are for Maryland's 2019 fiscal year.

[17] OHEP 2019, Table 7, p. 20.

Reduced rates for LMI customers up to a certain maximum consumption level

Providing a lower electricity rate for an initial tranche of electricity consumption is another approach. In California, LMI households are offered a discounted rate that is more than 30 percent lower than the rate for non-eligible households.[18] The assistance program is in the framework of a rate structure that rises with consumption, so that all households, including low-income households, must pay a higher rate if they consume more than the baseline amount, which is adjusted for climate and heating fuel. The rate discount for LMI households applies to consumption up to 400 percent of the baseline.

A significant difference between the California and Maryland approaches (rate discounts versus direct bill assistance) is that the California discount—effectively, the assistance amount—depends on the level of consumption, not the poverty level. Therefore, two eligible households with the same electricity use but very different incomes would get the same reduction in their electricity bill as a result of the discounted rate. For example, if the undiscounted bill were $2,000 per year, the discount would be $650. A three-person family at the upper limit of eligibility ($43,000 per year income) would see their electricity burden reduced from 4.7 percent to 3.1 percent. A family at 50 percent of poverty level would see their burden reduced from 18.6 percent to 12.6 percent—an energy cost that is still very high.

In principle, the California program provides a greater incentive for energy conservation, and efficiency is greater, notably for low-income homeowners. However, most low-income households are renters, for whom taking advantage of efficiency opportunities is more difficult and complex.

[18] For example, the rate discount offered by Southern California Edison is 32.5 percent (SCE 2021, pdf p. 1). SCE 2018 shows how residential rates are structured, rising with increasing consumption, by blocks. There are three blocks: use up to the baseline level; from the baseline level to 400 percent of the baseline, and higher than the 400 percent of the baseline.

Percentage of Income Payment Plans

Percentage of Income Payment Plan (PIPPs) limit household energy bills to an affordable amount that is set at a percentage of income, usually 6 percent. At any level of energy cost, the amount of assistance automatically increases as the household income level decreases. If household income is zero, some fixed charge is usually applied, for example, $10 per month. The portion of the bill above 6 percent is paid for by public funds, often coming from utility ratepayers. With proper design, PIPP funding can be combined with federal LIHEAP funds, which are federal block grants to states, to reduce energy burdens.

> *Of the various methods of energy bill assistance, Percentage of Income Payment Plans offer the surest way of reducing energy burdens to affordable levels and keeping them that way through the energy transition.*

PIPPs have critical advantages relative to other assistance types. Both direct payments (the Maryland approach) and the rate-discount model (the California approach) leave large numbers of households with unaffordable energy burdens after assistance. Moreover, there is no built-in protection for increasing bills or rates in the face of climate extremes and the energy transition. In contrast, the PIPP by its very structure ensures that all participants have their energy burdens reduced to an affordable 6 percent. This approach does not solve all problems of utility bills since, at the lowest end of the income spectrum (below 50 percent of poverty level), 6 percent of income is still a significant amount.

Another advantage over other types of assistance programs is that a PIPP automatically sustains the goal of keeping energy burdens at an affordable level through the vicissitudes of worsening weather extremes. Similarly, low-income households will be protected from any adverse impacts of changes in utility rate structure or even utility business models throughout the energy transition. For instance, demand response using smart appliances and electric cars will provide significant benefits to those who can participate, but participation will be more difficult for renters whose landlords may not invest in smart appliances or charging stations (even if an LMI household were able to afford an electric vehicle). Assistance amounts increase if incomes fall or bills go up and vice versa.

As a result, a significant reduction of conflicts between rent, utility bills, medical costs, and food can be sustained through a variety of external changes.

PIPPs have been successful from their early days in reducing energy burdens dramatically, as evidenced by significant increases of low-income participants who were current on their utility bills or one month in arrears, at most. For instance, Rhode Island's Narragansett Electric had 45 percent of households that were three or more months behind on their bills, despite getting LIHEAP assistance before enrollment in the PIPP offered by the utility. After enrollment, only 5 percent were more than one month behind. Similarly outstanding results were observed in the Clark County Public Utility District in Washington State.[19] The near-total elimination of low-income customers in default or serious arrears when their bills were reduced to an affordable amount is an indication of a broader improvement in the fiscal health of PIPP households with regard to their ability to manage their rent, food, medicine, and utility bills. As discussed in Section 5, *Transition to electric heating*, these benefits can far exceed the cost of a PIPP.

4. A national Percentage of Income Payment Plan

Six percent of gross household income is generally accepted as the upper limit of an affordable energy burden, including electricity and all other residential energy use, such as fossil gas or fuel oil for space heating (see box, *An affordable energy burden: Six percent of household income,* below). The national median energy burden for all households is about 3 percent.[20] This section presents two estimates of the amounts needed to fund a federal Percentage of Income Payment Plan:

1. Additional federal funds required over the 2022-2030 period for reducing the overall household energy burden to 6 percent, including electricity and all other fuel bills; and

[19] Colton 1991, pdf pp. 12-13.

[20] ACEEE 2020, Figure 1, p. 10.

2. Additional federal funds required to limit electricity bill burdens to affordable levels, defined as 6 percent for households using electricity as their main heating fuel. For homes not heated by electricity, the following affordability limits for the other fuels were applied:
    a. Three percent for households using fossil gas for space heating to allow for the 2-percent heating affordability limit and the fact that such homes also use fossil gas for water heating and cooking, making the overall fossil gas affordability limit 3 percent of gross income; and
    b. Two percent for the remaining households—that is, those using other fossil fuels or wood for heating.

All residential energy

The public finance firm Fisher, Sheehan & Colton publishes estimates of a "home energy affordability gap" each year for the country as a whole, for the various regions of the United States, and for each state.[21] The national affordability gap is an estimate of the difference between total household energy bills of LMI households (defined as having incomes less than 200 percent of the federal poverty level) and 6 percent of the incomes of those households; there is also an affordability sublimit of 2 percent of gross income for heating bills. The baseline year for inter-annual comparison is 2011. **Table 1** shows the total national gap for 2011, 2019, and 2020.

Table 1: National overall energy cost affordability gap estimates for households with income at or less than 200 percent of the federal poverty level

Year	Affordability Gap*	Comments

[21] The affordability gap data can be downloaded from a dedicated website created by Fisher, Sheehan & Colton (http://homeenergyaffordabilitygap.com/03a_affordabilityData.html).

2011	$38.6 billion	Baseline year, LIHEAP budget $4.4 billion = 4.9 million average heating and cooling bills
2019	$41.0 billion	LIHEAP budget $3.6 billion = 3.7 million average heating and cooling bills
2020	$36.5 billion	LIHEAP budget $3.3 billion = 3.5 million average heating and cooling bills

Source: Fisher, Sheehan & Colton 2021 and Fisher, Sheehan & Colton 2020, http://homeenergyaffordabilitygap.com/03a_affordabilityData.html.

*The affordability gap is the total gap, prior to factoring in any federal or state assistance.

Table 1 indicates that the overall affordability gap has remained about the same over the past decade, though the federal LIHEAP assistance money has trended downward (apart from funds related to the Covid-19 pandemic), covering fewer equivalent total heating and cooling bills. It is supplemented by state assistance of a similar order of magnitude.[22]

[22] For instance, in Maryland's fiscal year 2020, the total state-funded assistance was about $50.8 million, coincidentally equal to the federal LIHEAP assistance (known in the state as the Maryland Energy Assistance Program) in that year. For 2019, the corresponding figures were $60.8 million and $56.8 million, respectively. See Tables 1 and 2 of the state's annual report on assistance (PSC 2020). The 2020 figures do not include pandemic-related federal assistance.

An affordable energy burden: Six percent of household income

This energy affordability norm is derived from the U.S. Department of Housing and Urban Development (HUD) affordable housing cost of 30 percent of gross income "for rent and utilities" when calculating the amount of rental assistance (HUD 2017, pdf p. 5). The HUD glossary (2011) gives the following definition of housing affordability:

> Affordable housing is generally defined as housing on which the occupant is paying no more than 30 percent of gross income for housing costs, including utilities.

One-fifth of the affordable housing amount is allocated to utilities and the rest is allocated to rent; thus, an affordable energy burden is defined as 6 percent or less of gross income (ACEEE 2020, p. 51; see also Colton 2021, pp. 97-99 and p. 97, footnote 182). A guideline for affordability of space heating alone is 2 percent of gross income (from the definition by Fisher, Sheehan & Colton, http://www.homeenergyaffordabilitygap.com/01_whatIsHEAG2.html).

Electricity affordability gap

It is more difficult to calculate the gap for electricity bills alone because, among other things, it requires estimating heating bills and electricity bills separately for LMI homes heated with fuels other than electricity. The following sources of data were used to make an approximate estimate:

- The Residential Energy Consumption Survey (RECS) data compiled by the Energy Information Administration of the Department of Energy, with the most recent survey having been conducted in 2015;
- The Low Income Home Energy Data reports prepared by the Department of Health and Human Services as part of the LIHEAP program, with the most recent data being for the year 2017;
- A survey published by the American Council for an Energy Efficient Economy in 2020 that estimated LMI household energy burdens for the year 2017; and
- The Energy Information Administration data on residential energy consumption and prices by fuel.

Table 2 estimates the number of LMI households by heating fuel category. The estimates are approximate projections for 2021 based on the 2015 RECS data and estimates of households with energy burdens more than 6 percent in the ACEEE 2020 report, which provides energy burden data for 2017.

Table 2: Number of LMI households, by main heating fuel

	Main heating fuel*, **			
	All†	Electricity	Fossil gas	All other fuels‡
Total number of households with high energy burden, millions	31.0	11.6	15.8	3.6

Sources: Estimated by the author from RECS (EIA 2018) and ACEEE 2020, adjusted upward to get a 2021 estimate.

***** RECS data also show supplementary heating fuels. For example, a household heated with fossil gas may use supplementary electric heating.

****** Total number of households estimated for 2021 = 124 million. For simplicity, heating fuels in LMI households are assumed to be the same fractions as for the overall occupied housing stock. This figure may somewhat underestimate the electrically heated fraction of LMI households.

† ACEEE 2020 estimates the number of households with energy burdens of more than 6 percent as 25 percent of the total. The estimate of 31 million is 25 percent of the total number of households for 2021, estimated at about 124 million.

‡ The "All other fuels" category includes houses using fuel oil, kerosene, propane, and wood as their main heating fuels.

One-fourth of all households—about 31 million—have high energy burdens. About $29 billion per year will be needed to reduce energy burdens to an affordable 6 percent, with $20 billion per year needed for electricity bill affordability alone.

In order to estimate the electric bill affordability gap alone, it is necessary to factor out the bills and the affordability gaps for the other fuels. Unfortunately, LIHEAP data that are parsed by heating fuel provide only total energy use and energy expenditures in each category. Very detailed estimates made for a Maryland energy justice study indicate that the energy use for heating in non-electrically heated LMI households is about the same as the overall average,

though the home area is significantly lower.[23] LMI homes typically have less insulation and lower heating system efficiency, factors not unrelated to the fact that most of LMI families are renters. Estimates for excess energy burden estimates for non-electrically heated households are shown in **Table 3**.

Table 3: Estimated average energy bill per LMI household, by main heating fuel and excess burdens over affordable norms for non-electrically heated households*

	Electric	Gas	All other fuels
Total energy bills	$2,070	$2,150	$2,890
Bills for energy other than electricity	$0	$930	$1,410
Energy burden for non-electric fuels in excess of affordable amounts**	$0	$340	$1,020

Sources: Author calculations based on energy burden data by fuel in LIHEAP 2018, energy burden data in ACEEE 2020, and the analysis in Makhijani, Mills, and Makhijani 2015. The calculations assumed an average energy burden of 10.9 percent for LMI households. The energy burden was estimated by the author from ACEEE 2020 data that (i) 25 percent of all households had energy burdens of more than 6 percent and (ii) 13 percent of all households had extremely high energy burdens (more than 10 percent), with the highest quartile among them having energy burdens greater than 14.4 percent, indicating a fat tail of the energy burden distribution (ACEEE 2020, Table 2.5).

* A reasonableness test was performed to check the estimated electric and non-electric amounts. The Energy Information Administration's State Energy Data System provides state-by-state and national expenditures on energy by type of fuel and by sector. Data for 2019 (EIA 2019, Table E10) show that electricity expenditures were 70.9 percent of total residential sector energy expenditures. The analysis based on Tables 2 and 3 above implies electricity expenditures of 71.1 percent of total residential sector expenditures of all LMI households. The EIA table does not provide expenditures for the LMI household category.

** The heating affordability limit is 2 percent of gross income. This figure was applied to households using fuels other than electricity or fossil gas, since most of these households use electricity for cooking and water heating. For fossil gas heated households, fossil gas is also the usual fuel for water heating and cooking and, in some cases, for clothes drying. The upper limit of an affordable gas bill on this basis is about 3 percent of gross income, since roughly one-third of the gas is used for non-heating purposes, which leaves about 2 percent as the upper limit for heating affordability. The average LMI household income for the year 2017, derived from LIHEAP 2018, was $19,600.

[23] For a given heating fuel, LMI households use less electricity, largely because they have fewer appliances than non-LMI households.

When the excess energy burden criteria are applied to the number of households in **Table 2** above, the results are as follows:

- Energy burden above affordability for fossil gas heated LMI homes: $5.4 billion per year; and
- Energy burden above affordability for all other non-electrically heated homes: $3.7 billion per year.

Thus, the total non-electric energy affordability gap is about $9 billion per year. Subtracting this amount from the overall affordability gap of about $29 billion per year, derived above, gives an estimate of $20 billion per year for the electricity affordability gap. The total additional federal budget requirement for making electricity bills affordable for LMI households is about $20 billion per year. Adding $2 billion for administrative costs gives a federal budget requirement of $22 billion per year. This amounts to about $200 billion (rounded) for the 2022 to 2030 period, inclusive.[24]

5. Transitioning to electric heating

As is widely recognized, electrification of residential space and water heating in homes that now use fossil fuels will be essential for a transition to a decarbonized economy, in addition to a zero-carbon-emission electricity sector. Among other adjustments, fossil gas, fuel oil, kerosene, and propane heating will have to be replaced with efficient electric systems, typically highly efficient heat pumps (such as air-to-air cold-climate heat pumps and geothermal heat pumps). Assisting LMI homeowners (and landlords who rent to LMI families) in the switch to electrification is an essential complement to energy affordability. This tremendous task will take time, ambitious national climate policy, and sizable investment; electrification is therefore not a substitute for ensuring that energy burdens are affordable at the start of the transition to a decarbonized energy system.

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[24] This is, evidently, an approximate amount that assumes a constant amount needed for each year. On the one hand, the annual amount would tend to rise with energy price inflation. On the other, it assumes 100-percent participation for all nine years, even though it will take some time to achieve close to total participation. The implicit assumption in the calculation is that the underestimate and overestimate will approximately cancel out.

The combined impact of the investment needed to electrify fossil-fuel-heated households and changes in resultant energy burdens is a complex topic that is beyond the scope of this paper. Suffice it to say that process of electrification, which should also include efficiency investments,[25] should keep that combined impact in account to ensure equity in electrification and affordable energy burdens throughout the process.

Particular considerations for energy improvements

Efficient electrification of heating can have positive impacts on electricity use and bills for air conditioning. Specifically, cold-climate heat pumps are much more efficient in cooling mode than typical room or central air conditioners.[26] Thus, conversion from fossil fuel heating to cold-climate (or geothermal) heat pumps should considerably reduce cooling-related electricity bills in those cases where LMI homes have air conditioning.[27]

A holistic policy of electrification of space heating would include building performance improvement (in the sense of reducing the energy required for heating and cooling per square foot) and incentives for installation of efficient heat pumps. This combination will reduce LMI energy burdens overall. In a large number of cases, especially in hot and humid areas like the Southeast, it may also reduce electricity bill burdens, despite heating electrification, because air-conditioning bills would be considerably reduced.

Efficient electrification of heating now done by fossil fuels, as well as access to economic community solar energy, can systematically reduce CO_2 emissions and

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[25] The analysis in Makhijani, Mills, and Makhijani 2015 (p. 45) shows that low-income families live in less-efficient homes in terms of energy use per square foot, though overall energy use is lower because the area of LMI homes is smaller on average. There are a variety of causes for the lower efficiency, including the fact that landlords have no incentive to invest in efficiency when they don't pay the utility bills (a problem known as the "split incentive").

[26] And geothermal heat pumps, also known as earth-source heat pumps, are even more efficient.

[27] About 89 percent of LMI homes had some cooling equipment, but this figure includes fans in homes without air conditioning (LIHEAP 2018, Table 5, p. 8).

the funds needed to keep energy burdens affordable. Community solar programs can also reduce electricity bills if subscription rates are lower than utility residential rates. These programs should be increased as part of the transition to a decarbonized electricity system. Households that subscribe to such programs, including LMI households, would see their electricity bills decline. The cost of electricity for space and water heating for a household that converts to electricity from fossil fuels would also be correspondingly lower.

As noted above, efficient electrification, efficiency improvements, and other means to systematically reduce energy burdens will take time and investment. They are not a substitute for making energy burdens affordable. In other words, energy affordability at the start of the energy transition is still critical, even in the context of increasing electrification and solar access.

Tracking and evaluating energy burdens and the effectiveness of electrification and weatherization programs as well as community solar programs will be important to determine how the funds should be adjusted as electrification proceeds, along with other upgrades of the housing stock. Taking investments into account should be an important part of such evaluations.

6. Administration of funds

Federal funds could be directed to LMI household utility accounts in a number of ways, including:

- Block grants to states via the Department of Energy;
- Block grants to states via LIHEAP, which is in the Department of Health and Human Services; and
- Block grants via the Department of the Treasury, similar to the block grants for rental assistance in the American Rescue Plan.[28]

Whatever the mechanism for directing funds to LMI households, funds to administer the program will be needed for it to be effective. LIHEAP grants

[28] At the federal level, the Emergency Rental Assistance Program is administered by the Department of the Treasury. Utility bills are considered part of rent, and assistance may be used to pay them. See Department of the Treasury 2021.

include 10 percent for administration, meaning that states receive some $300 million to $500 million to administer the program, depending on the LIHEAP appropriation in any particular year. States that have their own electricity bill assistance programs also make allowance for administering those funds.

States should have adequate funds to administer Percentage of Income Payment Plans and increase enrollment. Enrollment in assistance programs is typically only a fraction of eligible households.

The application processes and documentation requirements for assistance programs often present considerable obstacles, particularly for people who are elderly or ill or who do not have broadband. Such obstacles can and do significantly reduce the number of people who apply and the fraction who actually get assistance once they have applied. Implementation of expanded assistance so that it reaches the vast majority of eligible households will also mean reducing these barriers and increasing both the application rate and the success rate for applicants.[29]

In any case, the success of a federal Percentage of Income Payment Plan will depend greatly on increased participation and will require budgetary support, which should therefore be included. Such support will provide states with the ability to create the infrastructure and do the outreach to increase enrollment to more easily enable eligible households to benefit from the program. At 10 percent, this support for making electricity affordable for LMI households in all states would be $2 billion per year.

7. Additional budgetary and social benefits

Greater social stability and access to essential needs: Making energy affordable for all LMI households greatly reduces the severe conflicts between essential expenditures that LMI families routinely face. The most-severe

[29] Zully Juarez, Senior Research & Policy Analyst at the Just Solutions Collective, is preparing a policy-related paper on energy burdens as a complement to the present effort, the main aim of which is to estimate the amounts needed for all states to implement a Percentage of Income Payment Plan.

consequences can range from foregoing meals or medicines at the required dosages to homelessness and complete dislocation.

These very same events also have consequences for society at large. For instance, the detailed Maryland energy justice study cited above estimated that the costs of shelter and the *added* costs of emergency room visits per homelessness event (averaging seven months) was about $28,000; of this amount, roughly $20,000 would be for the added emergency room visits.[30] The total for just two of the avoided impacts is almost 40 times greater than the $710 in average added annual assistance per energy-burdened household needed to make residential electricity affordable for all. The positive budgetary implications for the federal government include reduction in Medicaid expenditures by avoidance of extra emergency room visits and other medical expenses due to ill-health caused by energy bill conflicts with health-care expenses.

The benefits of affordable energy in terms of avoided social and economic costs would be vastly greater than the cost of a national Percentage of Income Payment Plan.

The LIHEAP survey cited above indicates that energy bill conflicts with rent or mortgage payment may result in about one percent (or more) of surveyed households becoming homeless each year. Data compiled by the Green and Healthy Homes Initiative in Baltimore indicate that remediating homes and making them more efficient reduced mortgage foreclosure notices drastically—by almost 90 percent.[31] Avoided homelessness could therefore save state and federal governments, as well as the private health care system, billions of dollars a year, in addition to preventing unnecessary trauma and disruption for children and families.

As noted, a Percentage of Income Payment Plan is critical not only for amelioration of present high energy burdens, but also for addressing the energy

[30] Makhijani, Mills, and Makhijani 2015, pp. 89-91.

[31] As cited in Makhijani, Mills, and Makhijani 2015, p. 91.

burdens that are increasing due to the impact of extreme weather events and for making the energy transition equitable.

Ability to get and keep a job: Another likely benefit would be added productivity at work, since high energy burdens contribute significantly to illness, according to a survey of those who received assistance at least once in the five-year-period prior to the survey.[32] This finding implies that making energy affordable would reduce lost workdays and promote labor productivity, which would result in higher tax revenues for the federal, state, and local governments.

Increased investments in energy efficiency: Since energy burdens of LMI families would be a fixed fraction of income, most reductions in energy burdens of LMI households due to efficiency investments would be reflected in reduced energy burden gaps and corresponding lower budgetary requirements for Percentage of Income Payment Plans. This situation creates an inbuilt social incentive for effective efficiency investments in existing affordable housing and for high efficiency standards for new affordable housing.

Adaptation to extreme weather events: Utility rates are already increasing significantly in some places due to the need to adapt the energy system to more-frequent and more-intense weather extremes. These same events are also increasing energy bills, for instance due to the increased need for air conditioning. Making utility bills affordable and keeping them that way as climate burdens increase and clean energy investments expand will enable equitable adaptation to climate change, at least so far as energy goes.

A just energy transition: Finally, the energy transition overall would become much smoother with the implementation of an effective PIPP program to limit energy burdens that reaches essentially all LMI households. Many needed changes in the business model for electricity—such as integration of distributed

[32] Twenty-five percent of those surveyed reported that they "kept their home at a temperature that was unsafe or unhealthy" because of high energy costs and "41 percent went without medical or dental care" (NEADA 2018, p. 2 [pdf p. 7]).

generation, extensive demand response, and real-time electricity rates—could then be implemented without the risk that large numbers of already economically vulnerable families would be adversely affected by the transition to a decarbonized electricity system.

8. Recommendations

In any policy or effort to transition individual states or the entire nation to a clean, renewable energy system, addressing energy burden is essential and a key aspect of climate justice. In the wake of the Covid-19 pandemic, when workers lost jobs and children were forced to learn from home, policymakers issued moratoriums prohibiting utility shut-offs, and many states, through the intervention of advocates, made sure that utilities provided payment options and other consumer protections. Ensuring adequate and accessible access to energy was widely understood as essential.

As we come to terms with the impact of more-severe weather events and to the scale, pace, and opportunity to transition to a just and renewable energy system, **the following recommendations will support the commitment to provide affordable energy to low- and moderate-income households.**

1. Create a program enabling a national Percentage of Income Payment Plan.
2. Fund PIPP in the federal budget at $22 billion a year from 2022-2030 to reduce electricity burdens to affordable levels.
3. Require tracking and evaluation of energy burdens and the effectiveness of electrification and weatherization programs, as well as community solar programs.
4. Determine how the funds should be adjusted as electrification combined with other upgrades of the housing stock proceeds.
5. Provide this information publicly and require public participation in reviewing and improving the program.

9. References

ACEEE 2020	Ariel Drehobl, Lauren Ross, and Roxana Ayala. *How High Are Household Energy Burdens?* Washington, D.C.: Alliance for an Energy Efficient Economy, September 2020. https://www.aceee.org/sites/default/files/pdfs/u2006.pdf
ACEEE 2016	Ariel Drehobl and Lauren Ross. *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities*. Washington, D.C.: Alliance for an Energy Efficient Economy, 2016. https://www.aceee.org/sites/default/files/publications/researchreports/u1602.pdf
CEC 2018	Stephanie Bailey. *Energy Equity Indicators Tracking Progress.* Sacramento, California, California Energy Commission, Docket Number: 18-IEPR-08, June 25, 2018. https://www.energy.ca.gov/sites/default/files/2019-12/energy_equity_indicators_ada.pdf
Colton 2021	Roger D. Colton. *Ratepayer-Funded Utility Bill Affordability: A Path forward to Serve Low-Income Connecticut Residents*. Belmont, Massachusetts: Fisher, Sheehan & Colton, February 2021. https://www.michigan.gov/documents/mpsc/Connecticut_affordability-_Final_040821_721903_7.pdf
Colton 1991	Roger D. Colton. *Percentage of Income Payment Plans as an Alternative Distribution of LIHEAP Benefits: Good Business, Good Government, Good Social Policy.* Boston, Massachusetts, National Consumer Law Center, 1991. http://www.fsconline.com/downloads/Papers/1991%2003%20MassElectric_PIP.pdf

CPUC 2021	Bridget Sieren-Smith, Ankit Jain, Alireza Eshraghi, Simon Hurd, Julia Ende, Josh Huneycutt, Andrew Ngo, Mark LeBel, Carl Linvill, and David Roland-Holst. *Utility Costs and Affordability of the Grid of the Future: An Evaluation of Electric Costs, Rates, and Equity Issues Pursuant to P.U. Code Section 913.1*. San Francisco, California: California Public Utilities Commission, April 2021. https://www.cpuc.ca.gov/about-cpuc/divisions/office-of-governmental-affairs/2021-reports-to-the-legislature
Department of the Treasury 2021	U.S. Department of the Treasury. *Emergency Rental Assistance: Frequently Asked Questions.* Washington, D.C.: U.S. Department of the Treasury, June 24, 2021 (revised). https://home.treasury.gov/system/files/136/ERA_FAQs_6-24-21.pdf
Desmond 2016	Matthew Desmond. *Evicted: Poverty and Profit in the American City.* New York, New York: Crown Publishers, 2016.
EIA 2019	Energy Information Administration. *State Energy Data System, Residential Sector Energy Expenditure Estimates, 2019, Table E10.* Washington, D.C.: U.S. Department of Energy 2019. https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_sum/html/sum_ex_res.html&sid=US
EIA 2018	Energy Information Administration. *Residential Energy Consumption Survey*. Washington, D.C.: U.S. Department of Energy, 2018. Tables online at https://www.eia.gov/consumption/residential/data/2015/
Fisher, Sheehan & Colton 2021	Fisher, Sheehan & Colton. *The Home Energy Affordability Gap 2020.* Boston, Massachusetts, April 2021. http://www.homeenergyaffordabilitygap.com/downloads/2020_Released_Apr21/HEAG2020%20Regional%20Fact%20Sheets.pdf
Fisher, Sheehan & Colton 2020	Fisher, Sheehan & Colton. *The Home Energy Affordability Gap 2019.* Boston, Massachusetts, April 2020. http://www.homeenergyaffordabilitygap.com/downloads/2019_Released_Apr20/HEAG2019%20Regional%20Fact%20Sheets%20Rev2.pdf

HUD 2017	*2018 HUD Affordable Housing Guide*. Washington, D.C.: U.S. Department of Housing and Urban Development, December 11, 2017. https://www.hud.gov/sites/dfiles/State/documents/2018-Affordable-Housing-Guide.pdf
HUD 2012	Office of Policy Development and Research. *Paths to Home Ownership for Low-Income and Minority Households.* Washington, D.C.: U.S. Department of Housing and Urban Development, 2012. https://www.huduser.gov/portal/periodicals/em/fall12/highlight1.html
HUD Glossary 2011	*Glossary of Terms to Affordable Housing*. Washington, D.C.: U.S. Department of Housing and Urban Development, terms archived in 2011. https://archives.hud.gov/local/nv/goodstories/2006-04-06glos.cfm
LBNL 2020	Galen Barbose, Sydney Forrester, Naïm Darghouth, and Ben Hoen. *Income Trends among U.S. Residential Rooftop Solar Adopters*. Berkeley, California: Lawrence Berkeley National Laboratory, February 2020. https://eta-publications.lbl.gov/sites/default/files/solar-adopter_income_trends_report.pdf
LIHEAP 2018	Office of Community Services. *Low Income Home Energy Data for Fiscal year 2017*. Washington, D.C.: Department of Health and Human Services, October 2018. https://liheappm.acf.hhs.gov/sites/default/files/private/notebooks/2017/RPT_LIHEAP_HENPart1LIHEData_No_FY2017.pdf
Makhijani, Mills, and Makhijani 2015	Arjun Makhijani, Christina Mills, and Annie Makhijani, *Energy Justice in Maryland's Residential and Renewable Energy Sectors*. Takoma Park Maryland: Institute for Energy and Environmental Research, 2015. https://ieer.org/wp/wp-content/uploads/2015/10/RenMD-EnergyJustice-Report-Oct2015.pdf
NEADA 2018	APPRISE. *2018 National Energy Assistance Survey: Final Report.* Prepared for National Energy Assistance Directors' Association. Washington, DC: NEADA, December 2018.

	http://www.appriseinc.org/wp-content/uploads/2019/02/NEADA-2018-LIHEAP-Survey.pdf
OHEP 2019	Office of Home Energy Programs. *Electric Universal Service Program (EUSP): Proposed Operations Plan for Fiscal Year 2020* – Submitted to the Public Service Commission. Annapolis, Maryland: Maryland Department of Human Services, May 2019. Item 544 in the Maryland Public Service Commission's docket number 8903 at https://www.psc.state.md.us/search-results/?q=8903&x.x=27&x.y=17&search=all&search=case
PG&E Press Release 2021	PG&E. "To Meet the Evolving Needs of its 16 Million Customers, PG&E Proposes Critical Investments to Reduce Wildfire Risk, Enhance Energy System Safety and Reliability, and Deliver More Clean Energy for California," Press Release. San Francisco, California: Pacific Gas & Electric, June 21, 2021. https://www.businesswire.com/news/home/20210630006036/en/To-Meet-the-Evolving-Needs-of-its-16-Million-Customers-PGE-Proposes-Critical-Investments-to-Reduce-Wildfire-Risk-Enhance-Energy-System-Safety-and-Reliability-and-Deliver-More-Clean-Energy-for-California
PSC 2020	Public Service Commission. *Electric Universal Service Program 2020 Annual Report.* Baltimore, Maryland: Public Service Commission, 2020. https://www.psc.state.md.us/wp-content/uploads/2020-EUSP-Annual-Report.pdf
SCE 2021	*California Alternate Rates for Electricity: Domestic Service – Schedule D-CARE*. Southern California Edison, May 14, 2021. https://library.sce.com/content/dam/sce-doclib/public/regulatory/tariff/electric/schedules/residential-rates/ELECTRIC_SCHEDULES_D-CARE.pdf
SCE 2018	*Schedule D: Domestic Service*. Southern California Edison, June 1, 2018. https://library.sce.com/content/dam/sce-doclib/public/regulatory/tariff/electric/schedules/residential-rates/ELECTRIC_SCHEDULES_D.pdf

Tax Policy Center 2020	Tax Policy Center. *Household Income Quintiles 1967-2018.* A joint publication of the Urban Institute and the Brookings Institution, 2020. https://www.taxpolicycenter.org/statistics/household-income-quintiles
Tong et al. 2021	Kangkang Tong, Anu Ramaswami, Corey (Kewei) Xu, Richard Feiock, Patrick Schmitz, and Michael Ohlsenc. "Measuring social equity in urban energy use and interventions using fine-scale data," *PNAS* Vol. 118, No. 24, April 2021. https://www.pnas.org/content/pnas/118/24/e2023554118.full.pdf
U.S. Census 2020	*U.S. Census Housing Data.* Quarterly Homeownership Rates by Race and Ethnicity of Householder for the United States: 1994-2020: Figure 8. Washington, D.C. March 2021. https://www.census.gov/housing/hvs/data/charts/fig08.pdf; other figures in this series of housing charts can be downloaded from the webpage showing homeownership and vacancies at https://www.census.gov/housing/hvs/data/charts.html
USA Facts 2020	"Homeownership Rates Show that Black Americans Are Currently the Least Likely Group to Own Homes," USA Facts, October 16, 2020. https://usafacts.org/articles/homeownership-rates-by-race/ accessed August 1, 2021.
Vibrant Clean Energy 2021	Christopher T.M. Clack, Aditya Choukulkar, Brianna Coté, Sarah A. McKee. *Why Local Solar for All Costs Less: A New Roadmap for the Lowest Cost Grid*. Boulder, Colorado: Vibrant Clean Energy, LLC, December 1, 2020. https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_ES_Final.pdf
Vilfranc 2021	Chrystelle L. Vilfranc. "'Hotter and more humid': Dangerous extreme heat will impact Indiana in coming years," *Indianapolis Star*, July 31, 2021. https://www.indystar.com/story/news/environment/2021/07/30/indiana-weather-extreme-heat-put-more-hoosiers-health-risk/8074218002/ accessed August 1, 2021.