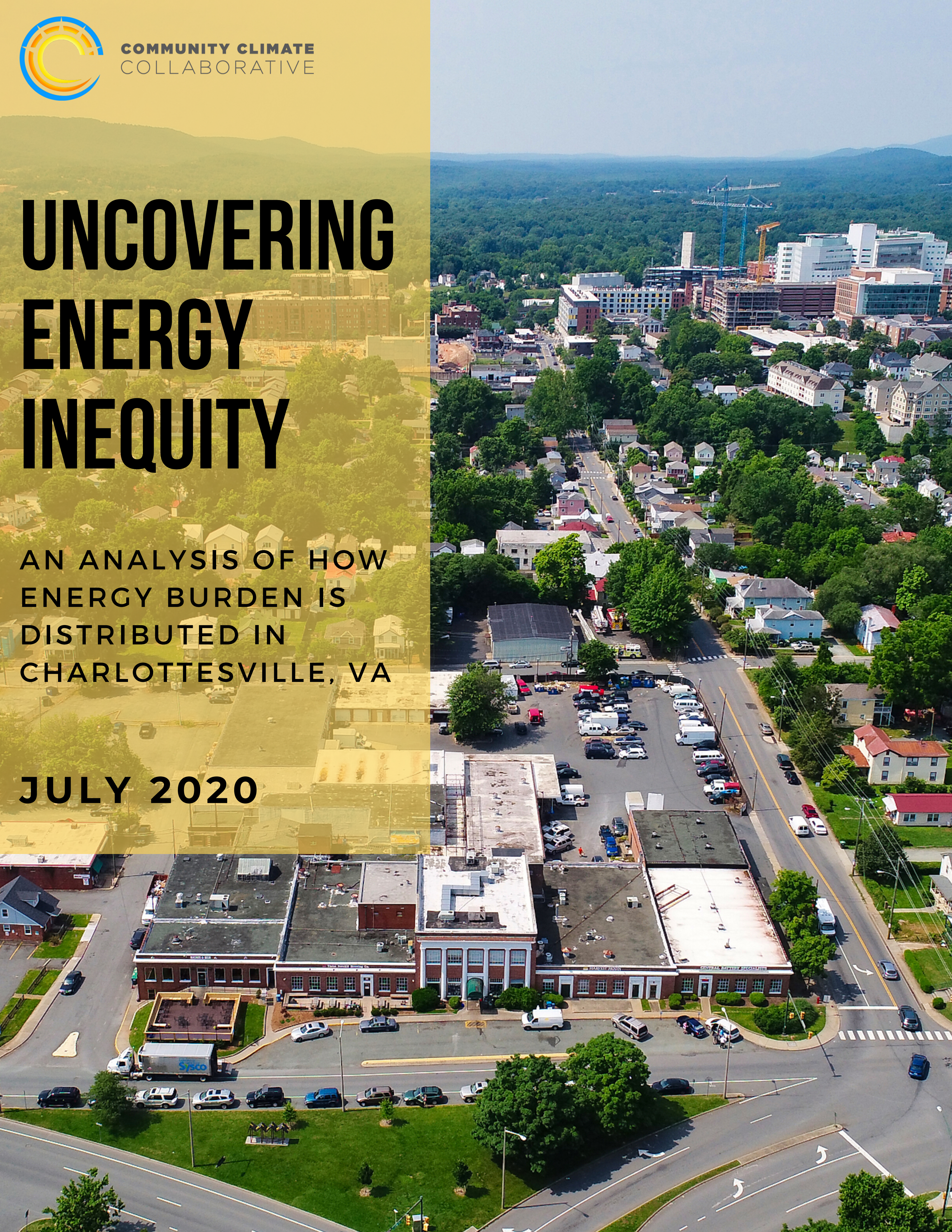
COMMUNITY CLIMATE COLLABORATIVE

UNCOVERING ENERGY INEQUITY

AN ANALYSIS OF HOW ENERGY BURDEN IS DISTRIBUTED IN CHARLOTTESVILLE, VA

JULY 2020



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Introduction

The City of Charlottesville has established goals to reduce net greenhouse gas (GHG) emissions by 45% by 2030 and to achieve carbon neutrality by 2050. The City has also committed to addressing equity in its Climate Action Plan and related policies, in an effort to make climate programs accessible and affordable for all residents in the area.

Minimizing energy burden, with a focus on the most severe incidences, must be an essential component of an equitable Climate Action Plan. To help the City of Charlottesville begin to address energy burden, C3 analyzed neighborhood-level data and subsequently developed a map of Charlottesville's most energy-burdened hotspots to pinpoint how different housing stock and demographic features relate to energy burden levels. C3 believes that the present analyses, and future energy burden mapping efforts, will provide valuable information to decision-makers, allowing them to design and implement climate policies with the highest energy conservation potential while significantly increasing the livability of Charlottesville's most economically-distressed households.

Recently approved state legislation, such as the HB 981/SB 1027 (Clean Energy and Community Flood Preparedness Act), seek to provide extra resources to help alleviate the energy burden of "historically economically disadvantaged communities'.[1] In light of such legislative measures, the information in this study provides key insights on how the City of Charlottesville (and similar municipalities throughout the Commonwealth, including Albemarle County) can best allocate or take advantage of forthcoming resources from the State Government and electric utilities' programs to effectively spur renewable energy investments and energy efficiency upgrades, allowing the City to work towards its goal of community-wide carbon neutrality by 2050.

Furthermore, in the wake of the COVID-19 pandemic, C3 considers this to be a decisive moment for the City to alleviate the economic distress of its residents by easing their energy burden. Additional resources will potentially be made available via Federal and State economic-recovery initiatives following this crisis; using them to support renewable energy and energy efficiency upgrades could simultaneously improve the physical health of energy-burdened households, contribute toward building a cleaner and safer economy, and put those in the clean energy sector back to work.

This report will equip community stakeholders and decision-makers with a more thorough understanding of how to promote energy equity and effectively allocate resources from the State and energy utilities toward residential energy efficiency and renewable energy programs in communities like Charlottesville.

1 A community with a majority of population of color or a low-income geographic area.

Glossary

Affordable Housing

The concept of "gross housing costs" ("housing costs", for short) is relatively simple, but its definition differs depending on the home ownership status of the household. The Central Virginia Regional Housing Partnership (CVRHP) states that for homeowners, housing costs includes mortgage payments, utilities, association fees, insurance, and real estate taxes. For renters, housing costs include contract rent and utilities (CVRHP, 2019).

The U.S. Department of Housing and Urban Development (U.S. HUD) defines that a household is under housing cost burden (or simply "Cost Burden") when a household pays over 30% of its annual income toward gross housing costs (U.S. HUD, 2020). Households suffer from severe cost burden when they spend over 50% of their annual household income on gross housing costs (U.S. Census Bureau). This report further defines Cost Burden [Alone] as when 30% to 50% of the household's income is spent on gross housing costs.[2]

As such, affordable housing can be defined as a home which does not impose a severe cost burden or cost burden [alone] on its residents.

Area Median Income

Area Median [Family] Income (AMI) is defined as the median household income for a particular geographic region, [3] often adjusted by household size (U.S. HUD, n.d.). The AMI, estimated for the fiscal year of 2016 at $ $77,800 per year for a household of 4 members in Charlottesville (Virginia Housing Development Authority, 2020), is frequently used to distinguish households by income brackets to determine categories such as low-income, moderate-income, and high-income households.

For instance, the HUD defines relevant household income brackets (U.S. HUD, n.d.; U.S. HUD, 2013) as follows:

- Extremely-Low Income [Alone]: incomes below 30% of AMI;
- Very-Low Income [Alone]: incomes 30% and above, up to 50% of AMI; [4]

[2] The definition of "Cost Burden [Alone]" aims to provide a individual categorization for those households that are cost burdened but not severely cost burdened.
[3] The "average median income" is the "middle income" of a certain population. The income level that approximately half of the population earn less than it and the other half earn more than it.
[4] Some parts of this report define Very-Low Income [Alone] as incomes 30% and above, up to 60% of AMI; according to the information available.

- Low Income [Alone]: incomes 50% and above, up to 80% of AMI; [5] and
- Moderate Income [Alone]: incomes 80% and above, up to 100% of AMI.

Energy Burden

Energy-cost burden (energy burden, for short) refers to the portion of a certain household income spent on home-energy costs, including electricity, natural gas, propane, and other energy sources (Drehobl & Ross, 2016). A household's energy burden provides an indication of energy affordability.

Researchers define an energy burden of 6.0% or higher as a high energy burden (ACEEE, 2019). [6] This report uses the following definitions:[7]

- High Energy Burden [Alone]: between 6.0% and 9.9%;
- Very High Energy Burden [Alone]: between 10.0% and 19.9%;
- Extremely High Energy Burden [Alone]: 20.0% or higher.

Energy Equity

Energy equity is defined by Stanford University as a context in which all households have equitable access to clean, affordable, and secure energy services, regardless of their demographic characteristics (such as ethnic background, income levels, geographic location, etc.). Such equitable access strives to close the gap between high- and low-income populations by not only reducing energy-cost burden, but also by improving productivity, education, and health (Stanford University, 2018).

Energy equity may overlap with climate justice as communities without equitable access to energy may not be able to combat the effects of climate change (such as rising temperatures), [8] despite historically contributing less to human-led global warming.

[5] Some parts of this report define Low Income [Alone] as incomes 60% and above, up to 80% of AMI; according to the information available.

[6] This energy affordability percentage is based on the following assumptions: (i) an affordable housing cost burden is less than 30% of the household's income; (ii) not more than 20% of housing costs should be allocated to energy bills. Consequently, in an affordable housing context, not more than 6% of the household income should be spent on energy costs.

[7] The complementary "Alone" definition aims to provide a clear understanding of the subgroup, as it is also accurate to consider (for example) that extremely/very-high energy burdens are also high energy burdens.

[8] Climate justice seeks to frame climate change as also a social and human rights issue rather than simply an ecological one. Supporting this concept are studies, such as that by Sampson and colleagues in 2011, stating that communities which have historically contributed the least to human-led global warming are [and will] often times [be] the most vulnerable to the adverse impacts of climate change and/or of the human activities causing it (Samson, Berteaux, McGill, & Humphries, 2011).

Census Tracts

Census tracts are defined as small and relatively permanent statistical subdivisions of a municipality. Each census tract is uniquely numbered, has a minimum population of 1,200 inhabitants, and a maximum population of 8,000 inhabitants (U.S. Census Bureau).

One of the major uses of census data is to treat the census tract (the main geographic unit for which data are published) as a proxy for "neighborhood." Often this decision is described as a forced choice, as the census tracts is usually the most granular data provided by the yearly published (with data pooled from a sample surveyed across five successive years) U.S. Census Bureau's American Community Survey (or ACS, for short).

As of 2010, Charlottesville was composed of 12 census tracts (Figure 1). Table 1 provides a heuristic approximation of the City's census tracts and its neighborhoods as defined by Charlottesville's Neighborhood Development Services (Figure 2).

TABLE 1	**Approximate Equivalence Between Census Tracts and Neighborhoods**
Census Tract	**Neighborhoods**
2.01	Barracks/Rugby, Rose Hill, and Venable
2.02	10th & Page and Venable
3.02	Martha Jefferson and Woolen Mills
4.01	Ridge Street
4.02	Belmont
5.01	Fifeville
5.02	Fry's Spring and Johnson Village
6	Jefferson Park Avenue
7	Barracks/Rugby, Barracks Road, Lewis Mountain, and Venable
8	Greenbrier and The Meadows
9	Locust Grove
10	North Downtown and Martha Jefferson
Source:	**C3's own elaboration based on data obtained from Neighborhood Development Services and US Census Bureau.**

Figure 1 – Census Tracts of Charlottesville

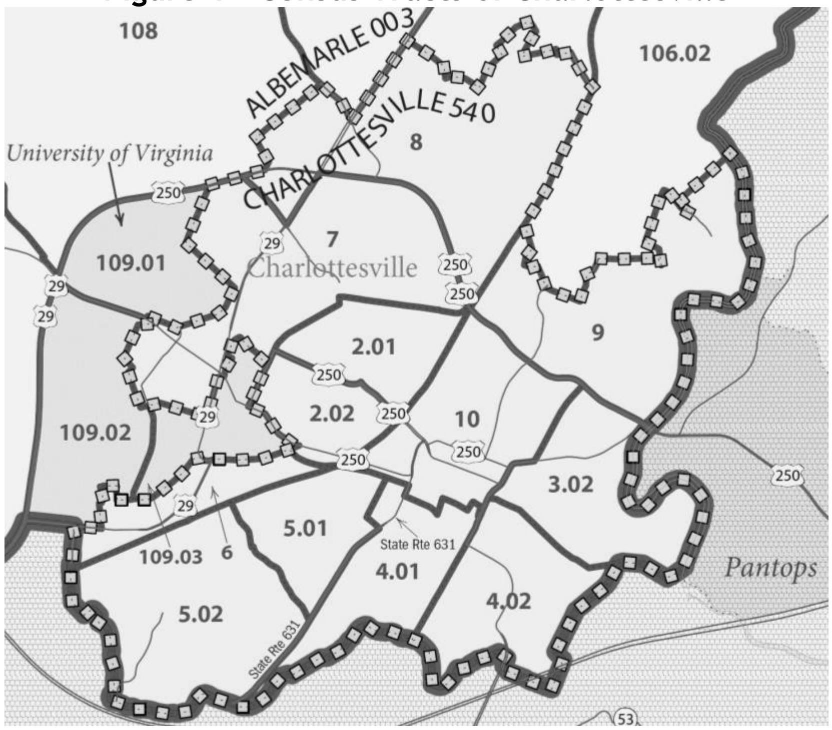


Figure 2 – Neighborhoods of Charlottesville

Source: Charlottesville's [Neighborhood Development Services](#).

Energy Burden: Where and Why?

The determination of a household's energy-cost burden relies on the interaction of two key variables: the household's home-energy costs and the household's income level. Consequently, it is normal to consider the determinants of each of these variables as potential drivers of households' energy burden levels.

Among the factors influencing a household's home-energy costs are the household size, the building-structure energy efficiency (e.g. building stock features), the energy efficiency of the appliances owned by the household, and the household's consumption habits.

Among the determinants of income level are the household's geographic location (which is less pertinent to this report, as it focuses only on the Charlottesville area) and the household's demographic characteristics, which include education level, gender, and race.

In the following sections this report identifies which variables are generally accepted as the main drivers of energy burden, explores their relationship with the main drivers of housing affordability, and presents a quick overview of Charlottesville's performance in each of these categories.

Section's Key Takeaways

- Renters and Extremely-Low income households are most likely to live in unaffordable housing contexts and, based on findings from national or regional studies, these two demographic groups are also more likely to experience higher energy burdens
- The key factors associated with lack of affordable housing contexts overlap with the key drivers recognized to contribute to higher energy burden levels. Namely, they can be summarized into: income levels, home ownership, household size, race, level of education, gender, age, and building features (e.g. year built)
- 39% of Charlottesville area residents with incomes below the poverty level are [UVA] students (FBCI & PES, 2018)

Drivers of Energy Burden

A wealth of research supports the finding that low-income households face a high energy burden relative to other households. The National Resource Defense Council (NRDC) highlights that the energy burden faced by low-income households is three times higher than other households (Martinez, 2016).

According to the ACEEE, while Virginia's median low-income energy burden is not quite as high as other Southeastern states, it aligns closely with the median low-income household's energy burden in the U.S. of 7.2%. The report indicates that low-income households comprise the group that faces the highest median energy burden, while overall African American households, Latinx households, low-income households residing in multifamily buildings, and renting households all face median energy burdens greater than the national median of 3.5%. Thus, as reported by the ACEEE, low-income status is not the only driver of high energy burden; rather, income, race, and homeownership status are all associated with energy burden (Drehobl & Ross, 2016).

Some experts group the factors that contribute to household energy burden into categories of "drivers," including physical, economic, political, and behavioral. Table 2 lists examples of factors organized by type of driver (Drehobl & Ross, 2016). It is important to note that drivers often overlap to create and exacerbate energy burden. For instance, research by Emmel and colleagues in 2010 indicated that low-income households are more likely to live in "older, draftier, and substandard housing" that is ripe for energy efficiency upgrades (Emmel, Lee, Cox, & Leech, 2010). As reported by Hernandez and colleagues in 2016, for some low-income demographic groups, particularly African Americans, this trend may be driven by the type of housing available due to the existence of historical racial residential segregation and the quality of affordable housing (Hernández, Jiang, Carrión, Phillips, & Aratani, 2016).

TABLE 2	Drivers of household energy burden
Type of driver	**Examples**
Physical	Inefficient and/or poorly maintained HVAC systems
	Heating system and fuel type
	Poor insulation, leaky roofs, and inadequate air sealing
	Inefficient large-scale appliances (e.g., refrigerators, dishwashers) and lighting sources
	Weather extremes that raise the need for heating and cooling
Economic	Chronic economic hardship due to persistent low income
	Sudden economic hardship (e.g., severe health event or unemployment)
	Inability or difficulty affording the up-front costs of energy efficiency investments
Policy	Insufficient or inaccessible policies and programs for bill assistance, weatherization, and energy efficiency for low-income households
	Certain utility rate design practices, such as high customer fixed charges, that limit the ability of customers to respond to high bills through energy efficiency or conservation
Behavioral	Lack of access to information about bill assistance or energy efficiency programs
	Lack of knowledge about energy conservation measures
	Increased energy use due to age or disability
Source:	**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", 2016**

Furthermore, a 2020 study found that historically redlined urban neighborhoods, in which the U.S. federal government deemed people of color and immigrants as "risky" or "hazardous" mortgage borrowers in the 1930s, had land-surface temperatures up to 12.8 degrees Fahrenheit higher than those of neighborhoods classified as "best" and "still desirable". Higher temperatures due to more concrete and less green space in such neighborhoods increase health risks from extreme heat, putting historically economically disadvantaged communities among the most affected by the adverse effects of global warming (Hoffman, Shandas, & Pendleton, 2020) and consequently more significantly impacted by energy burden.

According to a 2009 study by Lee and Emmel, in 2008, Virginia households with incomes more than 50% below the poverty level paid 56% of their annual income on residential energy bills (Lee & Emmel, 2009). Studies of energy burden in Virginia have revealed that, relative to households with more income, Extremely-Low Income households face more energy cost problems. Higher energy cost problems are associated with concerns about drafty homes as well as the need to borrow money or reduce consumption of other basic needs to pay energy bills (Emmel, Lee, Cox, & Leech, 2010). While these studies do not cite a single demographic factor as being the most critical, they suggest that policy makers should consider multiple drivers in the effort to alleviate high energy burden levels (Martinez, 2016).

Relationship and Similarities to (un)Affordable Housing

It is evident that, by construction, energy affordability has a direct impact on housing affordability. Housing is considered to be affordable when the housing costs experienced by the household represent less than 30% of its annual income. For renters and homeowners alike, home-energy costs are a key component of the overall housing costs. Consequently, lower home-energy costs result in lower housing costs overall, improving a home's affordability.

Less clear is the extent to which unaffordable housing is associated with higher energy burden; in principle, a household could have high housing costs due to high mortgage or renting costs, but not necessarily elevated energy costs. Thus, this report researched the demographic factors frequently associated with a lack of housing affordability in order to contrast them with the key drivers of energy burden. With this review, the report aims to identify opportunities to promote affordable housing through access to clean and affordable energy.

In addition to the extensive literature discussing factors correlated to housing affordability across the United States, the Charlottesville area is fortunate enough to have been the focus of a number of recently released studies related to the topic. The following section explores a select group of such studies.

Comprehensive Housing Analysis and Policy Recommendations Affordable and Workforce Housing, 2016

RCLCO's report found that households with higher income levels were more likely to be homeowners. Extremely-Low Income households made up the smallest share of all homeowners, at 10%, and the highest share of all renters, at 27%. Consistently, the ratio of homeownership of Extremely-Low Income households was the lowest among all income brackets, with only 24% owning their own homes (RCLCO, 2016).

According to RCLCO's report, in 2016, demand in Charlottesville exceeded the supply of affordable housing for Extremely Low-Income households that were choosing to either purchase or rent a home. For homebuyers with either Extremely-Low Income or Very-Low Income, the housing demand also exceeded supply of affordable homes (RCLCO, 2016).

It is interesting to note that the undersupply of affordable housing was also identified for both homebuyers and renters with income levels greater than 120% of AMI (RCLCO, 2016). C3 further examined the close relationship between income levels and homeownership later in this report (on section Energy Burden in Charlottesville) in order to better understand their impact on energy burden levels in the City.

Housing Needs Assessment Socioeconomic and Housing Market Analysis, 2018

The Form-Based Code Institute (FBCI) and Partners for Economic Solution (PES) report reiterates that Charlottesville's housing market is very tight with demand significantly exceeding supply. Rent and housing prices are too high for many of the City's households to afford. For Very-Low Income households, the market undersupply is forcing them to spend too much of their income on housing, live in overcrowded or substandard housing conditions, move outside the City to find less expensive housing, or even face homelessness (FBCI & PES, 2018).

Furthermore, the report indicates that the tight housing market allows landlords to discriminate against low-income households with limited financial resources, spotty or non-existent credit histories, arrest records, children, housing choice vouchers, or other factors (FBCI & PES, 2018).

As displayed on Table 3, the report finds that, during the period of 2011-2014, the number of cost burdened households in Charlottesville was nearly 6,250 (or 36% out of the City's total 17,980 households). Nearly 74% of them (4,615 households) were renters, while 85% of them had a household income lower than 80% of AMI (FBCI & PES, 2018).

TABLE 3	Households by Cost Buden, 2011-2014						
Household Income (% of AMI)	Cost Burden [Alone]		Severe Cost Burden		Cost Burden		Overall
<u>Owner Households</u>	Number	Percent	Number	Percent	Number	Percent	Number
30% or less of AMI	130	27%	195	40%	325	67%	485
30% to 50% of AMI	155	33%	120	26%	275	59%	465
50% to 80% of AMI	245	22%	140	13%	385	35%	1,100
80% to 100% of AMI	270	33%	45	6%	315	39%	815
100% or more of AMI	320	7%	15	0%	335	8%	4,465
Sub-total	**1,120**	**15%**	**515**	**7%**	**1,635**	**22%**	**7,330**
<u>Renter Households</u>							
30% or less of AMI	145	4%	2,270	64%	2,415	68%	3,570
30% to 50% of AMI	475	34%	530	37%	1,005	71%	1,415
50% to 80% of AMI	710	42%	135	8%	845	50%	1,685
80% to 100% of AMI	250	30%	-	-	250	30%	840
100% or more of AMI	100	4%	-	-	100	4%	2,760
Sub-total	**1,680**	**16%**	**2,935**	**29%**	**4,615**	**45%**	**10,270**
Total	**2,800**	**16%**	**3,450**	**20%**	**6,250**	**36%**	**17,600**
Source:	C3's own elaboration based on data obtained from Form-Based Code Institute (FBCI) and Partners for Economic Solution (PES),						

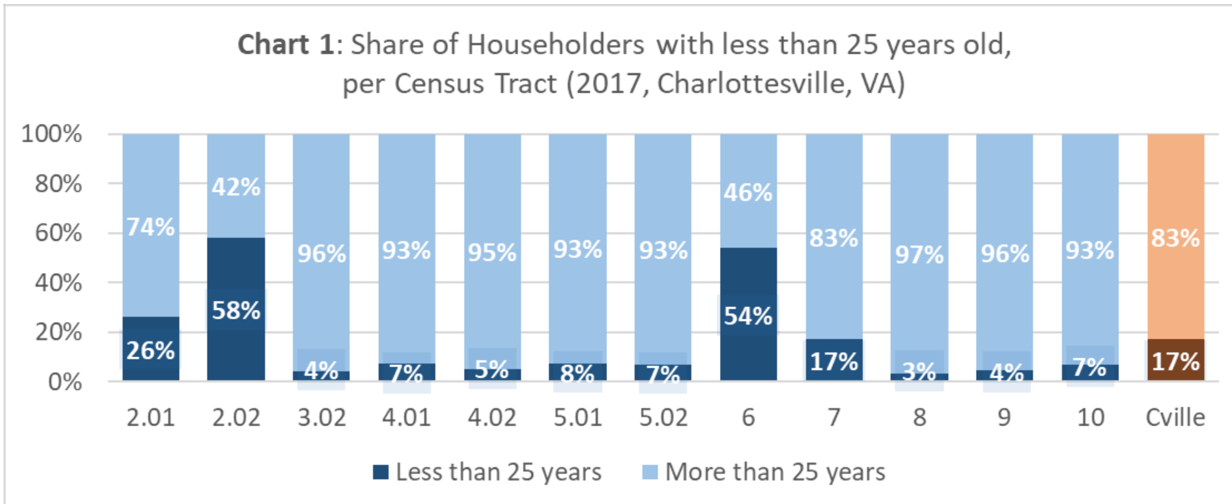
Table 4 depicts that, in 2017, there were 1,750 severely cost-burdened households, 940 cost-burdened [alone] households, 439 public housing/Section 8 units requiring repair or replacement, and 189 homeless individuals. In total, there were 3,318 households in the City with unmet affordable housing needs (FBCI & PES, 2018).

TABLE 4	Affordable Rental Housing Needs, City of Charlottesville 2017				
Household Income (% of AMI)	Units for Severely Cost Burdened Households	Units for Other Cost Burdened Households	Replacement Units for Public Housing/Section 8	Units for Homeless Families and Individuals	Total Units
2017 Rental Housing Needs					
<30% of AMI	960	150	439	189	1,738
>30% to 50% of AMI	630	180	NA	NA	810
>50% to 80% of AMI	160	290	NA	NA	450
>80% to 100% of AMI	-	320	NA	NA	320
Total Units	**1,750**	**940**	**439**	**189**	**3,318**
2040 Rental Housing Needs					
<30% of AMI	990	130	TBD	TBD	1,120
>30% to 50% of AMI	700	580	NA	NA	1,280
>50% to 80% of AMI	230	960	NA	NA	1,190
>80% to 100% of AMI	30	400	NA	NA	430
Total Units	**1,950**	**2,070**	**TBD**	**TBD**	**4,020**
Source:	C3's own elaboration based on data obtained from Form-Based Code Institute (FBCI) and Partners for Economic Solution (PES), 2018.				

As stated by the report, these numbers are significantly influenced by the presence of a large number of [UVA] students living off campus, who typically have other sources of income. The report observes that the U.S. Census Bureau has estimated that 39% of Charlottesville area residents with incomes below the poverty level are students (FBCI & PES, 2018).

According to the report, racial and ethnic concentrations continue to exist in Charlottesville, with the African American population representing 49% of the population in census tract 5.01 and 47% percent in 4.01; while the City's largest concentrations of Hispanic residents are in census tracts 4.02, 5.01 and 6.0. Patterns of the distribution of cost-burdened households per tracts indicated that tracts with a higher percentage of cost-burdened households (excluding those defined by the report as "[UVA] student-dominated tracts", tracts 2.01, 2.02, and 6.0) were clearly associated with lower percent of Caucasian residents. The data also suggested that there are no significant disparities among the distribution of housing-cost burden between African American or Hispanic households. (FBCI & PES, 2018).

Based on information provided by the FBCI & PES report, C3 was able to create Chart 1 with the percentage of householders with ages of less than 25 years per census tract in the City of Charlottesville. The chart aligns with the report "[UVA] student-dominated tracts" definition and suggests that tracts 2.02 and 6.0 (and, to a lesser extent, 2.01 and 7) are largely populated by students.



Orange Dot Report, 2018

The Orange Dot Report 3.0 showed that to afford the basic necessities of life—food, shelter, clothing and utilities in Charlottesville- an average family (one parent, two children) needs to earn more than $45,000 annually. The report also defines a quality job within reach as one that pays $25,000 or more but does not require the employee to possess a college degree. According to the report, examples of quality jobs within reach include certified nurse assistants, electricians, bus drivers, HVAC maintenance technicians, and administrative assistants (Schuyler, Orange Dot Report 3.0, 2018). On that note, the U.S. DOE cites the traditional HVAC industry as representing 1 in every 4 energy efficiency jobs in the United States (U.S. DOE, 2017).

The number of families in Charlottesville earning less than $35,000 increased by 10% between 2010 and 2016, while over that same time span, the number of families earning over $150,000 increased by 96% and the median income of families increased by 17%. However, since 2011, rents for a two-bedroom unit have increased by a staggering 42%, from $931/month to $1,325/month (Schuyler, 2018).

The report indicates that to get, maintain, and excel in a job, many no- and low-income individuals need access to resources beyond training. Those needed resources may include childcare, adequate transportation, stable housing, financial buffer, physical health, and mental health (Schuyler, 2018).

Comprehensive Regional Housing Study and Needs Assessment, 2019

A report prepared for Thomas Jefferson Planning District Commission (TJPDC)'s Central Virginia Regional Housing Partnership (CVRHP) found links between housing affordability, income level, and homeownership in the combined urban areas of Charlottesville and Albemarle County. Coinciding with most reports in this section, the CVRHP study concluded that households with higher income levels were more likely to be homeowners and that, between 2011 and 2015, Extremely-Low Income households made up the smallest group of homeowners (at 7%) and the largest group of renters (at 26%); as shown on Table 6.1 (CVRHP, 2019).

TABLE 6.1	Affordable Housing Needs, 2018 (Charlottesville and Albemarle County)					
Household Income (% AMI)	Owner		Renter		Total	
	Number	Percent	Number	Percent	Number	Percent
<30% of AMI	2,150	7%	6,115	26%	8,265	15%
>30% to 50% of AMI	2,655	8%	3,120	13%	5,775	10%
>50% to 80% of AMI	4,325	13%	5,000	21%	9,325	17%
>80% to 100% of AMI	2,925	9%	2,415	10%	5,340	9%
>100% of AMI	20,960	64%	6,945	29%	27,905	49%
Total	**33,015**	**100%**	**23,595**	**100%**	**56,610**	**100%**
Source:	C3's own elaboration based on data obtained from Central Virginia Regional Housing Partnership (CVRHP) Report, 2019.					

As indicated by Table 6.2, while making up only 15% of total households (Table 6.1), Extremely-Low Income households made up 44% of severely cost-burdened families, 100% of households living in substandard units, and 44% of households needing financial assistance (CVRHP, 2019).

TABLE 6.2	Affordable Ownership Housing Needs: Units or Financial Assistance (Charlottesville and Albemarle County)					
Household Income (% AMI)	Severely Cost Burdened		Substandard Units		Total	
	Number	Percent	Number	Percent	Number	Percent
30% or less of AMI	1,120	44%	29	100%	1,149	44%
30% to 50% of AMI	750	29%	0	0%	750	29%
50% to 80% of AMI	510	20%	0	0%	510	20%
80% to 100% of AMI	180	7%	0	0%	180	7%
Total	**2,560**	**100%**	**29**	**100%**	**2,589**	**100%**
Source:	C3's own elaboration based on data obtained from Central Virginia Regional Housing Partnership (CVRHP) Report, 2019.					

Households with Extremely-Low Income also represented 83% of applicants on CRHA waiting lists for housing choice vouchers and/or public housing as of July 2017, as observed in Table 7 (CVRHP, 2019).

TABLE 7	Applicants on the CRHA waiting lists for Housing Choice Vouchers and/or Public Housing (as of July, 2017)							
Household Income (% AMI)	Choice Vouchers		Crescent Halls		Public Housing		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
30% or less of AMI	1,183	84%	16	89%	354	79%	1,553	83%
30% to 50% of AMI	184	13%	1	6%	82	18%	267	14%
50% to 80% of AMI	32	2%	1	6%	10	2%	43	2%
Unknown	3	0%	-	-	-	-	3	0%
Total	**1,402**	**100%**	**18**	**100%**	**446**	**100%**	**1,866**	**100%**
Source:	**C3's own elaboration based on data obtained from Central Virginia Regional Housing Partnership (CVRHP) Report, 2019.**							

Analyzing information for the larger region of Planning District 10, the CVRHP report noted relevant differences in housing-cost burden as a function of the households' homeownership status. Of all homeowners in the area, 14% of households were cost-burdened [alone] and 8% were severely cost-burdened. In comparison, of all renter households, 18% were cost-burdened [alone] and 22.0% were severely cost-burdened (CVRHP, 2019).

TABLE 8	Share of Cost Burdened Households by Income Bracket, 2011-2015 (Planning District 10)					
Household Income (AMI)	**Cost Burden [Alone]**		**Severe Cost Burden**		**Total**	
Owner Households	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**
30% or less of AMI	1,055	23%	2,145	47%	4,585	7%
30% to 50% of AMI	1,255	22%	1,630	29%	5,680	9%
50% to 80% of AMI	2,235	25%	965	11%	9,055	15%
80% to 100% of AMI	1,645	26%	330	5%	6,440	10%
100% or more of AMI	2,455	7%	210	1%	35,660	58%
Total	**8,645**	**14%**	**5,280**	**9%**	**61,420**	**100%**
Renter Households						
30% or less of AMI	585	7%	4,685	60%	7,860	25%
30% to 50% of AMI	1,450	33%	1,670	38%	4,380	14%
50% to 80% of AMI	2,735	40%	490	7%	6,760	22%
80% to 100% of AMI	585	16%	4	0%	3,645	12%
100% or more of AMI	260	3%	39	0%	8,700	28%
Total	**5,615**	**18%**	**6,888**	**22%**	**31,345**	**100%**
All Households						
30% or less of AMI	1,640	13%	6,830	55%	12,445	13%
30% to 50% of AMI	2,705	27%	3,300	33%	10,060	11%
50% to 80% of AMI	4,970	31%	1,455	9%	15,815	17%
80% to 100% of AMI	2,230	22%	334	3%	10,085	11%
100% or more of AMI	2,715	6%	249	1%	44,360	48%
Total	**14,260**	**15%**	**12,168**	**13%**	**92,765**	**100%**
Source:	**C3's own elaboration based on data obtained from Central Virginia Regional Housing Partnership (CVRHP) Report, 2019.**					

Table 8 depicts that while Cost Burden [Alone] was distributed without a particular trend across income brackets, Severe Cost Burden was strongly linked to decreasing household income levels. 47% of Extremely-Low Income [Alone] homeowner households were severely cost-burdened, followed by 29% of Very-Low Income [Alone] homeowner households. Renters with Low Income [Alone] were the most cost-burdened group, at 41% of such households. Following the same trend as homeowners, 60% of Extremely-Low Income [Alone] renters were severely cost-burdened, followed by 38% of Very-Low Income [Alone] renters (CVRHP, 2019).

Regardless of homeownership, it can be concluded that households in the lowest income brackets suffer the most from Severe Cost Burden, while households in the low- to moderate- [Alone] income (LMI) brackets are most likely to suffer from Cost Burden [Alone] (CVRHP, 2019).

Although the relationship between race and cost burden was not directly investigated, the report observed that race seemed to be significantly correlated with homeownership. As of 2010, 55% of White households, 29% of African American households, 31% of Asian households, and 31% of Hispanic households in Charlottesville and Albemarle County owned their homes (CVRHP, 2019).

Hence, it could be extrapolated that, as renter households are more likely to be cost-burdened and a larger share of renters are non-White, racial groups with lower rates of homeownership are also more likely to be cost burdened. In other words, African American households were most likely to be cost-burdened by rental housing costs, followed by equal proportions of Asian and Hispanic households. No significant relationship was found by the report between education level and cost burden (CVRHP, 2019).

The Impact of Racism on Affordable Housing in Charlottesville, 2020

According to a report by the Charlottesville Low-Income Housing Coalition (CLIHC), to date, the City of Charlottesville has not invested sufficient resources in gathering or interpreting data related to the racial wage gap or the racial wealth gap amongst City residents and the relationship thereof to displacement or gentrification and housing insecurity. [9] In addition, to date, the City's quantitative analyses have not measured displacement of low-income and racial minority groups within the City's boundaries (CLIHC, 2020). In other words, although there are a wide variety of affordable housing studies analyzing Charlottesville's "housing gap," there are few studies focused on the displacement process occurring within the City.

CLIHC's report also provides valuable information about the origin of the relationship between lack of affordable housing and race in Charlottesville, which C3 discusses

[9] According to the CDC, gentrification is the process by which a certain geographic region (e.g. neighborhood or Census Tract) is transformed from low to high value, often via the purchase and renovation of houses in depreciated urban neighborhoods by upper- or middle-income families or individuals. Gentrification has the potential to cause displacement of long-time residents and businesses due to higher rents, mortgages, and property taxes (CDC, 2009).

further in the Historic and Systemic Inequalities: Population of Color section of this report.

Drivers of Energy Burden and (un)Affordable Housing - Summary

Our literature review identified established connections between unaffordable housing, households with Extremely/Very-Low Income levels, and occupants who rent their homes. While the review also suggests links between the likelihood of living in unaffordable housing with race, level of education, gender, age, and building features, due to the lack of sufficient data, no statistically significant relationships were found between these variables.

On balance, these findings indicate that household income and homeownership status are closely related to a household's affordable housing status. Literature also suggests that these two demographic groups are also more likely to experience higher energy burdens, spending a greater portion of their household income on energy costs than other households.

Generally speaking, the key factors suggested by existing literature to be associated with lack of affordable housing contexts overlap with the key drivers recognized to contribute to higher energy burden levels. Similarly, both set of drivers can overlap to exacerbate overall energy or housing cost burden levels.

Charlottesville's Underlying Context

Section's Key Takeaways

- There is no clear relationship between homeownership and building age;
- As household income decreases, homeownership also decreases:
  - 88% of Extremely-Low Income HHs are renters
  - 66% of all rental households earn less than 80% of AMI
- There is a high correlation between [formal] education level and race
- People of color are mostly concentrated in a few census tracts, making up between 52% and 66% of the population in tracts 4.01 and 5.01
- Similarly, average [formal] education level, homeownership status, and income levels are distributed in a fairly uneven manner across the City's census tracts
- Additional Quick facts:
  - 42% of properties were constructed after 2000, nearly 70% of them were constructed in the last 40 years
  - 69% of the City's population aged 25+ years has completed education beyond high school
  - 58% of Charlottesville households are renters
  - 46% of Charlottesville's households live with either extremely-low or very-low income levels
  - 67% of the population is White

Overview

In this section, the report seeks to depict how Charlottesville is positioned regarding the drivers of energy burden identified in previous sections. To achieve this, C3 analyzed neighborhood-level data aiming to pinpoint Charlottesville's strongest predictors of energy burden.[10] This exploratory analysis will focus on a selection of shared drivers of affordable housing and energy burden, namely: income levels, home ownership, household size, race, level of education, gender, age, and building features.

[10] C3's analysis will be based on Census Tract information. For a better understanding of how Charlottesville's Census Tracts relate to the City's neighborhood, refer to the section Census Tracts.

TABLE 9	Share of Total Population (Charlottesville, VA)		
Region	Population	Households	Average Household Size
Census Tract 2.01	2,946	1,196	2.5
Census Tract 2.02	4,943	1,426	3.5
Census Tract 3.02	2,634	1,166	2.3
Census Tract 4.01	3,937	1,489	2.6
Census Tract 4.02	4,396	2,176	2.0
Census Tract 5.01	3,767	1,486	2.5
Census Tract 5.02	5,116	2,165	2.4
Census Tract 6	3,881	1,173	3.3
Census Tract 7	4,401	1,584	2.8
Census Tract 8	4,144	1,476	2.8
Census Tract 9	2,159	1,021	2.1
Census Tract 10	3,214	1,622	2.0
Charlottesville	**45,538**	**17,980**	**2.5**
Source:	C3's own elaboration based on data obtained from Charlottesville Open Data and the U.S. Census Bureau American Community Survey (values for 2016).		

The City of Charlottesville has an average household size of 2.5 residents per occupied home (Table 9). Larger household sizes could be related to a lower energy consumption per capita, due to the shared use of energy among residents, such as for heating and cooling. However, a larger household size could also be related with higher energy costs overall and, assuming that the annual household income is held constant, this would yield a higher energy burden level per household.

The City's largest average household sizes are in census tracts 2.02 and 6. As observed by previous research, coincidently, these "[UVA] student-dominated" tracts have experienced conversions of single-family homes into student housing, indicating, perhaps, a large number of student households with multiple roommates (FBCI & PES, 2018).

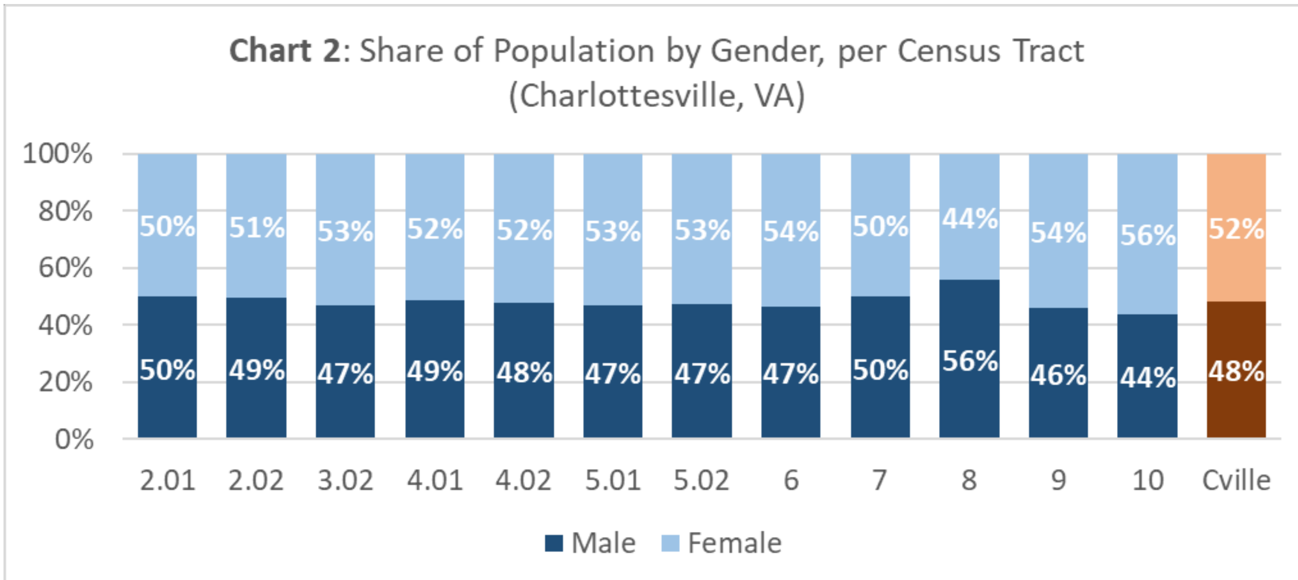
On average, households in census tracts 2.01, 8, and 9 have the highest median property value, while households in tracts 3.02, 5.01, and 5.02 have the lowest. Although the average household size of census tract 5.01 equals the overall City average, of 2.5 occupants, households in this tract had amongst the lowest median square footage of furnished living space (Table 10).[11]

[11] Year built values depicted on Table 10 and Chart 3 came from different data sources and yield conclusions that are not always aligned. This discrepancy is due to the fact that one database is more complete yet less accurate than the other.

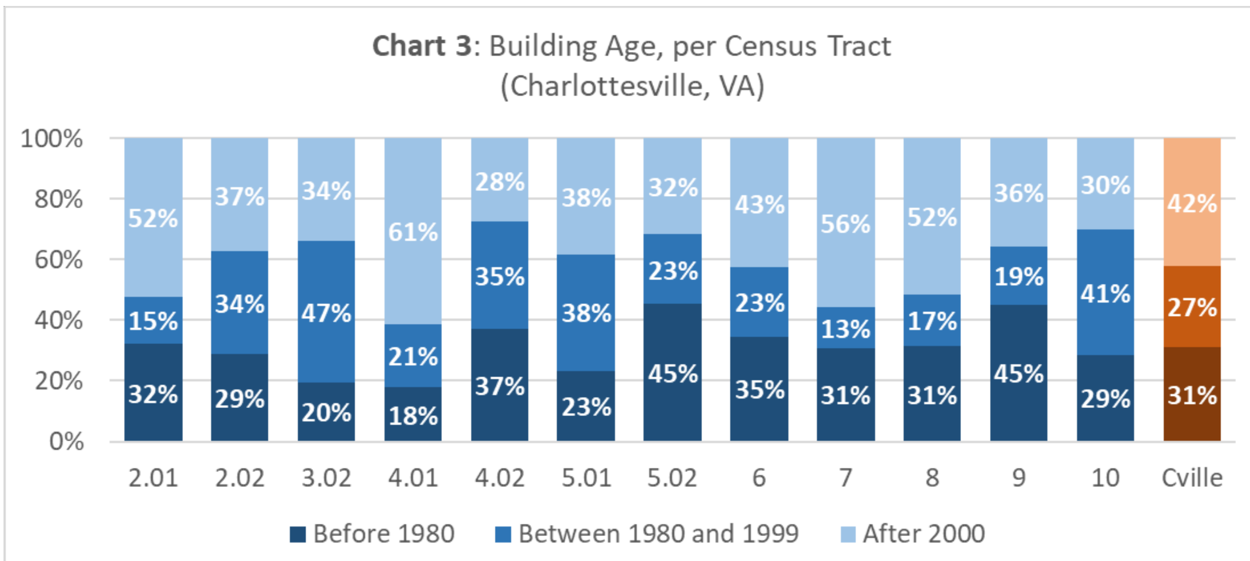
TABLE 10	Real Estate Highlights (Charlottesville, VA)		
Region	Total Property Value ($)	Year Built	Square Footage Finished Living
	Median	Median	Median
Census Tract 2.01	391,050	1953	1,434
Census Tract 2.02	251,250	1956	1,439
Census Tract 3.02	153,600	1934	1,298
Census Tract 4.01	236,550	1954	1,200
Census Tract 4.02	219,500	1969	1,388
Census Tract 5.01	188,700	1961	1,158
Census Tract 5.02	181,300	1978	1,200
Census Tract 6	242,800	1963	1,323
Census Tract 7	207,150	1966	1,012
Census Tract 8	479,300	1951	1,896
Census Tract 9	309,950	1963	1,628
Census Tract 10	231,000	1962	1,201
Source:	C3's own elaboration based on data obtained from Charlottesville Open Data and the U.S. Census Bureau American Community Survey (values for 2016).		

For most demographic features, meaningful analysis relies on having different levels presented by a specific factor in each census tract. Consequently, when dealing with a certain factor that is relatively homogenously distributed among tracts, the report's capacity to draw conclusions related to these features is limited. Most notably, as observed in Chart 2, this is the case of gender. Due to lack of more detailed data per census tract, [12] besides identifying that tracts 8 and 10 are clear outliers (albeit in different directions), it is virtually impossible to make any strong assertions after observing this data.

12 Chart 2 was elaborated by C3 with information obtained from Charlottesville Open Data and the U.S. Census Bureau American Community Survey (values for 2016).



Building Stock



Across Charlottesville, 42% of properties were constructed after 2000, 27% were constructed between 1980 and 1999, and 31% were constructed before 1980. However, there is some variation in building age between census tracts (Chart 3). [13] Most notable are tracts 5.02 and 9, in which nearly half of properties were constructed before 1980 (45% and 45%, respectively). In addition, nearly three-quarters (72%) of tract 4.02 residential building stock was built before 2000. If older housing units are more likely to be inefficient, it is possible that many households in census tracts 4.02, 5.02 and 9 would benefit from energy efficiency upgrades.

[13] Chart 3 was elaborated by C3 with information obtained from Charlottesville Open Data and the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016).

Census tract 2.01, 4.01, 7, and 8 are comprised of a relatively new housing stock, with between 52% and 61% of their buildings built after 2000. This could be an indicator that the housing stock present in these tracts is more energy efficient than the average Charlottesville's home, considering that Virginia's Uniform Statewide Building Code (USBC) has over the years increasingly promoted the construction of more energy efficient buildings

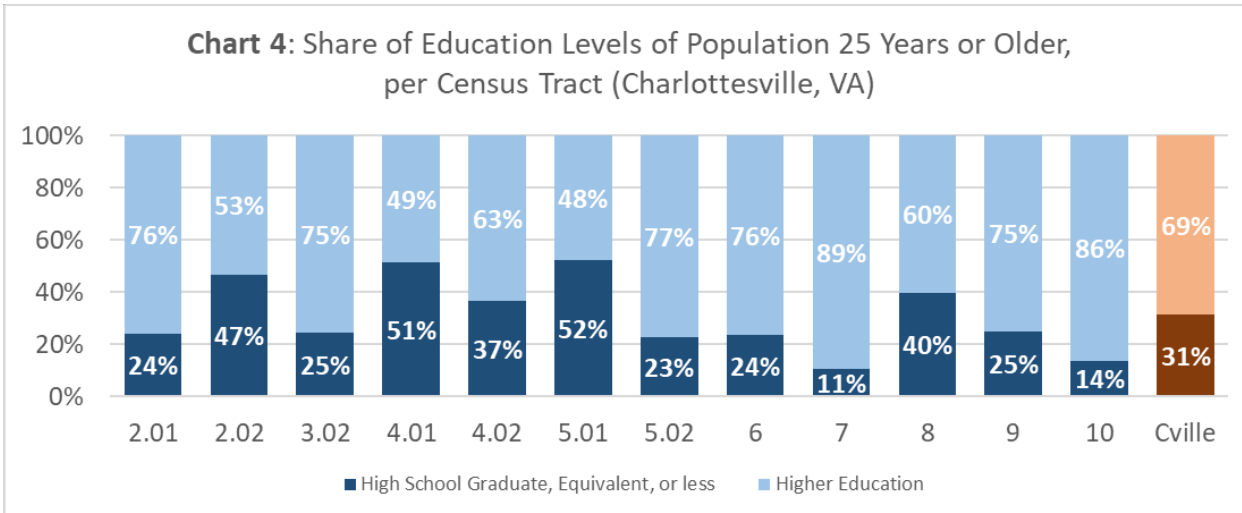
TABLE 11	Household Count per Income Level and Home Building Year (Charlottesville, VA)					
Year Built	Extremely-Low Income [Alone]	Very-Low Income [Alone]*	Low Income [Alone]*	Moderate Income [Alone]	100% or more of AMI	Overall
Before 1940	3.4%	1.3%	4.3%	3.7%	4.8%	**3.7%**
1940 - 59	5.3%	7.4%	7.8%	9.8%	10.8%	**8.6%**
1960 - 79	24.8%	21.2%	18.3%	17.7%	14.4%	**18.6%**
1980 - 99	29.5%	34.0%	23.6%	25.8%	24.1%	**27.1%**
2000 - 09	19.2%	21.3%	33.5%	27.4%	29.7%	**26.1%**
2010+	17.8%	14.8%	12.6%	15.6%	16.1%	**15.9%**
Overall	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Source:	C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016). *Both income brackets are defined with 60% of AMI as a threshold, instead of 50%.					

As depicted on Table 11, against what some might initially think, no clear relationship can be established between housing structure ages and household income levels in Charlottesville. Approximately 88% of the City's families live in homes that were built after 1960, while 91% of Extremely-Low and Very-Low Income households live in homes built after 1960. The bulk of Extremely-Low and Very-Low Income households, 55% of them, live in homes that were built between 1960 and 1999. In section Energy Burden in Charlottesville, C3 further analyzes the relationship between the age of building structures and levels of energy burden in the City.

Education Level

On average, Charlottesville's population is highly educated. More than two thirds (69%) of the City's population aged 25 years or older has completed education beyond high school. This share approaches nine out of ten inhabitants in two tracts. By contrast, approximately half of Charlottesville residents in tracts 2.02, 4.01, and 5.01 have either graduated high school or completed a lower [formal] education level.[14]

14 C3 believes it is important to consider all aspects of education such as formal, informal and non-formal; as they are all different forms of education that can contribute to an individual's overall education level.



"[UVA] student-dominated" census tract 2.02 (10th & Page and Venable) has nearly 52% more individuals with educational levels equivalent or lower than a high school diploma (Chart 4). [15] Considering that most population that is 25 years or older is not undergrad students, this outstanding share of population with lower [formal] education could be an indicative that this "student dominated" tract has an relevant number of lower income individuals and populations of color among its non-student population (due to the identified relationship between these demographics). This adds importance to the study of potential displacement and gentrification in "[UVA] student-dominated" tracts, as further discussed in section **UVA's Legacy**.

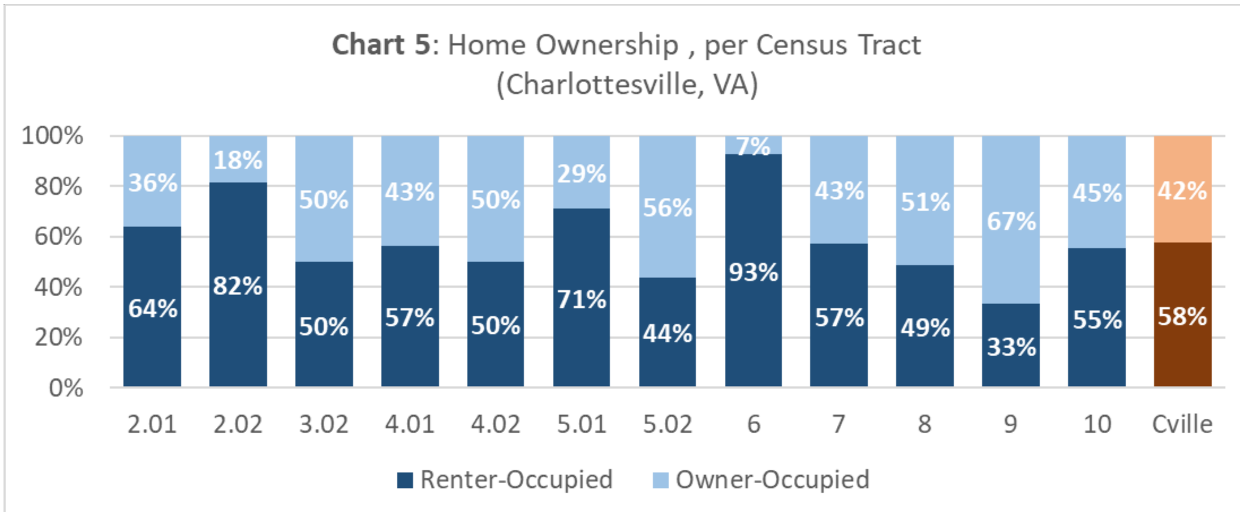
Although C3 was not able to find any dataset that provided information about education per income level or race for the year of 2016 in Charlottesville, it was possible to unveil some of these links via the study of the Pearson correlations coefficients among the incidence of certain race features and [formal] education levels. Most notably, after filtering out [UVA] student-dominated tracts, C3 identified a direct correlation of approximately 0.70 between the incidence of households with either African American or Hispanic/Latinx householder and the a higher presence of population aged 25 years or older that either graduated high school or completed only an equivalent or lower [formal] education level.[16]

Home Ownership

C3's analyses of Charlottesville's distribution of homeownership status follows the housing stock trends reported in the section Relationship and Similarities to (un)Affordable Housing. As illustrated by Chart 5, 58% of Charlottesville households are

[15] Chart 4 was elaborated by C3 with information obtained from Charlottesville Open Data and the U.S. Census Bureau American Community Survey (values for 2016).
[16] This correlation was estimated using information from the Charlottesville Regional Equity Atlas and the Low-Income Energy Affordability Data (LEAD) Tool. Both datasets use 2016 as the reference year.

renters, while 42% are homeowners.[17] The most striking outliers are "[UVA] student-dominated" tracts 6 and 2.02, where 93% and 83% of all households are renter-occupied, respectively. This is likely a result of tracts 2.02 and 6's proximity to UVA and higher proportion of student-occupied housing.



Other tracts, such as 2.01 and 5.01, also deviate from Charlottesville's distribution of owner versus renter-occupied homes, with the share of renters significantly larger than the overall share of renters in the City. In contrast, census tract 9 (approximately the Locust Grove neighborhood, according to the census tracts section) shows that nearly two thirds of its households are owner-occupied, a share that is 60% higher than Charlottesville's average.

The data contained in Table 12 reveals that there is not a significant relationship between homeownership and building age, suggesting that the decision to rent or purchase a home is not influenced by building age. That said, renters occupy a higher share of homes built before 2000, while homes built after 2000 are predominantly occupied by homeowners. Both renters and homeowners occupy more often buildings constructed after 1980, which represent 69% of Charlottesville' homes (Chart 3).

17 Chart 5 was elaborated by C3 with information obtained from Charlottesville Open Data and the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016).

TABLE 12	Household Count per Home Building Year and Home Ownership (Charlottesville, VA)		
Year Built	**Renter-Occupied**	**Owner-Occupied**	**Share of Renters**
Before 1940	439	235	65%
1940 - 59	773	774	50%
1960 - 79	2,609	730	78%
1980 - 99	3,011	1,856	62%
2000 - 09	2,230	2,468	47%
2010+	1,339	1,516	47%
Overall	**9,962**	**7,344**	**58%**
Source:	C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016).		

Table 13 indicates that as household income increases, the share of renter-occupied homes within income brackets decreases. For instance, 88% of Extremely-Low Income households in Charlottesville are renters, representing 34% of all renter-occupied homes in the City (despite making up only 22% of total households). Furthermore, 66% of all rental households earn less than 80% of AMI annually. Within this income bracket alone, of all households earning less than 80% of AMI, 76.6% are renters.

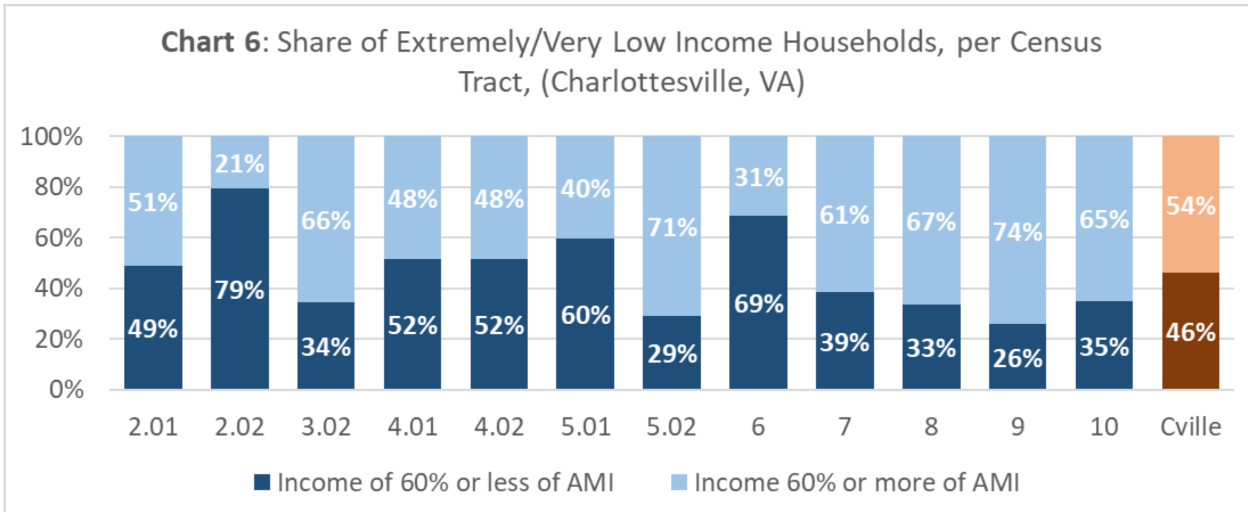
TABLE 13	Household Count per Income Level and Home Ownership (Charlottesville, VA)		
Income (% of AMI)	**Renter-Occupied**	**Owner-Occupied**	**Share of Renters**
0% - 30%	3,535	488	88%
30% - 60%	2,167	885	71%
60% - 80%	1,173	729	62%
80% - 100%	799	715	53%
100%+	2,727	4,762	36%
Overall	**10,401**	**7,579**	**58%**
Source:	C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016).		

Income

As depicted on Chart 6, 46% of Charlottesville's households live with either extremely low or very low-income levels.[18] [19] This value, however, is somewhat influenced by the elevated percentage of households living with less than 50% of AMI in "[UVA] student-dominated" census tracts 2.02 and 6.

18 Chart 6 was elaborated by C3 with information obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016).
19 Due to constraints of the information available via the LEAD Tool, this Chart 6 defines Extremely/Very Low-Income households as those with income lower than 60% of AMI.

Consequently, when analyzing income levels across Charlottesville's census tracts, it is important to recall that 39% of the City's residents with incomes below the poverty line are students (according to information from the 2012-2016 ACS).[20] Many of these students supplement their limited incomes with parental support, personal savings and college loans (FBCI & PES, 2018).



Filtering out [UVA] student-dominated tracts, in the year of 2017 tracts 4.01, 5.01, and 4.02 presented the lowest median household incomes, ranging from nearly $39,000 to $45,500 annually. These tracts also have the largest concentrations of households with incomes below $25,000. In contrast, the highest median household incomes are in census tracts 10, 8.0 and 5.02, ranging from $59,375 to $69,138 (FBCI & PES, 2018).

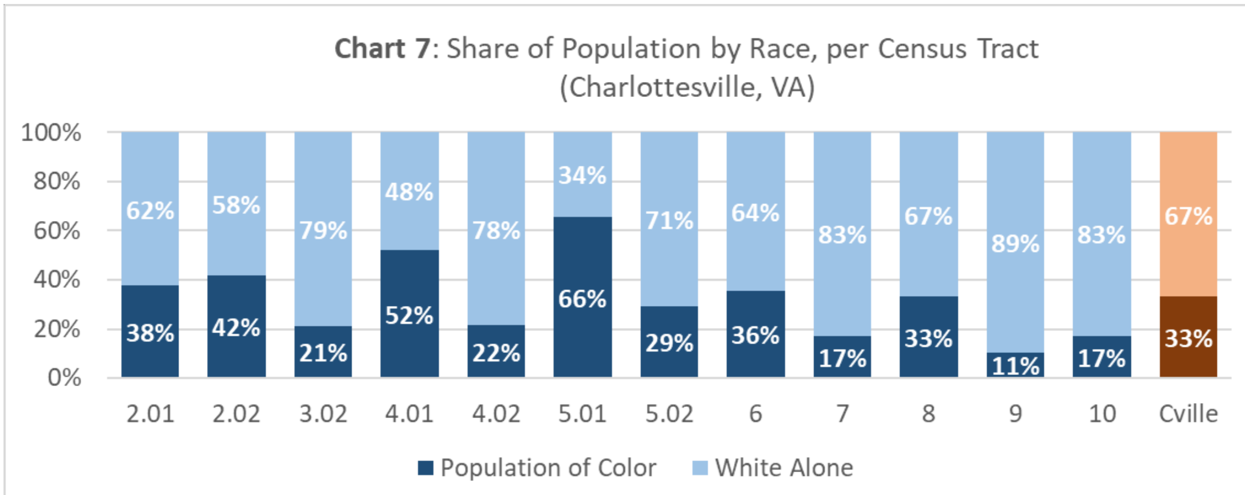
As observed by the FBCI & PES (2018) report, part of the explanation for the variation in incomes relates to the levels of education among the tracts' adult populations. In census tract 5.01, 52% of the population over the age of 25 has a high school diploma or lower [formal] education levels (Chart 4). Similarly, lower [formal] education levels are seen in tracts 4.01 and 4.02. The report further suggests that housing affordability for many households is an income-related issue (FBCI & PES, 2018).

Race

The FBCI & PES report depicts that low-income African American and Hispanic households bear a disproportionate share of the lack of affordable housing. The study adds, on section "Relationship and Similarities to (un)Affordable Housing", that census tracts with a majority of non-white residents have significantly higher shares of housing cost burdened households than do majority-white tracts (FBCI & PES, 2018).

[20] Although there is more than one definition of poverty line, in the context of this research it can be understood as Extremely low-income households (with household incomes at or below 30% of AMI).

Previous research presented in the "Relationship and Similarities to (un)Affordable Housing" section have identified that in our community race is a factor highly linked to drivers that contribute to energy burden and overall housing cost burden. While C3's report considers that race should not be understood as a driver of energy burden *per se*, analyzing the role of race is important to better understand our community's energy equity. This section points to how the distribution of populations of color in Charlottesville may be highly associated with energy burden hotspots in our community, revealing potential areas for energy equity improvement.



Charlottesville's population is 67% White. However, as observed in Chart 7, people of color make up between 52% and 66% of the population in census tracts 4.01 and 5.01.[21] Inversely, tracts 7, 9, and 10 have a White population between 83% and 90%. These latter tracts also presented significantly above-average [formal] education and income levels. Most notably, tract 9, with the highest proportion of White residents, also presented the highest rate of homeownership.

Drivers of Energy Burden in Charlottesville - Summary

Table 14 summarizes the results observed in previous sections about how drivers of energy burden are distributed within Charlottesville. The table uses a selection of variables to represent each of the identified drivers and, for each driver, depicts values colored in red for the census tracts that have shown the highest expressions of it and values colored in green for those tracts with lower expressions.

Hence, in a heuristic exercise, tracts with the highest concentration of red values are expected to present the highest energy burden levels. Inversely, census tracts with the highest presence of green values are expected to display the lowest energy burden

[21] Chart 7 was elaborated by C3 with information obtained from Charlottesville Open Data and the U.S. Census Bureau American Community Survey (values for 2016).

levels. Census tracts that present both red and green values should be evaluated by the net difference between the count of red values and green values.

It can be observed that as tracts 2.02 and 5.01 depicted elevated values for nearly all drivers of energy burden (with the exception of building year). According to existing literature, it should be expected that these tracts will present higher energy burden levels. Tracts 6 and 4.01 can also be pinpointed as candidates for high energy burden values. Inversely, tracts 3.02, 7, 9, and 10 present the lowest expression of drivers of energy burden and can be expected to have lower levels of energy burden overall.

TABLE 14	Drivers of Energy Burden, Share of Total per Census Tract (Charlottesville, VA)				
Region	Housing Stock Built Before 1980	High School Graduate, Equivalent, or less	Renters	Household Income 50% or less of AMI	Population of Color
Census Tract 2.01	32%	24%	64%	49%	38%
Census Tract 2.02	29%	**47%**	**82%**	**79%**	**42%**
Census Tract 3.02	**20%**	25%	50%	34%	21%
Census Tract 4.01	**18%**	**51%**	57%	52%	**52%**
Census Tract 4.02	37%	37%	50%	52%	22%
Census Tract 5.01	23%	**52%**	**71%**	**60%**	**66%**
Census Tract 5.02	**45%**	23%	44%	**29%**	29%
Census Tract 6	35%	24%	**93%**	**69%**	36%
Census Tract 7	31%	**11%**	57%	39%	**17%**
Census Tract 8	31%	40%	49%	33%	33%
Census Tract 9	**45%**	25%	**33%**	**26%**	**11%**
Census Tract 10	29%	**14%**	55%	35%	**17%**
Charlottesville	**31%**	**31%**	**58%**	**46%**	**33%**
Source:	Own elaboration based on data obtained from Charlottesville Open Data, the US Census Bureau American Community Survey and the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016).				

It can also be observed through Table 14 that for each census tract there seems to be a link between education, home ownership, income levels and race. For instance, tracts 7, 9, and 10 presented links between either higher educational levels and/or higher income levels with a more prevalent white population. Meanwhile, tracts 2.02, 4.01, and 5.01 showed an inverse relationship between either lower educational and/or income levels with a more prevalent population of color.

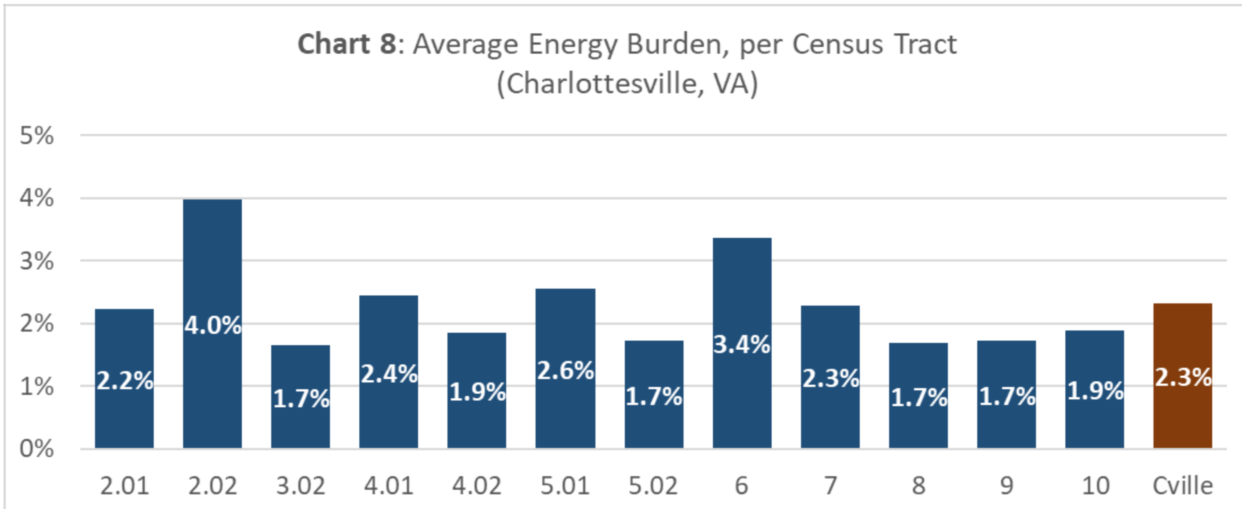
Energy Burden in Charlottesville

Section's Key Takeaways

- The average energy burden levels faced by households living in different tracts of the City varied up to nearly 2.5 times (from 1.7% to 4.0%).
- 4,852 households in Charlottesville face high to extremely high energy burden levels.
- Census tracts 2.02, 4.01, 5.01, 6, and 7 are, each of them, home to 500+ highly energy burden households
- Non-[UVA] student-dominated tracts are home to 3,152 households that pay more than 6% of their income on energy costs, with 2,465 of them paying more than 10% and 455 paying more than 20%.
- 47% of the City's extremely high energy burdened households live in [UVA] student-dominated tracts
- Given a same built year, homes occupied by renters seem to bear energy burden levels up to twice as much as the homeowners' average
- There is no clear link between the age of home units and the energy burden levels faced by their households
- When controlled by income levels, the average energy burden faced by households appear to be uncorrelated with their homeownership status
- Extremely-Low Income households face the highest average energy burden, of approximately 16% of their annual income
- 4,031 households spend more than 10% of their annual income on energy costs. All of them, strikingly, are either Extremely or Very-Low Income.
- Our analysis suggests that, when trying to promote energy equity and alleviate Charlottesville's highest energy burden levels, it should be a priority to focus on households' income levels rather than other housing or households' features

Energy Burden - First Glance

C3's analyses and estimations based on disaggregated information obtained at the Low-Income Energy Affordability Data (LEAD) Tool, a database created by the U.S. Department of Energy, unveil that the average energy burden levels faced by households living in different tracts of the City varied from 1.7% to 4.0% (a difference of nearly 2.5 times).[22] These findings serve as a natural complement to previous studies about energy burden in Virginia that were focused on ZIP Code areas, such as Virginia Poverty Law Center study about electricity burden (VPLC, 2017). The greater granularity of the census tract data combined with its more evenly distributed count of households (and availability of other demographic information for the same region) provides greater opportunities for studies and inferences related to energy burden.[23]



As expected in the section [Drivers of Energy Burden in Charlottesville - Summary](), Chart 8 shows that tracts 2.02, 4.01, 5.01, and 6 all presented the highest average levels of energy burden in the City.[24] Tract 2.01 can be considered the only energy burden outlier, as it has not presented a notoriously high value for any driver of energy burden.

Also as expected, tracts 3.02, 7, 9, and 10 depicted the lowest energy burden levels in the City. However, it is worth noting that their overall lesser energy burden levels do

22 Estimations often used a bottom-up approach, which considers that the various categories of granular data drawn from the used datasets (which are assumed to have been estimated in adequate manners) can be employed to estimate statistics for a larger aggregate group. For instance, non-overlapping categories of households from the same datasets (and of the same year) can be summed up to calculate the total number of households which fall into that category. Datasets from the same year were paired in this way to produce many of the report's Tables and Charts.
23 For instance, although Charlottesville has 4 different active basic 5-digit format ZIP codes, all of them are shared with Albemarle County (while all Census Tracts are circumscribed within a particular municipal boundary). Moreover, the count of residents living within the City's four different ZIP Code areas (which inevitably include residents of Albemarle) can vary up to 8.25 times.
24 Chart 8 was elaborated by C3 with information obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016). Average energy burden per census tract was estimated using a bottom-up approach by calculating the ratio between each tract's total households' energy expenditure and total households' income. The sum of the 12 census tracts' annual income and total annual energy costs were summed to calculate average energy burden for the City of Charlottesville.

not differ significantly from that of tracts 4.02, 5.02, and 8, which did not depict any particularly low presence of energy burden drivers.

Energy Burden – A Closer Look

At a first glance, Charlottesville's overall energy burden, of approximately 2.3% per household, appears to be considerably below the national average level of 3.5% (Drehobl & Ross, 2016). However, a closer look at the data reveals that 4,852 households in Charlottesville face high to extremely high energy burden levels (spending 6% or more of their income towards paying energy bills). As depicted by Table 15, this is most pronounced in census tracts 2.02, 4.01, 5.01, 6, and 7, where each of them is home to approximately 500 or more households that face a high energy burden or more.

Other tracts might depict a lower overall count of high energy-burdened households, but may present an elevated number of extremely high energy-burdened households (which face an energy burden of 20% or higher and account for over 850 households in Charlottesville). Such is the case for tract 2.01, where 160 households face extremely high energy-burdens.

In census tract 5.01, the incidence of high energy burdened households may be related to demographic and housing stock characteristics. For instance, 5.01 has a high share of non-white households, low-income households, and renter-occupied home, thereby providing support for the idea that these factors are in effect drivers of energy burden in Charlottesville.

TABLE 15	Count of Households with High Energy Burden (Charlottesville, VA)			
Region	High Energy Burden [Alone]	Very High Energy Burden [Alone]	Extremely High Energy Burden [Alone]	Total
Census Tract 2.01	71	111	160	**342**
Census Tract 2.02	63	534	236	**833**
Census Tract 3.02	25	144	0	**169**
Census Tract 4.01	132	403	94	**629**
Census Tract 4.02	0	321	0	**321**
Census Tract 5.01	149	297	150	**596**
Census Tract 5.02	129	124	10	**263**
Census Tract 6	0	525	0	**525**
Census Tract 7	81	278	140	**499**
Census Tract 8	0	247	0	**247**
Census Tract 9	58	31	16	**105**
Census Tract 10	113	165	45	**323**
Charlottesville	**821**	**3,180**	**851**	**4,852**
Source:	C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016).			

It is important to remember that these figures include a large number of students living off campus, who typically have other sources of income. Once again, as observed by

FBCI & PES (2018), 39% of Charlottesville area residents with incomes below the poverty level are students. This makes it complicated to accurately interpret the count of highly energy burdened non-student households in [UVA] student-dominated tracts (2.01, 2.02, and 6.0; labeled as red on Table 15).

Table 16 presents a comparison of the count of high energy-burdened households between the [UVA] student-dominated tracts and other tracts in Charlottesville. Although nearly 47% of the City's extremely high energy burdened households live in [UVA] student-dominated tracts (reinforcing the hypothesis of the relevant biasing effects of the marked low-income levels of undergraduate students), non-[UVA] student-dominated tracts present nearly 5 times the number of households bearing High Energy Burden [Alone] and 2 times the number of Very High Energy Burden [Alone].

TABLE 16	Count of Households with High Energy Burden (Charlottesville, VA)			
Census Tracts	High Energy Burden [Alone]	Very High Energy Burden [Alone]	Extremely High Energy Burden [Alone]	Total
Student Dominated	134	1,170	396	**1,700**
Non-student Dom.	687	2,010	455	**3,152**
Total	**821**	**3,180**	**851**	**4,852**
Source:	C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016).			

When analyzing only non-[UVA] student-dominated tracts, it can be observed that 3,152 households pay more than 6% of their annual income on energy costs each year, while 2,465 pay more than 10%, and 455 pay more than 20%. Remembering that energy costs are components of the overall housing cost burden faced by households affected by Charlottesville's affordable housing crisis, it is important to highlight that considerable improvements in the City's housing affordability levels could be achieved by an increased focus on specific efforts focus to reduce Charlottesville's energy burden levels (this is further illustrated by the case example on section Climate and Social Impacts of Promoting Energy Equity of this report).

By contrasting the drivers of energy burden identified by existing literature with actual energy burden levels observed in Charlottesville, it can be identified that unexpectedly households occupying homes built after 1960 are more likely to be highly energy-burdened relative to households occupying homes built before that year. Table 17 illustrates it by showing for each building age category the share of households that are (extremely/very) high energy burdened. Surprisingly, 12.6% of all households living in homes built between 1980 and 1999 face extremely high energy burdens (representing 614 households, or 72% of the City's total count of households facing energy burdens of 20% or more).

TABLE 17	Share of Households with High Energy Burden Levels per Home Building Year (Charlottesville, VA)			
Year Built	**High Energy Burden [Alone]**	**Very High Energy Burden [Alone]**	**Extremely High Energy Burden [Alone]**	**Total**
Before 1940	1.5%	13.2%	5.5%	**20.2%**
1940 - 59	2.7%	12.3%	2.6%	**17.6%**
1960 - 79	2.9%	25.1%	4.8%	**32.8%**
1980 - 99	4.2%	11.8%	12.6%	**28.6%**
2000 - 09	4.1%	16.5%	0.0%	**20.6%**
2010+	9.6%	25.1%	0.0%	**34.7%**
Total	**4.7%**	**18.4%**	**4.9%**	**28.0%**
Source:	C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016).			

Building features, including square footage of finished living space or renter occupancy, may explain some of this trend (e.g. if newer houses have greater heating/cooling needs), but it is not possible to state this with certainty using currently available data. It could also be argued that this may be a consequence of low quality building practices (discussed in section The Role of Energy Efficiency) or, again, may be a reflection of the fact that [UVA] student-dominated tracts have an significantly high percentage of homes built during or after the 2000s (as observed in section Building Stock). Overall, renters occupy less than half of homes built after 2000 (in comparison to the City average of 58%, as observed in section Home Ownership).

Table 18 shows how homeownership seems to play a key role when determining the energy burden levels experienced by households as a function of the construction year of their homes. Given a same built year, homes occupied by renters seem to bear energy burden levels up to twice as much of the those paid by homeowners.

Besides the difference in income levels between renters and owners (as analyzed in the section Home Ownership), the difference in energy burden levels associated with homeownership could be partially explained by the fact that homeowners are more likely and able to invest in long-term energy efficiency or renewable energy improvements, reducing their energy costs and burden (refer to section The Role of Energy Efficiency for a further discussion on the topic of the “split incentive” between renters and landlords).

TABLE 18	Avg. Energy Burden per Income Level and Home Building Year, (Charlottesville, VA)	
Year Built	**Renter-Occupied**	**Owner-Occupied**
Before 1940	2%	1%
1940 - 59	2%	2%
1960 - 79	4%	2%
1980 - 99	3%	2%
2000 - 09	3%	2%
2010+	4%	2%
Source:	C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016).	

Table 18 also indicates the absence of a clear link between the age of home units and the energy burden levels faced by their households, when controlling by homeownership status of householders. Moreover, if some minor relationship that can be extrapolated, it would be that in Charlottesville's context (potentially against general beliefs) most recently built home units are associated with higher energy burden levels than older ones. Overall, renter-occupied homes built between 1960 – 1979 and 2010 onward experienced the highest energy burden levels at 4% of their household's income.

As observed in Table 19, Extremely-Low Income households face the highest average energy burden, of approximately 16% of their annual income, while Very-Low Income renter- and owner-occupied homes face an average energy burden of 5% and 6%, respectively.

TABLE 19	Avg. Energy Burden per Income Level and Homeownership, (Charlottesville, VA)	
Income Level	**Renter-Occupied**	**Owner-Occupied**
Extremely-Low [Alone]	16%	16%
Very-Low [Alone]*	5%	6%
Low [Alone]*	3%	4%
Moderate [Alone]	3%	3%
100% or more of AMI	1%	1%
Source:	C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016). *Both income brackets are defined with 60% of AMI as a threshold, instead of 50%.	

Table 19 also suggests that the average energy burden level faced by households within a same income bracket appear to be uncorrelated with their homeownership status. Differences in burden levels due to homeownership, when present, were never bigger than 1% (while to some extent indicating, surprisingly, a higher burden on home owners rather than renters). This may be indicative that when trying to promote energy equity and alleviate Charlottesville's highest energy burden levels it should be a priority to focus on households' income level rather than homeownership. Furthermore, given the seemingly positive relationship between income levels and homeownership status, by targeting lower income households it should be expected to engage a population that is largely composed by renters.

TABLE 20	Avg. Energy Burden per Income Level and Home Building Year (Charlottesville, VA)				
Year Built	Extremely-Low Income [Alone]	Very-Low Income [Alone]*	Low Income [Alone]*	Moderate Income [Alone]	100% or more of AMI
Before 1940	15%	4%	3%	2%	1%
1940 - 59	14%	6%	3%	3%	1%
1960 - 79	16%	5%	3%	3%	1%
1980 - 99	21%	5%	3%	3%	1%
2000 - 09	14%	5%	4%	3%	2%
2010+	14%	6%	4%	3%	2%
Source:	C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016). *Both income brackets are defined with 60% of AMI as a threshold, instead of 50%.				

Table 20 shows that on average, Extremely-Low Income households spend 14% or more of their annual income on energy costs. Households with income higher than 30% of AMI spend on average about 5% or less their annual income on energy costs (hence, would not be considered as high energy-burdened). This can be more clearly observed on Table 21, which depicts that a total of 4,031 households in Charlottesville spend more than 10% of their annual income on energy costs; all of these energy-burdened households, strikingly, are either Extremely or Very-Low Income.

TABLE 21	Household Count per Income Level and level of High Energy Burden, All Fuels (Charlottesville, VA)			
Income Level	High Energy Burden [Alone]	Very High Energy Burden [Alone]	Extremely High Energy Burden [Alone]	Total
Extremely-Low Income [Alone]	10	3,162	851	**4,023**
Very-Low Income [Alone]*	807	18	0	**825**
Low Income [Alone]*	4	0	0	**4**
80% or more of AMI	0	0	0	**0**
Total	**821**	**3,180**	**851**	**4,852**
Source:	C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016). *Both income brackets are defined with 60% of AMI as a threshold, instead of 50%.			

Although C3 was not able to find any dataset that provided data regarding levels of energy burden per race in Charlottesville for 2016, a quick descriptive statistical analysis allowed us to observe that, for each census tract, the incidence of "white alone" households has an inverse correlation (of -0.57) with energy burden.[25] Even after excluding [UVA] student-dominated tracts, this inverse relationship remained significant at -0.51. Conversely, the presence of households with African American

[25] During the elaboration of this report, C3 estimated the correlation between energy burden and 864 unique demographic variables from Charlottesville, VA in 2016. This effort was done with the intent of identifying potential local energy burden drivers such as levels of including annual income, building age, race, householder age, householder gender, and education level.

householders was directly linked to energy burden levels, with a correlation coefficient of 0.46 for the entire City and of 0.32 for non-[UVA] student-dominated tracts. [26]

[26] This correlation was estimated using information from the Charlottesville Regional Equity Atlas and the Low-Income Energy Affordability Data (LEAD) Tool. Both datasets use 2016 as the reference year.

Discussion

Building Energy Use: Patterns and Solutions

Natural Gas

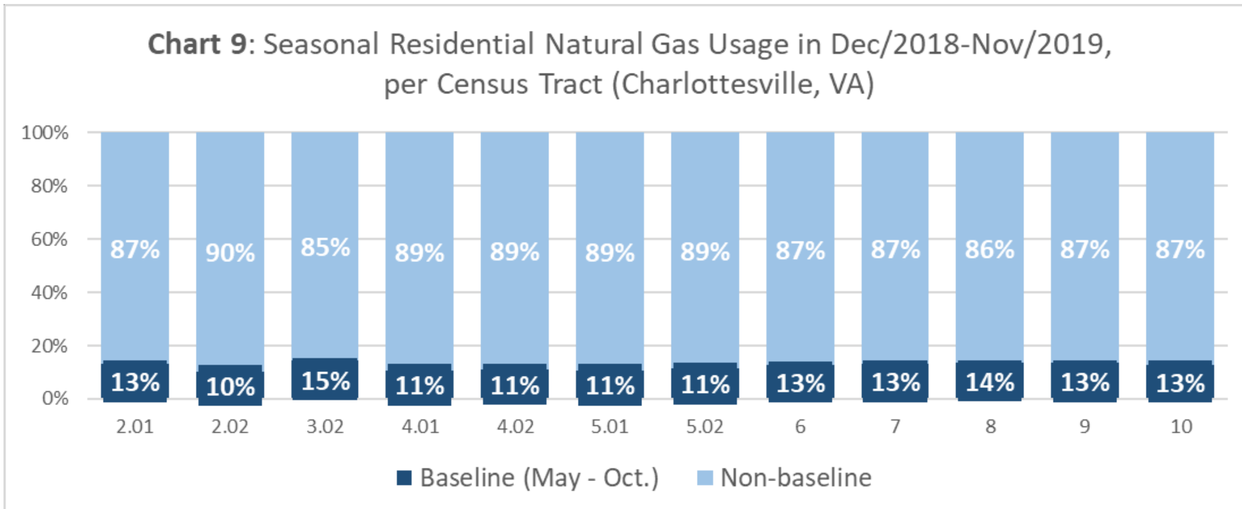
Energy burden includes all energy-related costs paid by the household, including electricity bills, natural gas bills, and other energy sources (e.g. wood/biomass, fuel oil, propane). Thus, understanding the extent to which energy burden is driven by either natural gas or electricity is critical to designing policies aimed at alleviating our community's energy burden.

TABLE 22	**Share of Total Annual Energy Cost per Fuel Type and Income Level, (Charlottesville, VA, 2016)**			
Income Level	**Share of Average Annual Energy Cost**			**Total Value ($)**
	Electricity	**Natural Gas**	**Other**	
Extremely-Low Income [Alone]	83%	15%	2%	**1,246**
Very-Low Income [Alone]*	77%	20%	3%	**1,474**
Low Income [Alone]	73%	24%	4%	**1,593**
80% or more of AMI	70%	27%	2%	**1,986**
Total	**74%**	**23%**	**2%**	**1,692**
Source:	**C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool (values for 2016). *Both income brackets are defined with 60% of AMI as a threshold, instead of 50%.**			

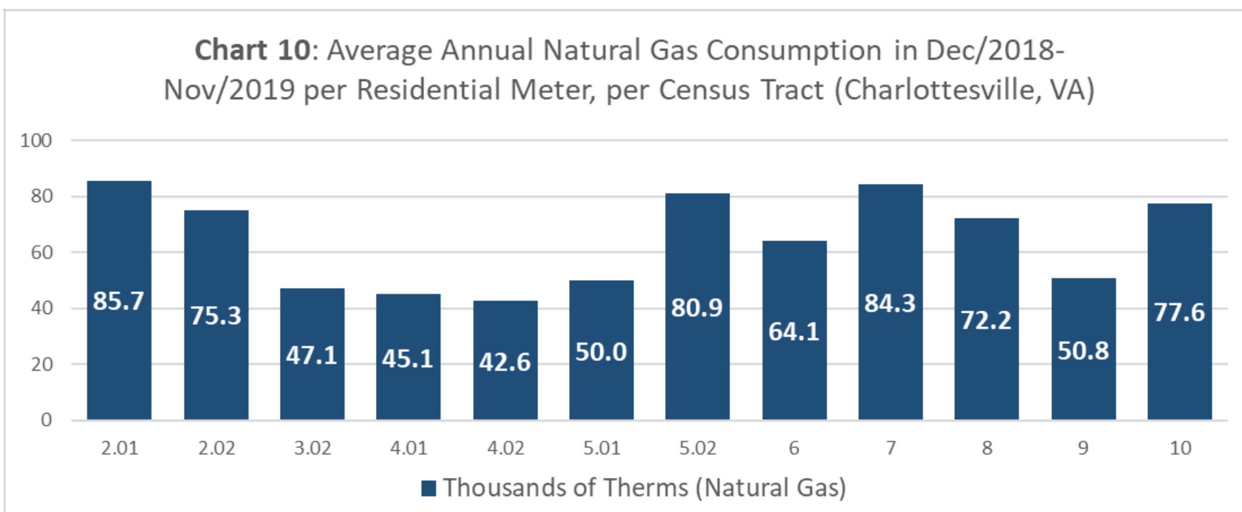
The City of Charlottesville has identified electricity and natural gas as the major fuel sources providing energy to residential buildings during 2016. Table 22 confirms the relevance of these two fuels and adds that, although nearly one-quarter of residential energy consumption in Charlottesville is spent on natural gas, households in the highest income bracket spend nearly twice as much of their energy budget on natural gas (at 27%) as Extremely Low-Income households (at 15%).

When trying to better understand households' building energy use, another important factor to identify is the share consumed by each possible end use (cooking, heating, etc.). This is of particular importance when studying natural gas consumption as end use varies largely with space conditioning needs and seasonal effects. After a long period of soliciting data from the City of Charlottesville and helping them understand its importance, Charlottesville Gas kindly provided C3 with census tract data for 12 consecutive months between 2018 and 2019.

This report, via Chart 9, briefly depicts how average natural gas consumption per household (i.e. per active residential meter; hence, averages per census tract do not consider the [lack of] consumption of households without a natural gas connection) varies among census tracts in function of seasonal consumption (heating) vs baseline consumption (other natural gas uses, such as cooking).[27] Further analysis particularly about natural gas consumption in Charlottesville and opportunities for energy savings will be release in a future report specifically about this fuel.



As observed in Chart 10, census tracts 2.01, 2.02, 5.02, 7, 8, and 10 presented the highest natural gas consumption levels.[28] These tracts do not share any distinguishing demographic pattern observed in section Drivers of Energy Burden in Charlottesville - Summary. However, our analysis has identified a high positive correlation (0.88) between the extent of utility gas connections and incidence of "white alone" households, revealing that this demographic is more likely to use natural gas as a source of energy.[29]



27 Chart 9 was elaborated by C3 with raw information kindly provided by Charlottesville Gas.
28 Chart 10 was elaborated by C3 with raw information kindly provided by Charlottesville Gas.
29 This correlation was estimated using information from the Charlottesville Regional Equity Atlas and the Low-Income Energy Affordability Data (LEAD) Tool. Both datasets use 2016 as the reference year.

An impressive number of 319 households in Charlottesville face an energy burden of 6% or higher due to natural gas consumption alone (without considering the consumption of electricity or other sources of energy), all of which have household incomes lower than 30% of AMI. Although these hundreds of families would greatly benefit from energy efficiency improvements related to natural gas use, adding relevance to existing Charlottesville Gas savings programs and the potential creation of new ones, it is important to remark that this number only represents a small fraction of the City's 4,067 households which face high energy burden due to electricity consumption alone. This suggests that energy efficiency upgrades for electric appliances may reach more residents and be more effective than natural gas-targeted upgrades in reducing Charlottesville's overall energy burden.

The Role of Energy Efficiency

According to the ACEEE, 35% of the excess energy cost-burden experienced by low-income families could be eliminated if energy efficiency improvements were made to bring their homes up to the efficiency level of the median U.S. home. Raising household energy efficiency to the median could eliminate 42% of excess energy burden for African-American households, 68% for Latinx households, and 97% for renters (Drehobl & Ross, 2016).[30]

Similarly, the U.S. Environmental Protection Agency (EPA) in 2018 estimated that homeowners could save $200 to $400 per year on their energy bills by making energy efficiency improvements, including sealing air leaks and upgrading air conditioning equipment.[31] Thus, the U.S. EPA recommends that local governments simultaneously tackle the affordable housing crisis and reduce residential GHG emissions by designing energy efficiency programs for affordable housing and low-income populations (U.S. EPA, 2018).

The analysis developed in this report revealed that low-income renters are more likely to be severely energy-burdened, meaning that energy efficiency upgrade financing could dramatically improve these households' welfare by reducing their annual energy costs.

Studies by Bird and Hernández, along with Gillingham and colleagues in 2011 and 2014, found that a key consideration here is the split incentive that exists between renters and landlords; that is, landlords have very little incentive to fund efficiency upgrades for their renters when the renters, and not the landlords, ultimately enjoy the energy savings associated with the upgrades. The main economic benefit to landlords in this case is the potential increase in property value they experience after making upgrades, but the uncertainty in future gains may prevent landlords from funding efficiency

30 Excess energy burdens were calculated as the difference between category-specific median energy burdens and the all-household median energy burden. Categories were defined based on income level, race, or homeownership.
31 Approximately 10%-20% of an average household energy bill in Virginia, according to the U.S. Energy Information Administration.

upgrades. In theory, renters may also invest in efficiency upgrades to save energy over time, but this behavior is inhibited by renters' uncertainty surrounding their length of stay in a given property (Gillingham & Palmer, 2014). If they think they will move out before they will have repaid an efficiency loan in full or reaped the full benefit of their energy savings, renters will be unlikely to invest in upgrades either on their own or with the help of a loan program (Bird & Hernández, 2012; Gillingham, Harding, & Rapson, 2011).

It is important to observe, however, that the potential increase in property value and rent prices requires that policy makers implement well-designed energy efficiency policies in a way that promotes both energy and housing affordability while protecting local residents from displacement processes. A good example of a program that has achieved this in a very successful manner occurred in Charlottesville in 2005 at the Park's Edge housing community and is further explored in section Climate and Social Impacts of Promoting Energy Equity.

In order to establish the baseline energy efficiency requirements of a certain areas' housing stock, building code standards can play a very important role. If future homes were built according to the best energy efficiency standards, households that move into these homes will be less likely to be energy-burdened and experience health problems associated with poor housing stock conditions (i.e., asthma, allergies, respiratory illnesses) than households that move into older, less efficient homes. For the specific case of Charlottesville, building scientist Tray Biasiolli cites air sealing as the most effective energy efficiency feature of a home to increase building durability and maintain resident health by preventing consumption of outside pollution or smoke and limiting mold growth at air leakage points (Biasiolli, 2020).

Research indicates that upgrade installers should take care to maintain sufficient outside air exchange when "tightening" a home to make it more efficient, ensuring that energy efficiency measures do not increase health risk for household occupants via inadequate ventilation (Wilson & Katz, 2010). HVAC upgrades using high quality filters and whole-house ventilation serve as necessary countermeasures to home tightening, preventing indoor moisture buildup which can threaten building durability and resident health. Tray Biasiolli observes that while homes constructed between 1980 – 1990 using fine grain particle board as exterior sheathing may be more susceptible to trapping moisture, homes constructed in Charlottesville today prioritize ventilation, particularly those adhering to green building standards, a commonplace expectation in the local housing market. Biasiolli adds that, over the last decade, demand for green building certified single-family homes driven by high-income buyers has grown such that new multifamily homes are now required to be certified through organizations such as Earthcraft to apply for low-income housing tax credits (Biasiolli, 2020).

For residents who cannot afford to own their homes or occupy older multifamily units not meeting green building standards, there is room for building code and policy changes to improve the energy efficiency of Charlottesville's housing stock, improving the welfare of low-income and cost-burdened households in the process. With proper countermeasures to maintain indoor air quality, energy efficiency improvements are shown to improve resident health overall, particularly for low-income families that can use money saved on energy costs to pay for other needs like food and medical care (Wilson & Katz, 2010). This would also help householders maintain and excel in their jobs, as freed up money could be used to secure critical resources such as adequate childcare, home stability, and transportation (Schuyler, Orange Dot Report 3.0, 2018).

Virginia's Uniform Statewide Building Code (USBC)

Building codes affect every member of modern society; from contractors to students, workers, and families. These regulations guide and determine the decisions that construction professionals will make in their future investments and projects. One of the most expensive consequences of older building codes is energy waste. Hence, as energy conservation becomes more important, new building codes are paying increased attention to address energy efficiency standards and other energy related aspects. (Williams, 2016)

According to the DOE, in 1973, Virginia adopted the Uniform Statewide Building Code (USBC) to establish regulations for the construction and maintenance of buildings (U.S. DOE, 2019). Multiple sources confer that, in accordance with Dillon's Rule, the USBC "supersedes the building codes and regulations of all localities and state agencies," and all localities are required to enforce the USBC (Virginia DHCD; Arkema, 2014; Henrico County, 2011).

Effective October 1, 2003, Virginia's USBC was modified significantly to meet the standards set by the International Energy Conservation Code (IECC), created in 2000 by the International Code Council (U.S. DOE, 2019). The IECC outlines model regulations designed to "result in the optimal utilization of fossil fuel and nondepletable resources in all communities, large and small" (IECC). Accordingly, a study by the Pacific Northwest National Laboratory regarding West Virginia's implementation of the IECC requirements projected that energy costs for homeowners would fall by about 16% on average (Lucas, 2006).

Most recently, the Insulation Institute reports that Virginia's 2015 USBC became effective on September 4, 2018, adding a new Energy Rating Index (ERI) compliance path for builders to achieve compliance (Insulation Institute). The Commonwealth's 2015 USBC also changed ceiling insulation levels, updated wood frame wall requirements, and added detail to air leakage testing standards (U.S. DOE, 2019).

Even with the Virginia USBC in place, many residential homes do not meet its standards. According to a study performed by the Southeast Energy Efficiency Alliance (SEEA), in a sample of 118 homes in Charlottesville 53% of homes tested between March 2015 and September 2016 did not meet the 6% duct leakage limit set by the 2012 USBC (Dzura, 2019). Further, recent USBC modifications have not made significant improvements in residential energy efficiency. The ACEEE notes that Virginia's USBC continues to use a version of the IECC established in 2009, and the DOE similarly contends that Virginia is less efficient than the 2015 IECC (Walton, 2017; U.S. DOE, 2019).

The Energy News Network observes that attempts to adopt increasingly energy-efficient codes have been hindered by some homebuilders and other stakeholders in recent years (Pierobon, 2018). The Virginia Department of Mines, Minerals, and Energy (DMME) adds that barriers including a limited understanding of energy savings potential as well as uncertainty surrounding building costs have further impeded the adoption of USBC amendments that surpass the minimum standards (DMME, 2017).

The Role of Renewable Energy

According to the DOE, as the most abundant energy resource on Earth, solar energy is being harnessed in an ever-growing effort to reduce household energy costs while foregoing the use of environmentally-harmful fossil fuels. Purchasing solar panels is favorable for households with high utility bills, living in sunny locations, qualifying for tax credits, or those seeking to increase home value. (U.S. DOE, 2016). This could mean an opportunity for areas that received severely limited real estate investment over time, historically underserved urban areas, as they usually present fewer environmental amenities like urban-tree canopy (Hoffman, Shandas, & Pendleton, 2020).

Nevertheless, the Clean Energy States Alliance reported that while demand for solar energy in the United States has grown by 23 times between 2008 and 2016 and installation continues to become more affordable with falling prices, such energy solutions often remain out of reach for LMI households (CESA, 2019).

In addition, members of historically economically disadvantaged communities can face unique obstacles, including a higher proportion of households living in rental units and thus not owning their roofs, below-average credit scores not qualifying for PV system financing, insufficient tax liability to take advantage of federal residential solar tax credits, and limitations imposed by federal housing assistance program (CESA, 2019).

Even so, with carefully crafted policies, solar photovoltaic systems for LMI households can ease energy burden while improving health by diminishing exposure to pollutants, raising property value, and providing jobs to under-served communities (CESA, 2019). One successful example of bringing the cost-saving benefits of solar energy to low-income households can be found in Washington D.C, where the municipality-sponsored Solar for All program offers residential solar installation (for single-family homes) or community solar facility subscriptions (for homeowners with ineligible rooftops, renters, and multifamily building residents) free to District households which receive government income assistance1 or earn 80% or less of the AMI. Operating on a first-come, first-serve basis, the program seeks to offset 50% of a household's electricity costs, saving beneficiaries approximately $500 per year through energy credits (DOEE, 2020).

Here in Charlottesville, a partnership between the City's government and Sun Tribe developed a free job-training program to give local residents the required knowledge to work in the solar industry. The so-called GO Solar program, named after the City's GO (Growing Opportunities) initiative, was the first one in the renewable sector. After the program's conclusion, Sun Tribe hired five of the GO Solar graduates, three African American, one Afghan national, and one white (McGowan, 2019).

Incentives for Lowering Energy Burden

Currently Available for Charlottesville's Residents

Public and private entities offer several monetary incentives for climate action through energy efficiency, renewable energy, and transportation measures. C3's Climate Action Incentives report informs Charlottesville and Albemarle County residents and business managers of their options to save money and take action against climate change. According to the report, as of January 2020, of the 32 incentives currently available to support residential climate action, 81% promote energy efficiency upgrades and 25% promote renewable energy investment (de Campos Lopes, Tilman, & Ivanova, 2020).[32]

Nearly two-thirds of the existing residential incentives provide monetary rebates, but are limited in scope, with 57% of rebates offered being lower than $100 and 76% of them lower than $500. Finally, 88% of residential incentives have at least one eligibility/qualifying criteria, with 47% of them requiring property ownership, 13% of them requiring good credit history, and only 16% of them requiring income- or age-qualifying status (de Campos Lopes, Tilman, & Ivanova, 2020)

The currently available incentives do not adequately address obstacles faced by households already likely to experience high energy burden, particularly renters who cannot afford homeownership (de Campos Lopes, Tilman, & Ivanova, 2020). For those who do qualify, rebates are limited to small energy efficiency retrofits which may not significantly reduce energy burden, resident health, or building structural integrity. While creating new climate incentives and programs could provide more opportunities overall, they must be coupled with better targeted qualifying criteria suited to serve low-income or renting households in order to equitably expand their access to affordable and clean energy.

Expected New Incentives (as a Result of VA GA 2020)

The Commonwealth's 2020 General Assembly passed multiple bills that will begin to address the energy inequities in communities across the Commonwealth. The bill

[32] C3 acknowledges the existence of other grants, not contemplated by C3's Climate Action Incentives report, that have a special focus on low-income households and housing affordability and are also available for Charlottesville's households. However, due to less specific definitions with respect to the terms of the grant (such as: household eligibility, eligible energy-related improvements, maximum grant amount, length of the waiting list/period, etc.) they were not considered in C3's analysis.

HB981/SB1027, that enables Virginia to participate in the Regional Greenhouse Gas Initiative (RGGI), includes parameters for how the revenues generated by the program will be allocated to implement low-income energy efficiency programs and authorizes localities to use those funds to provide loans for energy efficiency projects in low-income areas. The Virginia Clean Economy Act (HB1526/SB851) also introduced an Energy Efficiency Resource Standard, which mandates investor-owned utilities with energy efficiency programs to ensure they are relevant, effective, and widely implemented. Additionally, a bill ("Electric Utilities; Energy Efficiency Programs, Stakeholder Process", HB575) was also passed and increases the stakeholder engagement process for developing energy efficiency programs to ensure equitable input from community members on what they believe is relevant and effective.

Legislation to increase access to clean energy solutions was also passed in this year's General Assembly. The Solar Freedom Act increased limits on both net-metering and power purchase agreements, and now enables owners of multi-family residential buildings to install a renewable energy generation facility and sell the electricity to tenants (GA Report). This would allow low-income apartment buildings to sell solar energy directly to their tenants, possibly lowering the tenant's energy burden and increasing their access to clean energy. Similarly, a bill was passed that requires utility companies to pilot community solar development programs specifically in low- income communities, which would provide those and surrounding communities access to renewable energy from their existing energy provider.

The Virginia Clean Energy Advisory Board, which was set to expire in July 2022, was extended and now has increased membership with one new member required to have experience implementing low-income loan programs for distributed renewable energy. The board, which counts with the membership of two Charlottesville residents (including C3's executive director, Susan Kruse), has also been directed to develop guidelines to administer public power renewable grant programs.[33] Meanwhile, Virginia's DMME has been authorized to sponsor a statewide clean energy financing program.

Historic, Institutional, and Political Conditions Impacting our Community's Energy Equity

UVA's Legacy

The City of Charlottesville and surrounding region is perceived as a desirable place to live, attracting a wide range of households including families, professionals, affluent retirees, and students (RCLCO, 2016). The University of Virginia (UVA) alone draws students, faculty, and staff from around the world, generating significant economic activity and housing demand. However, this context contributes to an imbalance in the

[33] To date, no funding has been allocated Virginia Clean Energy Advisory Board's "Low-to-Moderate Income Solar Loan and Rebate Fund".

local housing market, where demand significantly exceeds the available supply (FBCI & PES, 2018). Hence, C3's analysis would be incomplete without considering the University's influence on Charlottesville's average energy burden levels and affordable housing market.

As the largest employer in central Virginia, with holdings of more than $1 billion in property in the City of Charlottesville alone, UVA is a major force in local housing trends. As observed by CLIHC, because of its non-profit status, UVA does not pay taxes on any of its real estate holdings (CLIHC, 2020).

University enrollment for the 2019-2020 academic year included 23,800 total undergraduate and graduate/professional students (UVA, n.d). Approximately 38% of students live in university-owned, operated, or affiliated housing, including all 3,927 first-year students, per requirement, and an estimated 5,117 upper-classmen (U.S. News & World Report; Kelly J. , 2019). The remaining 14,756 students (approximately 5,000 households, split between the City of Charlottesville and urban Albemarle County) live in private off-campus housing -not "purpose built" as student housing, including single-family homes and apartments- which could otherwise be occupied by local residents. As a part of its Brandon Avenue project, UVA completed the construction of upper-class student residence Bond House in late 2019, providing 313 single bedrooms (UVA, 2020). UVA has not released plans for expanding its offer of upper-class student housing units beyond the completion the project's second phase, which is expected to provide 350 extra beds (Kelly M. , 2020).

In the past decades, the University has received criticism for acquiring and expanding onto property previously owned by predominantly black neighborhoods, such as Vinegar Hill and the historical neighborhood of Gospel Hill during the 1960s. In the 1970s, private developers began purchasing historic homes and constructing small-scale apartment buildings along 14th Street NW, Jefferson Park Avenue, and Rugby Road targeted for off-campus student residents. By 2016, more student-targeted developments had occurred along 14th Street, Wertland Street, and West Main Street, including a few luxury apartment buildings owned and operated by national college student housing firms (Cameron, Feldenkris, & Arnold).

As discussed in section Overview of Charlottesville's Context, the youngest householders, those aged under 25, are concentrated in census tracts surrounding the University – 2.01, 2.02 and 6. These tracts, including much of the city's UVA-owned and privately marketed student housing, are also dominated by renter-occupied homes; 93% of households in tract 6.0 alone along Jefferson Park Avenue are occupied by renters (as observed in Chart 5). Census tracts 2.02 and 6.0 contain the highest proportion of Extremely/Very Low-Income Households, at 79% and 69% of households, respectively (Chart 6). These two locales also had above-average proportions of buildings constructed in 2000 or later, at 52% and 43%, respectively (Chart 3). In section Energy Burden in Charlottesville, it was revealed that census tracts 2.02, and 6.0 present some of the highest energy burden levels in Charlottesville (at 4.0%, and 3.4%, respectively; compared to the Charlottesville average of 2.3%).

The second-most energy burdened census tracts are 5.01, the Fifeville neighborhood (directly adjacent to [UVA] student-dominated tracts 2.02 and 6) and 4.01, the Ridge Street neighborhood, as seen in section census tracts. Tracts 5.01 and 4.01 have an average energy burden of 2.6% and 2.4%, respectively, and have majority non-white populations. Whether UVA's property acquisition and expansion (as is currently underway in tract 5.01) pushes residents to move into less energy-efficient housing is still to be determined, requiring a historical record of energy burden for homes that may have already been demolished for comparison to current energy burden.

Assuming that non-student residents must move to more costly or energy inefficient homes for lack of affordable housing substitutes, their energy burdens would rise. While further analysis is required to investigate this hypothesis, it is clear that the use of more off-campus student housing will increase Charlottesville's overall energy burden, regardless of whether affordable housing countermeasures are taken. In March 2020, the University announced a goal of helping to develop 1,000 to 1,500 affordable housing units in Charlottesville and Albemarle County over the next decade on UVA or UVA Foundation-owned land (Hester, 2020). Such steps may allow UVA property acquisition to keep pace with affordable housing availability.

Historic and Systemic Inequalities: Populations of Color

According to CLIHC's report, the Charlottesville City Council voted in 1912 to segregate the City, prohibiting the sale of property between people of different racial backgrounds, particularly if the surrounding neighborhood was inhabited by a majority of a different race. While explicit racial segregation laws were prohibited by the Supreme Court in 1917, new, high-value homes built between 1920-1950 hosting predominantly white neighborhoods were sold with deeds prohibiting the future sale of the property "to any person not of the Caucasian race" (CLIHC, 2020). By 1948, when this too was deemed unconstitutional, City officials had zoned Charlottesville into two categories: two-family residential zoning (exclusively available for FHA insured loans) and business, including multi-family homes and predominantly non-white neighborhoods. (CLIHC, 2020).

Today, areas reserved for whites-only persist via single-family zoning of predominantly white neighborhoods (CLIHC, 2020). C3's analyses found an inverse correlation of -0.41 between the presence of white population and African American population in Charlottesville as a whole; suggesting that, indeed, race is not evenly distributed throughout the City. [34]

Historical limitations of people of color from obtaining private home loans widened the homeownership gap and has very likely perpetuated the higher energy burden faced by these populations. A 2019 study analyzing major cities across the U.S. corroborates this

[34] This correlation was estimated using information from the Charlottesville Regional Equity Atlas and the Low-Income Energy Affordability Data (LEAD) Tool. Both datasets use 2016 as the reference year.

hypothesis, finding that residents of low-income in predominantly white neighborhoods are less energy-cost burdened than residents of predominantly non-white neighborhoods of similar income levels, largely due to historical segregationist housing policies pushing minority families to occupy housing stocks in worse conditions (Kontokosta, Reina, & Bonczak, 2019).

The U.S. Census Bureau's reveals that African Americans represented 18% of Charlottesville's population, while the Hispanic (non-white) population represents 5.7% (U.S. Census Bureau, 2019). This is of particular relevance when considering that, according to Don't Quit Your Day Job (DQYDJ), African American and Hispanic populations are disproportionally more highly represented among those households with the lowest income levels (DQYDJ, n.d.). To date, "the City has not invested in gathering or interpreting data related to the racial wage gap or the racial wealth gap amongst Charlottesville residents and the relationship thereof to displacement and housing insecurity. In addition, the City's quantitative analysis did not measure displacement of low-income and racial minority groups within Charlottesville" (CLIHC, 2020).

C3's adds to CLIHC's statement indicating that, to date, the City has also not invested in gathering or interpreting data regarding the percentage of its population that are immigrants, some of whom may lack the necessary documents to buy or formally rent their homes. The so-called undocumented population is particularly vulnerable and not able to apply for supported housing programs unless under specific conditions (Affordable Housing Online, n.d.). The Charlottesville Redevelopment and Housing Authority (CRHA) reports that, as of 2016, 85% of all voucher-based public housing residents were people of color, with 95% being African American households and only 1% being of Hispanic origin (CRHA). The low percentage of Latinx enrollment may be due to additional barriers to housing uniquely faced by immigrants.

According to Javier Raudales, from Sin Barreras, Latinx families with limited legal status or ability to fluently communicate in English face challenges in accessing the housing market or supported housing programs. Raudales adds that the requirement of certain documents to open a credit line can compound roadblocks to Latinx families when deciding where to live, as credit history plays a key role in accessing the housing market (Raudales, 2020).

Raudales remarks that policies seeking to promote affordable housing to historically-disadvantaged communities in Charlottesville should consider that some, such as the Latinx population, would prefer to keep living together due to their cultural and linguistic affinity. Affordable housing solutions which would fragment communities by requiring households to live further apart from each other would likely be unsuccessful (Raudales, 2020). Thus, affordable housing solutions seeking to alleviate housing costs and energy burden in Charlottesville must consider the unique challenges faced by communities of color and immigrant populations, including historical discrimination and legal barriers (e.g. documents) to housing programs.

Post-COVID-19 Pandemic and Economic Crisis

Planning for Health, Resilience, and Energy Equity

According to Race Forward's statement on April 15, 2020, when regional and national COVID-19 statistics became available, it was clear that Black, Latinx, and Native communities were being hit the hardest by the pandemic. This higher incidence can be partially explained by the fact that people of color are more likely to be working in "essential" jobs, and therefore are at much greater risk of exposure to SARS-CoV-2. Moreover, Race Forward cites that according to a recent analysis, Black and Latinx people are not only becoming infected at higher rates, but are also dying at higher rates than other racial groups (Race Forward, 2020).

This disparity may become more severe as economic assistance to support households in light of the recession caused by COVID-19 were not available for some historically-disadvantaged community members, such as recent immigrants. As stated by Javier Raudales, some Latinx families whose legal status prevents them from receiving both Virginia's unemployment benefits and the recently approved Federal stimulus package will be more seriously affected by the economic crisis (Raudales, 2020).

The aftermath of the global COVID-19 pandemic will require governments at all levels to act decisively to recover the physical and economic health of Charlottesville's community. As such, the City is likely to receive Federal and/or State economic stimulus funds to spur economic activities and potentially expand climate action programs. At the nexus of these two interests is the clean energy sector. A report from E2 reveals that 106,472 clean energy workers lost their jobs in March 2020 alone, with nearly two-thirds of those new unemployment claims filed within the energy efficiency industry. Stimulating the energy efficiency and renewable energy sectors would support more than 4,000 clean energy workers statewide while also improving the average energy efficiency of Charlottesville's residential and commercial operations (E2, 2020).

By doing this, Charlottesville could play an important role in alleviating the City's energy burden while simultaneously supporting clean energy sector workers and reducing the City's GHG emissions. Economic recovery in the clean energy sector presents an opportunity to drive economic activity in the United States more broadly, just as the nation observed after the Great Recession when the 2009 American Reinvestment and Recovery Act supported the weatherization of 1 million homes (E2, 2020).

A recent article from the Centers for Disease Control and Prevention (CDC) has identified that people with pre-existing conditions are more prone to COVID-19 infection, complications, and death. The CDC also found that some of the most common pre-existing conditions include respiratory and cardiac conditions (CDC, 2020). According to the NRDC, social factors such as inadequate, unhealthy, and unstable housing are proven to contribute to many of these pre-existing conditions; making people more vulnerable to COVID-19, especially in historically economically disadvantaged communities (NRDC, 2020). Moreover, research indicates that low quality housing conditions has been associated with lower health status and that, in contrast, properly executed energy retrofits and weatherization upgrades have been shown to result in improved health of residents, lower risk for respiratory illnesses, and fewer missed days of school and work (Wilson & Katz, 2010).

Besides alleviating energy burden, energy efficiency improvements could also improve Charlottesville's community members' health and diminish risks associated with respiratory diseases like the COVID-19. This is especially true for those residents, required to stay home due to COVID-19, living in poor housing conditions without access to renewable energy or energy efficiency upgrades. Thus, along with providing jobs, supporting residential energy efficiency programs and businesses in the wake of COVID-19 may be particularly important in improving resident health.

Climate and Social Impacts of Promoting Energy Equity

In this section, C3 aims to illustrate the environmental and social benefits that could be reaped through the promotion of energy equity and alleviation of energy burden. The following estimations assume that the City develops a program, potentially in conjunction with private sector or outside-government grants, to reduce the energy burden faced by its beneficiaries to an acceptable level of less than 6%. This could be achieved, as stated in section Building Energy Use: Patterns and Solutions, by widely deploying residential energy efficiency improvements and coupling them with renewable energy investments, where pertinent.

C3 assumes for this case example that the program is reserved for Extremely-Low Income households, as over 99% of this population faces high energy burden levels (6.0% or above) and this income category also represents 44% of Charlottesville's population living in unaffordable housing conditions (FBCI & PES, 2018).

For simplicity, this analysis also assumes that all energy burden is due to electricity consumption, that income levels are uniformly distributed within an income bracket, and that the program will benefit 1,000 households under two implementation criteria: (1) "first come, first served"; (2) "thoroughly targeted".[35] [36] It should be noted, however, that this hypothetical example only explores one out of many (and possibly better) program options.

As indicated by Table 23, this case example reveals that through the promotion of energy equity, the City could free up to 18% of each beneficiary's annual income,

[35] Under the first criterion, the average energy burden of the program beneficiaries is equal to the average energy burden faced by Extremely-Low income households (i.e. 17%). Under the second criterion, the average energy burden of the beneficiaries will be a weighted average of the highest energy-burdened households (i.e. 24%). This difference in households' baseline energy burden is a consequence of a combination of the assumed lower average income and higher energy costs of beneficiaries under the second criterion (both resulting from C3's assumption of uniformly distributed income levels within each income bracket).
[36] The average income level of participating households is assumed to be the same under both criteria.

potentially moving hundreds of households to affordable housing conditions. Besides generating local jobs and reactivating the economy, a program like this could also reduce energy costs equivalent to up to 750 average local residential energy bills, while reducing GHG emissions equivalent to up to 850 Charlottesville households' average annual electricity emission.

TABLE 23	Climate and Social Impacts of Promoting Energy Equity (Charlottesville, VA)				
Year Built	Average Energy Burden Level	Energy Saved per Year (kWh)	Income Saved per Year ($)	Freed Income (%)	GHG Emissions Avoided (Tons)
Per Household					
Criterion 1	17%	7,000	$808	11%	2.9
Criterion 2	24%	11,044	$1,276	18%	4.5
Aggregate (1,000)					
Criterion 1	17%	6,999,548	$808,448	11%	2,856
Criterion 2	24%	11,043,682	$1,275,545	18%	4,506
Source:	C3's own elaboration based on data obtained from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool and the U.S. Energy Information Administration (EIA).				

The diversity of benefits associated with energy improvements in Charlottesville was exemplified at the Park's Edge housing community, where homeowners invested in energy efficiency upgrades through a partnership with the Local Energy Alliance Program (LEAP) to reduce their residents' expenses. Crystal Barbour and her two children, beneficiaries of the initiative, stated that the energy efficiency upgrades led to a 50% decrease in monthly energy bills, thereby improving their quality of life overall. According to Crystal, "When bills were higher, I had to choose between paying the bill and something else. Sometimes it was groceries. You would just eat cheap when it was electric bill week" (VAMFEEC, 2018; Checknoff, 2020).

Conclusions and Contributions

The present report identified that 4,852 households in Charlottesville face high to extremely high energy burden levels (spending 6% or more of their income towards paying energy bills). This is most pronounced in census tracts 2.02, 4.01, 5.01, 6, and 7, where each of them is home to approximately 500 or more households that face a high energy burden or more. Aligned with the energy drivers' theory studied by the report, tracts 2.02, 4.01, and 5.01 present considerably above-average concentrations (if not the highest ones) of populations of color, population with [formal] education levels equivalent to high school or less, and households with extremely/very-low income levels.

The aftermath of the global COVID-19 pandemic will require governments at all levels to act decisively on recovering the physical and economic health of Charlottesville's community. As such, the City is likely to receive Federal and/or State economic stimulus funds to spur economic activities that could be used to expand climate action programs. Supporting energy equity, via enhanced access to energy efficiency and renewable energy, can improve households' quality of life while supporting local well-paying jobs.

Through targeted programs designed to relieve the most significant levels of energy burden (as mentioned in our case example), the City could significantly increase the discretionary income of program beneficiaries, potentially providing considerable improvements in the City's housing affordability levels. Moreover, besides alleviating energy burden, energy efficiency improvements could also improve community members' health and diminish risks associated with respiratory diseases like the COVID-19. This is especially true for those residents living in poor housing conditions without access to renewable energy or energy efficiency upgrades.

Studies also support that by only raising household efficiency to the median could eliminate excess energy burden by 42% for African-American households and 68% for Latinx households (Drehobl & Ross, 2016). C3's report identified that, in Charlottesville, the presence of African American householders has a direct correlation with census tracts with a greater percentage of households with high to extremely high energy burden levels. Literature suggests that populations of color bear a disproportionate share of the lack of affordable housing and seem to present smaller levels of homeownership. African-American and Latinx communities are also known to suffer greater rates of infection from Covid-19.

Current incentives alone will not adequately address energy inequity in Charlottesville, Virginia. Most existing residential incentives provide monetary rebates that are too limited in scope. A very small percentage of residential incentives is intentionally directed to historically economically disadvantaged communities, while nearly half of the incentives either require a good credit history or homeownership. These limitations put obstacles in front of households already likely to experience high energy burden, particularly renters who cannot afford homeownership. While creating new climate incentives and programs could provide more opportunities overall, they must be coupled with better targeted qualifying criteria suited to serve low-income or renting households in order to equitably expand their access to affordable and clean energy.

C3 hopes that the information presented in this report will equip community stakeholders and decision-makers with a thorough understanding of how to promote energy equity in communities like Charlottesville and provide important information to advocate for an equitable allocation of resources from governments and energy utilities towards residential energy programs. This report represents a beginning of our understanding of how energy inequity impacts our community and how cross-sectoral climate and affordable housing policies can help address it. Important questions, such as better understanding the energy burden dynamics of census tracts with elevated concentration of UVA student residents and the energy use intensity performance of different demographics, still need to be addressed by future studies. C3 believes that directing future research primarily to census tracts experiencing the most significant energy burdens will give our community and decision-makers the best comprehension of the drivers of energy inequity in the City.

Based on the findings of this report, C3 looks forward to designing future research, subsequent policy recommendations, and concerted policy advocacy efforts alongside Charlottesville's community stakeholders and residents experiencing elevated energy burdens.

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