

Cutting through Uncertainty: Making Local Clean Energy Policy Decisions with Limited Data

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ABSTRACT

Several studies have documented that only a handful of United States cities are collecting and reporting comparable, detailed, and accurate community-wide energy use data. Whether or not they have energy use data, city policymakers still need guidance in developing policies and programs that will correctly target the highest sources of energy use and greenhouse gas emissions.

Past policy research has used typologies of local communities, with cities grouped together by common demographic or economic indicators, to provide municipal leaders with policy adoption guidance. Existing research suggests that metropolitan statistical area population and city population growth rates are two variables that are closely aligned with economic factors that determine a community's energy and greenhouse gas emissions profile and local government budgets that enable or inhibit clean energy initiatives.

This paper uses available demographic, economic, and city energy use data collected from several recently published reports and databases to lay out a community-wide energy use typology for U.S. cities. While some preliminary research has been conducted to create such a typology, its scope has been limited to examining only the largest cities in the country. This paper builds on past research to create a typology that is applicable to a wider array of cities. It also provides guidance to local government leaders, especially those with limited access to location-specific energy data, on how to use the typology to inform their policy and program decisions.

Introduction

An increasing number of cities have adopted goals to reduce their community's greenhouse gas (GHG) emissions, and many are working to align those commitments with increasingly stringent global targets. The American Council for an Energy-Efficient Economy's (ACEEE's) *2021 City Clean Energy Scorecard* is a report tracking how 100 of the largest U.S. cities are adopting and working to achieve GHG emission reduction goals, ranking these cities based on a 0–100 score of their clean energy policies, programs, plans, and projects.¹ The report examines these city activities across four energy sectors – buildings, transportation, energy and water utilities, and local government operations – and at the community-wide level. The report found that 63 cities have adopted climate change mitigation goals, but only 38 cities have inventoried their GHG emissions. Of those, only 19 are on track to achieve their near-term goals (Samarripas et al. 2021). In working to inventory their GHG emissions and energy use, city sustainability staff may face challenges such as limited funding, staffing, or access to electricity,

¹ City clean energy policies, programs, and plans are scored according to metric criteria that reflect policy best practices, advance racial and social equity, or are designed to reduce GHG emissions using an innovative approach. For more on the *City Scorecard* methodology, see aceee.org/research-report/u2107.

natural gas, and vehicle-miles traveled (VMT) data. However, they also face an urgent need to reduce GHG emissions to avoid the worst climate change outcomes.

Recognizing the need to provide guidance on clean energy policies and programs to cities with limited community-wide GHG emissions and energy data, the *2021 City Clean Energy Scorecard* included an energy use and GHG emissions typology that grouped cities based on their recent population growth and the total population of their metropolitan statistical areas (MSA) (Samarripas et al. 2021). The selection of these indicators was based on a review of existing research and available data that linked these indicators to several city characteristics. Figure 1 summarizes the assumed links between these indicators and characteristics, and we describe the *City Scorecard's* approach to grouping cities using these indicators in more detail below.

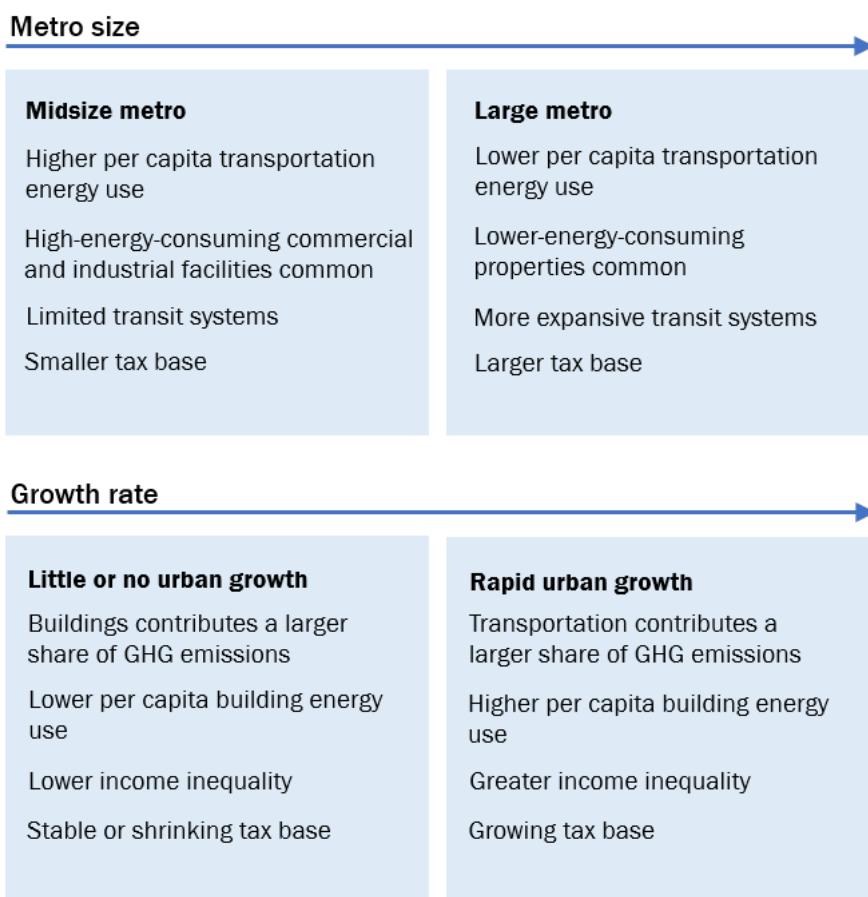


Figure 1. Associations between a city's metro population size, recent population growth, and various local characteristics

In the following sections, we review existing research that underlies assumptions regarding associations among a city's metro population size, recent population growth rate, and various factors that affect energy use and GHG emissions. We then update and analyze a city energy use dataset previously used in ACEEE's *Taking Stock: Links between Local Policy and Building Energy Use across the United States* report to test several assumptions about the typology groups shown in figure 1 (Samarripas and de Campos Lopes 2020):

- Are cities in large metropolitan areas more likely to have lower per capita building sector energy use than those in midsize metropolitan areas?
- Are high-energy-consuming facilities more common in midsize versus large metropolitan areas? If so, do energy trends in these places reflect this?
- Are cities in large metropolitan areas more likely to exhibit lower per-household vehicle miles traveled than those in midsize metropolitan areas?
- Do cities experiencing a faster rate of population growth have higher per capita building energy use?
- Do cities experiencing greater population growth have greater income inequality, an indicator of elevated greenhouse gas emissions?

Existing research on the links among these indicators is limited, and further research is warranted. This paper includes new research conducted to provide a clearer sense of what a city's population growth rate and metro population size may indicate about community-wide energy use, and while our findings help clarify the nature of these relationships, they are not definitive, as city-level energy data remains limited. Furthermore, very few cities have tracked and released data characterizing the period since the onset of the COVID-19 pandemic. The degree to which recent events may alter the trends and associations highlighted here is uncertain.

Overview of the *City Scorecard* Typology

The *Scorecard* grouped 90 of its 100 cities – excluding those with the 10 highest scores – into 6 groups based on the population of their respective MSAs and the population growth they experienced within their own municipal boundaries.² Figure 2 shows the criteria used to divide cities into groups. We provide a complete list of the *City Scorecard* cities in each typology group in Appendix A. We summarize the research underlying the choice of these indicators in the following sections.

² The 10 top-scoring cities in the *City Scorecard* were not included in the typology because it was created primarily to highlight the policy trends and opportunities of lower-scoring cities. The activities of top-10 cities are explored separately throughout the report. See aceee.org/research-report/u2107 for more information about how cities were selected for inclusion in the *City Scorecard*.

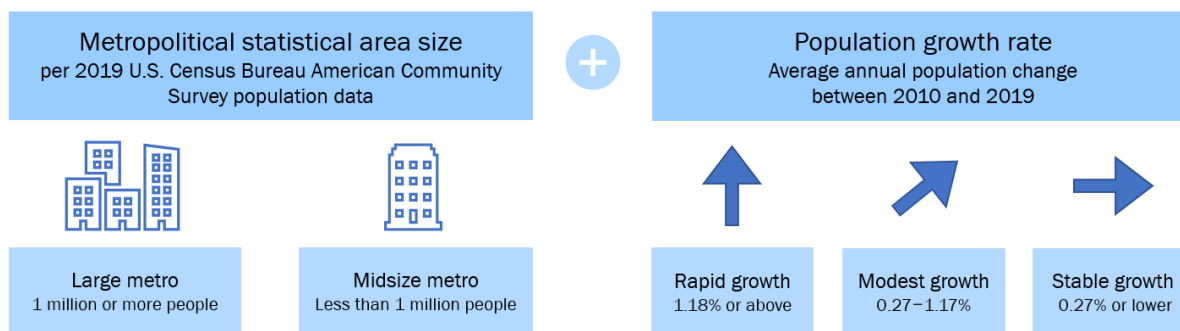


Figure 2. Methodology for grouping *Scorecard* cities. Note: Population growth groups were determined by assessing the distribution of average annual population growth rates for all U.S. cities with yearly U.S. Census Bureau population estimates between 2010 and 2019. The *Scorecard* team categorized cities with an average annual population change of 0.27% or less as having a stable population because no city experienced an average annual population decline of more than 0.70% except for San Juan, whose population declined by 2.27% annually.

MSA size and energy use

Cities in MSAs with populations of different sizes share several common characteristics that can affect their community-wide energy use and GHG emissions. Large metros, those with more than 1,000,000 people, are more often found in U.S. coastal states and the Southwest. Midsize metros, those with a population between 250,000 and 1,000,000, can be found everywhere in the United States, but they dominate the heartland: the Midwest, Great Plains, and South-Central regions (Berube 2019). Heartland states often have higher overall per capita energy use because of elevated energy consumption in the industrial and transportation sectors (Francis and Bradley 2018). It has been unclear whether these energy trends also apply to cities.

Economic data indicate that manufacturing companies are more common in midsize metros than large ones—they employ one in nine midsize metro workers—and this may be associated with the higher industrial energy use observed in heartland states. The healthcare, retail, education, and hospitality industries combine to employ another 44% of workers in midsize metros, and data from the US Energy Information Administration’s (EIA’s) 2012 Commercial Buildings Energy Consumption Survey (CBECS) indicate that these industries operate in the highest energy-consuming commercial facilities in the United States (EIA 2016; Berube 2019). Economic and job growth outside these sectors has been limited compared to larger metros. Many midsize metros have faced challenges in attracting professional service employers, especially technology companies, which often operate in lower-energy-consuming office buildings (EIA 2016; Berube 2019).

Midsize metros may have higher per capita transportation energy use, in part because they have more limited energy-efficient transit systems than larger MSAs. *The 2021 City Clean Energy Scorecard*’s analysis of large metro transit systems showed that these systems spend an average of \$175.96 per rider annually, while midsize metro systems spend an average of only \$57.83 annually (Samarripas et al. 2021). On average, 1.8% of midsize metro commuters use transit to travel to and from work, compared with an average of 3.4% of commuters in large metros (DOT 2021).

City population growth and energy use

The degree to which cities' populations are growing can also be indicative of several energy and energy-related trends. Cities often pursue strategies that promote population growth because "it generates immediate development revenue in the form of permit fees, utility fees, property tax increases and sales taxes" (Wogan 2017). Conversely, cities with declining populations can experience employment losses, abandoned buildings, a smaller tax base, and limits on city services (Hollander and Németh 2011). Rapidly growing cities can eventually face trade-offs to growth in that they will be responsible for the large costs associated with it. While property developers are typically responsible for covering the initial costs of the urban infrastructure that is needed to support new developments, cities are often responsible for covering the costs to repair and maintain that infrastructure in later years (Wogan 2017). Analyzing population growth at the metro level, Gottlieb (2002) and Fodor (2010) concluded that rapid urban growth is also associated with lower household incomes, higher unemployment, and greater poverty than their slower-growing counterparts.

Nijman and Wei (2020) offer support for the idea that these MSA trends are also true for cities. Increasingly, the expansion of companies and organizations specializing in information production and dissemination has spurred economic growth. These companies provide customized legal, financial, engineering, technology, or other, similar services to their clients. Firms like these have historically benefited from proximity to one another and to their clients, allowing them to exchange information more easily. However, these companies tend to provide middle- or high-income jobs only to people with advanced degrees. Many industries, such as manufacturing, that historically provided middle-income jobs to people with lower levels of education have left many growing cities, making it increasingly difficult for residents without advanced degrees to obtain work in well-paying positions. Nijman and Wei (2020) describe how New York City, which has experienced tremendous growth over the past century, typifies these trends. Consequently, the top 1% of income earners in the city accounted for 40% of all income in 2016, while the bottom 50% collectively had only 6% of all income. The researchers conclude that income inequality is increasing in these places.

Two studies indicate support for the idea that the increase in income inequality at the local level could be associated with increased energy use and GHG emissions. A study of U.S. states found that CO₂ emissions were higher in states that had a greater concentration of wealth among those in the top 10% of an area's incomes (Jorgenson, Schor, and Huang 2017). ACEEE's *Taking Stock* study, whose data serve as the basis for this paper's analysis, found that cities with an increasing share of their population living in poverty tend to see increased per capita building electricity use (Samarripas and de Campos Lopes 2020).

Transportation energy and GHG emissions data at the city level are limited, but available data support the assertion that cities with higher population growth have a larger share of their overall GHG emissions from transportation sources. Gurney et al. (2021) compared cities' self-reported inventory (SRI) GHG emissions data from 43 U.S. cities with emissions totals generated by their Vulcan 3.0 model. Thirty-one of these cities had complete SRI data and were large enough to have multiple years of US Census Bureau American Community Survey one-year population estimates. Figure 3 shows how the on-road and railroad transportation shares of cities' total GHG emissions compare to city average annual growth rates.³

³ We have excluded air and commercial marine vessel emissions as these vary considerably from city to city and because this activity may be outside the influence of city policies.



Figure 3. On-road and railroad transportation share of total city GHG emissions. *Note:* A version of this chart was originally included in *The 2021 City Clean Energy Scorecard* with available data for only those cities included in the *Scorecard*. It has been updated to include data from all cities with complete SRI data for the transportation and building sectors that were considered in Gurney et al. 2021. Average annual population growth rates were calculated using U.S. Census Bureau population estimates from between 2010 and 2019. The association between these two variables was found to be statistically significant using a regression analysis that returned a p-value of 0.0122.

Methodology

Using city-level energy, economic, and demographic data collected for *Taking Stock: Links between Local Policy and Building Energy Use across the United States*, this paper examines whether the city typology developed for *The 2021 City Clean Energy Scorecard* reflects several trends outlined above (Samarripas and de Campos Lopes 2020; Samarripas et al. 2021). *Taking Stock* analyzed datasets containing community-wide electricity data from 47 cities and counties and natural gas data from 33 cities and counties to determine the demographic, economic, and policy factors associated with observed differences in energy use across cities and across the years 2013-2016.⁴ Across these local municipalities, per capita building energy use declines were associated with decreases in the share of the population with low incomes and the share of households living in older homes.

Answering the research questions listed in the introduction of this paper required updating the original *Taking Stock* dataset with data from new sources. To address the question related to per-household VMT, this paper's analysis included modelled per household VMT data from the Center for Neighborhood Technology's (CNT) H+T Affordability Index (CNT 2021). We note that these data only include values at the geographic level of a core-based statistical area (CBSA), which characterizes activity within MSAs in our dataset. The availability of VMT data

⁴ See aceee.org/research-report/2020/04/taking-stock-links-between-local-policy-and-building-energy-use-across for a complete list of variables.

at smaller scales is limited, and these estimates are typically not calculated using consistent and comparable methodologies. These data are also reflective of activity only in 2015, but the typology's assumptions about cities in large and midsize metros are based only on differences in population size and not trends over time. We have therefore limited this paper's analysis of factors linked to metropolitan area size to available data from the year 2015.

To examine the degree to which cities in different metros had high-energy-consuming vs low-energy-consuming facilities, the analysis included county-level employment counts by industry from the US Bureau of Economic Analysis (BEA 2022). These data were collected for the year 2015 to align with CNT data. After collecting these data, we calculated a ratio reflecting the number of employees in health, education, hospitality, food service, and manufacturing jobs (typically performed in high-energy-consuming facilities) versus jobs that are typically conducted in private-sector office settings (often lower-energy-consuming facilities).

In examining relationships between city population growth rates and other factors, we considered both rates of change in these variables over the period of 2013 to 2016 and differences in the average values across these years. We used 2013-2016 data from the US Census Bureau's American Community Survey to examine differences in income inequality across cities experiencing different rates of population growth. These data were drawn from Table B19082: Shares of Aggregate Household Income by Quintile (Census Bureau 2022).

We were limited to using a subset of the data available from the *Taking Stock* report for this paper's analysis of building energy use trends because only 21 cities from the original dataset had both electricity and natural gas data.⁵ We were able to consider all cities from the report's datasets in assessing VMT trends. These data limitations meant that we were able to conduct only bivariate regression analyses of the associations between variables. As shown below, we used regression analyses to conduct tests of statistical significance and displayed data on charts with trend lines. A multivariate regression analysis, like the one conducted for the original *Taking Stock* report, was not possible as it would have required a larger sample. As such, our findings should not be considered as the final word on the relationships between these variables. Additional research with larger datasets is needed.

Findings

Differences in per capita energy use across metros

Our results indicate that a logarithmic relationship may exist between metro area population size and city building energy use. Cities' per capita energy use declines as their metro populations increase, but these declines are noticeably smaller for the largest metros. Figure 4 shows the observed association between these two variables. The association between these variables was found to be statistically significant using a regression analysis that returned a p-value of 0.0042.

⁵ The following 21 cities were included in the analysis: Baltimore, MD; Boston, MA; Cleveland, OH; Colorado Springs, CO; Denver, CO; Huntsville, AL; Knoxville, TN; Los Angeles, CA; Memphis, TN; Minneapolis, MN; New Orleans, LA; New York, NY; Philadelphia, PA; Richmond, VA; Rochester, MN; Sacramento, CA; Salt Lake City, UT; San Antonio, TX; Springfield, MO; Tallahassee, FL; and Washington, DC.

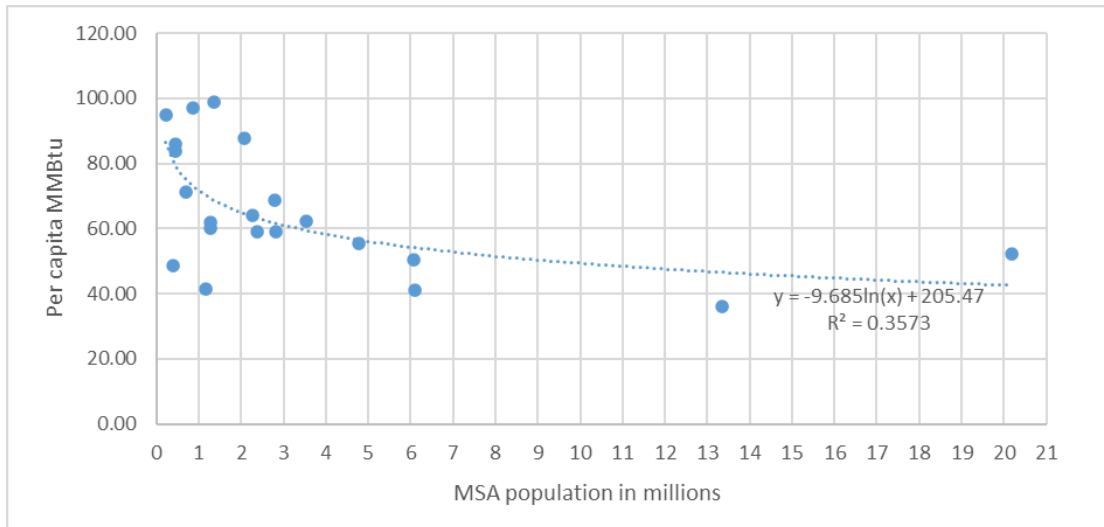


Figure 4. 2015 MSA population and per capita city building MMBtu.

To gain some understanding of what may be driving this potential relationship, we examined whether any of the statistically significant variables from the *Taking Stock* report exhibited a similar association between MSA population and per capita MMBtu. The age of a city's housing stock, measured using a housing age index, demonstrated some links to metro area size, but not in the expected direction.⁶ Figure 5 shows that cities in smaller metros, those with higher per capita energy use, have newer housing, indicated by a lower housing age index value.

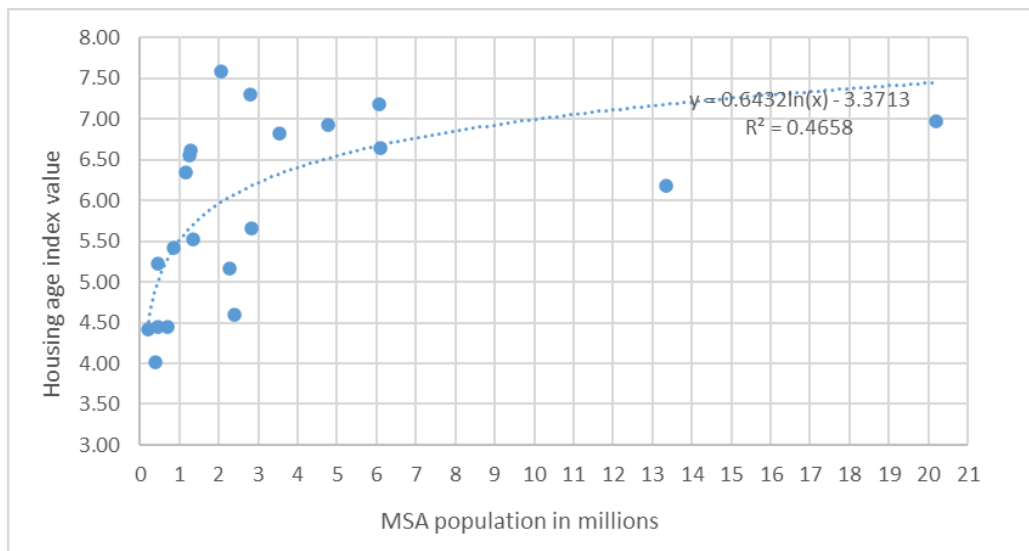


Figure 5. 2015 MSA population and city housing age index values. The associations between these two variables were found to be statistically significant using a regression analysis that returned a p-value of 0.0007.

Because the analysis indicates a relationship between metro area size and city housing, but not one that explains the association between metro size and energy use, we examined

⁶ See [aceee.org/research-report/2020/04/taking-stock-links-between-local-policy-and-building-energy-use-across](https://www.aceee.org/research-report/2020/04/taking-stock-links-between-local-policy-and-building-energy-use-across) for a detailed description of how the index was calculated.

whether other housing variables could help explain why cities in larger MSAs have lower per capita energy use. We found that the size of homes, measured with a residential unit room number index that increases in value as the number of rooms per home increases, holds the potential to explain a relationship between metro size and city building energy use.⁷ Figure 6 shows the association between these values, and figure 7 shows the relationship between residential unit room index values and per capita energy use.

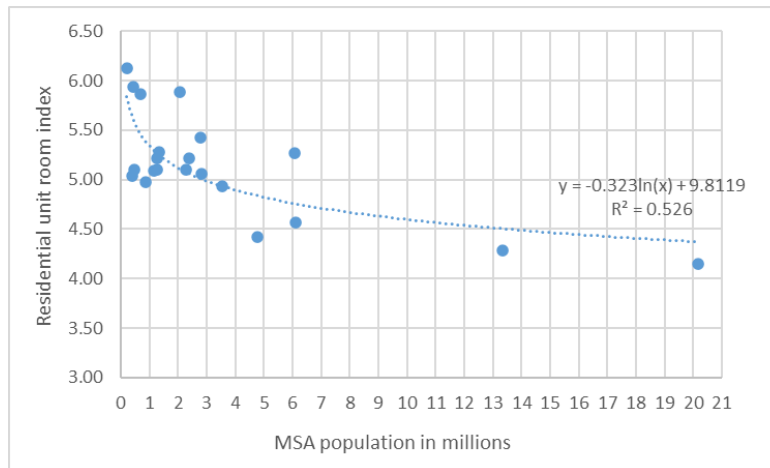


Figure 6. 2015 MSA population and residential unit room index values. The associations between these two variables were found to be statistically significant using a regression analysis that returned a p-value of 0.0002.

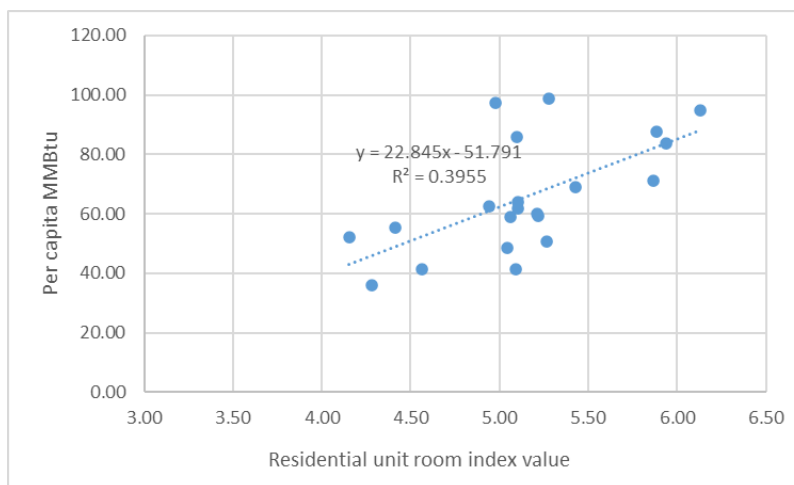


Figure 7. 2015 MSA city residential unit room index values and per capita MMBtu. The associations between these two variables were found to be statistically significant using a regression analysis that returned a p-value of 0.0023.

⁷ See [aceee.org/research-report/2020/04/taking-stock-links-between-local-policy-and-building-energy-use-across](https://www.aceee.org/research-report/2020/04/taking-stock-links-between-local-policy-and-building-energy-use-across) for a detailed description of how the index was calculated.

Taken together, our analysis indicates that cities in smaller metros have higher per capita energy use than those in larger metro areas. One reason for this may be because cities in smaller metros have larger homes.

Employment differences across metros

We closely examined the question of whether the prevalence of workers in higher-energy-consuming facilities – those used by the healthcare, education, hospitality, food service, and manufacturing industries – in smaller metro cities could be one of the underlying reasons for the observed difference in figure 4. Figure 8 shows the results of this analysis.

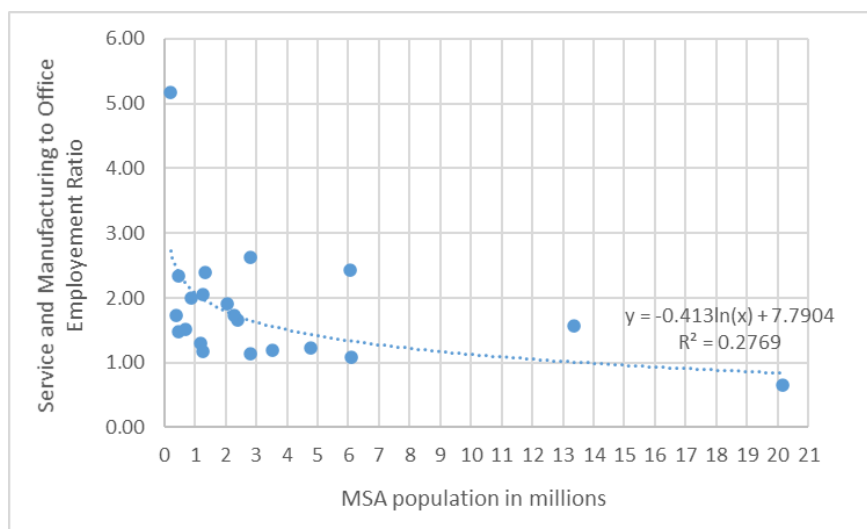


Figure 8. 2015 MSA population and ratios of healthcare, education, hospitality, food service, and manufacturing employees to office employees

Based on the available data, cities in smaller metros tend to have more workers employed in non-office-based industries. The association between these two variables was found to be statistically significant using a regression analysis that returned a p-value of 0.0143. Like the relationship between cities' metro population and per capita energy use, the data indicate a logarithmic trend. As noted previously, these industries' facilities have the highest levels of energy use among non-residential facilities. It should be noted that one of the reasons these industries' facilities consume more energy is because they are also among the largest classes of non-residential properties (EIA 2016). Taken together with the findings indicating that cities in smaller metros have larger homes, these results may indicate that cities in smaller metros consume more energy per capita because they tend to have larger residential and nonresidential buildings.

Differences in metro per household vehicle miles traveled

Our analysis of metro area populations and per-household VMT indicates support for the assertion that per-household VMT decreases as cities' metro area size increases. The results of

our analysis are shown in figure 9. The association between these two variables was found to be statistically significant using a regression analysis that returned a p-value of less than 0.0001.

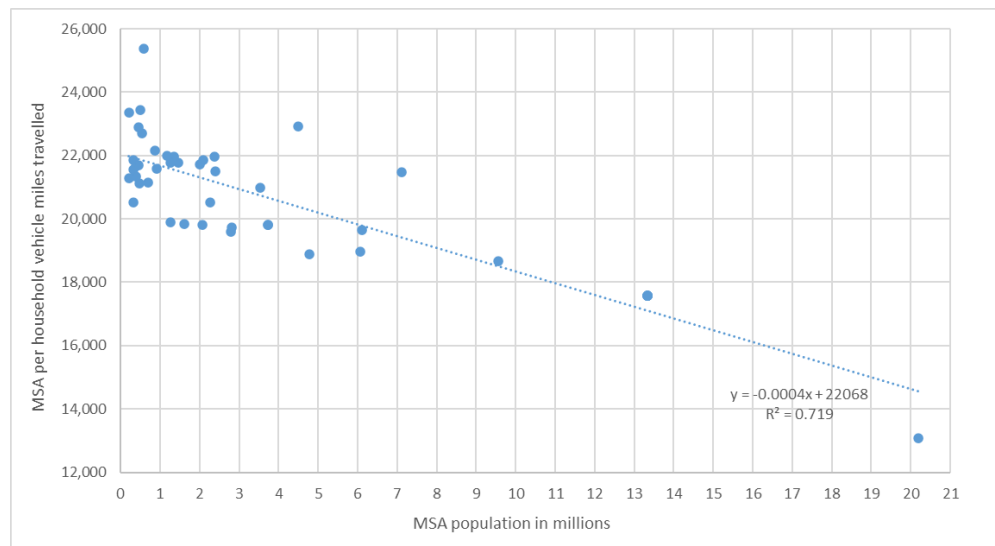


Figure 9. 2015 MSA population and per household VMT

City population growth and per capita energy use

While we examined whether associations exist between city population growth rates and per capita energy use using the same methods described above, we were unable to identify any statistically significant relationships between these variables. Previous research assumed that a relationship could exist between these factors based on the presumption that faster-growing cities had higher levels of income inequality; however, as we describe below, our city sample's data did not reflect this trend. In both cases, we are unable to conclude that these relationships do not exist as we had access to limited data for our analysis. It is possible that such relationships could be identified with a larger sample size.

City population growth and income inequality

We examined how shares of aggregate household income in the upper quintile differed across cities and years, but we were unable to detect any notable differences. Across all cities and years, households with incomes in the upper quintile of all household incomes had an aggregate share of income that hovered just above 50%. Nijman and Wei's 2020 study, which describes a relationship among professional service jobs, education levels, and income inequality, examined urban areas across the globe. It may be that these associations are more apparent on a global scale rather than a limited look at the United States. Samarripas and de Campos Lopes (2020) established a relationship between smaller shares of city populations with low incomes and lower per capita electricity use, although changes in the share of a population with low income and changes in income inequality are not necessarily linked. Furthermore, this paper's analysis was unable to find support for the argument that cities' growth rates and their low-income share of a population were linked.

Conclusion

This paper's findings reveal that a city's MSA population can be indicative of building and transportation energy use trends. However, it is less clear how a city's growth rate may be related to these variables. As highlighted in our review of Gurney et al. (2021) and Wogan (2017), city growth rates may be useful in characterizing a city's overall GHG emissions profile and tax base. Below, we summarize this paper's findings alongside the original research summarized by Samarripas et al. (2021).

Compared to those in midsize metros, cities in large metropolitan areas:

- Have lower per capita building energy use, and data indicate that this may be, in part, because cities in midsize metros have larger buildings.
- Have lower per household vehicle miles traveled, and this may be due, in part, to residents having access to and using more expansive transit systems.

Compared to those with limited or no population growth, rapidly growing cities:

- Are more likely to have a larger share of their GHG emissions originating from transportation sources.
- Have a growing tax base to help fund near-term initiatives, but these funds may become strained in future years as the need for infrastructure maintenance and repairs grows.

Rapidly growing cities are more likely to have local funding available to launch climate action policies, while those experiencing less growth may benefit from federal or state funding. Rapidly growing cities are also more likely to see substantial community-wide GHG emissions and energy-use reductions from creating transportation-focused initiatives while those experiencing less growth stand to benefit more from buildings-focused policies and programs. Even cities in the largest metro areas have room to reduce energy use from buildings and transportation, but our analysis indicates that those in smaller metros have the most pressing need to do so. For example, rapidly growing cities in large metros such as Las Vegas and Atlanta can benefit from increasing electric vehicle deployment or encouraging the creation of new homes and businesses near transit. Cities with a relatively stable or declining population, especially those in smaller metros, such as Columbia, SC, and Little Rock, AR, stand to benefit from buildings-focused initiatives such as energy benchmarking and building energy performance policies.

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Appendix A



Rapid growth
in large metro

Atlanta	Miami
Aurora	Nashville
Austin	New Orleans
Charlotte	Oklahoma City
Chula Vista	Orlando
Columbus	Phoenix
Dallas	Portland
Fort Worth	Raleigh
Henderson	Richmond
Las Vegas	San Antonio
Mesa	Tampa



Modest growth
in large metro

Grand Rapids	Sacramento
Houston	Saint Paul
Indianapolis	Salt Lake City
Jacksonville	San Diego
Kansas City	St. Petersburg
Louisville	Tucson
Philadelphia	Virginia Beach
Riverside	



Stable growth
in large metro

Baltimore	Memphis
Birmingham	Milwaukee
Buffalo	Newark
Chicago	Pittsburgh
Cincinnati	Providence
Cleveland	Rochester
Detroit	San Juan
Hartford	St. Louis
Long Beach	



Rapid growth
in midsize metro

Boise	Lakeland
Cape Coral	Madison
Charleston	Omaha
Colorado Springs	Reno



Modest growth
in midsize metro

Albuquerque	McAllen
Allentown	Oxnard
Bakersfield	Provo
Des Moines	Stockton
El Paso	Tulsa
Fresno	Winston-Salem
Greensboro	Worcester
Knoxville	



Stable growth
in midsize metro

Akron	Little Rock
Augusta	New Haven
Baton Rouge	Springfield
Bridgeport	Syracuse
Columbia	Toledo
Dayton	Wichita
Honolulu	

Figure A1. 2021 City Scorecard typology groups