

Sustaining the City: Trends in Energy and Carbon Management in Large US Metros

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ABSTRACT

Most good definitions of sustainability include economic, social, and environmental aspects. In this paper, two particular areas of sustainability related to all three components are investigated: energy and CO₂ emissions. As of this writing, more than 1000 cities in the United States have signed the Mayor's Climate Protection Agreement, but only 15% have created comprehensive estimates of their existing energy consumption and emissions profiles, making management a difficult task. In this paper, we provide estimates of both of these measures for the residential and commercial sectors for the 100 largest metropolitan statistical areas (MSAs) in the United States over the 2000-2010 period. This tracks the progress towards sustainable development in major urban areas nationally, identifying leaders and laggards, as well as opportunities for improvement.

For example, the commercial building sector in each MSA is divided into 12 building types in this analysis, so while the entirety of the commercial sector of a given MSA may be high performing, specific building types may be targeted for additional improvements in energy efficiency. The differentiated economic geography of local economies also suggests areas for focus due to scale – if a high proportion of commercial energy consumption takes place in the health care subsector, expanded efficiency programs may be warranted, even with high performance buildings. In sum, we expect this research to fill a major gap in the existing literature and to have real-world policy relevance for energy efficiency efforts in the areas where the vast majority of U.S. wealth and innovation are produced.

Introduction

Climate change remains one of the most pressing, multi-generational sustainability problems facing society. Its spatial and temporal scale has led many to the conclusion that the solution is an international accord, or at least a collection of nation-scale policies from the major emitters of greenhouse gases (Hansen et al., 2013). However, progress on this front has been lacking, given the time constraints to limit global warming to 2°C, as the international community agreed to at the Cancun Conference of the Parties in 2010.

The decades-long history of failure of international negotiations has led some to begin to argue that successful actions at smaller scales may ultimately prove to be the path towards addressing climate change (Ostrom, 2009). While greenhouse gases create a global problem, these emissions are strongly driven by economic activities that tend to occur in local consumption centers (Cox, Brown, & Sun, 2013). Focusing locally can enable easier measurement, policy experimentation, democratic community engagement, and new platforms for sharing best-practices between communities (Mulugetta, Jackson, & van der Horst, 2010).

The scale and challenges of climate change have led to its description as a super wicked problem and the perfect moral storm (Gardiner, 2006; Lazarus, 2009). Recent findings that past research was too optimistic, that current emissions trends exceed the worst-case scenarios of previous climate change synthesis reports, and that the window to cap warming at 2°C may well close by 2017, suggests that we should highlight “urgency” on the list of climate change problems (Arnell et al., 2013; International Energy Agency, 2011; Peters et al., 2013).

Aware that many of the costs associated with climate change may accrue to them and armed with a sense of moral duty, over 1000 mayors have signed the Mayor’s Climate Protection Agreement, committing their cities to meeting the would-have-been goals of the Kyoto Protocol for the United States as whole within their jurisdictions. There is reason to be hopeful about such efforts; research has found that local governments can be effective in pursuing broad climate change goals (Lee & Koski, 2012; Mazmanian & Kraft, 2009). But while these mayors have committed 90 million citizens to reducing emissions of greenhouse gases, most have not committed the resources necessary to quantify these emissions; less than 15% have formal Climate Action Plans (ICLEI, 2009). Without such information, city governments are trying to change direction without a baseline of metropolitan emissions (Krause, 2011). The presence of a goal or a plan (even a good one) may not be enough to actually produce different outcomes at local scales (Chandler, 2011). Given that nearly all of the largest US cities have signed the Mayor’s Climate Protection Agreement and also developed a sustainability or climate plan, the logical next steps are baselining energy consumption and emissions to understand where targeted actions may produce benefits (Cox, 2013). Many such actions may have beneficial spillover effects in the micro- and macroeconomy, particularly those related to energy efficiency (Brown, Baer, Cox, & Kim, 2014; Young & Mackres, 2013)

In US cities, most greenhouse gases are the result of energy consumption in buildings and transportation. Population, economic productivity, energy intensity, and carbon intensity (kgCO₂/MMBtu, eg) are major drivers of local emissions. Restricting emissions without negatively impacting population or economic growth requires expanding the use of low carbon energy and energy efficiency. The progress cities and metro regions have made in these areas has been partially quantified. The residential sector is the most-consistently studied sector by academics, although variations in data and methods have led to estimates that vary by up to 40% across these studies (Brecha, Mitchell, Hallinan, & Kissock, 2011; Brown, Southworth, & Sarzynski, 2009; Glaeser & Kahn, 2010; Jones & Kammen, 2011). A couple of these studies also included estimates for the transportation sector with similar methodology-driven divergences.

Guidance for local management of residential energy consumption is therefore available. On the other hand, the commercial sector has not been subject to the same degree of study, with no known comprehensive, academic studies of the sector at the city or metropolitan region scale. Our research steps into this gap, providing an estimate of energy and carbon emissions for the 100 most-populated metropolitan statistical areas (MSAs) in the US, focusing on the building types that drive these figures in MSAs. It also produces a 2010 estimate for the residential sector of all these MSAs, detailing leaders in the area as well as those with room for improvement. We use common EIA delimiters to define the sectors, studying the energy and emissions driven by activities within buildings. These MSAs produce 72% of US GDP and house 65% of the US population; with good management by these actors, US CO₂ emissions could be substantially reduced.

Methodology

The footprinting methodology used for this analysis is a combination of three major work efforts to categorize utility, residential, and commercial sector energy consumption and the resulting CO₂ emissions. The methods used to categorize each of these sectors are described in the following paragraphs.

Residential and Commercial Sector Methodology

The methodology for determining residential energy consumption and carbon emissions relies heavily on the Energy Information Administration's State Energy Data System (EIA, 2012). Per-capita estimates for energy consumption from on-site uses of coal, natural gas, petroleum-based fuels, and wood are calculated as the average for a person residing in the state where the economic and population center of the MSA exists (see Brown et al., 2008 for more detail). These energy consumption per-capita estimates could then be multiplied by the emissions factors for each fuel, which results in per-capita CO₂ emissions from each fuel. This exercise was undertaken for years 2000, 2005, and 2010. While this method is suitable for estimates of on-site fuel consumption, a more-specific estimate was developed for electricity to account for variations in electricity supplies, as described later in the paper.

For the commercial sector footprints, the number of buildings by building type for each MSA was estimated. Using the 2003 Commercial Building Energy Consumption Survey (CBECS) Microdata, buildings were grouped into twelve building types (assembly, education, food sales, food service, healthcare, large office, lodging, mercantile/service, small office, warehouse, other, and vacant). A total of 372 Monte Carlo simulations were run on this microdata to produce energy consumption estimates for electricity, natural gas, and fuel oil for each building type and census division. Since these values are specific to 2003, they were adjusted by the change in annual, state-specific commercial sector energy intensity for the commercial sector in the state where the economic center of the MSA exists to adjust to the year-of-interest. Energy intensities were calculated using the State Energy Data System and the Regional Economic Accounts from the Bureau of Labor Statistics.

To derive specific MSA estimates, CBECS microdata employees-per-building estimates were calculated for the same twelve building types in the nine census divisions. Using the American Community Survey (ACS) microdata stored in the Integrated Public Use Microdata Series (Ruggles et al., 2010), we matched every combination of 3-digit North American Industry Classification System (NAICS) code between 423 and 928 (representing the commercial sector) and the 492 ACS occupation codes to a building type. As the ACS occupation codes varied between 2010 and 2005, this was repeated for 2005. Using these codebooks, the nearly-3,000,000 respondents to the ACS in 2005 and 2010 could be matched to a building type in each MSA. Similar data from the 2000 decennial census was used for that year. Combining these employment-by-building type data with the employees-per-building estimates determined the number of buildings by building type in each of the 100 largest MSAs. Energy consumption could then be calculated based on the Monte Carlo analysis, along with the resulting CO₂ emissions. As with the residential sector, the electricity analysis is more complex and is specific to the utility serving the MSA.

Electric Utility Sector Methodology

The EIA collects data on the annual electricity generation by fuel with form EIA-923. Using maps of electric utility territories, the 100 largest MSAs were assigned to one of these utilities. When a utility serving an area purchased power to meet demand (reported in financial filings), the purchased energy was accounted for by weighting the generation mix with the characteristics of the power generator. The sole exception to this rule was if more-than-four transactions were required to get to the generator. In this instance, the average annual generation mix for the North American Electric Reliability Corporation (NERC) region was used to represent the generation mix in power purchases. This applies largely to utilities operating in deregulated New England markets, including 10 MSAs.

In cases where an MSA was served by multiple utilities, population-weighted territories were calculated. If one of the utilities covered a much greater footprint than the MSA and territories were not clearly divided by county, population-weighted values (of individuals and establishments) are calculated for the utility most-contained in the MSA border. The remainder of the population is assessed the characteristics of the spatially-larger utility. For example, the Salt River Project (SRP) and the Arizona Public Service Company (APS) serve the Phoenix-Mesa-Scottsdale AZ MSA. APS also serves most of the rest of Arizona. 2010 Census data was used to calculate persons-per-household for the counties in the MSA; multiplying this number by SRP residential customers produces the residential population receiving SRP power; the remainder is allocated to APS.

To understand source energy consumption and calculate the carbon intensity of electricity, measured in kgCO₂/kWh, the average heat rate by generation type for each utility was collected. These values are multiplied by the appropriate CO₂ emission factor to calculate kgCO₂/kWh for each power plant fuel type; weighting these values by generation and adjusting for transmission and distribution losses (using state averages, as reported in the State Electricity Profiles (U.S. Energy Information Administration, 2012)) determine utility-wide kgCO₂/kWh. These values are applied to the MSA, and weighted by population if necessary. This process is completed for 2000, 2005, and 2010.

Form EIA-861 collects information from utilities on electricity sales by sector and number of customers. From this data, average electricity consumption per residential customer (household) could be matched to MSAs within a utility territory. This data was then divided by the number of persons per household in each MSA, as reported by the US Census Bureau¹. The result is an estimate of per-capita residential electricity consumption by utility. If an MSA is served by multiple utilities, sales-weighted averages are used to determine the same value. Dallas, Houston, and San Antonio are the only MSAs where this methodology was not applied; the deregulated electricity market in Texas and the lack of a central generating utility for these MSAs made such a match impossible, as EIA-861 does not report values for companies that purchases electricity from the grid and then sell to a local market (as is the case for the majority

¹ In 2000, the US Census Bureau did not produce MSA-specific estimates of persons per household; in this instance, the average ratio between persons-per-household in the metro and state in 2005 and 2010 was multiplied by the year 2000 state-level persons-per-household to estimate MSA values for 2000.

of electricity sold in these three MSAs). For these three, Texas-wide averages for electricity consumption are used.

In the commercial sector analysis, site consumption of electricity was determined through the analysis detailed above. The average heat rates and carbon intensity for the utilities serving commercial load in an MSA were matched to the site consumption, adjusted for transmission and distribution losses, and used to calculate source energy totals as well as resulting CO₂ emissions.

Results and Discussion

Residential Sector Results

Across the past decade, residential energy footprints ranged from 22.7 Trillion British thermal units (TBTus) (Trenton-Ewing NJ MSA, 2000) to 1106 TBTus (New York City MSA, 2005) a ratio of 49-to-1. Across the 100 MSAs, total residential energy consumption increased from 11.9 Quadrillion British thermal units (Quads) in 2000 to 12.7 Quads in 2010. EIA shows national residential energy consumption increased from 20.4 Quads in 2000 to 21.9 Quads in 2010, meaning energy consumption grew by about 7% at both scales. Electricity is the most-used energy source, accounting for 67% of the average MSA's residential energy consumption. When comparing primary energy consumption, this value is three times greater than the next closest energy source (natural gas). Figure 1 shows the size of the residential energy footprints across the decade.

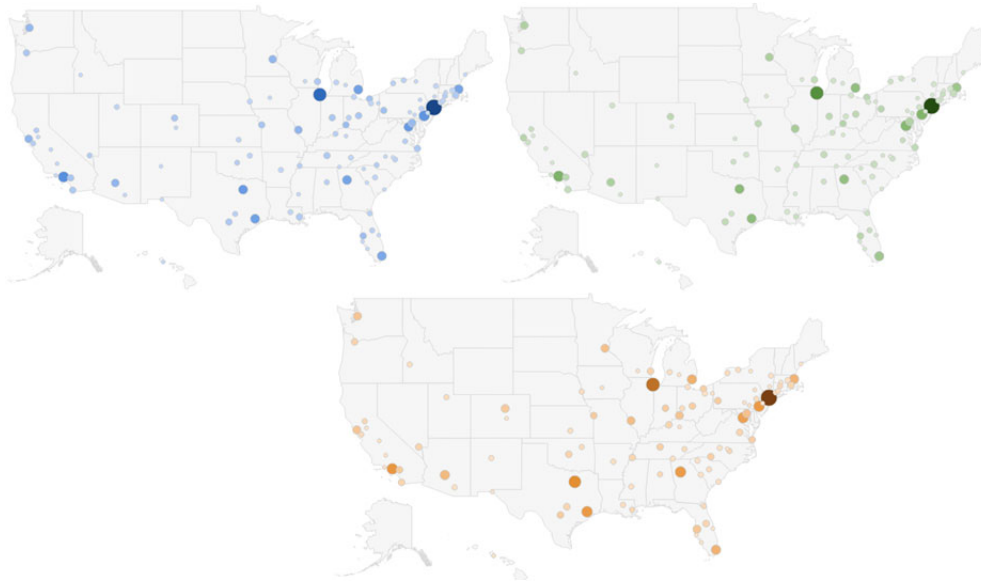


Figure 1. Residential energy footprints in 2000 (blue), 2005 (green), and 2010 (orange).

Per-capita measures of energy consumption ranged from 34.2 MMBtu/capita (Los Angeles CA, 2000) to 94.9 MMBtu/capita (Lexington KY, 2010). In terms of differences, Las Vegas showed the biggest decline between 2000 and 2010, a reduction of 16.7 MMBtu/capita,

while Dallas showed the greatest growth (8.1 MMBtu/capita). Table 1 provides a glimpse at the MSAs making the most progress and those with more room for improvement.

Table 1. 2010 residential energy intensity leaders and laggards

	Overall	Electricity	Natural gas
Leader #1	Los Angeles, CA	Los Angeles, CA	Honolulu, HI
Leader #2	San Diego, CA	San Diego, CA	Portland, ME
Leader #3	Honolulu, HI	New York City, NY	7-way tie
Laggard #1	Lexington, KY	Baton Rouge, LA	Chicago, IL
Laggard #2	Chattanooga, TN	Chattanooga, TN	Detroit, Lansing, & Grand Rapids, MI
Laggard #3	Cincinnati, OH	Lexington, KY	Denver, CO & Colorado Springs, CO
Most Improved (Absolute/%)	Las Vegas, NV (both)	Las Vegas, NV (both)	Detroit, Lansing, & Grand Rapids, MI/Scranton, PA
Least Improved (Absolute/%)	Dallas, TX (both)	Lexington, KY/Philadelphia, PA	Worcester, Springfield, & Boston, MA (both)

In general, the best performing cities tend to be located in mild coastal climates. Las Vegas achieved reductions across the board, showing an 11% reduction in electricity consumed on-site (27% in source terms) and a 10% reduction in the consumption of all other fuels. Boston shifted away from fuel oil towards natural gas, resulting in an increase in natural gas use per capita. Detroit shows signs of a fuel shift from natural gas to electricity, although the natural gas decline is greater than the uptick in all other fuels (including electricity), suggesting conservation and efficiency are also playing a role in Detroit.

Carbon emissions are highly variable across the MSAs due to electricity generation fuel sources and the distribution of energy consumption between the fuels used in the residential sector. In general, the meaningful difference is between electricity-related emissions and emissions from on-site natural gas consumption. Total footprints range in size from 0.6 MMTCO₂ (Stockton, CA, 2010) to 49.2 MMTCO₂ (New York City, 2000) a ratio of 82-to-1. Because they combine energy use with carbon intensity, the total MSA carbon footprints are more wide-ranging than are total MSA energy footprints. Per-capita carbon footprints range from 0.9 mtCO₂ (Bakersfield CA, 2010) to 8.3 mtCO₂ (Lexington KY, 2010). Las Vegas experienced the greatest reduction in per-capita CO₂ emissions at 1.8 MTCO₂ (a 35% reduction from 2000), while Orlando experienced the greatest increase (2.4 MTCO₂, a 133% increase from 2000).

Commercial Sector Results

Commercial sector energy consumption is influenced by the fuels used in the sector, driven by the types of buildings and the economic composition of the MSA-in-question. Electricity plays an even-larger role in meeting the energy demands in the 100 MSAs' commercial sector, comprising nearly 60% of site demand and over 80% of source energy consumption in 2010. We estimate the entire sector in these MSAs consumed 11.2 Quads in 2010, down from nearly 14 Quads in 2000. Compared to national trends that showed a 5% uptick in commercial energy consumption, growth must be coming from the smaller MSAs and in rural communities. MSA-wide commercial consumption estimates range from 25.1 TBtus (Charlotte

NC, 2005) to 815 TBtus (New York City, 2000). On average, energy consumption in 2010 was 19% lower than in 2000. Figure 2 shows the commercial energy consumption by MSA.

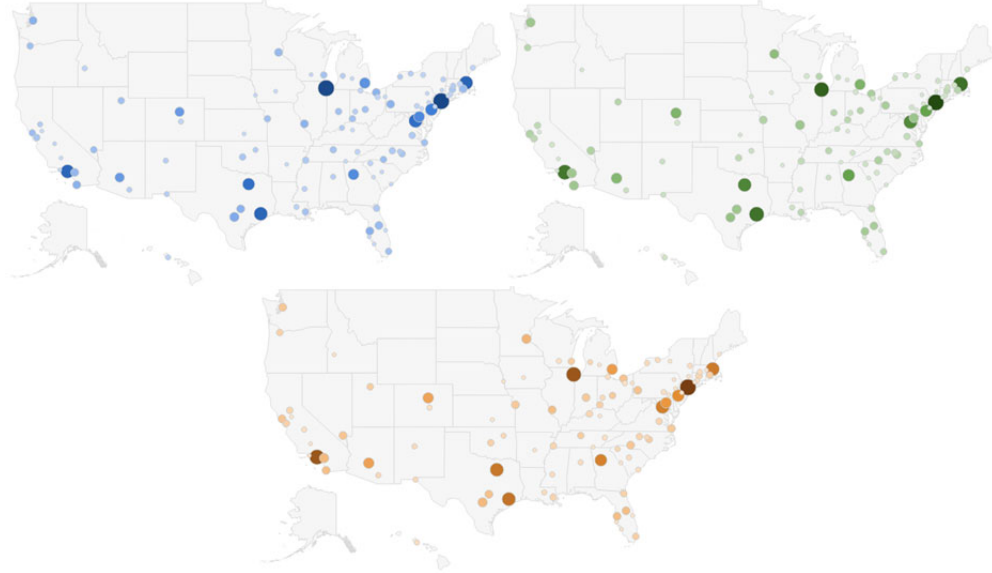


Figure 2. Total commercial energy consumption in 2000 (blue), 2005 (green), and 2010 (orange).

Given the importance of electricity as an energy source in the commercial sector, the carbon intensity of the electricity supply strongly influences the overall carbon footprints. In 2000 and 2010, Chicago has the largest overall footprint at 132 MMTCO₂ and 87 MMTCO₂, respectively. In 2005, Washington, DC's 74 MMTCO₂ tops the list. Smaller MSAs in California show the lowest carbon emissions, with Stockton and Bakersfield producing ≤ 0.25 MMTCO₂.

The types of buildings responsible for the largest share of energy varies by MSA, but in the largest MSAs, mercantile/service buildings are dominant consumers. For example, in Los Angeles, mercantile/service buildings are estimated to consume nearly 45% of commercial energy consumption. These buildings are the largest consumers in Chicago and New York as well. Lodging and educational services buildings are distant second and thirds in these MSAs, accounting for roughly 15% and 10%, respectively (Table 2).

Table 2. Commercial energy consumption by building type in the three largest commercial energy consuming MSAs

% of Total Energy	New York MSA			Chicago MSA			Los Angeles MSA		
	2010	2005	2000	2010	2005	2000	2010	2005	2000
Assembly	4.5	1.6	4.5	7.1	7.0	6.8	3.2	5.7	3.7
Education	10.3	11.5	11.2	11.0	10.9	10.8	8.4	8.1	8.5
Food Sales	0.4	0.5	0.5	1.2	1.2	1.2	0.1	1.2	1.2
Food Service	6.5	5.7	6.0	7.3	6.6	6.6	8.1	7.6	8.1
Health Care	8.8	8.1	8.2	8.0	7.7	7.7	5.4	5.3	5.7
Large Office	8.3	8.8	8.2	7.5	7.7	7.7	5.6	5.5	5.5
Lodging	16.7	16.6	15.8	13.6	12.8	12.7	13.4	11.4	12.0
Mercantile/Service	32.2	34.6	33.1	31.1	32.6	32.9	44.1	44.5	45.0
Other	3.6	3.8	3.7	4.3	4.4	4.4	3.2	3.0	3.1
Small Office	5.8	6.1	5.9	7.1	7.3	7.3	5.0	4.9	4.9

Vacant	1.1	1.1	1.2	1.2	1.2	1.2	0.7	0.7	0.1
Warehouse	1.5	1.6	1.6	0.7	0.7	0.7	2.0	1.7	1.7

Lastly, commercial energy intensity (measured in energy per GDP), by building type and overall, was calculated for each MSA. Energy intensities range from 0.4 kBtu/\$-2005 (Bridgeport CT, 2010) to 6.1 kBtu/\$-2005 (Durham NC, 2000). Looking at the largest energy-consuming building types (mercantile/service, lodging, and health care), we continue to find significant variation, as summarized in Table 3.

Table 3. Leaders and laggards in commercial energy intensity in 2010

	Overall	Mercantile/Service	Lodging	Health Care
Leader #1	Miami, FL	Bridgeport, CT	Bridgeport, CT	Des Moines, IA/San Francisco, CA
Leader #2	San Francisco, CA	Miami, FL/New York City, NY	San Francisco, CA	Miami, FL/Omaha NE/Seattle, WA
Leader #3	New York City, NY	Des Moines, IA/San Francisco, CA	Seattle, WA	Kansas City, MO/Los Angeles, CA/Minneapolis, MN/San Jose, CA
Laggard #1	Greenville, SC	Durham, NC	El Paso, TX/Greenville, SC	Springfield, MA
Laggard #2	Greensboro, NC	Greenville, SC	Tucson, AZ	Worcester, MA
Laggard #3	Durham, NC	Austin, TX/El Paso, TX/Greensboro, NC	Greensboro, NC	Providence, RI
Most Improved (Absolute/%)	Durham, NC/Seattle WA	Durham, NC/Des Moines, IA	Durham, NC/New Haven, CT	Providence, RI/Durham NC
Least Improved (Absolute/%)	Detroit, MI (both)	Detroit, MI & Minneapolis, MN/Minneapolis, MN	Youngstown, OH/Detroit, MI	Detroit, MI & Greenville, SC/Detroit, MI

Discussion

The five largest residential energy footprints are found in the same MSAs across all years, which tend to be the most populated. New York City, Chicago, Dallas, Washington DC, and Philadelphia (the last two alternate between 5th and 6th across the decade, with Washington taking 5th in 2010) have held these positions, although the trends are not the same for these areas. For example, New York's footprint declined by over 100 TBtus, while Dallas experienced growth of nearly 150 TBtus, highlighting the regional variation.

The five smallest energy footprints are also similarly consistent, with Trenton NJ, El Paso TX, Honolulu HI, Stockton CA and Bakersfield CA/Melbourne FL holding these positions across the decade. The alignment of these footprints with low population is less consistent; while Trenton is the smallest by population and footprint, none of the rest of the five-smallest group is one of the ten smallest by population.

Generally, residential per-capita energy footprints are shrinking, averaging a reduction of 1.8 MMBtu/capita, or about 3%, across the decade. However, 44 MSAs showed an increase over 2000 levels. These MSAs tend to be in the Midwest and the South, with only Denver,

Philadelphia, Pittsburgh, Los Angeles, and Tucson breaking that trend. While Los Angeles is 2nd overall in residential per-capita energy consumption (see Table 1), it has lost some ground on the energy-efficiency front. The leaders have more room for improvement.

In residential electricity consumption, only 29 MSAs show declines in per-capita electricity consumption since 2000. These 29 are widely distributed across the country, but largely miss the Midwest Region – Chicago is the only Midwestern MSA to show a decline in per-capita electricity consumption. In absolute values of improvement, Las Vegas is the clear leader, reducing residential electricity consumption by nearly 15 MMBtu/capita, followed by Portland (OR), San Francisco, and Seattle. As a percent change, Las Vegas leads all other MSAs across the decade, followed by San Jose, Bakersfield CA, and Fresno. Lexington, KY, Baton Rouge, and Indianapolis show the largest absolute increases in electricity consumption, while Pittsburgh, Philadelphia, Des Moines and Cincinnati show the largest percentage increases in electricity consumption per capita. Given Cincinnati's position as the 3rd most-intensive MSA already, this finding suggests that much more effort is required here.

The picture for the Midwest is rosier in looking at natural gas efficiency. Even though the Michigan MSAs (Detroit, Lansing, and Grand Rapids) rank 2nd-lowest for natural gas efficiency, they have shown the greatest absolute improvement. In percentage terms, Little Rock, Louisville, and Lexington show the greatest improvement, with 17 of the next 18 “most improved” MSAs residing in the Midwest. In many of these jurisdictions, it appears that fuel switching may at least partially explain these rankings, with many MSAs seeing nearly 1:1 tradeoffs between on-site electricity and natural gas.

The vast majority of MSA commercial sectors saw improvement over the past decade; 96 saw a decrease in energy intensity. Average reductions were 850 Btus/\$, which is substantial, as average intensity was 2700 Btus/\$ in 2000. Only Minneapolis and Detroit experienced an increase in energy intensity.

It is possible that part of the energy intensity trend is attributable to the economic recession. In the commercial sector, energy intensity improvements are fastest between 2000 and 2005. Perhaps the recession slowed investments in efficiency that occurred prior to the recession. The residential sector tells a more convincing recession-style story, where intensity increased between 2000 and 2005, then decreased between 2005 and 2010; this matches intuitions about energy consumption and personal income, if energy intensity were reflecting conservation efforts instead of efficiency. A t-test of 2000 and 2010 intensities shows that these changes were not statistically significant in the residential sector, but were in the commercial sector.

Durham, NC, while having the 3rd-highest energy intensity in 2010, appears to have also made the most absolute progress between 2000 and 2010, shaving nearly 2600 Btus/\$. In percentage terms, Seattle, Portland (OR), and Washington, DC, all showed nearly 50% improvements.

Our dataset also shows the importance of efficiency efforts for managing CO₂ emissions, especially when the electricity provider is not directly under municipal control. For example, Chicago, in 2000, had very carbon-intensive electricity, ranking 81st out of 100. By 2005, ComEd (Chicago's electricity provider) had changed contracts and purchased largely nuclear power – as a result, Chicago's carbon intensity declined, ranking 8th lowest in that year. By 2010, contracts had again changed, and Chicago was 76th overall, very close to where it had started the

decade. Philadelphia is an example where an energy purchasing utility worked to reduce CO₂ emissions across the decade, starting with a rank of 47th in 2000 and improving to 1st in 2010.

Comparison to ACEEE Scorecard

The American Council for an Energy Efficient Economy produced a report ranking cities on their energy efficiency (Mackres et al., 2013). Most of the energy and carbon data for specific cities came from the cities' own reports, and ACEEE notes the incomparability of one city to another due to discrepancies in methodology and reporting. ACEEE does provide a ranking of cities based on existing policies and efforts underway, which rates Seattle, New York City, Austin, Boston, Washington DC, and San Francisco as the leaders in building energy policies. Many of these cities' MSAs score well in this analysis as well; Seattle, New York City, San Francisco, and Washington DC all score in the top 10 in commercial energy efficiency. Boston and Austin do not fare quite as well, placing 28th and 92nd, respectively. Residential performance seems less well-connected to the buildings policies scores; four of these leading cities have residential energy intensities in the top thirty, but Boston is 33rd and Washington DC is 54th.

Conclusion

This study estimated and reviewed the progress in energy consumption in the 100 largest MSAs between 2000 and 2010 and provided the first academic estimate of commercial sector energy consumption and carbon emissions for these MSAs. The overall trend is that energy efficiency is improving across the largest MSAs in the United States and carbon emissions are falling. Energy efficiency has become a major policy issue in states and cities across the US during the past decade, due to its many benefits and bipartisan appeal. While this analysis cannot detail which policies had what effect, the evidence is clear that many MSAs made progress on these key aspects of energy and climate policy. The comparison to the ACEEE Scorecard also suggests that leaders in policy are not necessarily leaders in performance, and time lags between adopting policy and seeing results are important to keep in mind.

Certain aspects are worthy of special mention. In many cities, the primary means to control carbon emissions from electricity is through energy efficiency measures. This is typically the case when a major MSA falls within a utility territory that is much larger geographically, or when the utility serves more than just that MSA. Instances where the major utility is an energy purchaser (and thus has little in the way of generating capacity), MSAs can frequently experience rapid shifts in the carbon intensity of their electricity supply. Our dataset highlights how this can be both beneficial and harmful to CO₂ emissions overall.

Rapid improvements would be much more difficult to achieve for a utility locked-in to a fleet of generation plants. Our data shows some examples of large investor-owned utilities making significant changes over the course of the decade, led by Oklahoma Gas and Electric, which showed a 28% decline in carbon intensity. But this is not akin to the 99% decline seen in Chicago between 2000 and 2005; change in these MSAs will be a longer-term process, requiring action on a number of fronts.

This work should enable studies of effective policies as well as assist MSAs with managing energy and carbon emissions. It helps to fill a gap, enabling consistent comparisons within and between MSAs. These results can serve as an important benchmark. While the

literature suggests a diffusion of policies from central cities to other jurisdictions within the MSA is a regular occurrence, it is true that these city councils and mayors do not govern the MSA itself in almost all cases. Some cities in this analysis may have met their MCPA goals while the larger metro region did not. Urban form and population density are also drivers of energy use that deserve further investigation as causes of these results. Future research should also explore the specific variations by building type and fuel use to provide more particular policy guidance and identify best practices for governments engaged in these problems.

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