Blueprint for American Prosperity
Unleashing the Potential of a Metropolitan Nation

SHRINKING THE CARBON FOOTPRINT OF METROPOLITAN AMERICA

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EXECUTIVE SUMMARY

America's carbon footprint is expanding. With a growing population and an expanding economy, America's settlement area is widening, and as it does, Americans are driving more, building more, consuming more energy, and emitting more carbon. Rising energy prices, growing dependence on imported fuels, and accelerating global climate change make the nation's growth patterns unsustainable.

Metropolitan America is poised to play a leadership role in addressing these energy and environmental challenges. However, federal policy actions are needed to achieve the full potential of metropolitan energy and climate solutions.

America's Challenge

The nation's carbon footprint has a distinct geography not well understood or often discussed. This report quantifies transportation and residential carbon emissions for the 100 largest U.S. metropolitan areas, finding that metro area residents have smaller carbon footprints than the average American, although metro footprints vary widely. Residential density and the availability of public transit are important to understanding carbon footprints, as are the carbon intensity of electricity generation, electricity prices, and weather.

Limitations of Existing Policies

Numerous market and policy distortions inhibit metropolitan actors from more aggressively addressing the nation's climate challenge. Economy-wide problems include underpriced energy, underfunded energy research, missing federal standards, distorted utility regulations, and inadequate information. Policy impediments include a bias against public transit, inadequate federal leadership on freight and land-use planning, failure to encourage energy- and location-efficient housing decisions, and the fragmentation of federal transportation, housing, energy, and environmental policies.

A New Federal Approach

Federal policy could play a powerful role in helping metropolitan areas—and so the nation—shrink their carbon footprint further. In addition to economy-wide policies to motivate action, five targeted policies are particularly important within metro areas and for the nation as a whole:

- **Promote more transportation choices** to expand transit and compact development options

- **Introduce more energy-efficient freight operations** with regional freight planning

- **Require home energy cost disclosure when selling and “on-bill” financing** to stimulate and scale up energy-efficient retrofitting of residential housing

- **Use federal housing policy** to create incentives for energy- and location-efficient decisions

- **Issue a metropolitan challenge** to develop innovative solutions that integrate multiple policy areas

I. INTRODUCTION

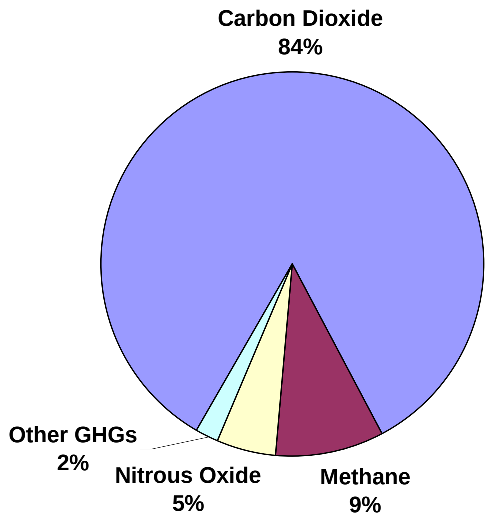
It is increasingly clear that climate change presents a serious global risk and demands an urgent response. With a growing population and an expanding economy, America's settlement area is widening and as it does, Americans are driving more, building more, consuming more energy, and emitting more carbon. Not surprisingly, how and where Americans live, work, and play are important issues for the nation's sustainability and energy security.

Carbon dioxide accounted for 84 percent of U.S. greenhouse gas (GHG) emissions in 2005, and is one of the most important contributors to climate change (see Figure 1). The vast majority of anthropogenic carbon dioxide is released when we burn carbon-based fuels, such as coal and oil, for energy.[1] (Here, the terms "carbon emissions" or "carbon footprint" both indicate emissions of carbon dioxide.)

Residential and commercial buildings alone account for 39 percent of the carbon emissions in the United States. Transportation accounts for one-third of U.S. emissions, and industry is responsible for 28 percent. An effective climate strategy must focus on reducing carbon emissions from all three sectors.

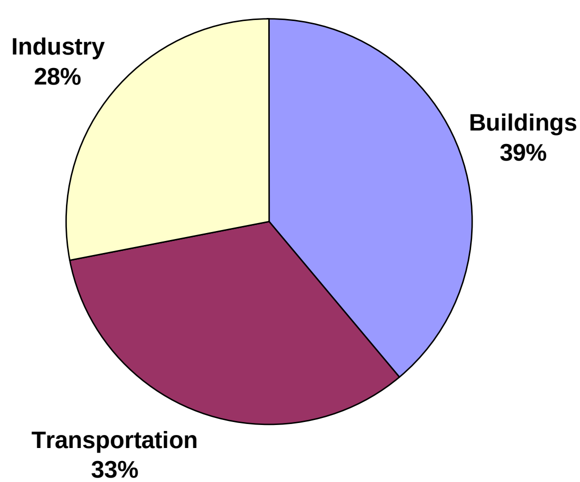
FIGURE 1
Carbon Dioxide Is the Most Prevalent Greenhouse Gas (GHG) Emitted in the United States, and It Primarily Comes from the Energy Used in Buildings and Transportation

U.S. GHG Emissions (2005)



Source: Environmental Protection Agency

U.S. CO_2 Emissions by Sector (2005)



Source: Energy Information Administration

Meeting the climate challenge requires adaptations and innovation in metropolitan America. With two-thirds of the U.S. population and nearly three-quarters of the nation's economic activity residing in the nation's 100 largest metropolitan areas, urban centers account for much of the nation's GHG emissions. At the same time, metropolitan America is the traditional locus of technological, entrepreneurial, and policy innovations. Its access to capital and a highly trained workforce have enabled metropolitan areas to play a pivotal role in expanding U.S. business opportunities while solving environmental challenges.

With 825 mayors having signed the U.S. Mayor's Climate Protection Agreement, metropolitan actors are at the forefront of state and national climate action. However, the lack of adequate data on emissions and comparative analysis make it difficult to confirm or refute best practices and policies. To help provide benchmarks and expand our understanding of carbon emissions, this report ranks the 100 largest metro areas by carbon emissions in 2000 and 2005 and quantifies the largest sources of carbon in these U.S. metropolitan areas. It does this by examining the fuels used by vehicles (personal and freight) and the energy used in residential buildings.[2] The carbon emissions from transportation and residential sources—discussed here as the metro area's partial carbon footprint—provide a foundation for identifying the pricing, land use, and other policy interventions that could reduce the energy consumption and carbon emissions of metropolitan America.

Numerous market and policy distortions inhibit metropolitan actors from more aggressively addressing the nation's climate change and energy security challenges. Five federal actions would create market incentives for a climate-friendly built environment, including putting a price on carbon; increasing energy research, development, and demonstration (RD&D); establishing a national renewable portfolio standard; helping states reform their electricity regulations; and improving information collection and dissemination on energy consumption, GHG emissions, and best practices.

Five additional federal initiatives would offer a powerful and complementary set of incentives to encourage energy-efficient, compact development and the use of low-carbon fuels in metropolitan America. These include 1) promoting more transportation choices to expand transit and compact development; 2) introducing more energy-efficient freight operations with regional freight planning; 3) requiring disclosure of home energy costs at purchase in combination with creative financing options for energy-efficient retrofitting; 4) using federal housing policy to create incentives for energy- and location-efficient decisions; and 5) issuing a metropolitan challenge to develop innovative solutions that integrate disparate policies on transportation, housing, energy, and environment.

"Shrinking the Carbon Footprint of Metropolitan America" is part of the *Blueprint for American Prosperity*, a multi-year initiative of the Brookings Institution Metropolitan Policy Program to put forth an integrated federal policy agenda that provides cities, suburbs, and metro areas with tools to leverage their economic strengths, grow in environmentally sustainable ways, and create opportunities to build a strong and diverse middle class. In this framework, environmental sustainability—particularly reduced carbon emissions—stands as a fundamental and crucial "driver" of long-term prosperity, and as such is the subject of several papers in the *Blueprint* series. Other papers in the series describe transforming the U.S. transportation system, encouraging energy-efficient improvements and practices by middle-class homeowners, and expanding and redeploying energy RD&D through energy-discovery institutes.

II. THE CLIMATE CHALLENGE FACING METROPOLITAN AMERICA HAS MANY FACETS

Greenhouse gas emissions are increasing, and the U.S. carbon footprint is expanding. Since 1980, carbon emissions in the United States have increased by almost 1 percent each year.[3] Emissions from the residential, commercial, and transportation sectors each increased by more than 25 percent during the past 25 years.[4] Industrial emissions have declined during this same period as the country has moved away from energy-intensive manufacturing and toward a service and knowledge economy. Much of what Americans once manufactured is now being imported from China, India, and other countries, thereby lessening U.S. greenhouse gas accounts.[5]

As a result, consumers are increasingly the driving force of domestic energy consumption and carbon emissions. Residential and commercial buildings and road transportation are expected to dominate energy demand and carbon growth in the future. Total U.S. carbon emissions are projected to grow by 16 percent between 2006 and 2030, making reductions all the more urgent to avoid the worst potential effects of a warming planet.[6]

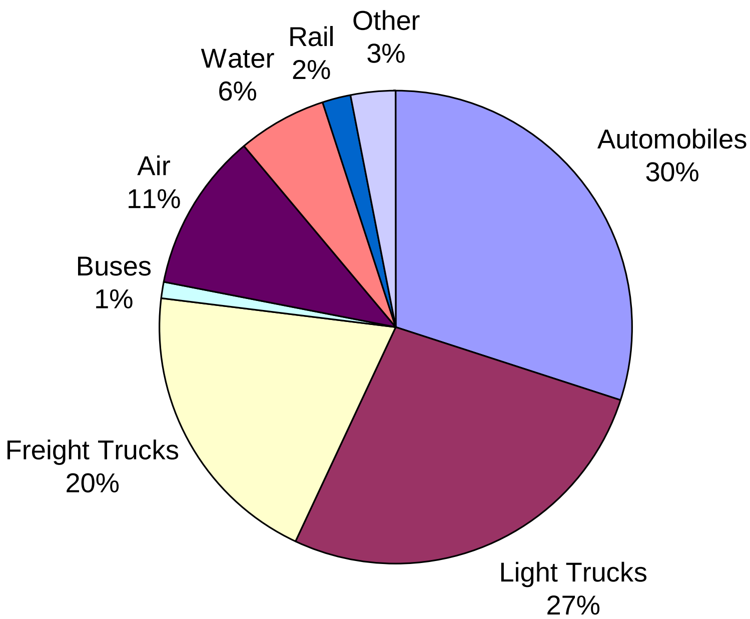
Four factors determine carbon emissions: (1) population, (2) economic output, (3) energy intensity of the economy, and (4) carbon intensity of the economy.[7] Shrinking the nation's carbon footprint, while allowing for population and economic growth, requires a strategic focus on reducing the *energy intensity* or *carbon intensity* of the U.S. economy. This requires either reducing the amount of energy needed to power the economy or reducing U.S. reliance on high carbon emitting fuels, such as coal. Reductions can be made in each sector as well as through multisector approaches.

Reductions will not be easy. Energy intensity is much higher in the United States than in many other developed countries. Even despite recent improvements, U.S. energy intensity is approximately two times higher than in Japan.[8] Although China overtook the United States and Europe in 2006 to become the world's largest carbon emitter, the United States will likely remain one of the most carbon-intensive nations, based on carbon emissions per capita.[9]

1. *The transportation sector accounts for much of the country's carbon emissions*

Transportation is responsible for one-third of the nation's carbon footprint, or 534 million metric tons of carbon emissions in 2005. Highway transport accounted for 80 percent of this total, dominated by automobiles (30 percent), light duty trucks (at 27 percent), and freight transport (at 20 percent) (See Figure 2). Air- and water-based transport are responsible for a majority of the remainder. The transportation sector is also the fastest growing. Between 1991 and 2006, transportation accounted for nearly one-half of the growth in U.S. carbon emissions.[10] With its dominant contribution to transportation emissions, highway transport trends deserve attention.

FIGURE 2
Automobiles and Trucks Produced Three-Quarters of the Nation's Carbon Emissions from Transportation in 2005



Source: Energy Information Administration

Suburbanization and rising wealth following World War II dramatically transformed American living and driving patterns. The country saw a ubiquitous increase not only in daily travel distances, but also in the frequency with which households used their vehicles to get to work, to shop, and to carry out a variety of personal business trips. Between 1970 and 2005, the average annual vehicle miles traveled (VMT) per household increased almost 50 percent, from 16,400 to 24,300.[11] At the same time, vehicle ownership per household increased even as average household size fell.[12] Commercial truck travel increased even more rapidly than passenger travel, at an annual rate of 3.7 percent compared with 2.8 percent for passenger travel.[13] Increased travel is responsible for worsening traffic congestion, wasted fuel, and rising carbon emissions.[14]

Despite significantly improved automotive engine technologies, miles per gallon (mpg) gains have leveled off since the mid-1980s, in part due to consumer preference for more powerful and larger vehicles, in particular the popular sports utility vehicles.[15] Most gasoline and diesel fueled vehicles use only 15 to 35 percent of the fuel's energy to move the vehicle down the road. The rest is lost to engine inefficiencies and idling.[16]

The U.S. transportation sector is primarily powered by gasoline, followed by diesel, which together accounted for 98 percent of the vehicle fuel consumption in 2005. On an energy basis, diesel is slightly more carbon intensive than gasoline (at 19.95 TgC per QBtu compared with 19.34 TgC per QBtu for gasoline), although diesel engines are generally more energy-efficient than gasoline engines.[17]

Improvements in fuels and technology have the potential to reduce carbon emissions from the transportation sector substantially. Cellulosic ethanol and biodiesel may prove to be important low-carbon fuel alternatives to gasoline and diesel.[18] For example, replacing one-quarter of projected gasoline use with cellulosic ethanol—a replacement rate viewed as achievable within 25 years—could cut carbon emissions by 15 to 20 percent.[19] Another promising alternative is hybrid electric systems that are recharged in off-peak hours by low-carbon electricity. Metropolitan areas are particularly well suited to low-carbon options because the capital investment needed to establish new refueling infrastructures is more economically feasible in high-density environments.

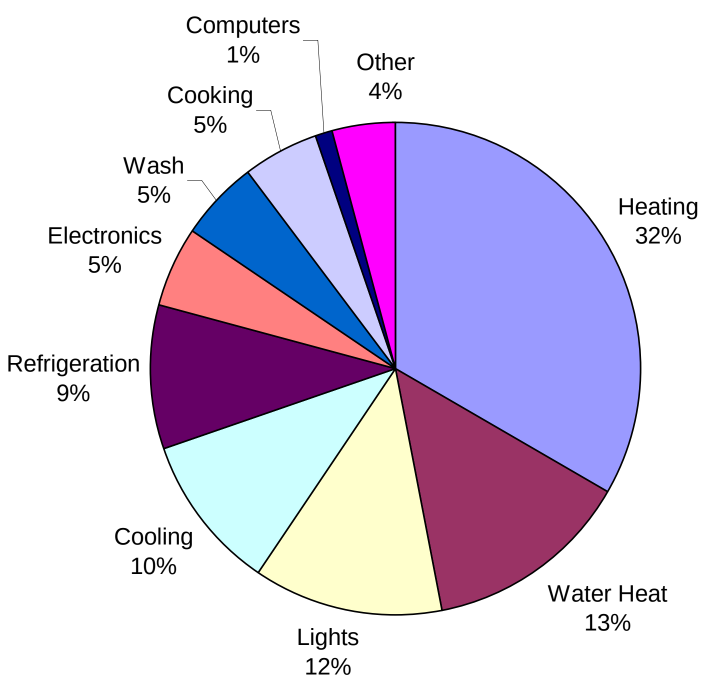
Under the Energy Independence and Security Act (EISA) of December 2007, automakers are required from 2011 on to increase the fuel economy of passenger vehicles by 40 percent, to a fleet average of 35 mpg by 2020.[20] The federal government is also directed to study and work toward "maximum feasible" fuel economy standards for small (8,500–10,000 pound) "work" trucks as well as medium and large commercial trucks. Significant increases in vehicle and truck fuel economy appear both feasible and justifiable.

After accounting for the effects from EISA, transportation energy use is projected to grow by 0.4 percent annually.[21] This increased energy use could drive up transportation carbon emissions 10.3 percent between 2006 and 2030.[22] During the same period, crude oil imports are forecast to rise from 66 to 71 percent of total supply, increasing U.S. vulnerability to petroleum supply and price disruptions. In the transportation sector in particular, energy and climate challenges are intertwined with energy security concerns.[23]

2. *Buildings account for even more of the country's carbon emissions than transportation*

Buildings—through the energy they use—are responsible for 39 percent of U.S. carbon emissions. Single-family homes, apartments, manufactured housing, and other residential buildings account for slightly more than one-half of these emissions, with commercial buildings (offices, businesses, hospitals, hotels, etc.) responsible for the remainder. In the United States, more than one-half of residential energy comes from the electricity households consume: 65 percent in 2000 and 68 percent in 2005.[24] Households use electricity for cooling (and some heating), for lighting, and increasingly for televisions, computers, and other household electronics (see Figure 3).[25] More than one-half of the electricity in this country is generated from coal at central station power plants that have operated at about 35 percent efficiency for more than a half century. Almost two-thirds of the energy embodied in coal is lost through the release of low temperature waste heat either at the power plant or along its route to the end user.[26] Depending on how the electricity is ultimately used, as much as 97 percent of the energy in the coal used to produce electricity can be lost as waste heat.[27]

FIGURE 3
Americans Used the Majority of Their Home Energy in 2005 for Space and Water Heating, Lights, and Cooling



Source: Energy Information Administration

The balance of U.S. residential energy consists of direct fuel consumption. Natural gas is the most common source of heating in buildings and is also used for heating water and cooking. On an energy basis, natural gas has the lowest carbon intensity among fossil fuels (with 14.47 TgC per QBtu compared with fuel oil at 19.95 and residential coal at 26.04 TgC per QBtu).[28] Other options not widely used include solar photovoltaics, solar lighting, and solar water heating, which are virtually carbon-free, and geothermal heat pumps, which are a low-carbon source of heating and cooling.

The United States has made remarkable progress in reducing the energy use and carbon intensity of its building stock and operations. These improvements are largely the result of advances in the energy efficiency of U.S. buildings following the 1973–1974 OPEC oil embargo, motivated in part by the significant proportion of electricity generated from petroleum fuels and the greater reliance on fuel oil for home heating at that time. Since 1972, building energy use overall has increased at less than half the rate of growth of the nation's gross domestic product (GDP), and residential energy use per household has declined.[29] At the same time, homes have grown larger homes and we use a broader range of equipment, especially air conditioning in the South and electronic equipment nationwide.

Despite these impressive efficiency gains, the total energy used in buildings almost doubled between 1970 and 2005, and the nation can expect to see building energy consumption increase by 0.8 percent per year through 2030.[30] Because of the dominance of electricity in this sector, and the anticipated large-scale expansion of the nation's building stock to accommodate population growth, carbon emissions from the built environment are expected to grow rapidly. While this new growth is occurring, most of the current stock of buildings will continue to be occupied, although much of it will have been redeveloped, which presents the parallel opportunity to upgrade to eco-friendly features in current buildings as new functionality is delivered.

3. Development patterns play a role in emissions from transportation and the built environment

The spatial arrangement of buildings and transportation infrastructure in communities and urban systems can play a role in carbon reduction. Urban form links the energy consumed in different building designs, densities, and land-use configurations to the energy required to support daily travel, provide freight pickups and deliveries, and support a rapidly growing number of on-the-job service trips.

Carbon-reduction benefits from more spatially compact and mixed-use developments that have access to rapid transit include:

- Reduced residential heating and cooling costs owing to smaller homes and shared walls in multi-unit dwellings
- The use of district energy systems for cooling, heating, and power generation
- Lower electricity transmission and distribution line losses
- Shorter freight and personal trips
- More use of public transit, and more walking and cycling instead of car trips

- Reduced waste streams
- Reduced municipal infrastructure requirements, including the reduced need for local street construction and shorter electric, communication, water, and sewage lines, requiring less energy and water treatment
- The use of microgrids to meet local electricity requirement with highly efficient distributed power generation
- Reuse of existing structures

Some studies have quantified the role of compact development in carbon reductions. For instance, the number of dwellings per acre is directly related to GHG emissions. With shared walls and generally smaller square footage, households in buildings with five or more units consume only 38 percent of the energy of households in single-family homes.[31] At a suburban density of four homes per acre, carbon dioxide emissions per household were found to be 25 percent higher than in an urban neighborhood with 20 homes per acre.[32]

Studies also show that household vehicle miles traveled vary with residential density and access to public transit.[33] Higher residential and employment densities, mixed land-use, and jobs–housing balance are associated with shorter trips and lower automobile ownership and use.[34] In comparing two households that are similar in all respects except residential density, the household in a neighborhood with 1,000 fewer housing units per square mile drives almost 1,200 miles more and consumes 65 more gallons of fuel per year over its peer household in a higher-density neighborhood.[35]

Less is known about how household behavior may change in response to changes in density or the concentration of housing or jobs. A recent simulation estimates that shifting 60 to 90 percent of new growth to development that is more compact would reduce VMT by 30 percent and cut U.S. transportation carbon dioxide emissions by 7 to 10 percent by 2050, relative to a trajectory of continued urban sprawl.[36] This effect is comparable to what might happen with a doubling of fuel prices.[37] It may be unrealistic to expect 60 to 90 percent of new growth in compact development, however, suggesting the secondary role that compact development might play to advances in efficiency, technology, and fuels. Other efficiency studies project even greater and more rapid GHG reductions, with savings of 10 percent of the U.S. 2001 level of GHGs possible within as few as 10 years, although again these results may be optimistic.[38]

Despite the contribution of these earlier works, the empirical evidence quantifying the role of development patterns on carbon reductions remains limited. Studies to date rely on single-sector, case study, or simulation approaches, which do not allow analysts to draw accurate or broad-based conclusions about the effects of policy changes on national emissions. What might seem true from a study in Seattle may not be true for residents in Cleveland or Atlanta.

A recent policy brief by Edward Glaeser and Matthew Kahn summarizes research that offers a more comprehensive study of metropolitan carbon footprints.[39] In addition to quantifying the transportation and residential carbon emissions of 66 large metropolitan areas, the analysis examines differences between central city and suburban emissions. Their major data sources are different from those employed here; they rely on the 2000 individual Public Use Microsample for household electricity and fuel consumption and the 2001 National Household Travel Survey for information on gasoline use from automobile transportation. Glaeser and Kahn's preliminary findings are largely consistent with the findings reported here, with some subtle differences.[40]

The Vulcan project at Purdue University has also recently released an inventory of carbon emissions data from multiple sources at very fine-grained detail for 2002.[41] The purpose of the Vulcan project is "to aid in quantification of the North American carbon budget, to support inverse estimation of carbon sources and sinks, and to support the demands posed by the upcoming launch of the Orbital Carbon Observatory."[42] The data will provide valuable context for understanding the carbon footprints of metropolitan areas, although it will take time to correlate the emissions data with the energy consumed by metropolitan households, businesses, and associated activities. Data that are more recent are needed to allow analysis of emissions change over time.

In short, before researchers can appropriately study the impact of proposed federal policy changes—or even the experiences from state and local efforts—the nation needs a consistent set of emissions data for multiple periods and at a level of resolution and scale that can be tied to the activities, land uses, and the infrastructure networks of metropolitan areas.

III. New Research Quantifies the Partial Carbon Footprint of Metropolitan America

This study begins to fill the substantial research gap by estimating partial carbon footprints for the nation's 100 largest metropolitan areas in 2000 and 2005. Additional information on the methodology and the findings are reported in two technical working papers, available at the Georgia Tech School of Public Policy website (www.spp.gatech.edu/faculty/workingpapers.php).[43]

The carbon footprints reported here are the most comprehensive to date for a data set this size and for two points in time. These estimates help us understand how certain urban features—including housing stock, transportation systems, urban morphology, and policy interventions—might contribute to different energy consumption and emissions profiles. The estimates also provide benchmarks for the challenging effort of identifying low-cost and effective ways of shrinking metropolitan carbon footprints.

Methodology

To produce comparable carbon footprints for the 100 largest metropolitan areas, the authors examined national databases for passenger and freight transportation and for energy consumption in residential buildings.[44] These estimates are as current as data sources will allow across metro areas, yet at the same time they are incomplete. Major omissions are the carbon emissions from commercial buildings, industry, and other modes of transportation such as planes, transit, and trains.[45] These sources account for roughly half of national emissions. For this reason, results for any particular metropolitan area should be treated with caution. Still, the majority of commercial buildings are powered by electricity derived largely from coal, and their spatial arrangement would be expected to follow the general compactness and density characteristics of residential developments in a metro area.[46] Thus, their footprints are likely to resemble those reported here for residential buildings, although this remains to be seen.

Personal and freight transportation. Information on the amount of energy used for transportation is unavailable at the metropolitan level. Instead, the authors derived estimates based on VMT data from the Highway Performance Monitoring System for both personal and freight transport.[47] They followed a three-step process:

1) Estimate the annual VMT within each metro area using highway traffic count data

2) Convert these VMT estimates to gallons of fuel consumed, by major fuel types, but principally gasoline and petro-diesel

3) Convert this fuel consumption into a) its equivalent energy content, and b) its equivalent carbon content

The results estimate the energy and carbon footprint created by each metro area's auto and truck travel.[48]

Residential buildings. The authors obtained data on electricity sales from Platts Analytics, including the total residential electricity sales and the total number of residential customers of utilities whose service territories include all or a portion of the 100 metropolitan areas.[49] They followed a five-step process:

1) Estimate the average electricity consumed per residential customer of each utility serving the metropolitan area

2) Estimate the number of households each utility serves within the metropolitan area by mapping the utilities' service districts at the ZIP code level

3) Adjust county estimates to account for landlord electricity payments, based on county-specific data on types of housing and region-specific data on how utilities are paid by housing type

4) Sum the final estimates by county across all of the counties within each metro area to produce metrowide estimates

5) Convert to carbon emissions estimates using statewide averages of the carbon content of electricity generation

The authors also estimated the magnitude of residential fuels (natural gas, fuel oil, kerosene, liquid propane gas, and wood) consumed in residential units in each metropolitan area, using the Energy Information Administration's (EIA) state data on fuel consumption in the residential sector and EIA's Residential Energy Consumption Survey data on fuel-specific consumption of different types of housing.[50] The results estimate the energy and carbon footprint created by each metro area's stock of residential buildings.

The authors also generated combined but partial carbon footprints for all 100 metro areas by summing the transportation and residential buildings footprints. Appendix A includes full data tables by metro area, with ranks, and Appendix B discusses limitations of the available data.

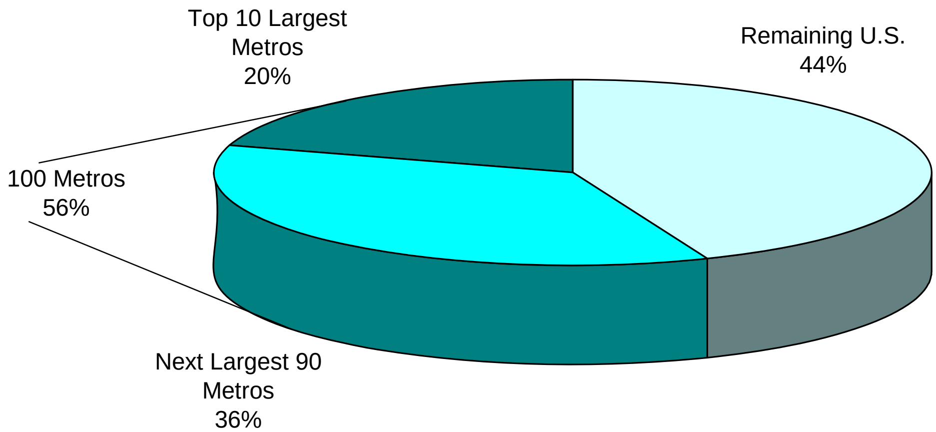
Findings

Analysis of the partial carbon footprints reveals five major findings regarding the size and growth of total carbon emissions, variation among metro areas, and impact of development patterns, transit usage, freight, weather, electricity sources, and electricity prices.

1. Large metropolitan areas offer greater energy and carbon efficiency than nonmetropolitan areas

Despite housing two-thirds of the nation's population and three-quarters of its economic activity, the nation's 100 largest metropolitan areas emitted just 56 percent of U.S. carbon emissions from highway transportation and residential buildings in 2005 (see Figure 4).

FIGURE 4
The 100 Largest Metro Areas Emitted Only 56 Percent of the Nation's Carbon Emissions from Transport and Residences in 2005

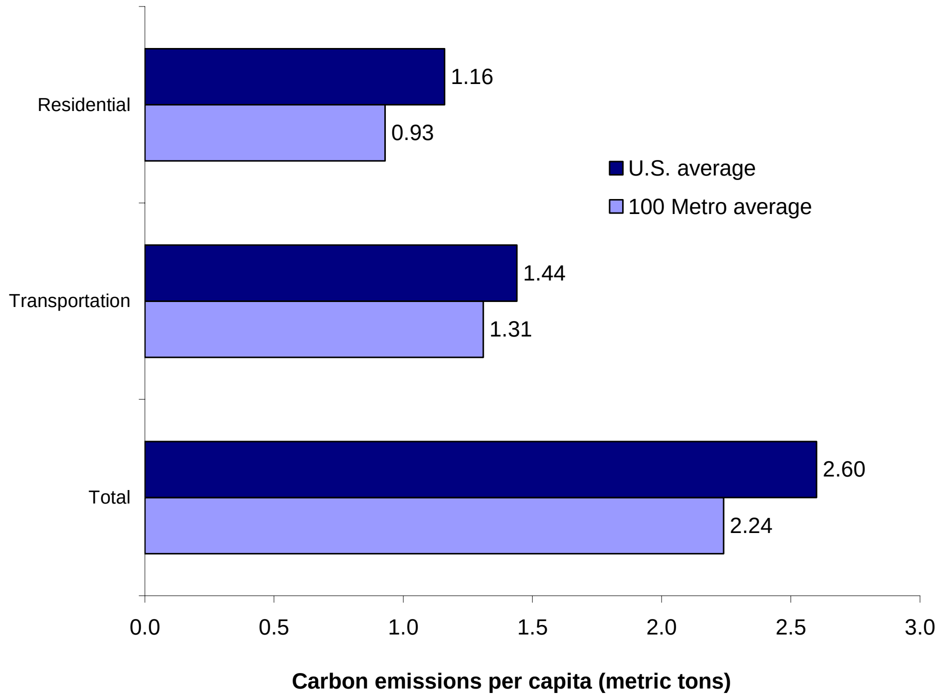


Source: Authors' calculations

Twenty percent of the nation's transportation and residential carbon emissions come from the 10 largest metro areas, indicating the dominant influence of a small number of large metro areas.

Residents of metro areas have smaller partial carbon footprints than the average American. The average metro area resident's partial carbon footprint (2.24 metric tons) in 2005 was only 86 percent of the average American's partial footprint (2.60 metric tons). The difference owes primarily to less car travel and residential electricity use, rather than freight travel and residential fuels.

FIGURE 5
Residents in the Largest Metro Areas Emitted Less Carbon than the Average American in 2005



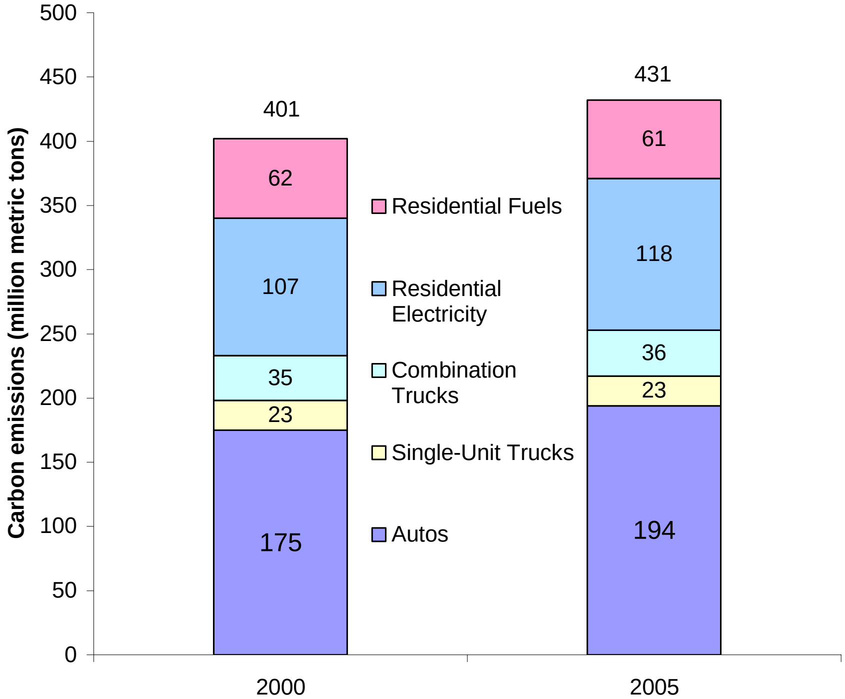
Source: Authors' calculations

2. Carbon emissions increased more slowly in metropolitan America than in the rest of the country between 2000 and 2005

Carbon emissions from highway transport and residences in major metro areas increased 7.5 percent from 2000 to 2005, slightly less than the national increase of 9.1 percent. The population of the 100 metro areas, on the other hand, grew by only 6.3 percent.

As a result, the average per capita footprint of the 100 metro areas grew by only 1.1 percent during the five-year period, while the U.S. partial carbon footprint increased twice as rapidly (by 2.2 percent) during this same timeframe. Thus, while 79 metro areas saw overall growth in their highway transport and residential carbon emissions from 2000 to 2005, only 53 metro areas increased their footprints on a per capita basis. Another 21 metro areas saw their carbon emissions from transport and residences decline from 2000 to 2005.

FIGURE 6
The Nation's 100 Largest Metro Areas Produced 431 Million Metric Tons of Carbon from Highway Transport and Residential Buildings in 2005, Up from 401 Million Metric Tons in 2000



Source: Authors' calculations

In the 100 metro areas and the nation at large, carbon emissions grew faster for auto transport and residential electricity use than for freight travel and residential fuels.

Trenton, NJ, and Chattanooga, TN, saw the most growth in both total carbon emissions and per capita footprints.[51] Youngstown, OH, and Grand Rapids, MI, conversely, each saw their carbon footprints decline by 14 percent during the five-year period—the largest declines in the 100 metro areas. Riverside, CA, Bakersfield, CA, and El Paso, TX, also reduced their per capita footprints by more than 10 percent despite increasing their total emissions.

Reversing the rising trend in emissions—as many climate scientists warn must happen to mitigate the effects of climate change—poses a distinct challenge for many metro areas and the nation as a whole. Based on data for these two points in time, metropolitan America is constraining the growth of its carbon footprints better than nonmetropolitan areas.

3. Per capita carbon emissions vary substantially by metro area

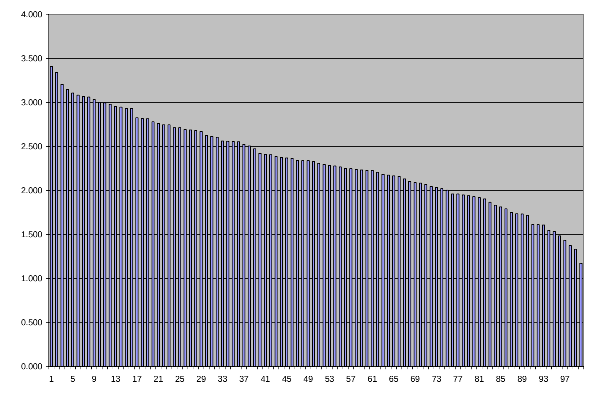
In 2005, per capita carbon emissions were highest in Lexington, KY, and lowest in Honolulu. The average resident in Lexington emitted 2.5 times more carbon from transport and residences in 2005 than the average resident in Honolulu, at 3.46 metric tons compared with 1.36 metric tons.

This variation is even more striking when adjusting for a metro area's economic output, or gross metropolitan product (GMP)—an indicator of *carbon intensity*. In this case, the carbon footprints range from a high of 97.6 million metric tons of carbon per dollar GMP in Youngstown, OH, to a low of 22.5 million metric tons per dollar GMP in San Jose, CA—more than a four-fold difference.

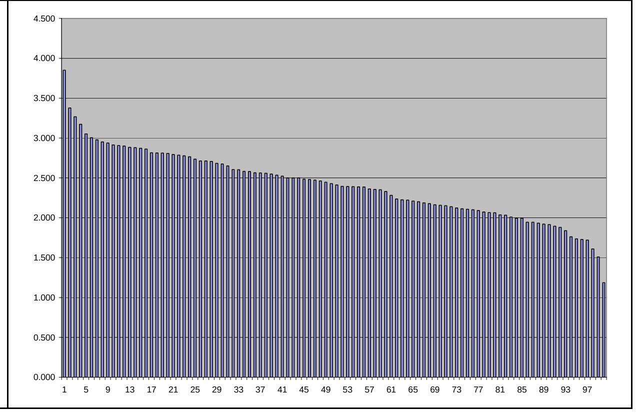
In other contrasts, residents in Nashville and St. Louis emitted twice as much carbon from transport and residences, on average, than residents in San Jose, CA, or Seattle. (Appendix A ranks the full set of 100 metro areas by their per capita emissions in 2005.)

FIGURE 7
Carbon Footprints Vary Substantially by Metro Area

2000



2005



Highest and Lowest Emitting Metro Areas Based on Per Capita Carbon Emissions

Year 2000	Carbon/ person	Year 2005	Carbon/ person
Lowest Emitters:		**Lowest Emitters:**	
Honolulu, HI	1.230	Honolulu, HI	1.356
New York-Northern New Jersey-Long Island, NY-NJ-PA	1.388	Los Angeles-Long Beach-Santa Ana, CA	1.413
Los Angeles-Long Beach-Santa Ana, CA	1.408	Portland-Vancouver-Beaverton, OR-WA	1.446
Portland-Vancouver-Beaverton, OR-WA	1.519	New York-Northern New Jersey-Long Island, NY-NJ-PA	1.495
San Diego-Carlsbad-San Marcos, CA	1.573	Boise City-Nampa, ID	1.507
Seattle-Tacoma-Bellevue, WA	1.627	Seattle-Tacoma-Bellevue, WA	1.556
Boise City-Nampa, ID	1.635	San Jose-Sunnyvale-Santa Clara, CA	1.573
San Francisco-Oakland-Fremont, CA	1.636	San Francisco-Oakland-Fremont, CA	1.585
Greenville, SC	1.694	El Paso, TX	1.613
San Jose-Sunnyvale-Santa Clara, CA	1.699	San Diego-Carlsbad-San Marcos, CA	1.630
Highest Emitters:		**Highest Emitters:**	
Nashville-Davidson--Murfreesboro, TN	3.135	Knoxville, TN	3.134
Kansas City, MO-KS	3.162	Harrisburg-Carlisle, PA	3.190
Louisville, KY-IN	3.187	Oklahoma City, OK	3.204
Youngstown-Warren-Boardman, OH-PA	3.205	St. Louis, MO-IL	3.217
Knoxville, TN	3.210	Nashville-Davidson--Murfreesboro, TN	3.222
Harrisburg-Carlisle, PA	3.252	Louisville, KY-IN	3.233
Oklahoma City, OK	3.282	Toledo, OH	3.240
Toledo, OH	3.344	Cincinnati-Middletown, OH-KY-IN	3.281
Lexington-Fayette, KY	3.480	Indianapolis, IN	3.364
Indianapolis, IN	3.552	Lexington-Fayette, KY	3.455

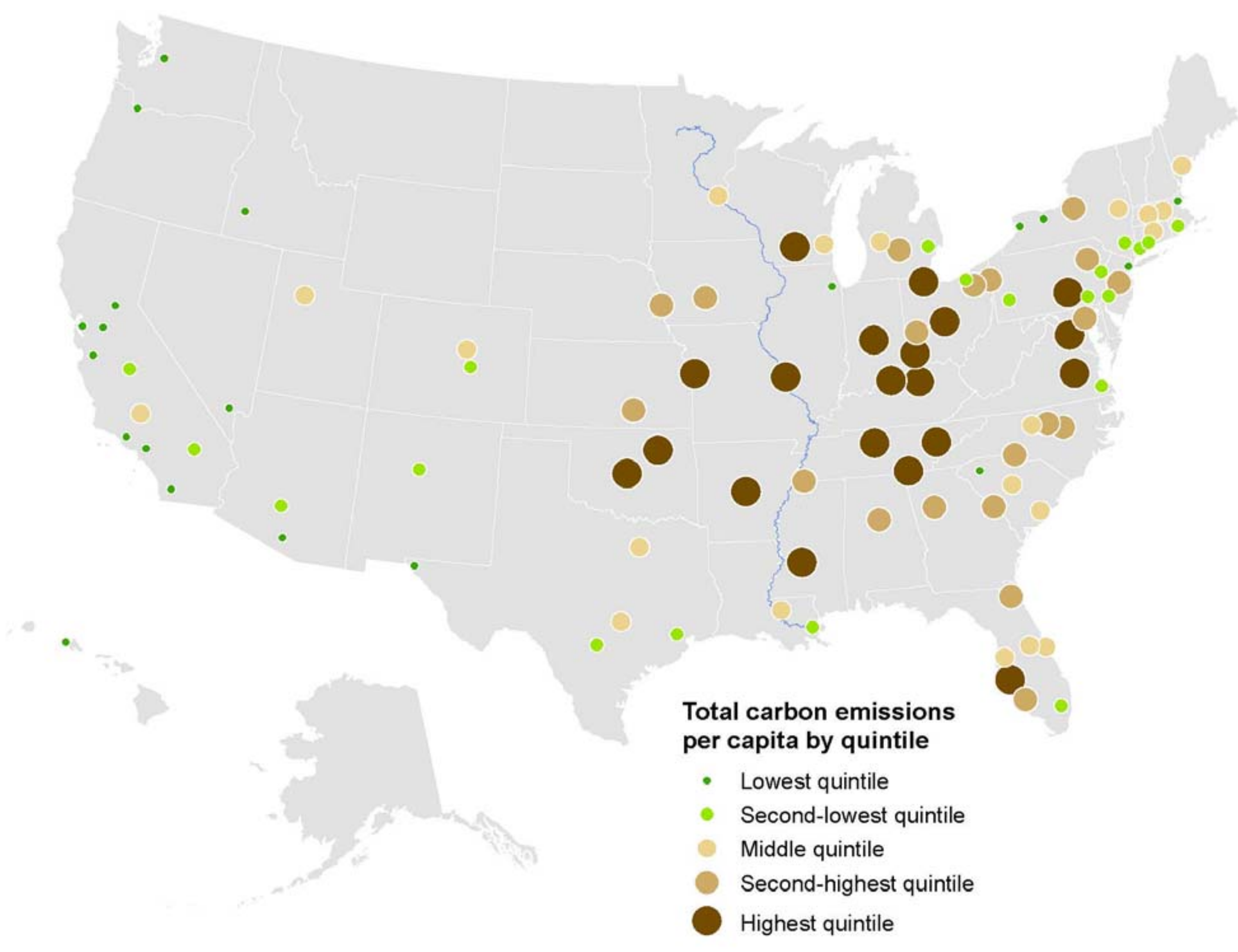
Source: Authors' calculations

Regional variation in carbon emissions is apparent as well. Most notably, the Mississippi River roughly divides the country into high emitters and low emitters (see Figure 8). In 2005, all but one of the 10 largest per capita emitters—Oklahoma City being the exception—was located east of the Mississippi. On the other hand, all but one of the 10 lowest per capita emitters—New York being the exception—was located west of the Mississippi. California alone was home to six of the twenty lowest per capita emitters.

A north-south divide is also apparent. Seven of the highest per capita emitters were located south of the Mason-Dixon Line, including two each from Tennessee, Ohio, and Kentucky. In the northern mid-Atlantic, Harrisburg, PA, Trenton, NJ, and Toledo, OH, are high per capita emitters.

FIGURE 8

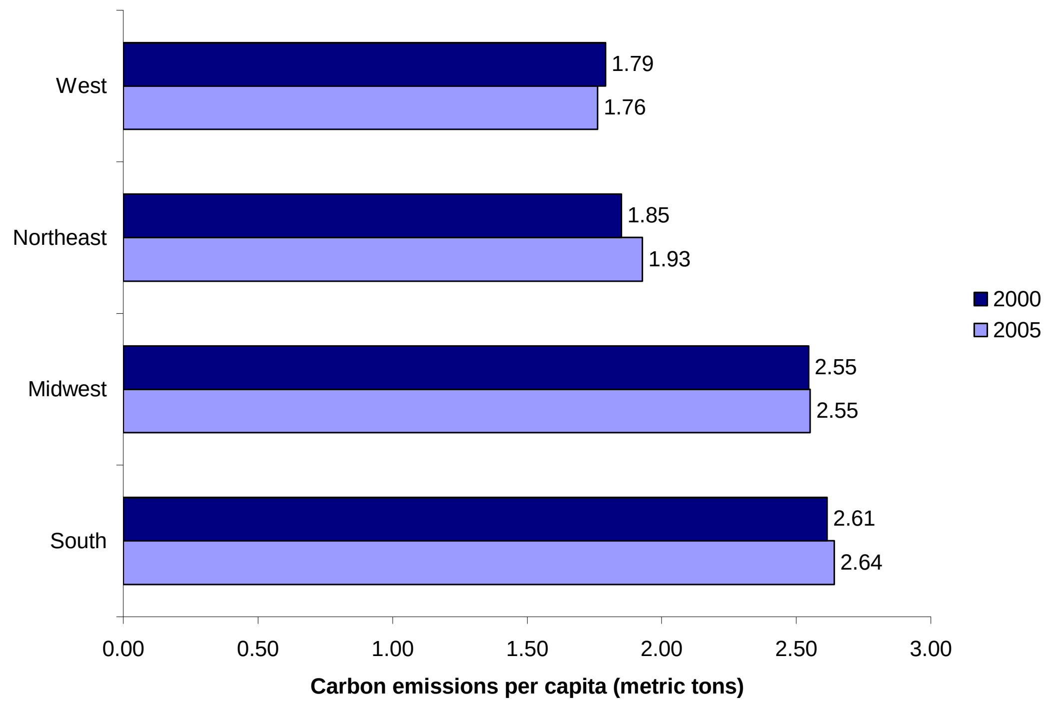
All Metro Areas with the Largest Per Capita Footprints Were Located in the East-Central and Eastern United States in 2005, While Most of the Metro Areas with the Smallest Per Capita Footprints Were Located in the West



Source: Authors' calculations

The West is the only region that reduced its partial carbon footprint between 2000 and 2005. The Midwest, Northeast, and South all increased their per capita carbon emissions. Reflecting the rapid growth and decentralization of many Southern cities, the carbon footprints of metro areas in the South grew more rapidly than in any other region. The South has the dubious distinction of having the largest carbon footprints from transport and residences of any region in both 2000 and 2005 (see Figure 9).

FIGURE 9
Southern and Midwestern Metro Areas Have Larger Average Transportation and Residential Footprints than Western and Northeastern Metro Areas



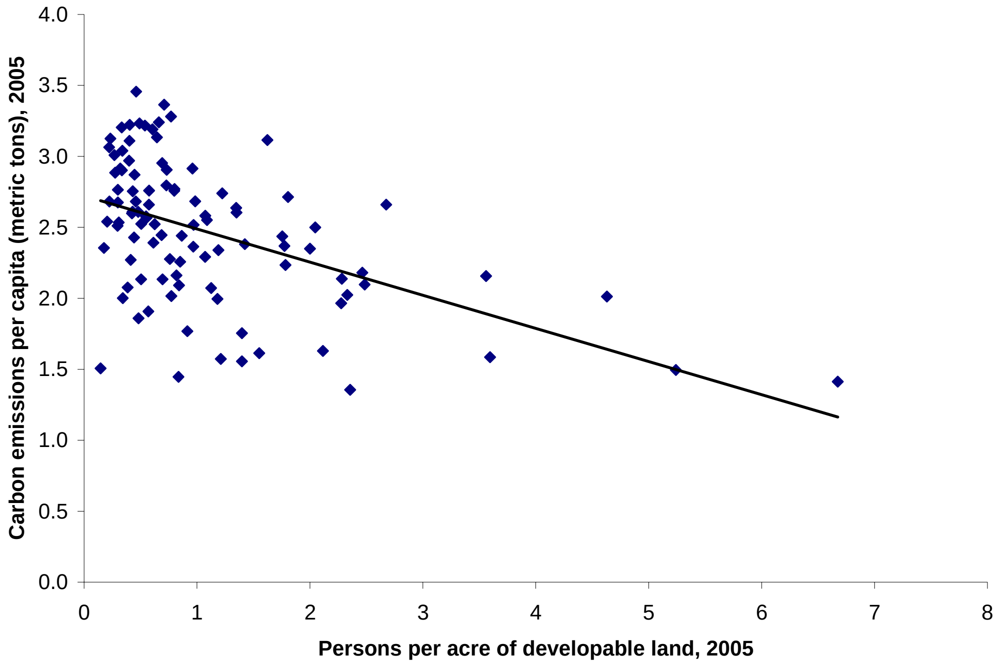
Source: Authors' calculations

4. Development patterns and rail transit play important roles in determining carbon emissions[52]

Density, concentration of development, and rail transit all tend to be higher in the lowest-emitting metro areas (see Figure 10 and Table 1).[53] Much of what appears as regional variation may actually be due to these spatial factors, as many of the older, denser cities in the Northeast, Midwest, and California (e.g., Boston, New York, Chicago, and San Francisco) are all low emitters.

Generally, knowing a metro area's overall density helps predict its carbon emissions. Dense metro areas such as New York, Los Angeles, and San Francisco stand out for having the smallest transportation and residential footprints. Alternatively, low-density metro areas such as Nashville and Oklahoma City are prominent among the 10 largest per capita emitters.

FIGURE 10
Denser Metro Areas Tended to Have Lower Carbon Footprints in 2005



Source: Authors' calculations

TABLE 1
Many of the Densest Metro Areas Had Relatively Small Transport and Residential Footprints in 2005

Metropolitan Area	Rank- Population density (2005)	Rank- Carbon footprint per capita (2005)
Los Angeles-Long Beach-Santa Ana, CA	1	2
New York-Northern New Jersey-Long Island, NY-NJ-PA	2	4
Las Vegas-Paradise, NV	3	18
San Francisco-Oakland-Fremont, CA	4	8
Miami-Fort Lauderdale-Miami Beach, FL	5	28
Trenton-Ewing, NJ	6	64
New Haven-Milford, CT	7	24
Bridgeport-Stamford-Norwalk, CT	8	30
Honolulu, HI[54]	9	1
Boston-Cambridge-Quincy, MA-NH	9	20
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	10	27

Source: Authors' calculations

The benefits of density are not necessarily unique to metro areas. The 100 largest metropolitan areas appear to perform better than nonmetro areas because of their overall density. However, large metro areas have a patchwork of higher- and lower-density areas—density is not uniform across the entire metro area. Therefore, whether in metro areas or small towns, the higher-density development have smaller transportation and residential carbon footprints. This pattern is confirmed by examining population or employment concentration measures, which reflect clustering at the ZIP code scale.[55] This approach to compact development also generates other benefits for its residents, such as the health, safety, and community benefits of walkable communities.[56]

Many metro areas with small per capita footprints also have sizable rail transit ridership (see Table 2). New York, San Francisco, Boston, and Chicago have some of the highest annual rail ridership in the nation, ranging from 296 to 757 miles per capita, and carbon footprints ranging from 1.5 to 2.0 tons of carbon per capita—much lower than the average of 2.2 tons for all 100 metro areas. Looking just at carbon footprints from highway transportation highlights a cluster of low emitters located along the Washington to Boston corridor (see Appendix A). In addition to benefiting from rail transit, these cities also tend to have high population densities characteristics of older cities of the Northeast.

TABLE 2
Many of the Metro Areas with Sizable Rail Transit Use Had Relatively Small Transport and Residential Footprints in 2005

Metropolitan Area	Rank- Annual passenger miles of rail transit per capita (2005)*	Rank- Carbon footprint per capita (2005)
New York-Northern New Jersey-Long Island, NY-NJ-PA	1	4
San Francisco-Oakland-Fremont, CA	2	7
Boston-Cambridge-Quincy, MA-NH	3	20
Chicago-Naperville-Joliet, IL-IN-WI	4	15
Washington-Arlington-Alexandria, DC-VA-MD-WV	5	89
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	6	27
Baltimore-Towson, MD	7	69
Atlanta-Sandy Springs-Marietta, GA	8	68
San Diego-Carlsbad-San Marcos, CA	9	10
Salt Lake City, UT	9	50
Los Angeles-Long Beach-Santa Ana, CA	10	2

**Includes light, heavy, and commuter rail.*

Source: Authors; Federal Transit Administration

There are exceptions to the rail-footprint connection. Washington, Baltimore, and Atlanta, for example, all have high rail transit ridership but also have substantially larger-than-average carbon footprints, underscoring the multi-dimensional nature of carbon footprints.

Finally, freight traffic poses a problem for metro areas trying to shrink their carbon footprints. Bakersfield, CA, for example, has the smallest residential footprint in the sample (at 0.35 metric tons per capita) but the largest transportation footprint in 2005 (at 2.2 metric tons), largely because of its freight traffic contribution. Jacksonville, FL, Sarasota, FL, and Riverside, CA, are similar, with the sixth, seventh, and ninth largest transportation footprints, combined with lower-than-average residential carbon footprints. All three metro areas have or are near port cities with sizable freight traffic. They also report significant miles of travel by combination trucks, which typically involve low efficiency trips that either start or end outside the metro area's boundaries.

5. Other factors, such as weather, the fuels used to generate electricity, and electricity prices are also important

Some areas may perform well on transportation but have large residential footprints. Cleveland, OH, Springfield, MA, and Providence, RI, fit this model. They fall among the 25 lowest emitters for highway transportation but are in the top 25 for residential emissions. These metro areas have high emissions from residential fuels, as do many other Northeastern and Midwestern metro areas.

Weather unmistakably plays a role in residential footprints. Many areas in the Northeast, for instance, have large residential footprints because of their stronger reliance on carbon-intensive home heating fuels such as fuel oil. Warm areas in the South often have large residential footprints because of their heavy reliance on carbon-intensive air conditioning. High-emitting metro areas concentrate throughout the mid-latitude states of the eastern United States where there are substantial combinations of cooling and heating requirements (see Appendix A). Alternatively, the 10 metropolitan areas with the smallest per capita residential footprints are all located along the West Coast, with its milder climate.

The fuel mix used to generate electricity matters in residential footprints. For instance, the Washington, DC, metro area's residential electricity footprint was 10 times larger than Seattle's footprint in 2005. The mix of fuels used to generate electricity in Washington includes high-carbon sources like coal, while Seattle draws its energy primarily from essentially carbon-free hydropower. A high-carbon fuel mix significantly penalizes the Ohio Valley and Appalachian regions, which rely heavily on coal power production. Alternatively, the investor-owned utilities in some states, such as California, no longer purchase electricity from coal power plants, and metro areas have lower carbon footprints. Table 3 lists the metro areas with smaller carbon footprints.

TABLE 3
Many of the Metro Areas That Rely on Low-Carbon Sources of Electricity Had Relatively Small Transport and Residential Footprints in 2005

Metropolitan Area	Rank- Carbon Content of Electricity (2005)	Rank- Carbon footprint per capita (2005)
Boise City-Nampa, ID	1	5
Portland-Vancouver-Beaverton, OR	2	3
Seattle-Tacoma-Bellevue, WA	3	6
Bakersfield, CA	4	53
San Diego-Carlsbad-San Marcos, CA	5	10
Riverside-San Bernardino-Ontario, CA	6	32
San Francisco-Oakland-Fremont, CA	7	8
San Jose-Sunnyvale-Santa Clara, CA	8	7
Oxnard-Thousand Oaks-Ventura, CA	9	11
Fresno, CA	10	22
Stockton, CA	11	19
Los Angeles-Long Beach-Santa Ana, CA	12	2
Sacramento--Arden-Arcade--Roseville, CA	13	12

**Based on state averages published in EIA's State Electricity Profiles.*

Source: Authors' calculations

Electricity prices also appear to influence the residential footprint. Each of the 10 metro areas with the lowest per capita electricity footprints in 2005 hailed from states with higher-than-average prices, including California, New York, Michigan, and Hawaii. On the other hand, many Southeastern metro areas with high electricity consumption have had historically low electricity rates.

* * *

The results help to highlight both the potential and the challenge of shrinking the carbon footprints of metropolitan America. First, the potential: large metro areas offer greater energy and carbon efficiency than nonmetropolitan areas. These areas share development patterns that show promise for reducing carbon emissions, such as higher density, more concentrated development, and rail transit.

Three pressing challenges, however, remain for metropolitan America:

- Carbon emissions grew faster between 2000 and 2005 than did the population in the 100 largest metro areas, which makes shrinking their per capita footprints all the more difficult.

- Many of the fastest-growing metro areas are also the least compact. This is evident in the rapid growth and decentralization in many Southern cities, such as Austin, TX, Raleigh, NC, and Nashville, TN, where metropolitan carbon footprints have been growing most rapidly. Thus, new development is often occurring in locations and in patterns that fail to take advantage of energy and location efficiencies.[57]

- Important factors that determine emissions may be largely out of metropolitan America's grasp, such as weather. Other factors may appear to be intractable, such as the high carbon intensity of locally available fuels and the high consumption arising from low energy prices.

Metro actors can take many actions to improve energy efficiency and reduce carbon intensity even in the face of these challenges. In the end, however, metro America will be hard-pressed to shrink its carbon footprint in the absence of supportive federal policies.

IV. The Federal Government Must Lead on Climate Policy

Given the emerging facts regarding the country's metropolitan carbon footprints, the need for action to stem emissions and alter current trends is gaining urgency.

1. The need for action is clear

Numerous energy-related environmental, security, resource, and infrastructure challenges await the United States and the world. If the global demand for energy continues to grow at the projected rate of roughly 2 percent annually, the world will require 702 quadrillion Btu (quads) of energy production in 2030—almost 60 percent more than the 447 quads consumed in 2004.[58] The energy technologies deployed today will shape the future energy landscape, its environmental emissions, American reliance on imported fuels, and American competitiveness in world markets for many decades. It is critical that energy industries and policymakers select the best options for today and for the long run. Part of the decisionmaking challenge is in ensuring that energy markets provide appropriate price signals, an issue discussed shortly.

Three primary national interests provide a compelling justification for action:

Carbon stabilization. Tackling climate change promises to be one of the most significant technological challenges of the twenty-first century. Climate scientists argue that global carbon emissions must be dramatically curbed in the next several decades—possibly by 50 to 60 percent over current levels—to stabilize atmospheric concentrations of carbon dioxide at around 450 to 550 parts per million.[59] It will require considerable scientific and engineering ingenuity as well as political adroitness to produce entirely new energy systems that curb GHG emissions while simultaneously powering global economic growth. Success will also necessitate institutional, economic, social, and policy innovations to foster the widespread and rapid deployment of technology and institutional or pricing solutions. As a leading carbon emitter, the United States must do its part.

Introducing new climate-friendly technologies to the marketplace involves "managing a resource that no one owns, that everyone depends on, and that provides a wide range of very different—and often public—benefits to different people in different regions over very long periods."[60] Because no one should be excluded from the climate benefits of GHG-reducing technologies, the private sector has little motive to invest in these technologies. In the absence of a market for GHG emission reductions, it can be difficult to turn a profit in climate-friendly technologies. As a result, their development and use generally falls short of socially optimal levels.

Solutions must go beyond breakthroughs in technologies and fuels. Lifestyle and behavioral changes are needed to reduce the metropolitan carbon footprint further. Suburbanization in the United States has resulted in rapid increases in VMT and loss of forestland available to absorb carbon dioxide.[61] Low-density development locks in dependence on cars by undermining the ability to support transit and to promote walking and cycling. Most subdivision regulations, parking, and street design standards also pose barriers to more compact development, as do various distorted fiscal policies, such as basing federal transportation funding on VMT levels.[62] Zoning ordinances, building codes, and land-use planning could enable development that is more compact. In sum, reducing carbon emissions further from compact development will require a major change in the way U.S. urban systems have been evolving during the past half-century.

Increased energy security. The U.S. transportation system is highly dependent (approximately 98 percent) on petroleum-based fuels. Reduced demand for gasoline not only means lower prices for consumers, but also less reliance on foreign oil. The United States now imports more than 60 percent of this fuel from abroad, and many of the suppliers are political unstable. The domestic demand for travel continues to grow rapidly, and the market for less energy-efficient modes (auto, truck, air) has grown in both the passenger travel and freight transport subsectors. Newly emerging economies, notably China, are also increasing demand for petroleum. American petroleum reserves offer only a short-term solution to a global fuel shortage such as the nation experienced during the 1973-1974 and 1979 oil embargoes.

At a Shell Oil meeting in Atlanta in December 2007, John Hofmeister, President of Shell Oil America, declared the market for hydrocarbon energy was broken. He was referring to the nationalization of oil production around the world, which has reduced global oil companies to marginal players.[63] High oil prices are principally the result of escalating demand for oil and the slow growth of petroleum production owing to nationalism and the increasingly expensive extraction of finite reserves. U.S. oil imports have grown by more than 2 million barrels per day (about 10 percent) since 2002, and this expansion was matched by an equivalent and simultaneous combined growth in oil demand by China and India. In addition, no new North American oil refineries have been licensed or brought online to refine crude oil in more than 30 years.

Analysts have suggested that OPEC's price goal is $70 to $80 a barrel. If prices continue to hover above $100, the U.S. economy will slow and we will purchase fewer barrels of oil. This is what happened in 1980, when oil prices spiked and sent the nation, and later the global economy, into a recession. Thus, the United States is well advised to improve vehicle fuel economy, expand the use of alternative energy sources, and reduce VMT to become less dependent on foreign oil and economies in regions of the world far outside U.S. influence or control.

Innovation and national economic competitiveness. Encouraging an energy-efficient built environment is principally about doing more with less through smart technologies—as they say: "Doing more and better with less for longer." Energy-efficiency does not mean living in the cold and the dark. Using advanced technologies, consumers can cut energy consumption and utilities bills while enjoying an expanded array of services. The key is technological innovation. Solid-state lighting, integrated heat-pump systems, smart windows, and combined heat and power systems are among the numerous high-efficiency building technologies that promise to deliver low-carbon energy services with no net cost to the economy.[64] Likewise, metropolitan America must develop and implement new technologies and savings from compact development. Reducing VMT through more efficient development leaves more money in consumers' pockets.

The drive toward more energy-efficient transportation and buildings stimulates technological innovations that can be marketed globally in a world that is placing higher premiums on green technologies. Today, materials RD&D in the United States is innovating at the nanoscale, where scientists can manipulate the fundamental properties of materials and systems (e.g., melting temperature, magnetism, and even color). Similarly, the realm of molecular biology now operates largely at a scale that allows scientists to tailor properties and phenomena to produce new materials and technologies. Because of the data and modeling intensity of these investigations, scientific and technical problems increasingly can be solved only with high-performance computing, and the United States excels in such computing capacity. By focusing this unmatched scientific and technological talent on developing next-generation clean energy and low-carbon technologies, the United States can help maintain its competitiveness in a carbon-constrained global economy.

2. The federal government has a responsibility to act

The federal government has an obligation to lead on climate policy. The "matching principle" in environmental law suggests that the level of jurisdictional authority should "match" the geographic scale of the environmental condition being addressed.[65] In the case of *global* climate change, this principle calls for national and international action. Yet only the federal government has the constitutional authority to negotiate climate agreements with other nations and, to the extent necessary, take punitive action against noncompliers.

A second justification for federal action is government's responsibility to set standards that protect the health and welfare of Americans. Human actions contribute to climate change through GHG emissions. There is also growing evidence that global climate change will have far-ranging effects on the U.S. population.[66] Since the mid-twentieth century, the American public has repeatedly called on the federal government to set emissions standards to prevent public harm. Federal standards on GHG emissions fall within this responsibility.

Yet the case for global and all-inclusive action is not absolute. Although climate change is truly a global phenomenon, most of the specific actions that contribute to it occur at much smaller scales.[67] These scales vary greatly by geography and population density, ranging from the consumption patterns of individual households to the supply chains of multinational corporations.[68]

Action at the local and national scales creates different sets of costs and benefits. Local action encourages *innovation* and can create opportunities for policy experimentation. It ensures that policy mechanisms are *flexible* enough to adapt to local circumstances and needs, thereby maximizing social welfare and minimizing cost. Economics teaches that regulations tailored to local circumstances will improve social welfare, and that centralization is prone to dis-economies of scale.

Local scales also promote more administrative efficiency given that state and local agencies are more agile and adaptive than federal or national agencies. As a result, they are better able to tailor solutions to local needs and preferences. Failure to take into account local conditions can lead to a one-size-fits-all prescription that is more often one-size-fits-nobody.[69]

National action has its own unique advantages. It is the best way to provide uniformity and minimize *transaction costs* among actors. After all, a ton of carbon has virtually the same effect on climate change if it is emitted in New York or Kansas City or San Jose. Centralization creates better economies of scale in data collection, and RD&D.

Global action is the only way to ensure that all states bear the burdens of addressing climate change and to minimize "free rides," emissions leakage, and *spillover* effects. State and local actions that restrict carbon-producing activities may encourage producers simply to shift to other locales with less restrictive policies. National action ensures that states and localities are not at an economic disadvantage by the lack of similar policies elsewhere. These same principles apply to international actors, providing a compelling justification for why the federal government must take decisive international action on climate goals.

The bottom line is that at all levels, policy intervention must be better aligned with the goals of climate sustainability, energy security, and national economic competitiveness. The federal government must engage in a stronger partnership with states and localities to ensure adequate responses and adaptation to climate and energy challenges.

TABLE 4
Costs and Benefits from Local and Federal Action on Climate Policy

Criteria	Local/Metropolitan	Federal
Innovation	Encourages innovation and experimentation	Stifles innovation and experimentation
Flexibility	Less rigid, and able to adapt to local conditions	More uniform and consistent, but less flexible
Transaction costs	More agile and adaptive administration, but also more expensive	Standardization minimizes transaction costs
Spillovers	Vulnerable to free ridership and emissions leakage	Minimizes free ridership and emissions leakage

Source: Benjamin K. Sovacool and Marilyn A. Brown, "Is Bigger Always Better? The Importance of Scale in Addressing Climate Change." In Fereidoon P. Sioshansi, ed. Carbon Constrained: Future of Electricity (New York: Elsevier, 2008).

V. CURRENT FEDERAL POLICY ON CLIMATE CHANGE IS INADEQUATE AND IN SOME INSTANCES FLAWED

Unfortunately, although the need for national action to curb carbon emissions is increasingly clear, the array of federal policies, rules, and available tools for reducing carbon emissions is incomplete and sometimes flawed.

The "market-failure model" guiding public policy debates today suggests that markets should be left alone by government unless market failures exist.[70] In competitive and efficient markets, suppliers produce what consumers want and are willing to pay for. When market failures exist, prices of goods and services do not accurately reflect their real value or their total costs, confounding the communication between consumers and producers and justifying public intervention.[71] Of particular relevance here are the external effects (or externalities) of fossil fuel combustion—in this case, the costs imposed on society by the use of fossil fuels that are not reflected in their prices.[72]

Market failures are distinct from other obstacles to socially valued outcomes. Therefore, some policy analysts have argued more broadly that any barrier to the achievement of a necessary social goal could be the object of public policy.[73] The result has been the large-scale government involvement in markets in an attempt to fix or compensate for voluminous market failures and barriers, particularly in energy markets.[74]

Over the years, these interventions have produced an array of "public policy failures" that now must be reformed.[75] Many of these failures operate at cross-purposes to the U.S. government's intentions to reduce GHG emissions, and they are distorting the marketplace for energy and low-carbon technologies.[76]

1. Several market and policy failures exist

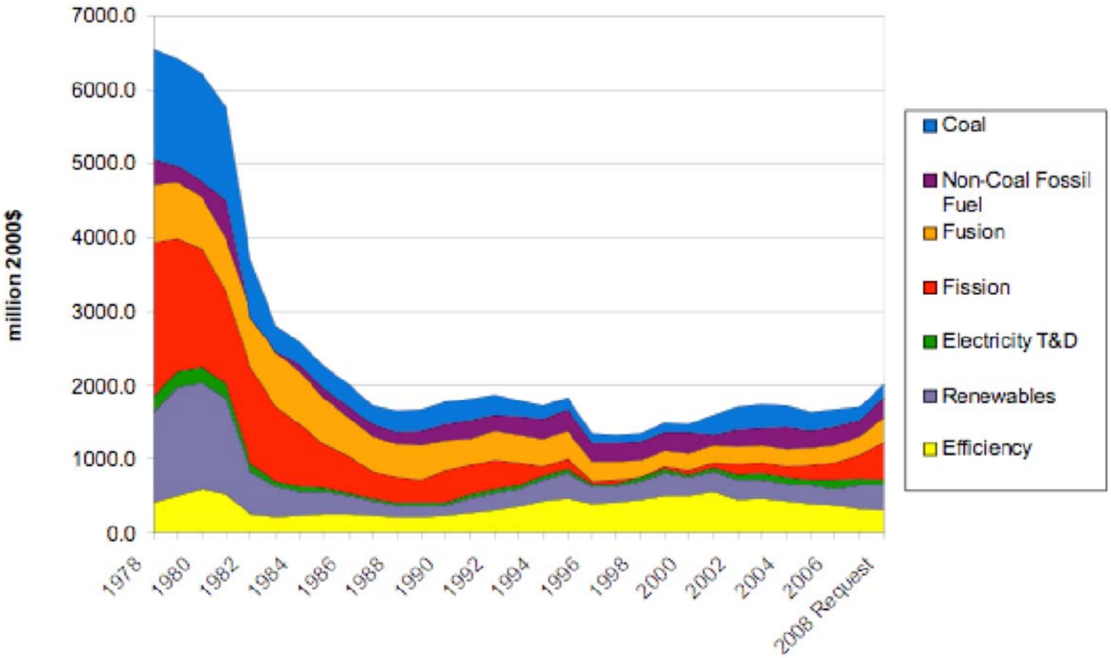
Market and policy failures include underpriced energy, underfunded energy RD&D, the absence of key federal standards, counterproductive utility regulations, and inadequate data collection and information on best practices.

Underpriced energy. Fossil fuels (and other energy resources) are underpriced largely because market prices do not take full account of the social costs associated with their use. Fossil energy creates untallied environmental costs, including air, water and land pollution, GHG emissions, and national security.[77] While some of these environmental costs are addressed through regulation—the costs of sulfur dioxide emissions, for instance—carbon emissions remain unregulated.

As a result, factories, businesses, consumers, and others are using more fossil fuel than is ideal for society. Setting a price on carbon emissions that reflects these external costs could correct this market failure.[78] Correct prices could also realign incentives across sectors. For instance, homeowners would have an incentive to invest in energy-efficient technologies in their homes; commuters would have an incentive to use or demand more energy-efficient transportation in response to higher gas prices; families and businesses would seek out more sustainable communities that mix energy-efficient housing with close proximity to jobs, schools, and transit nodes.

Underfunded federal energy RD&D. Just as fossil fuel use creates negative spillover effects, RD&D generates positive spillover effects in the form of innovations that can be used by other people and firms. Because these benefits cannot be fully captured as profits for the innovating firms, the private sector invests too little in RD&D. As a result, society loses out on the potentially large benefits of RD&D, a problem that is intensified because the federal government does not adequately fill the gap.[79] Department of Energy RD&D expenditures peaked in 1978 at approximately $6 billion (in 2000 dollars). Since then, annual energy RD&D budgets have shrunk to less than $2 billion annually (see Figure 11).[80] It is critical the country develops a new generation of climate-friendly technologies. Countries around the world are expanding their clean-energy research budgets, and advocates for increases in U.S. budgets are growing more numerous and vocal.[81]

FIGURE 11
Energy Funding for Research, Development, and Demonstration Has Declined Substantially Since 1978



Source: Kelly Sims Gallagher, "DOE Budget Authority for Energy Research, Development, and Demonstration Database"(Cambridge, MA: Energy Technology Innovation Policy, John F. Kennedy School of Government, Harvard University, 2007).

Lack of national standards. Inconsistent state policies are causing confusion in the marketplace. The lack of a harmonized regulatory setting also thwarts the economies of scale that can result from national markets. State building codes and renewable electricity portfolio standards are two examples of fragmented state governance that could benefit from national standards. Net-metering, environmental permitting, and utility rate regulations are among the many other "crazy-quilt" state-by-state policies that hinder the development of national markets so necessary for advancing new technologies, such as renewable energy and green building practices.[82]

On the other hand, some federal standards operate at cross-purposes to national efforts to reduce GHG emissions, and they are distorting the marketplace for energy and low-carbon technologies.[83] For example, environmental standards enable the continued operation far beyond their normal life of some of the most polluting generators in the country, and these standards create disincentives to investing in plant upgrades. Design flaws in other policies undermine their intended outcomes, as occurs with tax credits for hybrid electric vehicles that are authorized but cannot be claimed. Burdensome procedures add unnecessary sluggishness to the process of technological advancement. Conflicting social goals often explain these public failures. For example, the desire to promote U.S. energy security trumps the goal of mitigating greenhouse gases. Legal inertia is another cause. Laws often lag behind and thereby inhibit technological progress, as is true of building codes, CAFE standards, and tax depreciation schedules.[84] Clear, consistent, and nondistorting national standards would go a long way toward supporting a national environment for reducing metropolitan America's carbon footprint.

Inadequate information on local greenhouse gas emissions and best practices. Reliable information about climate-friendly options is often incomplete, unavailable, expensive, and difficult to obtain. Decisionmakers would benefit from a repository of best practices in carbon management. Across the federal government, more than 300 programs, policies, and activities promote the commercialization and deployment of GHG-reducing technologies, and many of these involve information outreach, labeling, and consumer education.[85] Nevertheless, information deficiencies remain, particularly in understanding the effectiveness of different carbon mitigation policies and programs.

The poor quality of information on carbon emissions at the metro, county and local level is problematic. Data on energy consumption and carbon emissions at the metropolitan and smaller scales must currently be interpolated and extrapolated, thereby compromising its accuracy. In combination with an inadequate use of modeling tools, these data deficiencies make it difficult for consumers, producers, and policymakers to create more efficient land use, transportation, and climate-friendly building designs. Baseline data and knowledge-sharing among the states are needed on issues such as reforming utility rate structures and encouraging compact development. The federal government is the appropriate entity to fill this gap. Fortunately, new data are being compiled—by the Vulcan Project and the communities participating in the upcoming Climate Registry—that will help fill the gaps.

2. Federal transportation and land-use policy falls short of its potential to spur energy- and location-efficient decisionmaking

In the transportation sector, the federal government favors highway construction over transit and provides inadequate leadership and vision in the freight transportation and land use planning arenas.

Federal transportation policy lessens the viability of energy-efficient development. Federal transportation policy rewards growth in passenger travel, while ignoring efficiency or cost-effectiveness of local transportation systems. For example, the Federal Highway Administration of the federal Department of Transportation apportions highway funding to the states from the Highway Trust Fund on a formula basis using estimates of each state's relative contribution of taxes to the fund.[86] Thus, federal transportation funding rewards states for high VMT, fuel use, and lane-miles of travel. States have no incentive to lower travel demand or energy consumption, such as by transit or compact development, because their transportation funding might be reduced.[87] So long as this funding formula continues, the task of reducing carbon emissions from transportation will be difficult.[88]

Federal transportation policy has long favored highway building over transit investments.[89] Transit projects are evaluated and funded differently than highways. The pot of available federal transit funding is so small that the federal government oversees a competitive process for new transit funding, requiring multiple and rigorous reviews that demonstrate a project's cost-effectiveness. Funding is also subject to annual congressional appropriations. Highways do not undergo the same level of scrutiny or funding uncertainty. Also, while highways typically receive up to 80 percent of federal funds (and 90 percent for improvements and maintenance), new transit projects are capped at 60 percent and often receive less.[90] States do not tend to make up the difference as they do with highways, meaning that transit projects often require 40 percent from local funding sources.

Federal deference to state and local land-use autonomy impedes the creation of more location-efficient metropolitan areas.[91] Land-use decisions are almost exclusively under local authority in America's federalist system. "Fiscal zoning" has become a common tool for local authorities to attract high-revenue-generating uses, such as commercial and clean industrial development, and to exclude higher-density housing that brings with it an added tax burden in the form of schools and other public services.[92] The result is a bias toward large-lot, single-family developments and an undersupply of more energy-efficient options in more compact configurations.[93] In general, the not-in-my-back-yard tendency has encouraged many communities to exclude locally undesirable land uses, leaving other communities to carry the burden of such facilities.

These practices often reduce intracommunity land-use mix and increase the distance of trips. Residents are also more reliant on personal transportation, and they drive longer distances, both of which have increased the cost burden for transportation to an average of 18 percent per household, and 36 percent for low-income households.[94]

Little power exists to influence the coordination of land-use plans at the metropolitan or wider regional scale. The spread of employment throughout metropolitan areas such as Los Angeles and the Washington–Baltimore regions has led to the gradual absorption of surrounding towns and the spaces between them, creating ribbon-like urbanized areas spanning 100 miles from end to end.[95] Only a limited number of states have taken legislative action to implement regionwide coordination of local land-use plans. Even when the power exists to require such coordination, it rarely has been used. Consensus is also lacking about how (legally, administratively, fiscally, or politically) to control land development.[96]

A broader federal role in supporting energy-efficient metropolitan area freight planning is warranted. As this report shows, approximately 24 percent of all highway fuel consumed and carbon emitted within the 100 largest metropolitan areas is associated with trucking. This freight activity is the neglected stepchild of the metropolitan transportation planning process. With the growth in truck traffic outpacing that of automobile traffic in most metropolitan areas, and with truck VMT expected to grow by more than 2 percent annually through 2020, this situation is poised for change.[97]

Currently, local planning jurisdictions largely control where freight terminals are situated within metro areas. Freight transport systems also tend to be designed only to meet the concerns of local—and often competing—jurisdictions.[98] The fragmented nature of such decisions can create problems in the location of high-volume facilities that handle trucks operating throughout metro areas and across many local jurisdictions. The federal government has acknowledged the need for better freight planning in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users of 1995 (P.L. 109-59, known as SAFETEA-LU), but additional steps are needed to realize the national goals in that law.

3. Federal housing and electric utility policy falls short of its potential to spur energy- and location-efficient decisionmaking

In the buildings sector, the federal government encourages homeowners to build larger homes than they need, and its housing finance activities do not encourage locationally or energy-efficient buildings. Federal incentives for energy-efficient investments are biased toward newly built homes and higher-income households, and state utility policies thwart energy efficiency improvements and low-carbon options.

The federal government does not adequately promote energy efficiency in its housing and building codes. Although the federal Real Estate Settlement Practices Act (RESPA) requires sellers to disclose hazards, impediments, lending terms, and other information to support buyers, they do not require that energy costs be disclosed. Beyond hampering consumers' efforts to choose more energy-efficient lifestyles, this omission is particularly troubling because of energy's large share of housing costs—especially in energy-inefficient homes.

Congress is currently debating amendments to both RESPA and the Truth in Lending Act (TILA) to improve information disclosure, but the amendments do not contain provisions for including energy costs or efficiency investments that affect the true costs of homeownership. Related to this, few Multiple Listing Service (MLS) systems include energy-related features or cost information. Because these systems are not overseen by the federal government, standards vary from place to place and may give buyers unreliable and inconsistent energy information.[99]

The federal government also fails to leverage its role in regulating building codes. Despite federal requirements that states adopt model building codes that contain minimum energy standards, the federal government remains mostly silent on state and local code enforcement, thus limiting impact. And while the Energy Independence and Security Act of 2007 established standards for energy efficiency in government, education, and commercial buildings, the law neglects laying out a federal role for improving the energy-efficiency of the nation's 75 million single-family residences.[100]

The federal government also fails to leverage its housing finance activities to stimulate energy-efficient building. The federal government has an opportunity to construct market-catalyzing financial products, such as energy-efficient and location-efficient mortgages (EEMs and LEMs). Although the federal government has attempted to offer EEMs, it has burdened the products with a complicated set of processes and design flaws that limit their feasibility. This has been made worse by the federal government's inability to enter into partnerships with private entities that could improve market penetration of alternative mortgage products.[101]

Federal incentives for energy-efficient investments are biased toward newly built homes and higher-income households. The government offers a $2,000 builders' tax credit for new residential construction. Likewise, a federal tax credit of $2,000 is available for homeowners who invest in photovoltaic (solar) systems—a relatively high-cost technology, which essentially exclude many lower-income families. Even if a broader section of the public used the tax credits and they allowed for technologies other than solar, their impact would be slight, as the incentives are set to expire by the end of 2008.

Mortgage tax policy and lending practices hinder climate-friendly development. Federal mortgage policies may exacerbate energy inefficiency. The mortgage interest deduction, for instance, encourages people to buy more and larger homes on larger lots in less-dense locales.[102] In addition, mortgage-lending practices encourage homebuyers to "drive until they qualify," that is, to seek more "affordable" housing farther from the urban core. The upshot of this trend is increased transportation costs. A recent study shows that for every dollar saved by moving farther out, families spend an additional $0.77 on increased transportation.[103] Current prices, however, do not account for the full range of environmental and social costs associated with transportation and fuels consumption, as outlined above, which may be as high as 7–15 cents per mile.[104] If transportation were properly priced, the implications of distorted federal housing policies would appear much clearer.

State utility pricing policies and cost-recovery regulations thwart energy-efficiency improvements and low-carbon options. Unfavorable electricity pricing policies and cost recovery mechanisms create obstacles for an array of clean energy technologies. In traditionally regulated states, for example, the utility return on investment is proportionate to the amount of energy sold; it therefore penalizes utilities for improved end-use energy efficiency and for distributed generation sold “off grid.” The origin of many of these policies often is based on long-standing practices that have been incrementally modified over years of regulatory oversight.[105] Because of these utility pricing policies, neither electricity generators, nor wires companies, nor consumers see the full value of energy efficiency or distributed generation. Without better price signals, it is challenging for the providers of energy-efficient products and on-site generators to transform consumer markets.

4. Federal policy is fragmented, making it difficult to integrate transportation, housing, and environmental policy to achieve national goals

Currently, states, localities, and others receive housing, transportation, energy, and environmental funds largely from four separate agencies: the Department of Transportation, the Department of Housing and Urban Development, the Department of Energy, and the Environmental Protection Agency. These agencies’ policies directly affect one another’s programs, although they are typically developed in isolation.

The current package of federal funds to states and localities at the very least discourages, and at most inhibits, integrative planning. The Catalog of Federal Domestic Assistance lists 187 different formula grants. Ninety percent of federal grants are categorical, which means their use is limited by strict federally determined formulas, such as the highway funding formula mentioned above. This degree of fragmentation across multiple agencies and jurisdictions discourages integrated planning and interagency cooperation.

Indeed, in this fragmented federal policy and funding environment, metro actors will be hard-pressed to develop the place-based transformative policies needed to address the climate challenge.

* * *

Given these problems in federal policy and the urgency of the climate challenge, it is time to move forward. The flaws in state and federal policy warrant a rapid response because delay creates lost opportunities. Investments in major new facilities and equipment are often only cost-effective when an upgrade, renovation, or system replacement is taking place. If improved technology is not installed at those points, the carbon-intensive status quo can be locked in for decades.[106]

The expectation of a stream of immediate and future benefits drives most investment and consumption decisions. Uncertainty is a deterrent to investment and contributes to a “wait-and-see” attitude among carbon emitters. Prolonged debates about alternative future policy scenarios can preempt commitments to clean energy and investments in carbon-intensive energy options. Policy uncertainty is particularly problematic when clean energy technologies are being launched into a market where carbon is not priced, codes and standards have not been developed, new policies are expected, laws fluctuate over time, "the rules" vary from place to place, and information about metropolitan carbon footprints is missing.

Given the pressing need to respond to the national, cross-boundary challenges of climate change, energy-security, and national competitiveness, the federal government should lead more decisively on matters such as correcting market failures, setting standards, and exchanging information. Its role in transportation should more strongly incorporate energy-efficiency and climate mitigation as important decisionmaking criteria while also reforming policies that presently favor energy-intensive modes over efficient ones. Similarly, the federal government should leverage its role in shaping the nation's housing market by making energy an important component of its information disclosure, investment, and finance policies.

VI. State and Local Governments are Taking the Lead on Climate Policy, But Their Efforts Must Be Complemented By Expanded Federal Action

In the face of large-scale market and policy failures, state and local governments are innovating as they exert significant policy leadership to tackle energy and climate change issues. The diversity of activities is staggering. Some of the most common actions range from GHG emissions reduction goals and regional cap-and-trade systems to state portfolio standards and technology development.[107]

The volume of state and local activity illustrates both the recognition of the climate challenge and a palpable desire to take public action. More important, states and localities serve as laboratories for incubating and testing policy innovations. Lessons learned can then inform federal climate policy design, implementation, and effectiveness. Given the unevenness across state policies, the advances of leading states lay the groundwork for lagging states—and the nation—to follow. At the same time, the inherent limits of state and local activity, especially in its scope, underscore the necessity of effective, targeted federal engagement.

1. States and localities are setting climate goals

Perhaps the most controversial element of climate policy is commitment to an emissions reduction target. The federal government faced criticism over its failure to ratify the 1997 Kyoto Protocol, which would have set a binding emissions reduction target for the country.

In the absence of a federal emissions target, states and localities have adopted their own climate goals. As of March 2008, 17 states had adopted statewide emissions reductions targets.[108] The state-level policies vary by effective date, stringency, and whether the targets are mandatory or voluntary. For instance, at least eight states (Oregon plus seven Northeastern states) have committed to reducing their emissions 10 percent below 1990 levels by 2020. Alternatively, Arizona committed to reducing to levels by 2020 to below its 2000 levels, and New Mexico committed to reducing its consumption to 10 percent below 2000 levels by 2020.

California launched an ambitious emissions reduction program when it adopted the Global Warming Solution Act (AB 32) in September 2006. AB 32 sets a goal of reducing California's GHG emissions to 1990 levels by 2020. While AB 32 is not the strictest state climate goal in the country, it is powerful; California's GHG emissions match those emitted by Australia.[109] AB 32 requires the state to undertake a GHG emissions inventory and mandatory reporting and verification of GHG emissions.[110] Toward this end, the California Air Resources Board is currently working with different agencies and sectors, including agriculture, electricity, forest, manufacturing, oil and gas refining, transportation, and waste management. The state is also considering other market-based mechanisms (such as a cap-and-trade system) and regulatory actions to meet the statewide climate goals.

Consistent with the axiom "think globally, act locally," localities are also setting their own climate goals and targets. Principal among these is the U.S. Conference of Mayor's Climate Protection Agreement (CPA), launched by Seattle Mayor Greg Nickels in February 2005. As of early April 2008, 825 mayors had signed on, representing 80 million Americans.[111] Signatories commit to "strive to meet or beat the Kyoto Protocol targets in their own communities, through actions ranging from anti-sprawl land-use policies to urban forest restoration projects to public information campaigns."[112]

ICLEI, an international association of local governments, launched a related effort—Cities for Climate Protection (CCP)— in 1993 . CCP encourages cities to reduce their GHG emissions and improve livability through a rigorous five-step reductions program. More than 150 U.S. cities and 600 cities worldwide have joined CCP.[113] As part of CCP, cities must inventory their GHG emissions. One of the first U.S. cities to estimate its carbon footprint was Somerville, MA, in 2001.[114] Many cities have now followed suit. In 2007, New York City published an inventory of its GHG emissions, conducted in cooperation with ICLEI.[115] With 0.25 percent of the world's greenhouse gases, this inventory was a major undertaking.

Occasionally, journalists or individual consultants attempt to assemble GHG emissions profiles for major urban areas, such as Chicago, Portland, OR, and Washington, DC.[116] Generally, the data and modeling approach used is highly variable, making it difficult to compare results across metropolitan areas. With more than 800 signatories to the CPA, there is clearly a pent-up demand for more cost-effective and consistent means of inventorying GHG emissions.[117] The partial carbon footprints presented earlier help to meet this demand by providing a methodology that could be applied consistently and quickly using publicly available data.

The special vulnerability of major cities to climate change coupled with their unique access to resources motivated the creation of a coalition of world cities called the C40 Cities Climate Leadership Group. Created in 2005, the partnership pledged to reduce carbon emissions and increase energy efficiency in large cities across the world.[118] Chicago, Houston, Los Angeles, New York, and Philadelphia are the U.S. member cities, and Austin, New Orleans, Portland, Salt Lake City, San Francisco, and Seattle are among the affiliated cities. Many of these same cities appear in lists of "best practices" and exemplary programs, suggesting climate policy innovation is indeed coming from a subset of leading cities. With support from the Clinton Climate Initiative, the partnership will provide a range of assistance to the C40 partner cities, including pooled procurements to lower the price of clean technologies, expert assistance to replicate best practices, and common measurement tools so that cities can track emission baselines and monitor progress. Again, the need for better benchmarking of carbon footprints is reflected in this list of priority activities.

2. Carbon pricing efforts have been initiated in states and regions across the country

In the absence of a federal carbon pricing policy, several regions have launched their own carbon cap-and-trade systems. A cap-and trade-system is a market-based tool that sets a cap on total carbon emissions and grants emitters credits (or allowances, through auctions or other means) for a set amount of emissions, which they can then trade with other emitters. In theory, such a flexible system allows reductions to happen in the most cost-effective manner feasible for all emitters.

New York's Governor Pataki formed the first of these regional initiatives in the Northeast in 2003.[119] The Regional Greenhouse Gas Initiative (RGGI) now includes 10 states—Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont—that have agreed to establish a mandatory cap on carbon emissions from power plants. The states begin with current levels in 2009, and agree to reduces emissions 10 percent by 2019. RGGI allows sources to trade emissions allowances. RGGI may grow in scope to include other GHGs, other sources, and to include other players (e.g., District of Columbia, Pennsylvania, and the eastern Canadian provinces).

Building on RGGI's success, similar regional initiatives have been launched recently in the West and Midwest. In August 2007, the Western Climate Initiative (WCI) members—Arizona, California, Montana, New Mexico, Oregon, Utah, Washington, and Canadian provinces of British Columbia and Manitoba—set an economy-wide emissions reduction target by 2020 of 15 percent below 2005 levels.[120] The target reductions apply to each of the six primary GHGs, including carbon dioxide. WCI plans to establish a market-based system (such as a cap-and-trade program) covering multiple economic sectors by August 2008.[121]

Likewise, six Midwestern states—Illinois, Iowa, Kansas, Michigan, Minnesota, and Wisconsin—along with Manitoba, Canada, signed the Midwestern Regional Greenhouse Gas Reduction Accord in November 2007. The accord commits participants to set a regional emissions reduction target, establish a multisector, market-based system, implement an emissions tracking system, and pass supportive policies (such as low-carbon fuels standards).[122] Ohio, Indiana, and South Dakota are observing the process and may join in the future.

Altogether, the three regional initiatives cover more than half of U.S. states and many of the largest metropolitan areas. These initiatives provide a test-bed for policy design of a national pricing scheme for carbon. They also benefit by learning from the European Union's Emission Trading Scheme (ETS), which was launched in 2005. The ETS covers more than 1 billion metric tons of carbon emissions from various power production and industrial sources across the European Union, valued at $23 billion in 2006.[123] A primary lesson from the ETS is the need for accurate and multi-year emissions data to price tradable emissions allowances properly. Critics of phase one of the ETS claim that many member states lacked clear emission data baselines, making it difficult to monitor progress.[124]

3. States are increasing their expenditures on energy RD&D

Some states are eclipsing the federal government in expenditures to support clean energy technology development and deployment. For example, 20 states and the District of Columbia have established Public Benefits Funds (PBFs) typically through the electric utility restructuring process. States use these funds to support energy efficiency and renewable energy RD&D; technology demonstration programs; rebates for technology investments; and energy education programs. The annual budgets for these state PBF programs grew to $1.6 billion in 2007.[125] Thus, state efforts now exceed DOE's expenditures on energy efficiency and renewable energy research, and they are more than one-half the federal government's agencywide expenditure on climate change technology development, which is estimated to average approximately $3 billion per year during fiscal years 2005, 2006, and 2007.[126] The federal government's funding of basic energy sciences enables fundamental breakthroughs in climate technology, as described in the Climate Change Technology Program's Strategic Plan.[127] However, translating technology advances into green products for the marketplace has become a strong suit of state programs. That is, state agencies generally focus on the deployment of new technologies, motivated often by the prospect of economic development, while the federal government generally focuses on fundamental research and technology development.

4. States are also leading on setting renewable energy standards

States are also taking the lead on setting renewable electricity standards. These standards typically require utilities to produce a certain share of their energy with renewable sources, sometimes in combination with energy efficiency, to decrease the carbon intensity of the U.S. economy.[128] The standards vary considerably by strength, target date, and which sources qualify as renewable.[129] In some states, such as New York, the renewable electricity standards apply to the state's total electricity consumption rather than to each energy provider. As of April 2008, 26 states and the District of Columbia had implemented standards, covering more than half of the country's population.[130] According to calculations by the Lawrence Berkeley National Lab, "current mandatory state [renewable electricity] policies will require the addition of roughly 60 gigawatts (GW) of new renewable energy capacity by 2025, equivalent to 4.7% of projected 2025 electricity generation in the U.S., and 15% of projected electricity demand growth."[131]

5. States and localities have looked to development patterns for clues to shrinking their footprints

California also passed landmark legislation to reduce GHG emissions from new vehicles (AB 1493).[132] In the past, California has received waivers from the Environmental Protection Agency to set its own, more stringent air emissions standards under the Clean Air Act. Other states can then adopt California's standards or the federal standards. The future of California's new vehicle legislation is in question, however, given that the state failed to receive a waiver from the EPA that would allow it to regulate GHGs as air pollutants. This decision has been appealed and 15 states stand ready to adopt California's GHG vehicle standards if the waiver is granted.[133]

Cities are also focusing on reducing emissions through transportation. For instance, Mayor McCrory in Charlotte, NC, initiated the public-private Clean Air Works! campaign within the eight-county Charlotte metro area. This campaign provides technical assistance to businesses with programs that encourage employees to change commuting patterns and driving behavior to reduce emissions.[134] Mayor Peterson in the greater Indianapolis area initiated a similar effort by focusing on business actions to promote air quality and climate protection.[135]

Climate-friendly land-use initiatives are underway at the state and local level. These include zoning ordinances to encourage higher density, mixed-use land developments; promotion of urban designs based on compact and readily accessible local street systems; more pedestrian- and cyclist-friendly pathways; and the use of green areas to mitigate the "heat island" effects created by asphalt, concrete, and other heat absorbing surfaces.[136]

Recently, states and localities have begun recasting these and other land-use initiatives as integral tools to reduce GHG emissions. For instance, Massachusetts issued an executive order in April 2007 that requires large development proposals to analyze GHG impacts as part of the environmental review process.[137] Maine advocated for a similar test in a large proposed development in December 2007.[138] These proposals build on California's efforts to regulate land-use development to meet its climate goals under the state's Environmental Quality Act (SEQA). The state has even sued one of its own counties for failure to include GHG review in its master planning process. With confusion over AB 32's implications for SEQA, the state passed SB 97 in 2007, which exempted public bond-funded projects from GHG challenges for two years while the state comes up with new rules.[139] All eyes remain on California as it assesses the role for land-use initiatives in achieving its climate goals. Similar efforts are now being proposed in Washington State, building on a local version in King County (Seattle).

* * *

Clearly state and local governments are creating valuable laboratories for testing climate-friendly policy innovations. However, the capacity and reach of the state and local policy initiatives are limited compared with what could be achieved with federal action. Indeed, state and local activity cannot accomplish by themselves the scale of emissions reductions needed to meet national climate and energy security goals. Inconsistent state and local activity, such as on renewable electricity standards and regional cap-and-trade programs, can also result in higher implementation costs than national programs and provide an uncertain and difficult regulatory environment for businesses operating across multiple jurisdictions.

The pro-metropolitan federal policy agenda presented in the next section builds on the dispersed but valuable policy experiences of states and localities, while providing wider geographic coverage.

VII. The Federal Government Must Take Action to Address Market Failures and Help Metropolitan America Shrink its Carbon Footprint

Federal policy can and should play a powerful role in helping metropolitan areas—and so the nation—shrink their carbon footprint. Such engagement should address both the major economy-wide policy problems discussed above, as well as address key issues in the transportation and housing sectors that have metropolitan-scale implications.

1. Several economy-wide policies are critical

As discussed above, the cross-boundary challenges of climate change, energy security, and national competitiveness justify a more decisive federal climate policy that corrects market failures on pricing and RD&D, sets national standards, and requires better information.[140] These steps are particularly critical and urgent given the rise in carbon emissions from metro areas and the nation as a whole between 2000 and 2005.

First and foremost among existing market failures is the absence of a price on carbon emissions; thus a key remedy involves ***getting the prices right***—internalizing the externalities of fossil fuel combustion and transportation to more accurately price the consumption of fossil-based energy. The actual policy mechanism could be a carbon tax or cap-and-trade program.[141]

Pricing carbon would encourage a wide range of activities to reduce carbon emissions, including lower-carbon fuels, energy efficiency, and carbon sequestration.[142] Pricing might also provide an incentive to make investments in existing structures and more accessible locations that would in turn offer workers and residents more transportation options and lower costs.[143]

Pricing carbon could have additional positive benefits if the resulting revenues were targeted strategically. If a cap-and-trade program is adopted, for example, sales of emission permits could generate revenues of $30 to $40 billion in the first 10 years of the program.[144] A portion of this revenue could be used to fund some of the policies described in this pro-metropolitan policy agenda.

Correcting energy prices will go a long way in stimulating demand for low-carbon, energy-efficient technologies. Because RD&D creates spillover benefits that cannot be fully captured by firms, the amount of RD&D will remain lower than optimal. Thus, the federal government must ***step up its investment in RD&D activities*** that will increase energy efficiency innovations and more quickly bring such innovations to market.

Proposals for increasing energy RD&D range from modest to immense. John Holdren suggests that a three-fold increase in federal energy RD&D funding could be achieved through a two-cent hike in the federal gasoline tax.[145] On the bolder side, a *Blueprint* paper examines the potential of multidisciplinary discovery innovation institutes (DIIs) to promote energy research, innovation, and commercialization. Ideally, funding for DIIs would dramatically raise national energy RD&D spending to a level that matches the seriousness of the nation's energy-efficiency and climate challenges. Federal RD&D expenditures total approximately $30 billion annually for health care and $80 billion for defense. A proposal of $40 to $50 billion for federal energy RD&D would be consistent with spending on other national priorities.[146]

Third, with the mosaic of renewable electricity standards now in place in more than 25 states and the District of Columbia, it is time for the federal government to ***establish a national renewable electricity standard*** so that renewable energy and energy efficiency markets can be fostered in a rational and predictable policy environment. A renewable electricity standard (RES) is a legislative mandate requiring load-serving entities (i.e., electricity suppliers) in a given geographical area to employ renewable resources to produce a certain amount or percentage of power by a fixed date. Typically, electricity suppliers can either generate their own renewable energy or buy renewable energy credits. Because electricity providers do not reside completely within the bounds of states (electricity is an interstate product), variation in state standards can be costly and onerous for utilities.

A national RES may not be necessary if actions are taken to appropriately price carbon, which would encourage the transition to low-carbon fuel alternatives. Unfortunately, current cap-and-trade proposals are insufficient to fully correct energy price imperfections, thus requiring additional actions to reduce the nation's carbon intensity. A national RES may also be easier to implement on a faster timeline than a full-fledged pricing scheme.

The federal government should ***help states reform their electricity regulations to create incentives for energy efficiency.*** Although electricity regulation is typically a state matter, the federal government could spur state utility commissions to reform their rate-making practices. Under current rate designs, "the utility's profits hinge on throughput—how much electricity flows through their wires. More sales, more profits. Actions that lead to conservation, appliance efficiency gains, and local generation all penalize utility profits."[147] Reforming this market distortion could create sizeable opportunities for utilities and energy services companies to turn a profit by addressing the large, aggregate demand for reducing utility bills in the nation's metropolitan areas.

Rural settings impose large transaction costs on energy-efficiency services. In contrast, metropolitan areas are natural markets for such products. This opportunity is what motivated the Kendall Foundation and its partners to create the Cambridge Energy Alliance—a $100+ million initiative dedicated to improving energy and water efficiency and reducing waste in the city of Cambridge, Massachusetts. The business case for the alliance is a sizable return on investment while shrinking the city's carbon footprint.[148] With receptive regulatory environments, this model could be replicated throughout metropolitan America.

Finally, a federal effort to ***provide better data on energy consumption and GHG emissions*** is critical in minimizing the nation's climate impact. An important step would require utilities to annually file energy sales data at small unit areas (i.e., the census tract or ZIP code level). The Vulcan Project is another step forward, and one that should be continued and expanded. By improving how we quantify energy and carbon footprints, we can create better benchmarks of progress. By providing data at a scale that is consistent with other socioeconomic and demographic data available from the federal government, we can better understand energy consumption within the context of the built environment, and we can clarify the causal influence of variables such as urban form and state and local policies. Without more geographically differentiated information, consumers, producers, and policymakers will find it difficult to act efficiently in land use, travel, and the built environment decisions.

By addressing these market failures, federal involvement in new and reformed policies can unleash the market forces needed to tackle energy and climate challenges.

2. Five pro-metropolitan actions are necessary

The five economy-wide policies are critical to achieving the nation's climate goals. As important as they are, however, they ignore the role of the built environment in reducing demand for energy and thus in shrinking the nation's carbon footprint. As the research reported above illustrates, location matters to carbon emissions. Federal climate legislation must address this reality. Metropolitan America offers an energy- and carbon-efficient alternative to nonmetropolitan areas. It is also a crucible for climate policy innovation and technological breakthroughs that will be necessary to meet the climate challenge.

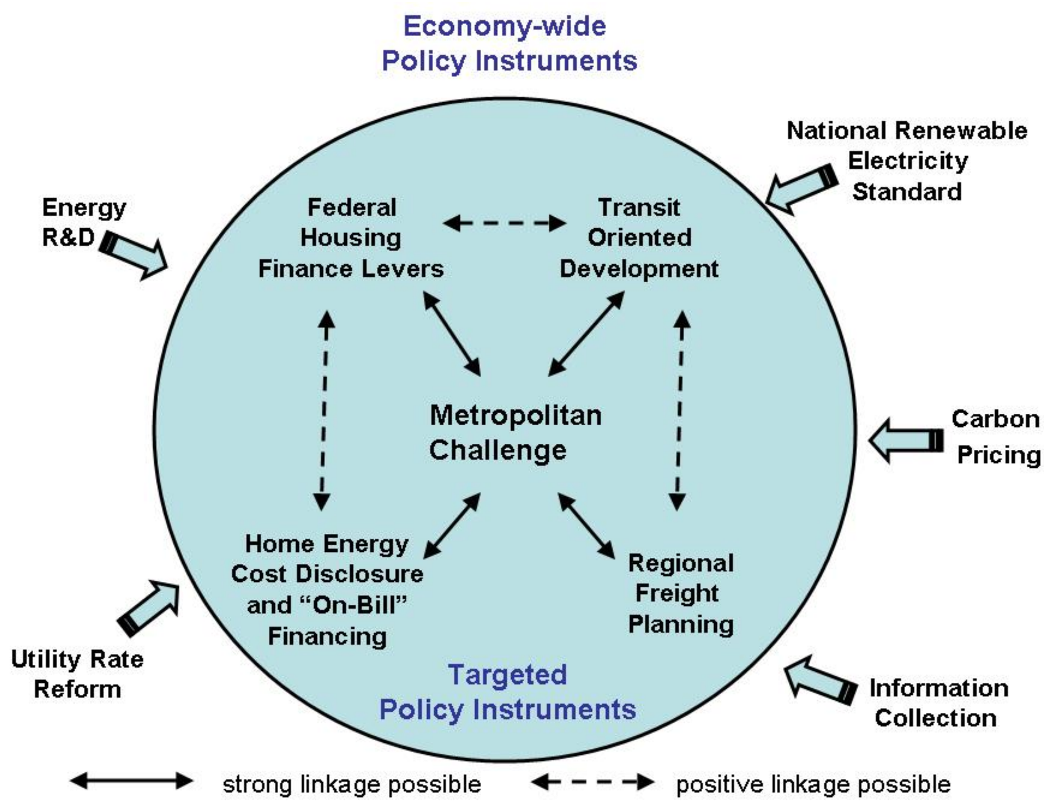
Five policy actions targeted to metro areas, therefore, have the potential to transform how consumers, producers, and policymakers in metropolitan America make decisions that influence the nation's climate and energy security goals.

TABLE 5
Five Pro-Metropolitan Policy Instruments Would Together Address Four Major Subsectors of the Economy

	Market Sector			
	Residential Electricity	Residential Fuels	Passenger Transportation	Freight Transportation
Promote More Transportation Choices	✕	✕	●	○
Engage in Regional Freight Planning	✕	✕	○	●
Require Energy Cost Disclosure and "On-Bill" Financing	●	●	✕	✕
Re-Examine Federal Housing Finance Levers	●	●	○	✕
Establish a Metropolitan Challenge Grant	●	●	●	○

● Major area of impact; ○ Secondary area of impact; ✕ No or negligible impact

FIGURE 12
Multiple Synergies Exist Between the Five General Policy Instruments and the Five Metro-Targeted Policy Instruments



Policy Action 1 and 2: Promote energy- and location- efficient development with two transportation and land-use strategies

The new research reported in chapter 3 highlights the important role of development patterns and transportation in metro carbon footprints. It also highlights the role that freight traffic plays. Two federal transportation strategies could help metro areas promote energy- and location-efficient development.

1. Promote more transportation choices to expand transit and compact development options

The federal government has little direct control over local-land use decisions. Yet, federal transportation decisions have widespread influence on local and regional development patterns. Moreover, federal transportation decisions have historically limited the viability of transit and transit-oriented development (TOD), which represents an important tool for shrinking carbon footprints by reducing vehicle miles of travel and associated fuel use.[149]

To remedy these policy flaws, the federal government should adopt a position of "modal neutrality," as Robert Puentes discusses in a *Blueprint* policy paper.[150] Under this scenario, the federal government does not favor one travel mode over another, such as highways over transit.

To that effect, the Department of Transportation (DOT) should subject proposals for highway projects to the same level of scrutiny as it does transit project proposals. After all, new highways can have the same dramatic economic and environmental impact on regions as new transit systems can; there is no reason for disparate evaluation. The DOT should require major investment studies and disclosure of long-term funding for highways and highway improvements, as it does for transit. Although economic and fiscal considerations are key criteria for evaluating projects, so too should environmental quality and energy efficiency. The upcoming transportation reauthorization provides the perfect opportunity for re-envisioning how transportation policy should to be structured and funded.

By establishing a clear vision for transportation that includes energy and climate change concerns, and by taking a modally neutral stance on new projects, energy-efficient investments—such as those in transit-oriented development—can become more feasible.

TODs can have potentially large impacts on energy intensity and GHG emissions. These impacts could be bolstered by synergies with other policies, notably policies that encourage urban infilling, such as the rejuvenation of urban brownfields, the development of urban enterprise zones, locating new federal buildings in promising mixed-use, higher-density commercial areas, and the use of alternative mortgage products such as energy efficient and locationally efficient mortgages (EEMs and LEMs). The result will give metropolitan areas more flexibility and the nation expanded options for addressing large-scale challenges.

2. Develop regional freight planning to introduce more energy-efficient freight operations;

The growth in truck traffic is outpacing automobile traffic in most metropolitan areas, and truck VMT is expected to grow by more than 3 percent annually through 2020. A broader federal role in supporting energy-efficient metropolitan freight planning is warranted.

The federal government gave freight more attention than ever in its 2005 SAFETEA-LU transportation legislation.[151] Building on SAFETEA-LU, the federal government should help establish a more effective functional planning relationship that crosses public-private and modal boundaries and considers intra- and inter-metropolitan freight operations. Opportunities for reducing the freight carbon footprint fall naturally into two classes

- the introduction of more energy-efficient intra-urban truck pickup and drop operations
- the location and operation of more energy-efficient freight intermodal terminals

Actions on both fronts would benefit from regional planning efforts with greater federal engagement.

To support more energy-efficient truck pickup and drop operations, locales should use federal dollars to develop and promote well-researched examples of energy-saving freight technologies and logistical systems. This includes RD&D support for enhanced data collection and analysis, as well as small demonstration projects that allow a carrier or shipper to reduce its monthly fuel bill and carbon footprint. Such projects should build on the experience of both the Best Urban Freight Solutions program in Europe and the EPA's Smartway Transportation Program.[152] The Smartway program works with states, banks, and other organizations to develop financial options for freight-moving companies to purchase fuel-saving and emissions-reducing devices.

There also is a federal role in helping metropolitan planning agencies collect and analyze information on where to best locate truck-rail, truck-water, and truck-air freight terminals. Federal authority in such decisions is located in the Interstate Commerce Act and its role in preventing state and local regulation from undermining the rail industry's ability to provide seamless—and therefore more competitive—long-haul service.[153] Here again the federal government can learn from the European experience of "freight villages," where different freight handling firms are located along with consolidation and break-bulk operations associated with very high volumes of metro-area truck trips.[154]

As before, the upcoming transportation reauthorization provides a perfect context to encourage better freight planning along established national freight corridors that often span multiple metropolitan and non-metropolitan areas. The program should have a goal of avoiding some of the massive upcoming growth in truck freight VMT through better planning and enhanced intermodal opportunities.

Policy Actions 3 and 4: Encourage energy- and location- efficiency in housing decisions with two policies.

The new research reported in chapter 3 also illustrates the important role that weather, fuel mix, and electricity pricing have on emissions from residential buildings. Federal housing policy can help to encourage energy- and location-conscious housing decisions in the face of these larger, structural factors.

3. Require home energy cost disclosure when selling, and "on-bill" financing to stimulate and scale up energy-efficient retrofitting of residential housing

The Real Estate Settlement Procedures Act (RESPA) is intended to protect homebuyers from unforeseen risks and costs when buying a home. RESPA should be expanded to include unseen costs, particularly those related to energy.[155] Sellers should be required to disclose energy costs to a potential buyer for a period of several years before the sale. RESPA should also require the uniform disclosure of energy-efficient investments or energy-efficient certifications previously awarded to the home. With these disclosures, buyers can gauge energy costs and how those costs may be influenced by the building's current features.

The 2007 Energy Independence and Security Act requires performance information for federal buildings, and California is considering a similar requirement. In addition, the 2003 Energy Performance of Buildings Directive (EPBD) in England and Wales promotes improved energy performance of buildings in the European Community. Implementing the EPBD will encourage owners and tenants to choose energy-efficient buildings when seeking new accommodation and to improve the performance of buildings they occupy. The EPBD is seen as an important contribution to reducing carbon emissions within the United Kingdom's climate change program.[156]

There may also be a role for the federal government to develop standards for various multiple listing service (MLS) systems.[157] In this way, "green" or energy-efficient features in home listings would mean the same thing from one MLS service to another, thereby allowing buyers to better compare efficiencies and eliminate opportunities to "greenwash" listings by including items that may have little to do with energy efficiency. Similar standards should be applied to VMT and walkability scores in the MLS system.

To encourage energy retrofits of the existing housing stock, the federal government should collaborate with utility companies, banks, municipalities, housing agencies, and consumer groups to create meter-secured, "on-bill financing" options for home energy efficiency.[158] On-bill financing allows homeowners to pay the upfront costs of efficiency improvements in their monthly utility bills from the savings generated by the investment. By securing the upfront costs to the "meter," multiple dwellers in the same unit benefit from the investment and shared savings. The plan, while simple on paper, requires a partnership among multiple entities to coordinate auditing (to study which energy-efficiency investments are most beneficial), financing, installation of improvements, and utility metering. Although versions of this option are emerging, the fragmented nature of the market appears ripe for federal involvement.

4. Use federal housing financing to create incentives for location-efficient mortgages, and reform policies that lead to the overconsumption of housing

Price signals in the real estate market do not fully reflect the energy- or location-efficiency of buildings. For example, few mortgage lenders adjust the price-to-equity ratio or affordability criteria for families on the basis of the cost of personal transportation associated with a specific location. An efficient market would increase the amount of money homebuyers could borrow when they will live in neighborhoods where they can shop at nearby stores and use public transit, thereby saving them money.[159]

The market has used a variety of financial incentives to encourage compact energy and travel-efficient land use, including the use of developer impact fees and local and regional business tax incentives. Location Efficient Mortgages® (LEMs) are one such option.[160] The justification for extending the debt limit for families locating in locationally efficient neighborhoods is based on transportation savings. The amount of a LEM loan is determined by adding the transportation savings to a family's qualifying income.[161] LEMs are currently available in Chicago, Seattle, San Francisco, and Los Angeles, but federal programs are very limited and poorly designed.[162] The program has not received much publicity, and it has not spread to other states.

A well-designed and promoted national program, however, could persuade more borrowers to take greater advantage of LEMs, particularly if transportation costs and congestion continue to increase in urban areas. Although a national program may not affect land-use or transportation patterns to the same extent that a major increase in transit could, LEMs would spur individuals to use transit and limit sprawl.[163] LEMs can also encourage urban renewal without excessive gentrification, given that the program is targeted to low- and moderate-income families.

While reinvigorating its LEM program, the federal government should expand its range of fiscal incentives to stimulate investments in residential energy efficiency, which are quite small and limited primarily to new construction or the high-cost solution of solar power. Should the federal government extend such tax incentives beyond 2008, the incentives should be revamped to reach a wider audience and cover an expanded set of energy efficiency options.

In addition, because research suggests that the mortgage interest deduction leads to the purchase of larger houses and contributes to suburbanization, the federal government should examine whether its signature homeownership policy is undercutting other efforts to reduce energy use and carbon emissions.[164]

Policy Action 5: Issue a metropolitan challenge to develop innovative solutions that integrate multiple policy areas

A final and potentially transformative tool to reduce the carbon footprint of metropolitan America would be to issue a challenge to all metropolitan actors. Meeting the climate challenge will ultimately require innovation and creativity to link fragmented transportation, housing, energy, and environmental policies beyond anything considered so far. This is more than just comprehensive planning by individual jurisdictions; this involves comprehensive and integrated planning and increased investment at the metropolitan scale over a sustained period with the goal of massively transforming the design and workings of the built environment. Metropolitan America simply does not have the scale and the resources to do this alone.

As mentioned earlier, “one size fits all” national approaches may stifle the creativity and innovation needed from metro areas to identify the effective and transformative actions necessary to shrink the carbon footprints of Metropolitan America. The federal government should issue a new challenge—perhaps emerging from the ongoing congressional climate policy process or the housing and transportation appropriations process—to encourage metropolitan actors to find new ways to integrate transportation, energy, buildings, workforce, and land-use policies as a means to slow energy consumption and reduce GHG emissions. Potential models for this challenge grant exist in the Department of Transportation’s Urban Partnership Program to reduce congestion and in the Department of the Interior’s Water 2025 challenge grant program.

Under this challenge, grants—of about $100 million or more each—could be awarded in a competitive process to metro actors with proposals for growing differently (for example, denser growth along transit corridors or dramatic increases in home energy efficiency). The government could pool and expand existing but disparate finance streams to generate funding for the grants. These streams could include urban infill and brownfields redevelopment, which do not currently have enough funding to spur innovative and transform development strategies.

In addition to supporting energy and climate goals, this new program could support local planning objectives such as employment growth, development of low-income housing, and alternative transportation choices and accessibility.[165]

* * *

In sum, the recommended portfolio of economy-wide and sector-specific policies addresses the principal market and policy flaws that handicap metropolitan America from contributing more vitally to the nation’s energy and climate challenges. Table 6 recaps the relationship between these policies and flaws, and offers recommendations to address each flaw.

TABLE 6
Ten Recommended Policies That Would Help to Correct the Inadequacies or Flaws in Current Federal Policy

Flaws Addressed by the Policies	Economy-wide Policies
Underpriced energy	Put a price on carbon to account for the external costs of fossil fuel combustion
Underfunded federal energy RD&D	Increase funding of energy RD&D to increase energy-efficient and low-carbon innovations and accelerate their use
A lack of national standards	Establish a national renewable electricity standard to foster low-carbon energy markets in a rational and predictable policy environment
State utility pricing policies and cost-recovery regulations thwart energy efficiency improvements and low-carbon options	Help states reform their electricity regulations to promote energy efficiency
Inadequate information on local GHG emissions and best practices	Improve information collection and dissemination on emissions and best practices for states and localities

Flaws Addressed by the Policies	Targeted Policies
Federal transportation policy makes more energy-efficient development patterns less viable	Promote more transportation choices to expand transit and compact development options
Federal deference to state and local land use autonomy	Develop regional freight planning to introduce more energy-efficient freight operations
Federal government does not adequately promote energy efficiency in buildings in its housing and building code policies Federal incentives for energy-efficient investments are biased toward newly built homes and higher-income households	Require energy cost disclosure and "on-bill" financing to stimulate and scale up energy-efficient retrofitting
Federal transportation policy inhibits energy-efficient development patterns Mortgage tax policy and lending practices hinder climate-friendly development Federal government fails to leverage its housing finance activities to stimulate energy-efficient building	Use federal housing financing to create incentives for location-efficient mortgages and reform policies that lead to the overconsumption of housing
All of the above	Issue a metropolitan challenge to reward metro areas for developing innovative spatial solutions

VIII. CONCLUSION

This paper has documented the many ways that metropolitan America could accelerate the transition to a built environment that will reduce carbon emission significantly while enhancing energy security and national competitiveness. The U.S. economy continues to grow, and with it come increased demands on the country's transportation and building infrastructures and services. As a result, Americans are in the enviable position of being able to invest in climate-friendly, energy-efficient facilities and infrastructures. Yet, as the nation considers future actions, metro areas and the built environment have been largely left out of the discussion when, in fact, it is metro areas that can have the largest impact.

As the U.S. population and GDP grow, the nation must reduce the energy intensity of its economic system, lower the carbon intensity of its energy consumption, and save energy through compact development. Because such transformations require capital, they are often only cost-effective when capital assets are first being built, or when major upgrades, renovations, or system replacements are occurring. If improved technology is not installed at those points in time, the carbon-intensive status quo can be locked in for decades. All these considerations make focusing on the built environment in reducing our carbon footprint more urgent. Much of this infrastructure is concentrated in the largest metropolitan areas.

The option to create a climate-friendly metropolitan environment does not necessarily translate into selecting low-carbon alternatives. Numerous flaws prevent the market from operating efficiently in tackling the climate problem—the most important being the lack of a price on carbon. The federal government must create new programs and policies and expand others to encourage decisions that shrink the nation's carbon footprint, including increasing energy RD&D spending, developing a national renewable electricity standard, and providing technical assistance to states and localities.

In addition, this report recommends five federal initiatives to promote energy-efficient compact development in metropolitan America. First, federal transportation policy must place highway and transit decisions on an equal footing, which would encourage new transit-oriented development and redevelopment of existing urban spaces. This in turn will expand public transit use. Second, the federal government must make targeted efforts to improve energy- and location-efficient housing decisions, such as requiring greater disclosure of home energy costs in combination with "on-bill" financing options, which would help to upgrade the energy integrity of the metropolitan building stock. Finally, the federal government should issue a challenge grant, linked to a sizable financial carrot, to encourage metropolitan areas to shrink their carbon footprints by integrating housing, transportation, and economic development policies.

Together, a federal metropolitan portfolio of carbon policies could place metropolitan America at the forefront in helping to solve the nation's energy and climate challenges.

APPENDIX A: CARBON FOOTPRINT RESULTS FOR 100 METROPOLITAN AREAS

TABLE A1
Per Capita Carbon Emissions from Transportation and Residential Energy Use, 2005

Metropolitan Area	**Rank**	**Carbon Footprint (metric tons)**
Honolulu, HI	1	1.356
Los Angeles-Long Beach-Santa Ana, CA	2	1.413
Portland-Vancouver-Beaverton, OR-WA	3	1.446
New York-Northern New Jersey-Long Island, NY-NJ-PA	4	1.495
Boise City-Nampa, ID	5	1.507
Seattle-Tacoma-Bellevue, WA	6	1.556
San Jose-Sunnyvale-Santa Clara, CA	7	1.573
San Francisco-Oakland-Fremont, CA	8	1.585
El Paso, TX	9	1.613
San Diego-Carlsbad-San Marcos, CA	10	1.630
Oxnard-Thousand Oaks-Ventura, CA	11	1.754
Sacramento--Arden-Arcade--Roseville, CA	12	1.768
Greenville, SC	13	1.859
Rochester, NY	14	1.908
Chicago-Naperville-Joliet, IL-IN-WI	15	1.965
Buffalo-Niagara Falls, NY	16	1.995
Tucson, AZ	17	2.000
Las Vegas-Paradise, NV	18	2.013
Stockton, CA	19	2.016
Boston-Cambridge-Quincy, MA-NH	20	2.024
Phoenix-Mesa-Scottsdale, AZ	21	2.072
Fresno, CA	22	2.076
Lancaster, PA	23	2.091
New Haven-Milford, CT	24	2.097
Poughkeepsie-Newburgh-Middletown, NY	25	2.133
Colorado Springs, CO	26	2.134
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	27	2.137
Miami-Fort Lauderdale-Miami Beach, FL	28	2.156
New Orleans-Metairie-Kenner, LA	29	2.162
Bridgeport-Stamford-Norwalk, CT	30	2.181
Cleveland-Elyria-Mentor, OH	31	2.235
Riverside-San Bernardino-Ontario, CA	32	2.257
San Antonio, TX	33	2.270
Pittsburgh, PA	34	2.276
Houston-Baytown-Sugar Land, TX	35	2.292
Virginia Beach-Norfolk-Newport News, VA-NC	36	2.340
Detroit-Warren-Livonia, MI	37	2.350
Albuquerque, NM	38	2.355
Allentown-Bethlehem-Easton, PA-NJ	39	2.364
Providence-New Bedford-Fall River, RI-MA	40	2.368
Hartford-West Hartford-East Hartford, CT	41	2.381
Denver-Aurora, CO	42	2.392
Charleston-North Charleston, SC	43	2.429
Milwaukee-Waukesha-West Allis, WI	44	2.436
Minneapolis-St. Paul-Bloomington, MN-WI	45	2.440
Springfield, MA	46	2.446
Tampa-St. Petersburg-Clearwater, FL	47	2.499
Baton Rouge, LA	48	2.511
Worcester, MA	49	2.517
Salt Lake City, UT	50	2.522

Metropolitan Area	Rank	Carbon Footprint (metric tons)
Albany-Schenectady-Troy, NY	51	2.524
Columbia, SC	52	2.534
Bakersfield, CA	53	2.540
Orlando, FL	54	2.551
Austin-Round Rock, TX	55	2.567
Greensboro-High Point, NC	56	2.576
Dallas-Fort Worth-Arlington, TX	57	2.582
Portland-South Portland-Biddeford, ME	58	2.599
Palm Bay-Melbourne-Titusville, FL	59	2.604
Grand Rapids-Wyoming, MI	60	2.609
Durham, NC	61	2.610
Akron, OH	62	2.637
Scranton--Wilkes-Barre, PA	63	2.660
Trenton-Ewing, NJ	63	2.660
Omaha-Council Bluffs, NE-IA	65	2.676
Wichita, KS	66	2.681
Syracuse, NY	67	2.682
Atlanta-Sandy Springs-Marietta, GA	67	2.682
Baltimore-Towson, MD	69	2.714
Cape Coral-Fort Myers, FL	70	2.739
Lansing-East Lansing, MI	71	2.754
Charlotte-Gastonia-Concord, NC-SC	72	2.757
Youngstown-Warren-Boardman, OH-PA	73	2.758
Des Moines, IA	74	2.765
Dayton, OH	75	2.769
Raleigh-Cary, NC	76	2.795
Memphis, TN-MS-AR	77	2.870
Augusta-Richmond County, GA-SC	78	2.885
Birmingham-Hoover, AL	79	2.901
Jacksonville, FL	80	2.905
Madison, WI	81	2.914
Sarasota-Bradenton-Venice, FL	81	2.914
Columbus, OH	83	2.952
Kansas City, MO-KS	84	2.969
Little Rock-North Little Rock, AR	85	3.009
Richmond, VA	86	3.039
Jackson, MS	87	3.063
Chattanooga, TN-GA	88	3.110
Washington-Arlington-Alexandria, DC-VA-MD-WV	89	3.115
Tulsa, OK	90	3.124
Knoxville, TN	91	3.134
Harrisburg-Carlisle, PA	92	3.190
Oklahoma City, OK	93	3.204
St. Louis, MO-IL	94	3.217
Nashville-Davidson--Murfreesboro, TN	95	3.222
Louisville, KY-IN	96	3.233
Toledo, OH	97	3.240
Cincinnati-Middletown, OH-KY-IN	98	3.281
Indianapolis, IN	99	3.364
Lexington-Fayette, KY	100	3.455
Average Footprint for the 100 Largest Metro Areas		2.235

Source: Authors' calculations

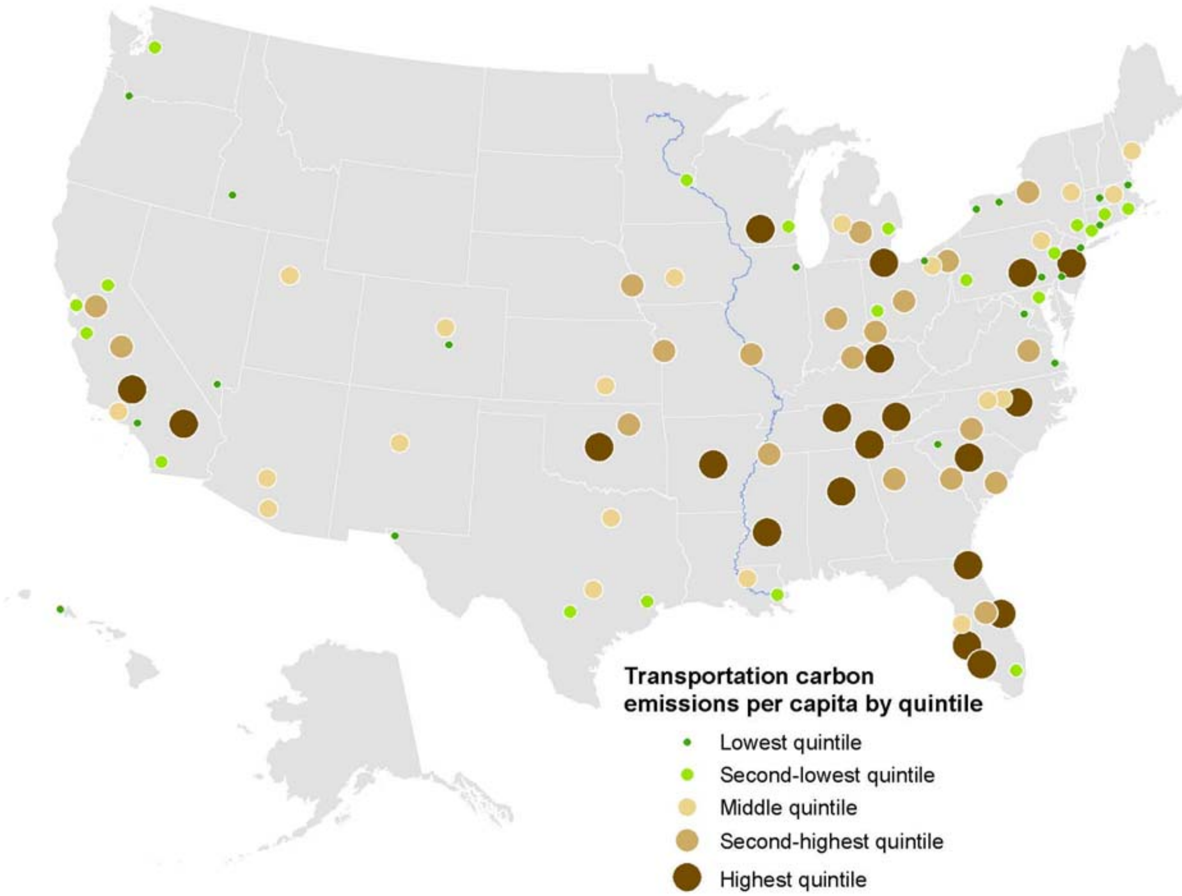
TABLE A2
Per capita Carbon Emissions from Transportation, 2005

Metropolitan Area	Highway Rank	Highway Total (metric tons)	Auto Rank	Auto (metric tons)	Truck Rank	Truck (metric tons)
New York-Northern New Jersey-Long Island, NY-NJ-PA	1	0.825	1	0.664	7	0.161
Honolulu, HI	2	0.847	3	0.786	1	0.061
Rochester, NY	3	0.950	7	0.812	2	0.138
Buffalo-Niagara Falls, NY	4	0.982	6	0.801	12	0.181
Los Angeles-Long Beach-Santa Ana, CA	5	1.022	17	0.882	3	0.139
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	6	1.023	5	0.789	22	0.234
Boston-Cambridge-Quincy, MA-NH	7	1.028	14	0.872	6	0.156
Lancaster, PA	8	1.030	2	0.767	29	0.263
Las Vegas-Paradise, NV	9	1.032	12	0.845	13	0.186
Portland-Vancouver-Beaverton, OR-WA	10	1.053	13	0.860	15	0.193
Boise City-Nampa, ID	11	1.059	10	0.830	20	0.229
Cleveland-Elyria-Mentor, OH	12	1.072	11	0.842	21	0.230
New Haven-Milford, CT	13	1.103	16	0.876	19	0.227
Colorado Springs, CO	14	1.109	21	0.937	9	0.172
Springfield, MA	15	1.114	23	0.948	8	0.166
El Paso, TX	16	1.129	9	0.830	39	0.300
Chicago-Naperville-Joliet, IL-IN-WI	17	1.132	8	0.820	41	0.312
Virginia Beach-Norfolk-Newport News, VA-NC	18	1.145	33	1.004	4	0.141
Greenville, SC	19	1.151	15	0.874	33	0.277
Washington-Arlington-Alexandria, DC-VA-MD-WV	20	1.157	30	0.984	10	0.173
New Orleans-Metairie-Kenner, LA	21	1.163	4	0.789	50	0.374
Providence-New Bedford-Fall River, RI-MA	22	1.168	37	1.014	5	0.154
San Jose-Sunnyvale-Santa Clara, CA	23	1.183	34	1.009	11	0.174
Pittsburgh, PA	24	1.185	19	0.913	32	0.272
Bridgeport-Stamford-Norwalk, CT	25	1.193	28	0.972	18	0.220
San Francisco-Oakland-Fremont, CA	26	1.195	32	0.998	16	0.197
Seattle-Tacoma-Bellevue, WA	27	1.200	24	0.955	25	0.245
San Antonio, TX	28	1.255	27	0.969	36	0.286
San Diego-Carlsbad-San Marcos, CA	29	1.270	48	1.078	14	0.192
Miami-Fort Lauderdale-Miami Beach, FL	30	1.295	42	1.031	30	0.264
Houston-Sugar Land-Baytown, TX	31	1.308	41	1.030	34	0.278
Hartford-West Hartford-East Hartford, CT	32	1.309	45	1.046	28	0.263
Poughkeepsie-Newburgh-Middletown, NY	32	1.309	35	1.010	37	0.299
Milwaukee-Waukesha-West Allis, WI	34	1.310	43	1.038	31	0.272
Dayton, OH	35	1.318	18	0.898	62	0.420
Allentown-Bethlehem-Easton, PA-NJ	36	1.337	26	0.964	49	0.373
Sacramento--Arden-Arcade--Roseville, CA	37	1.346	47	1.063	35	0.283
Minneapolis-St. Paul-Bloomington, MN-WI	37	1.346	50	1.090	27	0.256
Detroit-Warren-Livonia, MI	39	1.348	60	1.131	17	0.217
Baltimore-Towson, MD	40	1.355	44	1.044	40	0.311
Oxnard-Thousand Oaks-Ventura, CA	41	1.361	54	1.116	24	0.245
Wichita, KS	42	1.362	40	1.028	45	0.335
Denver-Aurora, CO	43	1.367	55	1.116	26	0.251
Akron, OH	44	1.371	39	1.023	48	0.348
Baton Rouge, LA	44	1.371	25	0.956	59	0.416
Tucson, AZ	46	1.394	20	0.924	74	0.470
Dallas-Fort Worth-Arlington, TX	47	1.406	49	1.081	43	0.325
Phoenix-Mesa-Scottsdale, AZ	48	1.414	22	0.940	77	0.474
Albuquerque, NM	49	1.431	31	0.990	67	0.442
Portland-South Portland-Biddeford, ME	50	1.443	51	1.097	47	0.346
Salt Lake City, UT	51	1.476	29	0.981	80	0.495
Worcester, MA	52	1.478	77	1.242	23	0.237
Tampa-St. Petersburg-Clearwater, FL	53	1.512	71	1.212	38	0.300
Austin-Round Rock, TX	54	1.518	57	1.119	54	0.398

Metropolitan Area	Highway Rank	Highway Total (metric tons)	Auto Rank	Auto (metric tons)	Truck Rank	Truck (metric tons)
Greensboro-High Point, NC	55	1.522	53	1.104	60	0.418
Scranton--Wilkes-Barre, PA	56	1.524	36	1.011	81	0.513
Des Moines, IA	57	1.528	70	1.206	42	0.322
Grand Rapids-Wyoming, MI	58	1.536	69	1.197	46	0.339
Durham, NC	59	1.542	56	1.119	64	0.424
Albany-Schenectady-Troy, NY	60	1.559	75	1.231	44	0.328
Youngstown-Warren-Boardman, OH-PA	60	1.559	38	1.015	87	0.544
Omaha-Council Bluffs, NE-IA	62	1.566	63	1.147	61	0.419
Cincinnati-Middletown, OH-KY-IN	63	1.575	61	1.140	66	0.436
Stockton, CA	64	1.622	46	1.059	89	0.563
Kansas City, MO-KS	65	1.630	64	1.159	75	0.471
Atlanta-Sandy Springs-Marietta, GA	66	1.634	73	1.224	58	0.410
Charleston-North Charleston, SC	67	1.637	66	1.175	69	0.462
Lansing-East Lansing, MI	68	1.649	78	1.247	55	0.402
Columbus, OH	69	1.652	67	1.176	78	0.476
Orlando-Kissimmee, FL	70	1.684	81	1.277	57	0.408
Fresno, CA	71	1.687	62	1.146	86	0.541
Memphis, TN-MS-AR	72	1.692	65	1.162	85	0.530
Louisville, KY-IN	73	1.700	59	1.129	91	0.571
Tulsa, OK	73	1.700	87	1.305	53	0.395
St. Louis, MO-IL	75	1.707	76	1.235	76	0.473
Syracuse, NY	76	1.720	91	1.333	51	0.387
Charlotte-Gastonia-Concord, NC-SC	77	1.724	79	1.256	73	0.468
Indianapolis, IN	78	1.732	58	1.127	94	0.605
Richmond, VA	79	1.738	92	1.335	56	0.404
Augusta-Richmond County, GA-SC	80	1.740	74	1.226	82	0.514
Lexington-Fayette, KY	80	1.740	52	1.101	96	0.639
Raleigh-Cary, NC	82	1.754	82	1.277	79	0.477
Birmingham-Hoover, AL	83	1.756	93	1.335	63	0.421
Palm Bay-Melbourne-Titusville, FL	84	1.759	85	1.295	70	0.464
Columbia, SC	85	1.771	72	1.216	88	0.554
Cape Coral-Fort Myers, FL	86	1.808	95	1.373	65	0.435
Madison, WI	87	1.814	94	1.353	68	0.461
Oklahoma City, OK	88	1.846	90	1.320	84	0.526
Chattanooga, TN-GA	89	1.858	80	1.272	92	0.586
Knoxville, TN	90	1.867	97	1.402	71	0.465
Trenton-Ewing, NJ	91	1.877	100	1.483	52	0.394
Riverside-San Bernardino-Ontario, CA	92	1.885	83	1.289	93	0.596
Nashville-Davidson--Murfreesboro, TN	93	1.886	88	1.319	90	0.567
Sarasota-Bradenton-Venice, FL	94	1.897	96	1.381	83	0.516
Jacksonville, FL	95	1.902	98	1.435	72	0.467
Little Rock-North Little Rock, AR	96	1.999	84	1.293	97	0.706
Toledo, OH	97	2.005	68	1.190	99	0.815
Harrisburg-Carlisle, PA	98	2.041	89	1.320	98	0.721
Jackson, MS	99	2.073	99	1.459	95	0.614
Bakersfield, CA	100	2.189	86	1.303	100	0.886
Average Transportation Footprint for the 100 Largest Metro Areas		1.310		1.004		0.305

Source: Authors' calculations

FIGURE A1
Per Capita Carbon Emissions from Transportation, 2005 (metric tons)



Source: Authors' calculations

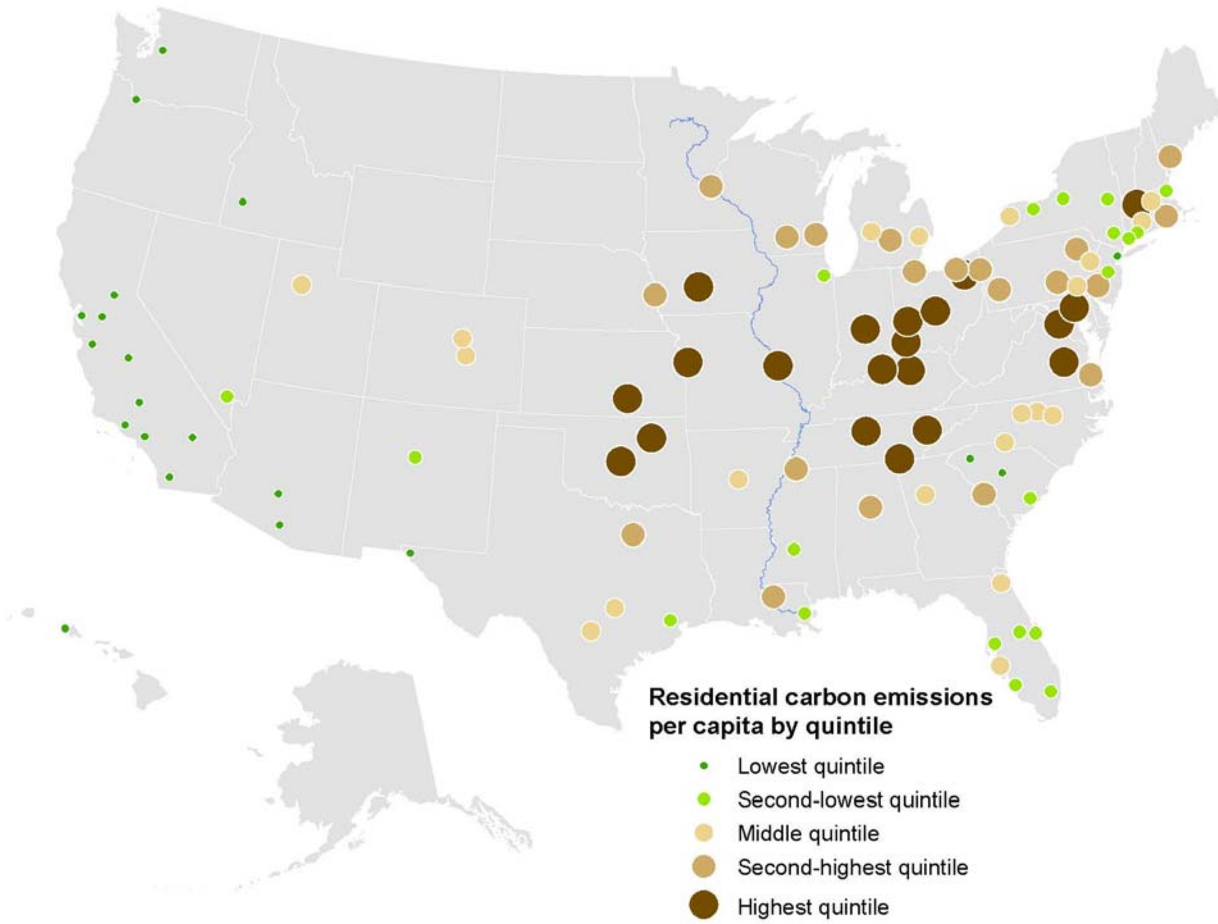
TABLE A3
Per Capita Carbon Emissions from Residential Energy Use, 2005

Metropolitan Area	Rank	Residential Total (metric tons)	Residential Electricity (metric tons)	Other Residential Fuels (metric tons)
Bakersfield, CA	1	0.350	0.159	0.191
Seattle-Tacoma-Bellevue, WA	2	0.356	0.154	0.202
San Diego-Carlsbad-San Marcos, CA	3	0.360	0.157	0.202
Riverside-San Bernardino-Ontario, CA	4	0.372	0.184	0.188
San Jose-Sunnyvale-Santa Clara, CA	5	0.389	0.190	0.199
Fresno, CA	6	0.390	0.202	0.187
San Francisco-Oakland-Fremont, CA	6	0.390	0.176	0.215
Los Angeles-Long Beach-Santa Ana, CA	8	0.391	0.213	0.178
Portland-Vancouver-Beaverton, OR-WA	9	0.393	0.198	0.196
Stockton, CA	10	0.394	0.200	0.193
Oxnard-Thousand Oaks-Ventura, CA	10	0.394	0.189	0.205
Sacramento--Arden-Arcade--Roseville, CA	12	0.422	0.198	0.225
Boise City-Nampa, ID	13	0.447	0.143	0.304
El Paso, TX	14	0.483	0.364	0.119
Honolulu, HI	15	0.509	0.495	0.014
Tucson, AZ	16	0.606	0.509	0.097
Phoenix-Mesa-Scottsdale, AZ	17	0.658	0.570	0.087
New York-Northern New Jersey-Long Island, NY-NJ-PA	18	0.670	0.225	0.445
Greenville, SC	19	0.709	0.567	0.142
Columbia, SC	20	0.764	0.625	0.139
Trenton-Ewing, NJ	21	0.783	0.275	0.508
Charleston-North Charleston, SC	22	0.792	0.654	0.138
Poughkeepsie-Newburgh-Middletown, NY	23	0.824	0.313	0.511
Chicago-Naperville-Joliet, IL-IN-WI	24	0.833	0.374	0.459
Palm Bay-Melbourne-Titusville, FL	25	0.845	0.818	0.027
Miami-Fort Lauderdale-Miami Beach, FL	26	0.861	0.841	0.020
Orlando, FL	27	0.866	0.842	0.025
Albuquerque, NM	28	0.924	0.618	0.306
Cape Coral-Fort Myers, FL	29	0.932	0.906	0.026
Rochester, NY	30	0.958	0.384	0.574
Syracuse, NY	31	0.962	0.390	0.571
Albany-Schenectady-Troy, NY	32	0.966	0.381	0.584
Las Vegas-Paradise, NV	33	0.981	0.755	0.227
Houston-Baytown-Sugar Land, TX	34	0.983	0.858	0.125
Tampa-St. Petersburg-Clearwater, FL	35	0.988	0.961	0.026
Bridgeport-Stamford-Norwalk, CT	35	0.988	0.304	0.684
Jackson, MS	37	0.990	0.834	0.156
New Haven-Milford, CT	38	0.994	0.292	0.702
Boston-Cambridge-Quincy, MA-NH	39	0.996	0.412	0.584
New Orleans-Metairie-Kenner, LA	40	0.999	0.849	0.150
Detroit-Warren-Livonia, MI	41	1.002	0.385	0.617
Jacksonville, FL	42	1.003	0.979	0.024
Little Rock-North Little Rock, AR	43	1.010	0.803	0.207
Buffalo-Niagara Falls, NY	44	1.014	0.404	0.609
San Antonio, TX	45	1.015	0.880	0.135
Sarasota-Bradenton-Venice, FL	46	1.018	0.990	0.028
Denver-Aurora, CO	47	1.025	0.625	0.400
Colorado Springs, CO	47	1.025	0.620	0.405
Allentown-Bethlehem-Easton, PA-NJ	49	1.027	0.558	0.469
Charlotte-Gastonia-Concord, NC-SC	50	1.033	0.846	0.187
Worcester, MA	51	1.038	0.429	0.609
Raleigh-Cary, NC	52	1.041	0.859	0.182
Salt Lake City, UT	53	1.046	0.661	0.385

Metropolitan Area	Rank	Residential Total (metric tons)	Residential Electricity (metric tons)	Other Residential Fuels (metric tons)
Atlanta-Sandy Springs-Marietta, GA	54	1.049	0.837	0.211
Austin-Round Rock, TX	54	1.049	0.913	0.137
Greensboro-High Point, NC	56	1.054	0.856	0.198
Lancaster, PA	57	1.061	0.565	0.496
Durham, NC	58	1.067	0.879	0.188
Hartford-West Hartford-East Hartford, CT	59	1.073	0.360	0.712
Grand Rapids-Wyoming, MI	59	1.073	0.486	0.586
Pittsburgh, PA	61	1.091	0.539	0.552
Minneapolis-St. Paul-Bloomington, MN-WI	62	1.094	0.658	0.436
Madison, WI	63	1.101	0.659	0.442
Lansing-East Lansing, MI	64	1.105	0.503	0.602
Omaha-Council Bluffs, NE-IA	65	1.109	0.756	0.354
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	66	1.114	0.619	0.495
Milwaukee-Waukesha-West Allis, WI	67	1.125	0.692	0.434
Scranton--Wilkes-Barre, PA	68	1.136	0.581	0.554
Baton Rouge, LA	68	1.139	0.994	0.145
Augusta-Richmond County, GA-SC	70	1.145	0.915	0.230
Birmingham-Hoover, AL	70	1.145	0.986	0.159
Harrisburg-Carlisle, PA	72	1.149	0.621	0.528
Portland-South Portland-Biddeford, ME	73	1.156	0.248	0.908
Cleveland-Elyria-Mentor, OH	74	1.163	0.694	0.468
Dallas-Fort Worth-Arlington, TX	75	1.177	1.046	0.131
Memphis, TN-MS-AR	76	1.178	0.995	0.183
Virginia Beach-Norfolk-Newport News, VA-NC	77	1.194	0.917	0.277
Youngstown-Warren-Boardman, OH-PA	78	1.199	0.767	0.432
Providence-New Bedford-Fall River, RI-MA	79	1.200	0.515	0.685
Toledo, OH	80	1.235	0.755	0.480
Des Moines, IA	81	1.237	0.840	0.397
Chattanooga, TN-GA	82	1.252	1.054	0.199
Akron, OH	83	1.266	0.780	0.485
Knoxville, TN	84	1.267	1.068	0.200
Columbus, OH	85	1.300	0.824	0.476
Richmond, VA	86	1.301	0.997	0.304
Wichita, KS	87	1.319	0.930	0.389
Springfield, MA	88	1.332	0.718	0.614
Nashville-Davidson--Murfreesboro, TN	89	1.336	1.150	0.186
Kansas City, MO-KS	90	1.339	1.024	0.315
Oklahoma City, OK	91	1.358	1.077	0.282
Baltimore-Towson, MD	91	1.358	1.015	0.343
Tulsa, OK	93	1.424	1.140	0.284
Dayton, OH	94	1.452	0.956	0.495
St. Louis, MO-IL	95	1.510	1.195	0.314
Louisville, KY-IN	96	1.532	1.318	0.215
Indianapolis, IN	97	1.632	1.235	0.397
Cincinnati-Middletown, OH-KY-IN	98	1.706	1.255	0.451
Lexington-Fayette, KY	99	1.715	1.477	0.238
Washington-Arlington-Alexandria, DC-VA-MD-WV	100	1.958	1.611	0.347
Average Residential Footprint for 100 Largest Metro Areas		0.925	0.611	0.314

Source: Authors' calculations

FIGURE A2
Per Capita Carbon Emissions from Residential Energy Use, 2005 (metric tons)



Source: Authors

APPENDIX B: DESCRIPTION OF DATA GAPS

Transportation Data Gaps. Only one data source—the Federal Highway Administration's Highway Performance Monitoring System (HPMS)—can be used to compare vehicle travel activity across different metropolitan areas. Although the quality and coverage of this vehicle traffic count-based data sample has improved significantly in recent years, the current state-based sampling methods lack a sampling frame able to total metropolitan regional travel activity. Different states have different priorities in selecting sampling sites and the amount of effort devoted to the data collection exercise. Therefore, consistency in sample design is not guaranteed across different metro areas. That is, the database is not yet a true inventory of traffic on the nation's entire roadway system.

A second area of concern when using such data is the general absence of readily accessible alternative sources of information against which to compare the resulting VMT estimates. Doing so will require much more effort on a metro area-by-area basis, and would require recourse to each region's VMT forecasts, such as those typically associated with a region's long-range transportation plan. Consistency across planning models then becomes an issue. Many models are blind to the reduced traffic benefits of higher-density housing and increased transit. As such, an urban infill project in a dense, transit-rich area that doubled in population would be projected to double traffic when in fact the traffic generation could be much smaller.[166]

Of particular concern with respect to the estimates presented here is the lack of data on local area, within-community, auto and truck VMT as it moves over low-capacity local roads. Current traffic counters are unable to capture this activity and there is no proven method for obtaining such estimates across the wide range of conditions that exist. This represents yet one more gap in the nation's and metropolitan areas' passenger and freight database. It also has important implications for the results reported here. Travel in areas with more extensive use of local roads rather than highways will be undercounted.

Under the limited resources of the current study, it was impossible to derive public transit-based fuel use and carbon emission totals for the top 100 metropolitan areas. The principal drawback was the lack of a readily available match between the data on individual transit agency reporting of fuel consumed by different service types (fixed route bus, light and commuter rail, demand-responsive vanpool, etc.) and the assignment of such agency services to specific metropolitan regions. Reasonable estimates, however, are possible given that the Federal Transit Administration requires fuel consumption reports. Presently, and with the notable exception of the New York/northern New Jersey metropolitan area, such activity is only a small percentage of each metropolitan area's energy or carbon footprint.

A second general area of concern is converting auto and truck VMT estimates into mile per gallon (mpg) fuel consumption estimates. The biggest gap in data here is in truck mpg data, given the broad range of vehicle size classes and regional differences in the use of some of the larger, combination trucks—a gap that will widen if the recent cancellation of the U.S. Census Bureau's Vehicle Inventory and Use Survey program remains in force.[167]

The need for much better data on freight flows has been the subject of considerable debate. The Transportation Research Board of the National Academies and others have urged the federal government put considerably more resources into filling freight activity data gaps.[168] This is yet another reason the federal government should pay more attention to such data collection efforts in the future.

In particular, the nation needs better origin-to-destination (OD) freight traffic movement data. Traffic counter data must also be translated into freight traffic movement data; these data could be used to calculate more robust VMT estimates. Given the considerable costs and reluctance in the private sector to supply such potentially sensitive business data, support is warranted for programs that finance and make greater use of nonintrusive forms of electronic data interchange and collection methods in obtaining truck movement data.[169]

Residential and Commercial Data Gaps. There is no publicly available national source of data to estimate energy consumption in buildings at the metropolitan scale. The Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS) provide the foundation of most U.S. building and appliance energy-efficiency analyses. The Department of Energy's Energy Information Administration (EIA) now conducts these analyses every four years. However, the sample sizes are too small to produce reliable estimates at the scale of a metropolitan area.

RECS is a sample survey of approximately 5,000 households nationwide that collects information on energy use and expenditures associated with household characteristics. The latest available energy information is for 1997; housing characteristics are available from the 2001 survey, and 2005 energy data will soon be available. The data are published for census divisions and for the four largest states. The household data are collected by personal interview and include the number of rooms; age of unit; family income; year of construction; type of structure (single family/2-4 unit/5+ units/manufactured home); who pays the utilities; presence of energy-conserving equipment such as high-efficiency heating equipment and glazed windows; and the types of energy sources used for particular activities such as space heating and water heating. Energy consumption and expenditures data are collected from energy suppliers (for electricity, natural gas, LPG, and fuel oil).[170]

CBECS is based on a survey of energy use and expenditures associated with characteristics of commercial buildings. The latest available data are for

2003 from a sample of 5,000 to 6,000 buildings nationwide. The data are analyzed down to census divisions but are unavailable for individual states or smaller geographic units, such as metropolitan areas. Data on building characteristics include floor space; year of construction; number of floors; hours of occupancy; primary building activity, type of HVAC equipment; and presence of energy-conserving features including lighting sensors and variable air volume HVAC. Energy consumption and expenditures data are collected for electricity, natural gas, fuel oil, and district heat.[171]

The EIA publishes annual data at the state level including "State Energy Consumption, Price, and Expenditure Estimates" and "State Electricity Profiles," which are helpful when analyzing metropolitan energy profiles. However, the data are insufficient for detailed metropolitan-scale footprints.[172] Utilities annually file energy sales data with the federal government, in FERC Form 1 and RUS Form 12. These data provide a means of estimating electricity consumption at the metropolitan scale, but sophisticated (and proprietary) software tools combined with GIS information are needed to accomplish this.

An e-mail request for energy data from State Energy Offices (SEO) uncovered only one SEO that provides publicly available information on residential and commercial electricity consumption by county. In particular, data on annual residential electricity consumption is publicly available through 2005 for all of the counties of California.[173] The state employs several dozen energy analysts to provide the kind of data and analysis necessary to support such data assembling and analysis.

Because of the lack of publicly available small-area electricity consumption data, the authors obtained proprietary utility sales data from Platts Analytics that could be analyzed by ZIP code.

NOTES

[1] Fuel combustion produced 94.2 percent of the carbon dioxide emitted in United States in 2006. See Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2006" (2008).

[2] Complex data processing issues prohibited the authors from completing the commercial and industrial data analysis in time for this paper's release. Forthcoming analysis will include commercial electricity emissions plus emissions from additional transportation sources such as transit, rail, and air.

[3] Energy Information Administration, "Annual Energy Review" (2007), Table 12.1.

[4] Ibid.

[5] See data on industrial output and energy intensity indicators for the U.S. Department of Energy, "U.S. Energy Intensity Indicators: Trend Data," available at http://intensityindicators.pnl.gov/trend_data.stm (accessed May 1 2008).

[6] Energy Information Administration, "Annual Energy Outlook" (2007), Table A19; Intergovernmental Panel on Climate Change, "Climate Change 2007: The Physical Science Basis; Summary for Policymakers" (2007).

[7] According to Yoichi Kaya, "Impact of Carbon Dioxide Emission Control on GNP Growth: Interpretation of Proposed Scenarios," paper presented to the IPCC Energy and Industry Subgroup, Response Strategies Working Group, Paris, 1990, carbon emissions are related to population, gross domestic product, and energy consumption as follows:

C Emissions = Population × GDP/Population × E/GDP × C/E

where C = net carbon emissions to the atmosphere

E = energy consumption

GDP = gross domestic product

GDP/Population = productivity of the economy

E/GDP = "energy intensity" of the economy

C/E = "carbon intensity" of the energy system

[8] Council on Competitiveness, "Competitiveness Index: Where America Stands" (2006).

[9] Ibid.

[10] In a business as usual scenario, emissions from the transportation sector are expected to continue to grow at the most rapid rate between now and 2030. According

to the U.S. Energy Information Administration, an increase of approximately 10 percent in carbon emissions from transportation will be seen over that period. See Energy Information Administration, "Annual Energy Outlook"; Frank Gallivan and others, "The Role of TDM and Other Transportation Strategies in State Climate Action Plans." *TDM Review* (2007): 10–14.

[11] Bureau of Transportation Statistics, "National Transportation Statistics 2007" (2007), Table 1-32.

[12] The average grew from 1.16 vehicles per household in 1969 to 1.89 vehicles per household in 2001 (latest data). See Oak Ridge National Laboratory, "Transportation Energy Data Book, Table 8.5, available at http://cta.ornl.gov/data/index.shtml (May 1 2008). Household size has declined from 3.14 to 2.57 persons over the same period. See U.S. Census Bureau, "Families and Living Arrangements", Table HH-1, available at www.census.gov/population/www/socdemo/hh-fam.html (May 1 2008).

[13] Freight travel increased from 62.2 billion vehicle miles traveled in 1970 to 222.8 billion in 2005. Passenger travel increased from 1,048 billion vehicle miles traveled in 1970 to 2,767 billion in 2005. See Bureau of Transportation Statistics, "National Transportation Statistics 2007,"Table 1-32.

[14] According to the Texas Transportation Institute's latest urban mobility report, this congestion cost the nation $78.4 billion in 2005 in lost time and wasted fuel when summed across all of its 437 urban areas: an average annual cost of $707 per traveler. David Schrank and Tim Lomax, "The 2007 Urban Mobility Report" (College Station, TX: Texas Transportation Institute, 2007).

[15] Environmental Protection Agency, "Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2007" (2007).

[16] See "Advanced Technologies and Energy Efficiency" (publisher: date) available at www.fueleconomy.gov/feg/atv.shtml (May 1 2008).

[17] This approach was based on the description and carbon content numbers reported by EIA, which reports gasohol as part of its average gasoline carbon content per Btu estimate. Energy Information Administration, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2001; Annex B "Methodology for Estimating the Carbon Content of Fossil Fuels." available at http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/LHOD5MJQ62/$File/2003-final-inventory_annex_b.pdf (May 1 2008).

[18] The Energy Independence and Security Act of 2007 extends and adds to the 2005 Energy Policy Act Renewable Fuels Standard by setting a goal of 36 billion gallons of renewable fuel annually by 2022, including 16 billion gallons from cellulosic sources. "H.R. 6: Energy Independence and Security Act of 2007," available at www.govtrack.us/congress/bill.xpd?bill=h110-6 (May 1 2008).

[19] National Commission on Energy Policy, "Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges" (2004).

[20] For a summary of EISA, see Fred Sissine, "Energy Independence and Security Act of 2007: A Summary of Major Provisions" (Washington: Congressional Research Service, 2007).

[21] Energy Information Administration, "Annual Energy Outlook," Table A2. Recently released 2008 estimates are substantially reduced over 2007 estimates.

[22] Ibid, Table A18.

[23] David B. Sandalow, *Freedom from Oil: How the Next President Can End the United States' Oil Addiction* (New York: McGraw Hill, 2007).

[24] Energy Information Administration, "Annual Energy Review," Table 2.1b.

[25] Ibid., Table A18.

[26] Thomas R. Casten and Robert U. Ayres, "Energy Myth Eight - Worldwide Power Systems Are Economically and Environmental Optimal." In Benjamin K. Sovacool and Marilyn A. Brown, eds., *Energy and American Society - Thirteen Myths* (New York: Springer, 2007).

[27] Ibid.

[28] Annex B, Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2001" (2007).

[29] Marilyn A. Brown, Frank Southworth, and Therese Stovall, "Towards a Climate-Friendly Built Environment" (Washington: Pew Center on Global Climate Change, 2005). See also Energy Information Administration, "Annual Energy Outlook," Table A2.

[30] Buildings carbon emissions are expected to increase approximately 1.4 percent per year over the next 25 years, resulting in a projected 41 percent increase in buildings carbon emissions between 2005 and 2030. Energy Information Administration, "Annual Energy Outlook," Table A18.

[31] Brown, Southworth, and Stovall, "Towards a Climate-Friendly Built Environment."

[32] Patrick Mazza, "Transportation and Global Warming Solutions." *Climate Solutions Issue Briefing* (May 2004): 1–4.

[33] John Holtzclaw, "A Vision of Energy Efficiency" (Washington: American Council for an Energy-Efficient Economy, 2004).

[34] Mary Jean Bürer, David Goldstein, and John Holtzclaw, "Location Efficiency as the Missing Piece of the Energy Puzzle: How Smart Growth Can Unlock Trillion Dollar Consumer Cost Savings" (Washington:, 2004).

[35] Thomas F Golob and David Brownstone, "The Impact of Residential Density on Vehicle Usage and Energy Consumption," available at http://repositories.cdlib.org/itsirvine/wps/WPS05_01 (March 31 2008).

[36] Reid Ewing and others, "Growing Cooler: The Evidence on Urban Development and Climate Change" (Washington: Urban Land Institute, 2007).

[37] Based on a -0.3 long-term elasticity of VMT with respect to fuel price, a doubling of fuel prices would reduce VMT by 30 percent. Victoria Transport Policy Institute, "Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior," available at www.vtpi.org/tdm/tdm11.htm (April 8 2008).

[38] Bürer, Goldstein, and Holtzclaw, "Location Efficiency as the Missing Piece"; Holtzclaw, "A Vision of Energy Efficiency."

[39] Edward L. Glaeser and Matthew Kahn, "The Greenness of Cities" (Cambridge, MA: Harvard University, 2008).

[40] For example, Glaeser and Kahn find that "Per capita emissions generally are lowest in Western metropolitan areas and highest in Southern ones. Metropolitan areas in the Northeast and Midwest fall in between these two extremes." Ibid, This empirical analysis arrives at slightly different conclusions about the Midwest and South.

[41] These data are available at an hourly timescale and a common 10 km grid. For more information, see www.purdue.edu/eas/carbon/vulcan/index.php

[42] Ibid.

[43] See Marilyn A. Brown and Cecelia (Elise) Logan, "The Residential Energy and Carbon Footprints of the 100 Largest Metropolitan Areas." Working Paper (Georgia Institute of Technology School of Public Policy, 2008); Frank Southworth, Anthon Sonnenberg, and Marilyn A. Brown, "The Transportation Energy and Carbon Footprints of the 100 Largest Metropolitan Areas." Working paper (Georgia Institute of Technology School of Public Policy, 2008), available at www.spp.gatech.edu/faculty/workingpapers.php.

[44] The International Council for Local Environmental Initiatives (ICLEI), the U.S. Environmental Protection Agency, the Sierra Club and others have developed software and guidelines to assist local governments in estimating their carbon emissions. On the one hand, the footprint methodology employed here is consistent with the principles of these guidelines; on the other hand, the mechanics used here are quite distinct.

[45] The authors obtained commercial and industrial electricity sales data from Platts Analytics, but complex data processing issues prohibited them from completing the commercial and industrial data analysis in time for this paper's release. Forthcoming analysis will include commercial and industrial electricity emissions plus emissions from additional transportation sources such as transit, rail, and air.

[46] Jason Furman and others, "An Economic Strategy to Address Climate Change and Promote Energy Security" (Washington: Brookings Institution, 2007).

[47] For a detailed description of how the annual vehicle miles of travel activity, gallons of fuel consumed, and associated annual energy and carbon contents of these fuels were estimated, see Southworth, Sonnenberg, and Brown, "The Transportation Energy and Carbon Footprints of the 100 Largest Metropolitan Areas."

[48] The transportation estimates do not account for wasted fuel due to idling or low speed travel in congested conditions. Future research could add an adjustment factor based on estimates of congestion severity.

[49] The authors are grateful to Platts Analytics for allowing the Georgia Institute of Technology to use their national database on utility sales, and to Steve Piper and Curt Ophaug-Johansen. For a detailed description of how the electricity sales data were used to estimate the electricity consumption of each metropolitan area, and its associated energy and carbon emissions, see Brown and Logan, "The Residential Energy and Carbon Footprints of the 100 Largest Metropolitan Areas."

[50] Energy Information Administration, "State Energy Data System" available at www.eia.doe.gov/emeu/states/_seds.html (May 1 2008).

[51] However, the 2000 daily vehicle miles of travel figures for Chattanooga, TN are identified as being unreliable in Highway Statistics 2000 (Table 72) as noted in footnote 43 of Southworth, Sonnenberg, and Brown, "The Transportation Energy and Carbon Footprints of the 100 Largest Metropolitan Areas."

[52] Findings 4 and 5 are based on preliminary results from a multiple regression analysis that predicts per capita transportation and residential carbon footprints in 2005 using eight variables. Three variables describe a metro area's urban form: population density, population concentration, and presence of rail transit. Two variables describe a metro area's weather: cooling degree-days and heating degree-days. One variable is the average electricity price in the metro area's primary state. Two control variables were also used for the metro area's population size and its economic productivity (output/person). In combination, the six primary explanatory variables explain nearly half (49 percent) of the variation in per capita carbon footprints across metro areas. Specifically, per capita carbon footprints are lower in metro areas with higher population densities, higher concentrations of population, with at least 10 miles of rail transit infrastructure, fewer cooling degree-days, fewer heating degree-days, and higher electricity prices. Complete urban form measures are not available for Bridgeport, CT, Palm Bay, FL, and Honolulu, HI – resulting in a sample size of 97 metro areas for the regression analysis. For more information, see Brown and Logan, "The Residential Energy and Carbon Footprints of the 100 Largest Metropolitan Areas."

[53] Various urban form measures, including density, population concentration, and transit availability, were included in preliminary analyses. Population density was defined as the number of persons per acre of "developable" land, which excludes water bodies and protected lands such as national and state parks. Although this metric is useful, it is incomplete and does not capture spatial distribution patterns. Population concentration alternatively was defined as the degree to which population was distributed equally throughout the metro area, using a delta index. The values range from 0 to 1, and higher values indicate less clustering and more even distribution of population. For more information, see Southworth, Sonnenberg, and Brown, "The Transportation Energy and Carbon Footprints of the 100 Largest Metropolitan Areas."

[54] The data set used had no available information on the portion of land in Honolulu that was "developable," as in the all other metro areas. Alternatively, the authors computed population density for Honolulu using the U.S. Census Bureau's data on land area from

the Census 2000, yielding a result very similar to the average population density in Boston. Honolulu's density calculation may be a lower estimate than if non-developable land, like parks, could be excluded.

[55] For more information, see Southworth, Sonnenberg, and Brown, "The Transportation Energy and Carbon Footprints of the 100 Largest Metropolitan Areas."

[56] For an in-depth discussion of the multi-dimensional concept of compact development, see Ewing and others, "Growing Cooler."

[57] This was also a conclusion of Glaeser and Kahn, "The Greenness of Cities."

[58] Energy Information Administration, "International Energy Outlook" (2007).

[59] William Collins and others, "The Physical Science Behind Climate Change." *Scientific American* (August 2007): 64–73; Intergovernmental Panel on Climate Change, "Climate Change 2007."

[60] Congressional Budget Office, "The Economics of Climate Change: A Primer" (2003).

[61] Ewing and others, "Growing Cooler"; William Fulton and others, "Who Sprawls Most? How Growth Patterns Differ across the U.S." (Washington: Brookings Institution, 2001).

[62] An overview of the apportionment of funds from the Federal Highway Trust Fund can be found in Katherine Siggerud, "Testimony before the Subcommittee on Highways, Transit, and Pipelines, Committee on Transportation and Infrastructure, U.S. House of Representatives; Overview of Highway Trust Fund Estimates" (Washington: Government Accountability Office, 2006).

[63] Exxon/Mobil, BP, Chevron, Conoco/Phillips, and Shell altogether own or control less than 5 percent of proven global oil reserves.

[64] See Brown, Southworth, and Stovall, "Towards a Climate-Friendly Built Environment."

[65] Henry N. Butler and Jonathan R. Macey, "Externalities and the Matching Principle: The Case for Reallocating Environmental Regulatory Authority," *Yale Journal on Regulation* 14 (1996): 24–66.

[66] Collins and others, "The Physical Science Behind Climate Change."; Intergovernmental Panel on Climate Change, "Climate Change 2007."

[67] Robert W. Kates and Thomas J. Wilbanks, "Making the Global Local: Responding to Climate Change Concerns from the Ground Up," *Environment* 45 (3) (2003): 12–23.

[68] Benjamin K. Sovacool and Marilyn A. Brown, "Is Bigger Always Better? The Importance of Scale in Addressing Climate Change." In Fereidoon P. Sioshansi, ed., *Carbon Constrained: Future of Electricity* (New York: Elsevier, 2008).

[69] Jonathan H. Adler, "Jurisdictional Mismatch in Environmental Federalism," *New York University Environmental Law Journal* 14 (2005): 130–135.

[70] Jerry Taylor and Peter Van Doren, "Energy Myth Five - Price Signals Are Insufficient to Induce Efficient Energy Investments." In Benjamin K. Sovacool and Marilyn A. Brown, eds., *Energy and American Society - Thirteen Myths* (New York: Springer, 2007).

[71] John D. Donahue, *The Privatization Decision* (New York: Basic Books, 1991).

[72] Congressional Budget Office, "Evaluating the Role of Prices and R&D in Reducing Carbon Dioxide Emissions" (2006).

[73] Barry Bozeman, "Public-Value Failure: When Efficient Markets May Not Do," *Public Administration Review* 62 (2) (2002): 393–406.

[74] Marilyn A. Brown, "Market Failures and Barriers as a Basis for Clean Energy Policies," *Energy Policy* 29 (14) (2001): 1197–1207; Marilyn A. Brown, "Obstacles to Energy Efficiency," *Encyclopedia of Energy* 4 (2004): 465–475; Bill Prindle, "Quantifying the Effects of Market Failures in the End-Use of Energy" (Washington: American Council for an Energy-Efficient Economy, 2007).

[75] Marilyn A. Brown and Sharon (Jess) Chandler, "Governing Confusion: How Statutes, Fiscal Policy, and Regulations Impede Clean Energy Technologies," *Stanford Law and Policy Review* (forthcoming).

[76] The George W. Bush administration in 2002 announced a national goal of reducing GHG intensity (that is, emissions per dollar of real GDP) by 18 percent from 2002 to 2012. See Pew Center on Global Climate Change, "Analysis of President Bush's Climate Change Plan" available at www.pewclimate.org/policy_center/analyses/response_bushpolicy.cfm (April 11 2008).

[77] A vast literature exists on the market failure in carbon-based energy prices. For good overviews, see: Brown, "Market Failures and Barriers"; Congressional Budget Office, "Evaluating the Role of Prices and R&D." For information on unpriced energy security costs, see David L. Greene and Sanjana Ahmad, "Costs of U.S. Oil Dependence: 2005 Update" (Oak Ridge: Oak Ridge National Laboratory, 2005).

[78] Congressional Budget Office, "Evaluating the Role of Prices and R&D in Reducing Carbon Dioxide Emissions."

[79] Ibid.

[80] Kelly Sims Gallagher, "DOE Budget Authority for Energy Research, Development, and Demonstration Database" (Cambridge, MA: Energy Technology Innovation Policy, John F. Kennedy School of Government, Harvard University, 2007).

[81] Daniel Clery, "A Sustainable Future, If We Pay up Front," *Science* 315 (2007): 782–783.

[82] Brown and Chandler, "Governing Confusion."

[83] Ibid.

[84] Ibid.

[85] Bob Marlay, Deputy Director, U.S. Climate Change Technology Program, Office of Policy and International Affairs, U.S. Department of Energy, "Deployment of GHG-Reducing Technologies." Presentation to the Laboratory Energy R&D Working Group, Washington, DC, November 7, 2007.

[86] General Accounting Office, "Highway Trust Fund: Overview of the Highway Trust Fund Estimates" (2006).

[87] For more information, see Robert Puentes, "A Bridge to Somewhere: Rethinking American Transportation for the 21st Century" (Washington: Brookings Institution, forthcoming).

[88] Ewing and others, "Growing Cooler."

[89] Edward Beimborn and Robert Puentes, "Highways and Transit: Leveling the Playing Field in Federal Transportation Policy." In Bruce Katz and Robert Puentes, eds., *Taking the High Road: A Metropolitan Agenda for Transportation Reform* (Washington: Brookings Institution, 2005).

[90] Puentes, "A Bridge to Somewhere."

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