CNU XVI – New Urbanism and the Booming Metropolis
April 3-6, 2008
Austin, TX

The Impact of Transportation and Urban Planning on Carbon Emissions: A Case Study of Cambridge, MA

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Abstract

Over a quarter of greenhouse gas emissions produced in the United States are attributed to the transportation sector. Recent findings suggest that reducing vehicle miles traveled will be necessary to meaningfully reduce these emissions. Accomplishing this goal will require a renewed interest in creating and enhancing rich urban form. The dense, mixed-use community structure of Cambridge, MA, in addition to recent policies in the city, have resulted in low single occupancy vehicle shares and widespread use of sustainable, non-motorized modes. As a result, Cambridge's transportation related greenhouse gas emissions are lower than average emissions in the State of Massachusetts and in the nation. In this report we look at the specific policy approaches that have led to this outcome.

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Introduction

Concern about global climate change continues to increase in the United States. According to the Environmental Protection Agency (EPA), total U.S. greenhouse gas emissions have increased by 16 percent since 1990; 28 percent of those emissions are attributed to the transportation sector (Inventory, 2007). Consequently, attention has been directed towards reducing automotive emissions and pressure has recently been placed on the EPA to regulate carbon dioxide (CO_2) emissions, which account for more than 80 percent of human-made GHG. However, a recent report by the nonprofit environmental advocacy group, Environmental Defense, suggests that improving fuel efficiency and moving away from non-carbon fuels will not be enough to solve the problem – that we must also look at reducing travel demand (DeCicco & Fung, 2006). This goal of reducing travel demand is, however, one that most politicians and policy makers have been slow to recognize as a viable solution to global warming.

One prescription that has been put forward for lowering vehicle miles traveled (VMT) is a renewed focus on building dense, mixed-use communities with well-connected street networks in which priority is given to non-automotive modes of transportation. Cambridge, MA, just to Boston's north – home to Harvard University and the Massachusetts Institute of Technology (MIT) – is one community that still retains many of these characteristics. Cambridge's unusually dense land use and street network is partly a legacy of three centuries of development but is also attributable to the fact that the city has largely eschewed the pattern of urban renewal, that has altered the traditional settlement patterns, and highway construction, that has disrupted the street pattern in most American cities over the last 60 years. As such, it serves as a good case study to investigate the degree to which urban form influences carbon emissions from transportation. As part of the assessment in this research, we compared Cambridge to neighboring Boston and three other New England cities that are about the same size as Cambridge.

Over the last decade, Cambridge policy makers have been very aggressive in developing measures that promote the use of alternative modes of transportation. Therefore, in this study we characterize these methods and examine the extent to which Cambridge has been successful in slowing the rate of carbon emissions by reducing their use of automobiles. We believe that this decade long experiment in Cambridge might hold valuable lessons for other communities as they develop transportation and land use strategies for reducing carbon emissions for transportation. In this paper, we will focus primarily on the policies that have been put in place as part of Cambridge's livability and climate policy over the last decade.

About Cambridge

Cambridge is a small city in an even smaller area – 101,365 people in a land area of 6.4 square miles. In 2000, it was the fifth densest city in the USA with more than 100,000 people. It is part of the greater Boston area – separated from Boston only by the Charles River along its southern border and often partnered with its neighbor as the "Boston/Cambridge area."

A history of progressive transportation planning in Cambridge (then Newtowne) can be traced back to 1630, when its founders established an organized street network uncommon to

most other early villages of the Massachusetts Bay Colony (Sullivan, 1999). As recently as 1976, citizens in Cambridge helped to defeat a proposed eight-lane expressway (Interstate-695), which would have bisected the present neighborhoods of Cambridgeport, Area IV, and Wellingon/Harrington ("Inner Belt"). As we will discuss later, this pro-active approach to transportation planning in Cambridge seems to have continued to this day.

In order to better understand the structure and function of Cambridge in its New England context, we will compare it to the three next largest New England cities: Lowell, MA, Waterbury, CT, and Manchester, NH. Although similar in size, the cities are notably different. Cambridge's higher population density and mixed land uses offer an opportunity for transit, walking, and bicycling unmatched in more sparsely organized cities. We will also compare Cambridge to its neighbor, Boston, which shares many regional amenities including the transit system.

Cambridge's concerted attention to global climate protection dates back to 1999 when it joined the Cities for Climate Protection (CCP) through the International Council for Local Environmental Initiatives (ICLEI). The city's proposed actions for reducing carbon emissions are outlined in their climate protection plan of 2002. The plan addresses environmental issues but it also has goals encompassing energy, transportation, land use, and waste management policies. As important as the climate protection plan is, the foundation for effective transportation and land use planning addressing this issue had been laid years earlier. This is reflected in the fact that in Cambridge only 13 percent of total carbon emissions is attributable to the transportation sector compared to the national average of 28 percent (Inventory, 2007).

In 1992, Cambridge instituted a Vehicle Trip Reduction Ordinance, which was the first to mandate non-motorized transportation programs. The city's growth management document, *Toward a Sustainable Future,* first released in 1993 by the Cambridge Planning Board and the Department of Community Development, acknowledges that the city has nearly reached its vehicular capacity and identifies "non auto forms of transportation" as the "best hope for improving mobility." Finally, in 1998, Cambridge instituted a parking and transportation demand management (PTDM) ordinance, discussed later in more detail. The major policy and design measures outlined in the climate protection plan and addressed in other Cambridge policies focus on two goals: first, to reduce the number of single occupancy vehicles (SOV) within the city and, second, to promote the use of alternative modes (transit, bicycle, and walking). Policies supporting these goals are discussed in the following sections.

Policies for Limiting Parking

Many cities offer parking incentives to residents and employees; Lowell, MA, for example, offers free parking to prospective tenants of vacant commercial buildings. New York has provided free parking to city employees for years, despite that city's struggles with automobile congestion. Many cities often do not make the connection between parking policy and single occupancy vehicle use. For this reason, Cambridge remains one of the few cities in the country that has developed parking policy specifically designed to reduce single occupancy vehicle use. They are able to effectively do so because of the dense transportation infrastructure already in place.

In 1998, Cambridge instituted a parking and transportation demand management (PTDM) ordinance intended to "regulate and control atmospheric pollution from motor vehicles," reduce congestion, improve access, and improve mobility. The ordinance requires businesses that build or expand parking facilities to register all non-residential parking spaces with a designated PDTM Planning Officer and file a PDTM plan meant to reduce SOV trips below a specified share determined by their area's characteristics. The Director of the Cambridge Department of Traffic, Parking, and Transportation is charged with investigating violations, issuing notices to violating parties, and following up with fines or with facility closure.

The PDTM ordinance, however, is not the only tool for controlling parking in Cambridge. Whereas most zoning regulations require a minimum number of parking spaces for new developments, the current Cambridge zoning ordinance imposes a maximum in sensitive areas – none of the other cities investigated does this. In almost all instances, Cambridge has considerably lower minimum parking requirements then the other New England cities looked at in this study. As shown in Figure 1, some of Waterbury's and Manchester's minimum parking requirements actually exceed the maximum allowances in Cambridge.

Required Parking Spaces		Cambridge	Lowell	Waterbury	Manchester
General Retail	Min	1.1 - 2.0	1.1 - 2.0	5.0	4.0
(per 1000 sq. ft.)	Max	1.7 - 4.0	-	-	-
Single Family Res.	Min	1.0	2.0	1.5	2.0
(per dwelling unit)	Max	-	-	-	-
Multi-Family Res.	Min	1.0	1.0	1.5	2.0
(per dwelling unit)	Max	-	-	-	-
Dining	Min	*3.3 - 10**	10 - 20	10	*16.7**
(per 1000 sq. ft.)	Max	*5.0 - 20**	-	-	-
General Office	Min	1.0 - 1.25	2.5	4.0	2.5
(per 1000 sq. ft.)	Max	2.0 - 2.5	-	-	-
Secondary School	Min	5.0	6.0	-	7.0+
(per classroom)	Max	-	-	-	-

**converted from parking spaces per seat, where 1 seat = 20 sq. ft. (from Cambridge Zoning Ordinance)*

FIGURE 1 Required parking for New England cities per zoning regulations

The difference in how the cities describe their parking policies is also noteworthy. Cambridge zoning ordinance intends to "reduce traffic congestion, noise, vibrations, fumes and safety hazards [...] thereby promoting health and welfare of the public." Lowell, in contrast, plans for "sufficient off-street parking space to meet the needs of persons […]" and Manchester intends to achieve, above all else, "adequate vehicular access."

Promoting Alternative Modes of Travel

The leading transportation alternative in dense urban settings is public transit – usually subways, buses, and trolleys. Cambridge is served by one heavy rail line (the Red Line) with six subway stations all operated by the Massachusetts Bay Transportation Authority (MBTA).

Running northwesterly from Boston, the Red Line averaged approximately 71,500 daily boardings from 2002 to 2006, or 0.7 boardings per resident per day (Demographic Profile, 2007). Unfortunately, only 13 percent of Cambridge is within a ¼-mile radius of a subway station and one-half is within a ½-mile radius. Furthermore, the city's influence over the MBTA is limited. Therefore, planners focus their attention on the non-motorized modes over which they have more control. Fortunately, Cambridge's land use pattern is such that cycling and walking are viable options. In addition, roughly 47 percent of workers who live in Cambridge also work in Cambridge. This is just slightly above average for small New England cities, but unlike other cities (because of its high density) this means that more than 25,000 people in Cambridge live less than 4.5 miles from their place of work.

The Cambridge Pedestrian Advisory Committee was established in 1995; the Cambridge Pedestrian Plan followed in 2000. The plan sets forth detailed standards for pedestrian design including path and sidewalk widths, lighting, amenities, and Americans with Disabilities Act (ADA) compliance. It also addresses traffic control issues including pedestrian crossings, signals and markings, and traffic calming. Finally, it identifies the importance of complimentary services – most notably, transit access.

One major pedestrian project in Cambridge, the so-called "Super Crosswalk," attempts to reclaim the streets for pedestrians in the busy Harvard Square central business district. More recently, the city took this concept one step further by adopting the "shared street" model found in the Netherlands, London, and Germany. In the redesign of Cambridge's Palmer St. and Winthrop St., the area between buildings has been laid with a continuous brick surface and will be used by all modes, including slow-moving automobiles. Curbs and markings are eliminated under the assumption that the streets will be self-explaining; automobiles, bicycles, and pedestrians all use the same space for movement. These measures are aided by Cambridge's deep-rooted pedestrian culture, but they act to encourage and reinforce walking within the city.

Bicycle use has recently become major subject of attention in Cambridge. In 1991, the Cambridge Bicycle Committee was established (Hall, 1998). The city has been retrofitting its streets for bicycles since October of 1995, when its first bike lane was installed. Today, there are approximately 35 miles of *two-way* bicycle facilities – enough to travel between Cambridge's most distance edges more than seven times – plus five additional miles currently planned. As shown in Figure 2, more than 20 percent of Cambridge streets now contain designated bike facilities and the city encourages bicycle use on all streets. Forty percent of the existing facilities are exclusive bike and pedestrian paths and 36 percent are designated on-street bike lanes. Some of the more innovative facilities include contra-flow bike lanes on otherwise one-way streets, blue bike lanes to indicate a yield maneuver, and on-sidewalk bike tracks on the MIT campus (this is one of the first places in the country where these Danish style facilities have been used). Of the New England cities investigated for this report, only Cambridge requires bicycle parking in its zoning regulations – at least one bike space per 10 required car spaces must be provided at every facility.

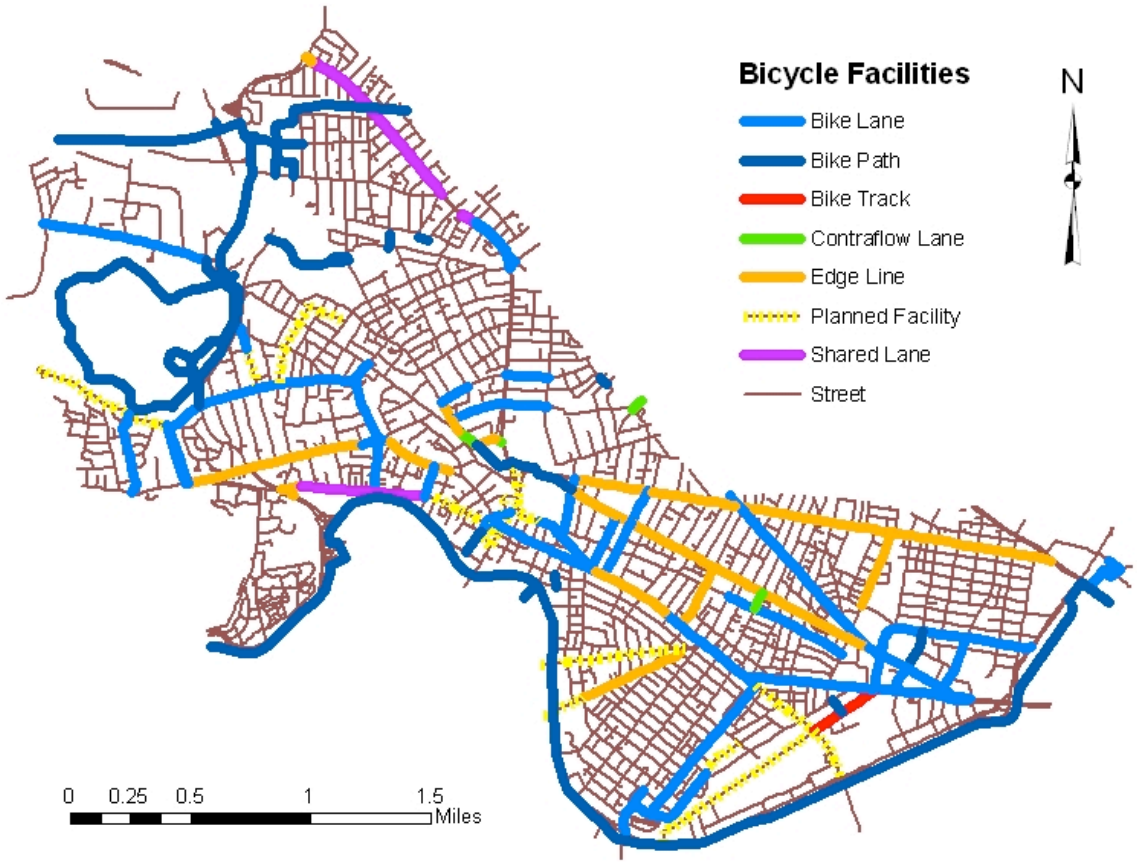

FIGURE 2 Cambridge bicycle facilities by type

Impacts on Travel and Carbon Emissions

According to mode share data from the 2000 census, Cambridge has been remarkably successful in diversifying their transportation system and relying less on automobiles. The data shows that driving alone accounted for 35 percent of commuter trips in Cambridge. While this is the largest share of any mode, the drive-alone shares in Lowell, Waterbury, and Manchester, are at least twice as high – closer to the national average of 76 percent.

In the year 2000, there were a reported 41,764 vehicles in Cambridge households, or 0.41 vehicles per capita. Other similar sized New England cities reported 0.50 to 0.61 vehicles per capita – again closer to the national average of 0.6 vehicles per capita. This seemingly small difference amounts to roughly 9,000 to 15,000 more vehicles per city, or as much as 25 percent difference.

Between 2004 and 2005, the number of submitted parking and transportation demand management (PTDM) plans nearly doubled and more than half of the projects met their mode split goals – lowering their SOV share 20 to 40 percent below baseline rates. SOV shares in 2003 were as low as 23 percent for some projects. By 2005, projects achieved SOV rates as low as 6 percent and no higher than 56 percent (Anderberg, 2007).

Although public transportation is the second most popular mode in Cambridge (25%), the city's use of non-motorized modes is considerably more impressive. In neighboring Boston, sometimes called "America's walking city," 13 percent of residents commute by walking, compared to the State of Massachusetts (4.3%) and the U.S. (2.9%). In Cambridge, however, this figure is a staggering 24 percent; neither Lowell, Waterbury, or Manchester exceeds even five percent. In addition to walking, 3.9 percent of Cambridge residents commute by bicycle; this is more than twelve times the bike share in any small New England city examined and four times the bike share in Boston.

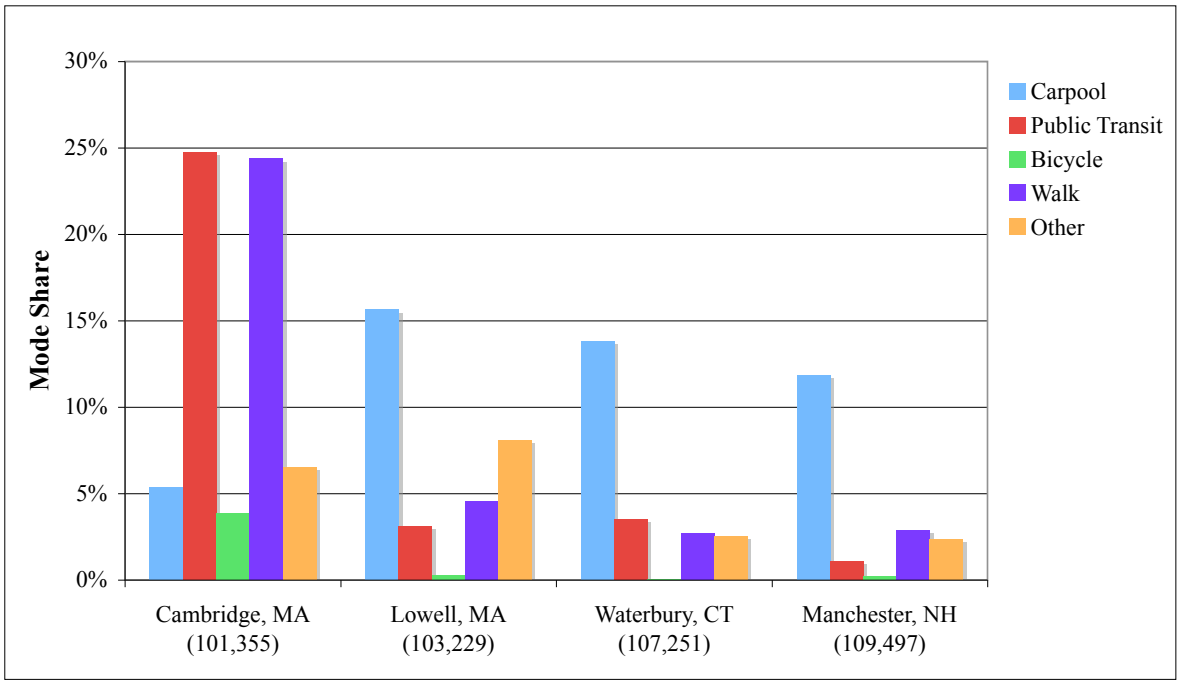

FIGURE 3 Commute mode shares for small New England cities (~100,000 people)

Cambridge has acknowledged in a number of its policies that measures for promoting and improving alternative modes of transportation serve to reduce energy consumption, provide accessibility, and improve the quality of life in the city. Nonetheless, these local effects should not overshadow the policies' impact on reducing GHG. Nationally, in the year 2000, GHG emissions in the transportation sector were 6.78 metric tons of carbon equivalent (MTCE) per capita (Inventory, 2007). In 1998, transportation GHG emissions in Cambridge were an estimated at 223,000 MTCE, or roughly 2.22 MTCE per capita ("Cambridge Greenhouse Gas Emissions," 2007). In the state of Massachusetts, this value was as high as 5.05 MTCE per capita in 2000 ("Per capita greenhouse gas"). Furthermore, while Massachusetts GHG emissions increased by five percent from 1990 to 2000, Cambridge emissions increased by roughly one percent in that same period.

Conclusions

Due to its historically dense structure and also to its aggressive transportation and land use policies, the city of Cambridge has been able to reduce vehicle miles traveled, lower SOV mode

shares, and rely more on sustainable alternative modes of transportation. This shift appears to have resulted in lower GHG emission rates in the transportation sector.

Although much of Cambridge's success is due to centuries of successful city building, policy makers have also taken measures more recently to ensure protection of the global climate. In the transportation sector, which accounts for 13 percent of emissions, the city's goals include reducing vehicle miles traveled (VMT) and promoting alternative modes. Measures by Cambridge for achieving these goals include limiting the share of single occupancy vehicles (SOV) by businesses, restricting parking, and establishing pedestrian and bicycle plans.

The city's parking and transportation demand management (PTDM) ordinance has successfully reduced SOV shares. Compared to New England cities of similar size, Cambridge has a low share of commuters who travel by car and high shares of those to walk and cycle. Finally, per capita GHG emissions in Cambridge are half the Massachusetts average and one-third the national average. Furthermore, these emissions are increasing at a much lower rate than in all of Massachusetts.

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