Cool Moves

Transit in New England and its Role in Curbing Global Warming Pollution

ENVIRONMENT NEW HAMPSHIRE
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Environment New Hampshire Research & Policy Center

Clean Water Fund

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Written by:

Tony Dutzik, Frontier Group

with contributions from:

Matthew Davis of U.S. PIRG Education Fund
and members of the New England Climate Coalition

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Executive Summary

New England's transportation system produces more carbon dioxide pollution – the leading contributor to global warming – than any other part of the region's economy. Cars, SUVs and other light-duty vehicles are the leading polluters. If New England hopes to fulfill its commitments to reduce global warming pollution – and achieve the 80 percent reductions in emissions scientists believe will be necessary to stave off the worst impacts of global warming – we must reduce emissions from the transportation sector.

New England states that have made significant investments in transit are curbing emissions of global warming pollutants, using less gasoline, and enjoying a host of other benefits. Improving and expanding transit service in the region will play a vital role in addressing New England's global warming and energy challenges.

New England transit systems reduce global warming pollution and save large amounts of oil.

- In 2005, transit use averted more than 1.7 million metric tons of carbon dioxide pollution in New England, equivalent to taking 310,000 cars off New England's roads for a year. Increases in ridership on many New England transit services due to higher fuel prices mean that transit is likely delivering even greater benefits today.
- Transit also saved more than 240 million gallons of gasoline in New England in 2005, enough to fill more than 24,000 tanker trucks.
- States that have made a greater investment in transit services have reaped more global warming emission benefits. (See Table ES-1.) Massachusetts, which has the most extensive transit network in New England and invests far more in transit than any other New England state, accounted for about three-quarters of the emission reductions. New Hampshire, whose sparse transit network reflects a lack of state investment, and Vermont, the most rural state in the U.S., achieved no direct emission reductions from transit according to our analysis, although transit service does provide other important social and economic benefits.

Table ES-1. Carbon Dioxide Emission Reductions from Transit Service

State	CO_2 Emission Reductions (metric tons)
Massachusetts	1,307,923
Connecticut	402,303
Rhode Island	30,464
Maine	807

Rail transit delivered the largest reductions in global warming emissions.

- Commuter rail and other forms of rail transit (such as the Massachusetts Bay Transportation Authority's subway and light rail networks and the Amtrak intercity rail network) accounted for most of the emission reductions from transit use. (See Table ES-2.) Vanpool programs, in which transit agencies provide vans for groups of commuters who use them to travel to and from work, also provided significant emission reductions relative to the small number of New England commuters currently using the services.

Table ES-2. Carbon Dioxide Emission Reductions from Transit by Mode

Mode	CO_2 Emission Reductions (metric tons)
Commuter Rail	685,924
Heavy Rail (Subway)	639,898
Light Rail	241,200
Intercity Rail (Amtrak)	132,093
Bus	25,188
Vanpool	14,866
Trolleybus	1,109

Bus service presents a more complex picture.

- Many bus services in New England deliver global warming emission reductions and energy savings, and the number of bus services that deliver those benefits is increasing as ridership rises. However, not all bus services "break even" on global warming emissions. Several New England transit agencies have taken innovative steps to reduce their global warming emissions and gasoline consumption – for example, by using cleaner alternative fuels instead of diesel, using smaller and more fuel-efficient vehicles, and by using creative strategies to boost ridership. Other New England transit agencies should follow their lead.

Transit service provides a host of other benefits to the public.

- Global warming emission reductions and energy savings are just two of many benefits provided by transit. Other benefits include:
  - Mobility Benefits: Transit provides a transportation lifeline for those who do not own or cannot drive a car. It also serves as a valuable source of backup transportation for many New Englanders who usually drive and will become increasingly important as the region's population continues to age.
  - Community Benefits: Transit can help promote more compact land-use patterns that allow more trips to be taken on foot or via bike while consuming less land and reducing the cost of public services. Transit can even give a boost to tourism.
  - Efficiency Benefits: Transit enables the rest of the transportation system to work more efficiently, cutting down on traffic congestion that wastes time, wastes fuel and causes excess pollution. The availability of high-quality transit can also reduce the cost of owning, maintaining and fueling vehicles, saving consumers' money.
- Various types of transit services are designed to provide different benefits, with some services more successful at providing basic mobility and others succeeding at "getting cars off the road." The value of transit service to a community can only be evaluated by taking all benefits into account.

To address the region's global warming and energy challenges, New England should invest in developing a 21st century transit system that provides convenient, affordable and comfortable transit service to more New Englanders.

- New England states should move aggressively to build important transit projects, many of which have been on the drawing board for years or decades. Among those projects are commuter rail service to southern New Hampshire, extension of Downeaster rail service in Maine and commuter rail service in Rhode Island, extensions of the MBTA Blue and Green lines and construction of the greater Boston Urban Ring, and creation of commuter rail service in central Connecticut.
- The region's leaders should anticipate future needs and plan for projects that would enhance the efficiency of the region's transit system, such as the greater Boston north-south rail link, as well as the Boston-Montreal and Boston-Maine high speed rail corridors.
- The region should work to boost transit ridership by improving existing transit services, learning from innovations made by transit agencies in the U.S. and abroad. The region should invest in maintenance of the current system, as well as in simple innovations – such as real-time schedule information at transit stops, prioritization of transit vehicles at traffic signals, and on-board wireless Internet – that can encourage more riders to take transit, thus delivering additional global warming emission reductions and energy savings.
- Making the necessary investments in transit will require the region to rethink its transportation spending priorities. State and federal transportation budgets are facing increasing strain as gas tax revenues level off and transportation infrastructure needs increase. New England states should increase the share of overall transportation funding devoted to transit, eliminate subsidies for automobile use, and develop funding mechanisms that both encourage the use of transportation alternatives and provide new revenues for improvement and expansion of transit.

Introduction

Addressing global warming and reducing our dependence on oil are two goals most New Englanders can agree on. New England states have carved out a path of leadership on both issues, agreeing to regional goals to cut global warming pollution, adopting mandatory limits on global warming emissions from power plants, requiring new cars to produce fewer global warming pollutants (a move which will likely also save oil), and taking cutting-edge steps to promote renewable energy and energy efficiency.

We have much to be proud of. But when it comes to finding ways to curb the spiraling growth of vehicle travel on our highways – which increases our contribution to global warming, makes us ever more dependent on foreign oil, and causes problems ranging from traffic congestion to smog – the region has failed to respond adequately.

There are many reasons why reducing growth in vehicle travel is more difficult than, for example, curbing pollution from power plants. Transportation is a complex issue with no "silver bullet" solutions. It is tied up with other complex issues, including land use. Real solutions require large, long-term public investments at a time when state budgets are squeezed. And transportation is woven through many aspects of how New Englanders perceive the quality of their lives.

The realities of global warming and diminishing oil supplies, however, are unforgiving and they demand our attention. To respond to those realities, New England must build a 21st century transportation system with efficient, reliable and widespread transit service at its core. Cars and trucks will still have an important role to play in our transportation future, and the region should continue to work to make them as efficient and clean as possible. But to achieve our global warming emission reduction goals, and to reduce the impact of rising oil prices on our economy, New England must ensure that more of our travel takes place via transit, on foot, or by bicycle – and that less of it takes place in single-passenger automobiles.

Transit already makes important contributions to life in New England, providing for the transportation needs of those without cars, easing congestion on our highways, helping to clean our air, and saving millions of gallons of oil and more than a million tons of global warming emissions every year. But for all its benefits, transit service in New England today is often fragmented, poorly funded, and of varying quality.

A substantive, long-term commitment to transit in New England could enable the region to meet its energy and global warming challenges while moving people quickly, reliably and comfortably around the region. The energy savings and global warming emission reductions delivered by transit in the region are just a taste of the benefits that could be delivered with a bold commitment to improving and expanding transit service in New England.

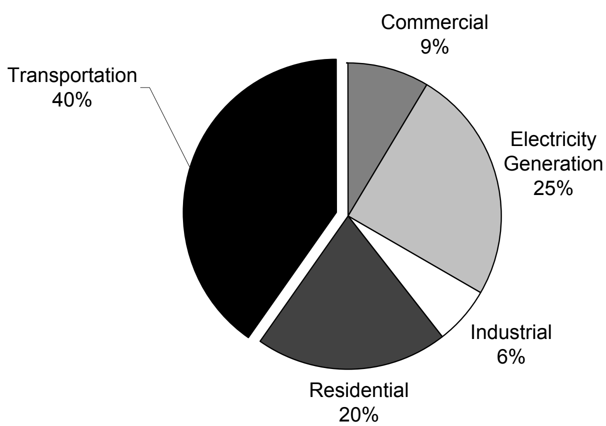
Transportation and the Global Warming and Energy Challenges

Transportation is the leading source of global warming pollution in New England, with cars and light trucks (such as pickups, SUVs and minivans) producing most of that pollution. Reducing global warming pollution from transportation will take efforts on multiple fronts, including making vehicles more fuel-efficient, using lower carbon fuels and reducing vehicle travel.

Cars and Light Trucks Are a Major Source of Global Warming Pollution

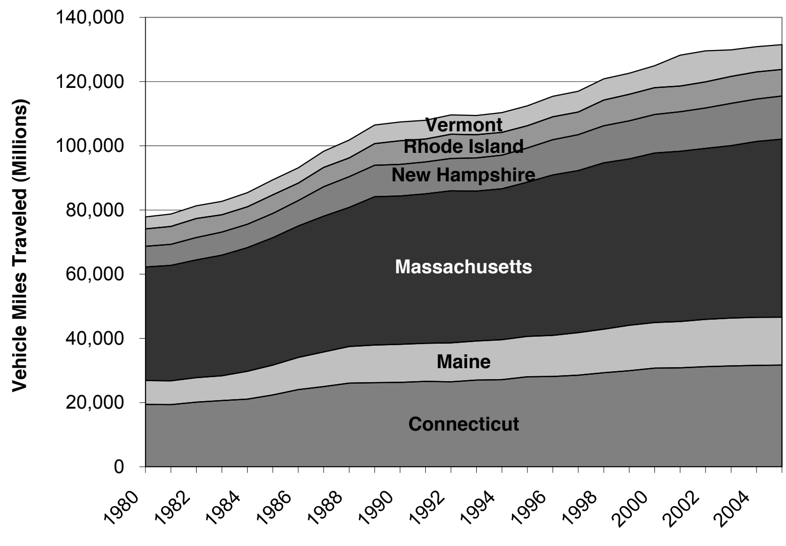
Transportation is responsible for 40 percent of New England's emissions of carbon dioxide, the leading global warming pollutant.[1] Consumption of motor gasoline for transportation – the vast majority of which is used to power cars and light trucks – was responsible for 30 percent of the region's carbon dioxide emissions in 2004. (See Fig. 1.) Cars and trucks produce more carbon dioxide pollution than all the region's power plants put together.

Fig. 1. Emissions of Carbon Dioxide by Sector in New England, 2004[2]



To reduce global warming emissions from cars and light trucks (such as pickups, SUVs and minivans), five of the six New England states have adopted the Clean Cars Program, which was initially developed by the state of California. The Clean Cars Program sets the first-ever limits on tailpipe emissions of pollutants that cause global warming, and will require an approximate 30 percent reduction in global warming pollution from new cars and light trucks by 2016.[3]

Fig. 2. Vehicle-Miles Traveled in New England, 1980-2005[4]



But reducing per-mile emissions is unlikely to reduce global warming pollution enough to address the problem. Nor is it likely to be enough to wean New England from dependence on foreign oil. To achieve those goals, New England must also halt and reverse the growth in vehicle travel in the near future.

Over the last 25 years, the number of miles traveled on New England's roads has increased by nearly 70 percent, for an average growth rate of a little more than 2 percent per year.[10] (See Fig. 2.) Should that rate of growth continue, vehicle travel in the region would increase by another 24 percent between now and 2018, wiping out virtually all of the emission savings delivered by the Clean Cars Program.

Reducing oil consumption and global warming pollution from vehicles will require efforts on two fronts. We must continue to reduce per-mile pollution from cars with better vehicle technology and the use of low-carbon fuels such as sustainably produced biofuels. Yet, we must also reduce the number of miles driven by providing more and better transportation options to New Englanders.

Many New Englanders undoubtedly would choose to drive less – thereby reducing the amount of time

What Science Says We Need to Do About Global Warming

There is broad scientific consensus that human activities – and particularly the burning of fossil fuels – is causing the earth to warm. The impacts of global warming are already being felt in New England and elsewhere around the globe. Since 1970, average annual temperatures in the Northeast have been rising at a rate of 0.5° F per decade, with an increase in the number of days of extreme summer heat, reductions in winter snow pack and ice cover, and rising sea level.[5]

A recent analysis suggests that temperature increases within the range of those predicted by climate scientists for the Northeast could have a devastating impact on the region's economy and environment over the next century. Among the potential impacts include the loss of a reliable ski season everywhere in the region but Maine, a dramatic spike in the number of summer days over 100° F, the loss of important tree and bird species from the region, and increased risk of devastating coastal flooding caused by rising seas and more intense storms.[6]

To prevent the worst impacts of global warming, the world must prevent global average temperatures from rising by more than 2° Celsius (3.6° F). And to have a reasonable chance of achieving that target, we must hold the atmospheric concentration of global warming pollutants below 450 parts per million (carbon dioxide equivalent).[7] But time is running out: global average temperatures have already risen by more than 1.3° F and will rise by at least another 0.4° F as a result of emissions already made.[8] The concentration of global warming pollutants in the atmosphere is already 427 parts per million (carbon dioxide equivalent) and rising rapidly.[9]

Because the United States has historically been the world's leading emitter of global warming pollutants, we will have to cut emissions more quickly and more deeply than other nations, although action by every country is critically important.

At minimum, the United States must:
- Start reducing emissions of global warming pollution now.
- Cut emissions by at least 15 to 20 percent by 2020.
- Reduce emissions by at least 80 percent by 2050.

The New England states have already begun to take action to reduce emissions of global warming pollution. But further action will be necessary in the years to come if we hope to prevent the most dangerous impacts of global warming on New England's environment, economy and way of life.

they spend sitting in traffic and dodging rising gasoline prices – if they had both convenient alternatives and the right set of incentives. There are many ways that New England states can realign their transportation policies to provide additional choices to New Englanders and to encourage them to drive less.

Reducing Vehicle Travel: No Silver Bullets

Reducing growth in vehicle travel in New England requires rethinking our transportation priorities in fundamental ways. But there are no "silver bullet" solutions. The New England Climate Coalition's 2006 report, *Shifting Gears*, listed 20 steps the region can take to reduce global warming emissions from transportation, including many directed at reducing vehicle travel. Among the most promising options are the following:

- **Encouraging transit and low-carbon transportation options** by expanding the region's rail infrastructure, improving transit service in cities, suburbs and small urban areas, and improving bicycling and pedestrian facilities.
- **Promoting "smart growth"** through compact development, transit-oriented development, and impact fees that make sprawling development pay its own way.
- **Reducing single-passenger automobile commuting** through commute-trip reduction programs and live-near-work/live-near-transit incentives.
- **Reallocating the costs of driving** through strategies such as pay-per-mile automobile insurance, parking reform, and elimination of financial incentives for driving.
- **Revamping transportation planning and finance** to emphasize least-cost planning, requiring the consideration of global warming emissions in transportation planning decisions, and investing in transit and other transportation alternatives.[11]

Reducing global warming emissions from New England's transportation system will require coordinated efforts on many fronts. But improved, expanded transit service is a central part of any vision of a modern 21st century transportation system for the region that reduces our emissions of global warming pollution, curbs our dependence on foreign oil, and ensures mobility for New England residents.

Transit Today: Curbing Global Warming Pollution, Saving Energy, and Delivering a Host of Other Benefits

Transit in New England makes an important contribution to the region's efforts to reduce global warming pollution and curb our dependence on oil. At the same time, transit provides a wealth of other benefits to New England communities, ensuring mobility for those without cars, encouraging more compact land-use development patterns, and serving as an important part of the region's transportation system.

How Transit Reduces Global Warming Emissions and Saves Energy

Evaluating the global warming and energy benefits of existing transit services requires one to ask several "what if" questions. If transit did not exist, how would transit riders travel instead? How much would highway congestion increase and how would that affect energy consumption and pollutant emissions? What would land-use patterns look like? Could a city such as Boston, whose population doubles during the course of an average work day, continue to exist in its present form without transit service?[12] And if it couldn't, what might it look like instead?

The answers to each of these questions determine how much benefit transit can be assumed to deliver in energy and global warming emissions. This section describes briefly what forms of transit are included in the analysis and the assumptions we made about each of the categories of benefits delivered by transit. A more detailed discussion of these issues is presented in the "Methodology" section at the end of this report.

Accounting for the Global Warming and Energy Benefits of Transit

Transit saves energy and reduces global warming pollution in several ways.

First, and most obviously, transit replaces trips that would otherwise be taken in automobiles. Were transit service to cease, not every trip would be replaced by an automobile trip – some trips might be taken on foot, while others might not be taken at all.[13] For the sake of this analysis, however, we assume that trips not taken via transit would be made via some other vehicle, and that those vehicles would have an average occupancy of just under 1.5 passengers (including the driver).[14]

Second, transit use reduces traffic congestion on roads, reducing the amount of time that other travelers spend sitting in traffic, idling their engines and wasting fuel. To estimate these benefits, we relied on 2003 data from the Texas Transportation Institute (TTI), which estimated the amount of gasoline saved by transit through reduced congestion effects in 85 metropolitan areas across the country.[15] TTI did not evaluate congestion reductions in New England's smaller metropolitan areas.

Third, the presence of high-quality transit in a community allows for more compact land-use patterns and reduces average vehicle ownership. Residents of transit-dense communities are more likely to walk or bike to complete basic tasks or, when they do drive, they are more likely to drive shorter distances than residents of areas with little transit service. Moreover, residents of transit-dense communities own fewer vehicles than residents of other communities, meaning that other trips must take place by means other than car. As a result, people living in transit-dense communities drive significantly fewer miles than residents of areas with little transit service, leading to the conclusion that each mile traveled via transit "leverages" further reductions in vehicle travel – thus saving fuel and reducing global warming emissions.[16]

Estimates of the impact of transit on overall vehicle travel in a community vary significantly and there has been little analysis of the differing impacts on land-use and vehicle ownership of various types of transit service (e.g. commuter rail versus urban rail service versus bus service).[17] In addition, analysis of leveraged travel reductions related to transit have failed to answer convincingly the "chicken and the egg" question of whether availability of transit service causes more compact land-use patterns or more compact land-use patterns make good transit service possible.

Clearly, however, the existence of high-quality transit is correlated with less car-dependent land-use patterns in some places and creates the potential for such patterns in others. Boston, for example, with its high density of downtown jobs, its walkable city streets, and compact neighborhoods simply could not exist in its current form if travel on the MBTA transit system were to be replaced with travel by automobile.

It is reasonable, therefore, to assume some leveraging of vehicle travel reductions from existing transit service in New England. However, our estimates of leveraged vehicle travel reductions are on the conservative end of the values presented in the literature and we assume no leveraging effect at all from bus service or intercity rail.

Transit Services Included and Not Included in This Analysis

Public transit can be defined as any publicly operated transportation system (or any system that is privately operated under contract to a government entity). For the purposes of this report, we have chosen a narrower definition of transit as being transportation service that:

- Is intended to transport more than one rider at a time.
- Is operated by a government agency or operated privately under contract to a public agency.
- Uses vehicles not owned by the users.

To be included in this report, a transit service also had to meet a fourth criterion: it must collect or report enough data to allow for evaluation of energy consumption from transit operations. For most transit services considered in this report, data were reported to the federal government's National Transit Database (NTD). In a few cases, we contacted transit system operators directly to solicit data that would enable us to estimate energy savings and global warming emission reductions.

As a result, our analysis includes the following transit services:

- Bus, subway, light rail and commuter rail services reporting to the National Transit Database.
- Government-coordinated or government-subsidized vanpool services.
- Amtrak intercity rail service (which provides a mix of commuter-oriented and long-distance travel in the region).[18]

We exclude the following:

- Transit services that do not report to the NTD (generally those operated by small transit providers in rural areas).
- Privately operated intercity bus services (such as Greyhound or Trailways), except in rare cases when those services report to the NTD.
- Privately operated vanpool services.
- Demand response or "paratransit" service, which often transports one or a small number of riders at one time.
- Carpools arranged through government-operated rideshare matching programs.
- Ferry service, for which accurate comparison with automobile trips is impossible. Ferries generally serve areas that are either inaccessible by car or for which an automobile trip would require a much lengthier trip than the "as the crow flies" distance traveled by the ferry. As a result, any emission comparison for ferry service must be done on a case-by-case basis, which is beyond the scope of this report.

Transit Reduces Global Warming Pollution and Energy Consumption in New England

Transit Reduced Global Warming Pollution by More than 1.7 Million Metric Tons in New England in 2005

Transit service reduced global warming pollution in the region by more than 1.7 million metric tons during 2005, the equivalent of taking more than 310,000 cars off New England's roads each year.

Not surprisingly, transit delivered the greatest global warming emission benefits in states with the most extensive transit infrastructure. (See Table 1.) By far the largest impact was in Massachusetts, where transit accounted for more than 1.3 million metric tons of emission reductions. The second largest impact was in Connecticut, where transit saved more than 400,000 metric tons in 2005. Maine and Rhode Island both experienced small reductions in global warming pollution from transit, while Vermont and New Hampshire experienced no measurable global warming emission benefits in 2005 in this analysis. (However, our methodology does not include emission savings from congestion reductions in smaller cities or any land-use or vehicle ownership impacts of bus service. Including these impacts would increase the global warming emission benefits of transit in Vermont, New Hampshire and rural areas in other New England states that rely on bus service.)

Table 1. Carbon Dioxide Emission Reductions from Transit Service[19]

State	CO_2 Emission Reductions (metric tons)
Massachusetts	1,307,923
Connecticut	402,303
Rhode Island	30,464
Maine	807

MBTA

Commuter rail networks such as the MBTA remove thousands of vehicles from New England's highways every day, reducing congestion, global warming emissions and gasoline consumption.

Transit Saved 240 Million Gallons of Gasoline in New England 2005

In addition to reducing global warming emissions in New England, transit service reduced New England's consumption of fossil fuels. Transit operations in New England saved approximately 240 million gallons of gasoline in 2005, or enough gasoline to fill more than 24,000 tanker trucks.[20] (See Table 2.) (Note that while transit service in New Hampshire did not generate direct global warming emission benefits, it did provide for a modest reduction in overall gasoline consumption.)

Table 2. Gasoline Savings from Transit, 2005

State	Gasoline Savings (million gallons)
Massachusetts	174.0
Connecticut	63.9
Rhode Island	5.2
Maine	0.2
New Hampshire	0.1

Global Warming Emission Reductions from Transit Increased in 2006

Rising gasoline prices triggered substantial increases in transit ridership in many parts of New England during 2006. As of the time of this writing, full data for transit energy use and passenger travel in 2006 were not yet available from the National Transit Database. Some transit agencies, however, have reported updated ridership and vehicle usage data for 2006 that allows for a rough estimate of the impact of increased ridership on global warming emission reductions in 2006.

Among the 22 New England transit agencies reporting 2006 data (most of them agencies operating bus fleets), the number of passenger miles traveled via transit increased by 3.6 percent between 2005 and 2006, delivering approximately 5,700 metric tons of additional global warming emission reductions. (See Table 3.)

Table 3. Percentage Increases in Passenger-Miles Traveled for New England Bus Transit Agencies, 2005 to 2006 (partial list)[21]

Agency	State	Pct. Change
Worcester Regional Transit Authority (WRTA)	MA	22.9%
Connecticut Transit - Hartford Division (CTTransit)	CT	12.3%
Chittenden County Transportation Authority (CCTA)	VT	11.9%
Cape Cod Regional Transit Authority (CCRTA)	MA	11.3%
Nashua Transit System (NTS)	NH	10.3%
Merrimack Valley Regional Transit Authority (MVRTA)	MA	9.2%
Connecticut Transit - New Haven Division (CTTransit)	CT	8.9%
Norwalk Transit District	CT	8.0%
Manchester Transit Authority (MTA)	NH	7.6%
Southeast Area Transit (SEAT)	CT	5.7%
Montachusett Regional Transit Authority (MART)	MA	4.6%
Greater Bridgeport Transit Authority (GBTA)	CT	3.3%
Middletown Transit District (MTD)	CT	2.6%
Connecticut Transit - Stamford Division (CTTransit)	CT	1.5%
Housatonic Area Regional Transit (HART)	CT	1.5%

The region's largest transit agencies – including the MBTA and the Metro-North New Haven Line – have not yet reported 2006 data, but ridership numbers suggest that these services also delivered greater carbon dioxide emission reductions in 2006. Ridership on commuter rail lines increased significantly on the MBTA (0.9 percent), the Metro-North New Haven Line (3 percent), and Shore Line East (8.3 percent).[22] And through the third quarter of 2006, ridership on MBTA heavy rail subway (12.9 percent increase) and light rail (5.6 percent increase) systems had also jumped sharply.[23] Ridership on the Downeaster train between Portland, Maine and Boston increased by 31 percent between fiscal year 2005 and fiscal year 2006.[24] These early estimates suggest that transit service delivered even greater energy savings and global warming emission reductions in 2006 than in 2005.

Factors in Global Warming and Gasoline Savings from Transit in New England

The differences in energy savings among the states are due to a variety of factors – including the modes of transit used, ridership, and the types of vehicles and fuels used to provide transit service.

Rail Transit Accounts for Most of the Emission Reductions

Some transit modes are designed to deliver greater energy and global warming emission savings than others. Transit systems that rely more on rail transit, or that incorporate vanpools into their service offerings, are more efficient at reducing gasoline consumption and global warming emissions than systems that rely exclusively on buses.

Of the 1.7 million metric tons of carbon dioxide emissions prevented by transit, commuter rail (39 percent) accounted for the largest share of emission reductions, with most of the remainder coming from light rail and heavy rail subway operations, all of them in the Boston metropolitan area, as well as Amtrak intercity rail service. (See Table 4.) Bus service accounted for the next largest share of emission reductions, though with wide variations in the degree of reductions among transit agencies. (See "Bus Transit: A Vital Service with Mixed Benefits for Global Warming and Energy Use," page 15.) The four vanpool programs included in our dataset – in Chittenden County, Vermont, and the states of Connecticut, Maine and Massachusetts – accounted for more than 14,000 metric tons in savings.

Table 4. Carbon Dioxide Emission Reductions from Transit by Mode, 2005

Mode	CO_2 Emission Reductions (metric tons)
Commuter Rail	685,924
Heavy Rail (Subway)	639,898
Light Rail	241,200
Intercity Rail	132,093
Bus	25,188
Vanpool	14,866
Trolleybus	1,109

As with global warming emissions, the biggest savers of gasoline were rail operations. Rail operations are particularly important for conserving gasoline because some Metro-North commuter rail lines and Boston's heavy and light rail systems operate on electricity. The MBTA's Boston-area bus system is also a significant saver of gasoline, since many MBTA buses operate on compressed natural gas. (See Table 5.)

Northern New England Passenger Rail Authority

Amtrak's Downeaster rail service experienced a 31 percent increase in ridership between fiscal year 2005 and fiscal year 2006.

Table 5. Gasoline Savings from Transit by Mode, 2005

Mode	Gasoline Savings (million gallons)
Commuter Rail	94.4
Heavy Rail (Subway)	83.0
Light Rail	29.8
Intercity Rail	21.7
Bus	11.9
Vanpool	1.8
Trolleybus	0.5

COMMUTER RAIL

Each of the region's commuter rail services produced savings in global warming emissions. In the case of the region's two major commuter rail systems – the Boston-area MBTA network and the Metro-North rail network in western Connecticut – the savings were substantial. (See Table 6.)

HEAVY AND LIGHT RAIL SERVICE

In contrast to commuter rail, which transports commuters over long distances, heavy rail (subway) and light rail systems transport riders shorter distances in densely populated urban areas. New England's only light rail, subway and trolleybus (electric buses connected to overhead wires) services are in the Boston metropolitan area and are administered by the MBTA. (See Table 7.)

Table 7. Carbon Dioxide Emission Savings from MBTA Operations, 2005

Mode	CO_2 Emission Reductions (metric tons)
Heavy Rail (Subway)	639,898
Light Rail	241,200
Trolleybus	1,109

Table 6. Carbon Dioxide Emission Reductions from Commuter Rail Systems, 2005[25]

State	Agency Name	CO_2 Emission Savings (metric tons)
MA	Massachusetts Bay Transportation Authority (MBTA)	361,440
CT	MTA Metro-North Railroad (New Haven Line)	323,345
CT	Connecticut Department of Transportation (Shore Line East)	1,138

istockphoto.com/Jo Ann Snover

The MBTA's heavy rail subway network supports compact land-use patterns that reduce the number of miles residents of Boston and nearby communities drive on the region's roads.

INTERCITY RAIL SERVICE

Amtrak's intercity rail network also makes a significant contribution toward reducing global warming emissions in New England. Amtrak trains attract a variety of passengers, including those who use the service for their daily commutes along with those who use Amtrak as a substitute for longer-distance trips that would otherwise have taken place via car or airplane.

Data provided by Amtrak enabled us to estimate energy consumption and global warming emissions from three intercity train lines in New England: the Downeaster service between Portland, Maine and Boston; Springfield-New Haven line service in western Massachusetts and central Connecticut; and Northeast Corridor service between Boston and New York City. Several other Amtrak train lines – including the Vermonter and Ethan Allen routes and the Lake Shore Limited service that traverses Massachusetts between Boston and Albany – were not included in this analysis.

Amtrak's Northeast Corridor service, which includes the Acela high-speed rail service, delivered significant global warming emission benefits, as did the Downeaster. Amtrak's Springfield line, which is powered by diesel locomotives, did not show a global warming emission benefit in this analysis.

Table 8. Carbon Dioxide Emission Reductions from Amtrak Intercity Rail Service, 2005

Route	CO_2 Emissions Savings (metric tons)
Northeast Corridor	134,719
Downeaster	2,383

Vanpools Deliver Consistent Reductions in Carbon Dioxide Pollution

The other transit mode that delivered consistent reductions in global warming emissions is the vanpool. Vanpools are a non-traditional form of transit service, in which a transit agency (or other government, non-profit or for-profit entity) supplies a van to a group of commuters who then use it to commute to and from work. Vanpool participants typically pay a flat monthly fare for the service, with the volunteer driver (a vanpool member) receiving a discount. Vanpools have proven to be a successful way to bring transit to difficult-to-serve suburb-to-suburb commutes.

The National Transit Database, on which this analysis is largely based, only collects information on some vanpool operations. In New England, two vanpool programs were included in the 2005 dataset: the "Easy Street" vanpool program run by The Rideshare Company under contract to the state of Connecticut and the vanpool program operated by the Chittenden County Transportation Authority in Vermont. In addition, we sought information from vanpool agencies in Massachusetts and Maine, from which we were able to estimate emissions savings from vanpool operations in those states.

All four services reduced global warming pollution. However, vanpool programs in all four states serve only a small fraction of the riders served by conventional transit services. Additional commuters are served by privately operated vanpool services, but those services are not included in this analysis.

Table 9. Carbon Dioxide Emission Reductions from Vanpools, 2005

State	Vanpool Agency	CO_2 Emission Reductions (metric tons)
CT	Greater Hartford Ridesharing Corporation - The Rideshare Company	8,470
MA	MassRides	5,346
ME	GoMaine	974
VT	Chittenden County Transportation Authority (CCTA)	76

Bus Transit: A Vital Service with Mixed Benefits for Global Warming and Energy Use

The story of transit's impact on the global climate becomes more complicated when it comes to bus service. Several kinds of transit are lumped together under the heading of bus service in New England. Commuter express buses serve much the same function as commuter rail in some areas, carrying large numbers of suburban commuters to and from jobs in central cities. Urban buses enable riders to navigate the region's cities in much the same way that light rail does. And in small urban and rural areas, fixed-route bus service provides a mix of services – diverting would-be commuters from the roads in some cases, and providing basic mobility in others. Complicating matters further is the fact that some bus lines serve as "feeders" to commuter rail or urban rail systems, enabling more travelers to use those systems for the main part of their journeys.

BACTS

Transit doesn't just save energy in large cities. Bangor, Maine's BAT Community Connector has combined comfortable, appropriately sized buses with sleek design to attract riders and reduce global warming pollutant emissions.

The twin imperatives of bus service – to enhance mobility and to promote transportation system efficiency – sometimes work at cross purposes. Ensuring basic mobility for those without access to other forms of transportation may require operating some services at times or in places where their contribution to the efficiency of the system is small.

The 37 bus services in our sample delivered modest global warming emission reductions in the aggregate. Some bus services – including those serving larger cities, incorporating long-distance commuter bus service, or using more efficient or cleaner buses – provided net global warming benefits, while others – mainly those serving smaller cities – did not. Table 10 shows the agencies that had a net positive impact on global warming emissions.

Table 10. Carbon Dioxide Emission Reductions from Bus Service, 2005

State	Agency	CO_2 Emission Reductions (metric tons)
MA	Massachusetts Bay Transportation Authority (MBTA)	28,440
RI	Rhode Island Public Transit Authority (RIPTA)	8,041
MA	Brockton Area Transit Authority (BAT)	3,322
RI	Bonanza (BZ)	2,981
MA	Pioneer Valley Transit Authority (PVTA)	304
CT	Connecticut Transit - New Haven Division (CTTransit)	277
CT	Connecticut Department of Transportation (CDOT)	237
ME	City of Bangor - BAT Community Connector (BAT)	119
MA	Merrimack Valley Regional Transit Authority (MVRTA)	91

Based on 2006 ridership data, several more bus transit agencies now appear to be contributing to progress against global warming than in 2005. CT Transit's Hartford division appears to have joined the New Haven division in delivering global warming emission benefits, along with New Hampshire's Nashua Transit System and the Greater Bridgeport Transit Authority in Connecticut. In addition, several other agencies moved closer to "breaking even" on global warming emissions in 2006. Ridership data do not indicate whether transit agencies have moved toward the use of cleaner vehicles within the past year, another change that would have reduced carbon dioxide emissions.

Rising Transit Ridership in Vermont

The increase in transit ridership in 2006 was not limited to transit agencies serving larger New England cities. Rural transit agencies, many of which offer a limited number of fixed transit routes combined with demand response service, also saw ridership skyrocket in response to higher gasoline prices.

In Vermont, transit ridership increased by an average of 9 percent between fiscal year 2005 and fiscal year 2006.[26] The greatest increases in ridership were on Connecticut River Transit in Springfield (27 percent increase), Rural Community Transit in St. Johnsbury (23 percent), and the Vermont ridership of Advance Transit in the Hartford area (19 percent). Only two of 12 agencies experienced a decline in ridership; both had instituted fares during the course of the year, reducing ridership.

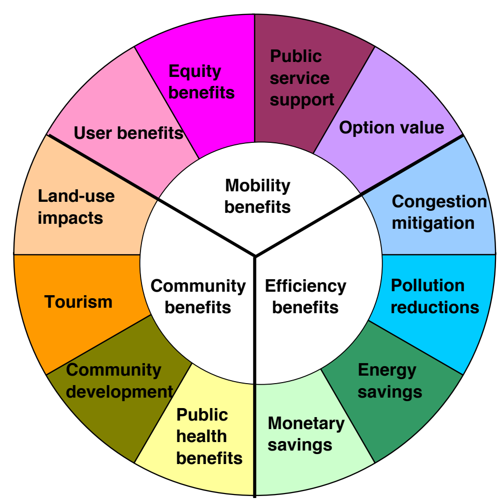
It is important to note that this analysis likely understates the global warming benefits delivered by bus service, particularly in smaller metropolitan areas of New England. We assume no gasoline savings from congestion reduction outside of the region's largest metropolitan areas (Boston, New York, Providence, Hartford, Springfield, New Haven and Bridgeport-Stamford) and assume that bus service plays no role in leveraging vehicle travel reductions through more compact land-use patterns or reduced vehicle ownership. In reality, bus transit likely plays a role in reducing at least local traffic congestion and may "leverage" additional reductions in vehicle travel in some locations. These impacts may be significant enough to balance out the mild net global warming impact of bus service in some areas of New England.

How Transit Benefits New England: Beyond Global Warming and Energy

Reducing global warming emissions and saving energy are just two of the many benefits delivered by transit in New England. Even in cases where particular transit services do little to reduce global warming emissions or oil consumption, they can still deliver large benefits to communities in other ways.

Transit provides three types of benefits to New England: it enhances the mobility of our population (particularly those who do not or cannot drive), it delivers benefits that are shared by the entire community, and it bolsters the efficiency of our transportation system, thereby saving energy and reducing pollution.[27] (See Fig. 3.) All of these goals are important, but different transit systems are designed to deliver different types of benefits.

Fig. 3. Benefits of Transit



Mobility Benefits

Transit provides basic mobility to thousands of New England residents who either do not own a car or are unable to drive. For these New Englanders – who include many elderly people, low-income families, children and the disabled – transit is a lifeline connecting them to education, jobs, medical care, shopping and other important services.

For many other New Englanders, transit represents an easier, cheaper or less stressful way to get to work, school or other destinations. And for still others, transit represents a safety net, providing transportation options during inclement weather or when their vehicles are being repaired.

The Victoria Transport Policy Institute, a Canadian transportation think tank, lists four categories of mobility benefits provided by transit:

- **User benefits** – The direct benefits enjoyed by transit riders. A suburban commuter who uses commuter rail, for example, might benefit from the ability to get work done while riding the train or experiencing less stress in his or her daily commute.
- **Equity benefits** – Benefits provided to the "transportation disadvantaged" – those people who cannot afford to own a car or cannot (or should not) drive. Transit ensures that the elderly, the disabled, children, the poor and other non-drivers benefit from transportation system investments.
- **Public service support** – Transit is often a backbone of social service delivery networks, helping people to access medical care, education or other public services. If transit service did not exist, social service providers would need to invest money in alternative forms of transportation (for example, school buses or ambulance service) to ensure that their clients could access necessary services. Thus, transit service contributes to the efficiency of delivering these public services.
- **Option value** – The value provided to people other than regular transit users from their ability to use transit as a backup form of transportation. The availability of transit service allows some drivers to avoid the expense of owning or renting a second car when their primary vehicle is in the shop or otherwise unavailable. Transit is also an important option for communities as they plan their response to potential disasters. Finally, transit provides redundancy in the case of a systematic failure of other transportation systems. For example, the national passenger rail network played an important role in the immediate wake of the September 11th terrorist attacks when air traffic was shut down. Communities also often turn to transit as an alternative during highway closures and other unexpected events.

Community Benefits

Transit can also deliver important benefits to the entire community. The existence of high-quality transit reduces dependence on cars and helps make more compact development patterns possible, thereby allowing a greater share of trips to be taken by transit, by bike or on foot. Transit also increases the value of nearby properties and can even help increase tourism.

High-quality transit service can serve as a focus for community redevelopment, boosting property values and making possible more compact and efficient land-use patterns.

- **Land-Use Impacts** – Transit allows for the creation of more compact communities in which a greater variety of locations can be reached by transit, on foot or by bicycle. Transit uses far less land than automobile transport and requires far less space for parking.[28] As a result, transit can play an important role in preventing suburban sprawl-type development that eats up open space and increases public costs for infrastructure. To be most effective at delivering these benefits, however, transit must be combined with good land-use policies to create "transit oriented development."
- **Community Development** – Transit is an important asset in local economic development strategies. Studies have shown that land in immediate proximity of transit stops is generally more valu-

able than land farther away.[29] Transit can support compact commercial districts, link workers with available jobs, and enable people to save money on transportation, thereby providing them with more money to spend at local businesses.

- **Public Health Benefits** – Transit (particularly when provided by clean, low-emitting vehicles) can reduce emissions of pollutants that cause or exacerbate a range of health problems, from asthma to heart disease. Transit accommodates the creation of communities where walking and biking – rather than a sedentary, car-centered lifestyle – are more common. Several studies have linked sprawling development patterns with a higher incidence of obesity and other health problems.[30]
- **Tourism** – Finally, some forms of public transportation can help to draw tourists, giving a further boost to local economies. Heritage trolleys, historic railways and some ferry services are tourist attractions in their own right. In addition, transit can play an important role in getting large numbers of tourists to and from special events like festivals and sporting events.

Efficiency Benefits

Transit can also be designed to make transportation systems more efficient. Some of the gains are realized in improved energy efficiency and reduced emissions of pollutants. Others are realized through monetary savings.

Monetary Savings

Availability of transit service can reduce a host of public and private costs, including:

- The cost to individuals of owning or operating a vehicle. Cities with vigorous transit networks have lower levels of car ownership, and residents spend less on transportation than in other cities.[35]
- The cost of expanded highways and parking facilities. It is a commonly held myth that road users pay for the cost of highway infrastructure via user fees such as gasoline taxes. In fact, governments subsidize highway travel through expenditure of general fund revenue and spending on services such as highway law enforcement. In 2005, federal, state and local governments spent more than $39 billion in non-user fee revenue on highways, accounting for more than one-quarter of total spending.[36] Meanwhile, private businesses in auto-dependent areas must pay to provide and maintain large parking areas to accommodate people who travel by car. Transit reduces these public and private costs by reducing demand for highway expansion and reducing the need for large parking areas.

Congestion Mitigation

Transit systems reduce the number of vehicles that travel on highways, particularly during peak hours, thus reducing congestion. Highway congestion is costly, wasting time, wasting fuel, and causing increased emissions of health-threatening pollutants. In the Boston metropolitan area in 2003, transit operations saved approximately 54 million hours of traveler delay, or more than one full day per year (27 hours) for every rush-hour traveler. The congestion reduction benefits of transit were worth approximately $900 million in the Boston metropolitan area alone during 2003.[37]

Energy Savings and Pollution Reductions

As described earlier, transit can contribute in a number of ways to the goals of saving energy and reducing pollution. Transit often delivers energy savings directly – by replacing inefficient car trips with trips on higher-efficiency transit modes – and indirectly, by reducing traffic congestion and encouraging land-use patterns that lead to further reductions in vehicle travel.

Understanding Transit's Benefits

Transit services vary widely in their ability to deliver energy savings and global warming emission benefits. For example, transit agencies throughout New England operate "demand response" (or paratransit) systems that are designed to provide basic mobility to the disabled or elderly. In terms of energy consumption, demand response systems tend to be less efficient than automobile transport, since vehicle occupancy is low and demand-response vehicles are often large passenger vans. But, demand response provides a vital societal function in ensuring that the elderly and disabled are able to obtain necessary services and to participate more fully in society.

At the other end of the spectrum are systems that are designed mainly to improve the efficiency of the

Economic Benefits from Transit: The Upper Connecticut River Valley

Transit can play an important role in boosting local economies. The Upper Connecticut Valley region of New Hampshire and Vermont, centered on the town of Lebanon, NH, is one of many small urban and rural areas in New England with transit service. However, the local transit agency, Advance Transit, is unusual.[31] Thanks to partnerships with Dartmouth University, Dartmouth-Hitchcock Medical Center and local towns, Advance Transit provides fare-free transit service throughout its service area. Partly as a result, Advance Transit has experienced massive growth in ridership; the number of trips taken in 2005 was two-and-a-half times greater than the number taken a decade earlier.[32] Despite a population of only 45,000 in the six towns served by the agency, Advance Transit accounted for 1.5 million passenger-miles of travel in 2004.[33]

Providing multiple fixed bus routes and free fares costs money. Advance Transit's fixed-route bus service had a $1.4 million budget in 2005. But the benefits of the service exceed the costs.

A 2005 study by the Upper Valley Transportation Management Association estimated that Advance Transit provided the following economic benefits:

- An estimated $1.2 million paid in wages to workers who depended on the bus for transportation to and from work.
- Approximately $375,000 in avoided transportation expenses for private vehicle owners who took the bus instead.
- At least $16,000 per year in avoided need for new parking spaces.
- At least $170,000 in avoided taxi trips.
- Additional, unquantified benefits for quality-of-life improvements, avoided local traffic congestion, avoided pollution, and land-use impacts.[34]

Investment in low-cost, high-quality local bus service has benefited the Upper Valley region in many ways. Similar benefits likely accrue to other New England communities that invest in transit.

transportation system. Commuter rail, for example, often does an excellent job of removing a lot of vehicles from highways – particularly vehicles that would otherwise travel into congested city centers. In so doing, commuter rail can save a great deal of energy compared with automobile travel (though again, the degree of overall benefit depends on prevailing land-use patterns). However, commuter rail plays less of a role in serving basic needs for mobility within a community.

By focusing on the energy and global warming emission impacts of current transit service in New England, this report captures just a small part of the overall benefits of transit in the region. Extensive, affordable and high-quality transit service is important to New England communities and deserves broad public support. The potential to use transit to address the region's energy and global warming challenges provides yet another reason to invest in transit.

Transit in the 21st Century: Addressing New England's Global Warming and Energy Challenges

Transit service in New England reduces the region's contribution to global warming and saves oil. But current transit operations barely scratch the surface on what can be achieved. Some New England states make only limited investments in transit, while in others, transit agencies continually struggle for funds against other transportation and public priorities. In addition, throughout the region, responsibility for planning and providing transit services is divided among city, state, regional and federal governments, making it difficult to create an integrated vision for the role of transit in New England's future.

Investment in Transit: We Get Out What We Put In

There is no such thing as a free lunch, and that is particularly true with regard to transit. States that fail to invest in transit will largely fail to reap the benefits.

Massachusetts has historically invested more in transit than any of the other New England states, and by a wide margin. The state government spent more than $1 billion in transit in 2005, three times more than the next closest state (Connecticut).[38] (See Table 11.) The results of that investment can be seen in the large contribution transit makes to global warming emission reductions and energy savings in the state. Moreover, Massachusetts' large investments in capital – for projects such as the extension of commuter rail service to the South Shore area – will likely deliver global warming emission reductions for years to come.

Table 11. State Expenditures on Transit, 2005[39]

Connecticut	$331,504,000
Maine	$6,801,000
Massachusetts	$1,067,384,000
New Hampshire	$4,361,000
Rhode Island	$43,880,000
Vermont	$14,087,000

Yet, Massachusetts transit agencies, like those in other states, continue to struggle to make ends meet. And not even Massachusetts invests as much money in transit as is warranted. The Texas Transportation Institute estimates that congestion reductions from transit saved $900 million in wasted time, wasted fuel and other economic costs in 2003 in the Boston metropolitan area alone – an amount nearly as great as the annual state investment in transit for the entire commonwealth of Massachusetts.[40] Transit and transit-friendly land-use patterns also enabled Boston-area residents to spend less on transportation than the national average, enabling them to spend more money in the local economy.[41] Adding in the myriad other benefits of transit service in the region – from its economic development impacts to its key role in linking people to jobs and important public services to its contribution to reducing pollution – leads to the conclusion that Massachusetts gets much more than its money's worth from its current investments in transit.

It should come as little surprise that transit has done little to reduce global warming emissions or gasoline consumption in New Hampshire given that state's history of paltry support for public transit. In 2005, for example, state investment in transit was approximately $4 million, or just over $3 for every resident of the state.[42]

In some cases, institutional roadblocks prevent states from making necessary investments in transit. Maine and New Hampshire both have state constitutional prohibitions against the use of gasoline tax revenues to support transit. As a result, transit agencies in those states must generally turn to other sources – including local governments, the federal government and transit riders – for the revenue they need to keep transit service running.

The failure of New England states – and the federal government – to invest adequately in transit system expansion and operations has kept transit from making the contribution that it should to reducing the region's global warming emissions and curbing oil consumption. For transit to play an important role in achieving these objectives, local, state and federal officials must increase their investments in efficient, affordable and high-quality transit service.

Using Transit to Fight Global Warming

Transit service already plays a key role in reducing global warming pollution in New England. But it could play an even bigger role in the future, if New England states plan together and invest in expanding and enhancing transit service in the region.

Take Advantage of Missed Opportunities

Throughout New England there are important transit projects that have languished for years – in some cases decades – due to funding problems and other barriers. Taking advantage of these missed opportunities should be among the region's first priorities.

Southern New Hampshire Commuter Rail

New Hampshire is perhaps the state with the most to gain from a revival of commuter rail service. Commuters from New Hampshire to the city of Boston create more than 70,000 pounds of global warming emissions per year, and even more emissions are created by commuters heading to other Boston-area locations.[43] Analysis conducted by the Nashua Regional Planning Commission estimated a potential local market of more than 19,000 daily riders and more than 70,000 occasional riders for a Manchester-Nashua-Boston rail service.[44] Regional leaders have been working for years to restore rail service to the corridor and hope to have the service in place by 2010.[45]

Continuation and Extension of the Downeaster

Amtrak's Downeaster rail service from Portland, Maine to Boston has been a rousing success, with rapidly increasing ridership (up 31 percent from fiscal year 2005 to fiscal year 2006) and a positive contribution to energy savings and global warming emissions.[46] However, the federal funding that currently sustains the Downeaster is scheduled to expire in 2008 and efforts to extend the rail line up the coast to Brunswick and Lewiston have stalled.

Central Connecticut Commuter Rail

Connecticut has long considered providing commuter rail service in the busy New Haven-Hartford-Springfield corridor, which is currently served by Amtrak trains. Service could begin as soon as 2010. State officials in Connecticut, Massachusetts, Vermont and New Hampshire should consider whether further extensions of commuter rail service are warranted.

Rideworks

Commuter rail service in Connecticut reduces global warming pollution and eases congestion on Connecticut's crowded roads. Expansion of commuter rail service to the Springfield-New Haven corridor could produce additional benefits.

Rhode Island Commuter Rail

After years of discussion, construction has begun on the extension of MBTA commuter rail service to T.F. Green Airport and Warwick and North Kingstown, Rhode Island. The Warwick intermodal transportation facility, which will house the rail station as well as bus and rental car terminals, is scheduled to open in late 2009. The new rail service will create new opportunities for Rhode Island residents to access the greater Boston transit network and provide a clean, low-emission way for travelers to access the airport.

Expanding and Improving the Efficiency of the MBTA

The Boston-area MBTA's subway and light rail system is the core of the region's transit network. Yet, subway or light rail service fails to touch several densely populated areas near the city, including parts of Somerville and Medford, which could be reached by an extension of the Green Line, and the city of Lynn, which could be reached by an extension of the Blue Line. The state is beginning design of a project to connect two of Boston's key transit lines, the Red Line and the Blue Line, which would increase the efficiency of the entire MBTA system. In addition, the MBTA has begun what should be a wholesale renovation of the Fairmount line, an underused commuter rail line that travels through some of Boston's poorest, most transit-dependent and most congested neighborhoods.

Another key project for the future of transit in the Boston area is the "Urban Ring." The core MBTA subway and light rail network is a hub-and-spokes system, requiring riders seeking to go from one outlying location to another to travel all the way into the center of the city and back out again. The absence of a ring or loop line (common in rapid transit systems in foreign countries) makes transit a much less attractive transportation option for these travelers and increases the strain on the central transit network. Massachusetts is currently designing a bus rapid transit-based Urban Ring. A rail-based system would likely be even more successful in improving the connectivity of the region's transit lines, and attracting riders.

Expansion of Vanpool Programs

As described earlier, vanpool programs can deliver significant energy and global warming emission savings, while enabling transit service to reach difficult-to-serve suburb-to-suburb commutes. New England states should continue to bolster and promote their vanpool services in an effort to reach more commuters. In addition, New England should encourage the expansion of privately run vanpool and ridematching programs by requiring employers to take steps to reduce the number of their employees who drive alone to work.

Build for the Future

At the same time that New England states take advantage of obvious missed opportunities to expand transit service, the region should begin thinking about and planning for longer range projects that will become necessary to accommodate expanded use of transit in the years and decades to come.

Taking the Train Through Boston

The renewed interest in commuter and intercity rail service north of Boston – along with potential future capacity problems at South Station – should reinvigorate interest in creation of a North-South rail link through Boston. Currently, commuter and intercity rail lines terminate at Boston's North and South stations, with an approximately 1-mile gap between the two. Rail passengers seeking to continue their trip on the other side of the city must navigate two subway lines to transfer between the stations. Construction of the North-South rail link would enable commuters from south of the city to reach destinations north of the city faster and with greater ease (and vice versa), and could enable Amtrak trains from north of Boston direct access to the busy Northeast Corridor, connecting them to the remainder of the region's rail network.

Study the Potential for High-Quality Transit in Smaller New England Cities

Many smaller New England cities once supported streetcar service and may be able to support light rail or bus rapid transit networks. Smaller New England cities should consider, and begin planning for creation of new high-quality transit services. Connecticut's proposed Hartford to New Britain busway is one potential step in this direction.

Eliminate Bottlenecks

As rail transit becomes more popular, rail systems will come to experience bottlenecks that will hamper efforts to expand ridership. Limited capacity at New York's Penn Station has thus far prevented direct connections with the New Haven Line. The addition of new commuter rail service south of Boston is anticipated to take up the remaining track space at Boston's South Station, creating the need to expand the station. Commuters on the MBTA's Worcester line face delays and crowded conditions due to the sharing of tracks with freight rail operations. New England transportation officials should work to identify and address these and other bottlenecks as they consider future expansion of the region's transit networks.

Plan for High-Speed Rail

The federal government has designated 10 proposed high-speed rail corridors in the United States, several of which pass through New England, including connections between Boston and Montreal, and Boston and Portland, Maine.[47] Construction of high-speed rail between Boston and Montreal would enable riders to travel between the two cities in approximately

4 hours and 30 minutes, opening new opportunities for rail travel in northern New England and between the United States and Canada.[48]

Boost Ridership through Better Transit

Imagine waiting for the bus at an attractive shelter, where you check the real-time electronic timetable to see how many minutes it will be until the next bus arrives. As you get on the easy-to-board low-floor bus, you surrender your ticket or wave your smart card (no need to fumble for change), sit down in your ergonomically designed seat, and watch as the traffic signals before you change from red to green, speeding you and your fellow passengers on your way.

Real-time timetables, low-floor buses, and integrated traffic signals that give priority to buses are among the technologies widely used in Europe (even in small European cities) to make bus travel easier, more comfortable and more accessible.[49] Similar innovations in rail travel – along with the general provision of reliable, fast and integrated transit service have made transit a much larger contributor to transportation needs in Europe and parts of Canada than in most of the United States. Transit is used for about 10 percent of urban trips in Europe, compared to 2 percent in the United States.[50]

Higher gasoline prices provide an opportunity for New England transit agencies to attract new customers, while innovative service offerings, lower fares, and more comfortable buses can keep those new travelers riding transit. Several New England transit agencies have tried novel approaches to boost ridership. Agencies have formed partnerships with institutions such as universities to provide free or reduced fare transit service to certain groups, thus ensuring a consistent customer base for transit service. One transit agency, Advance Transit in the Upper Connecticut Valley region of Vermont and New Hampshire, has used partnerships to provide fare-free transit over its entire network.

Other agencies have taken new approaches to promoting their services. Bangor's BAT Community Connector invested in convenient low-floor buses and subsequently launched an effort to rebrand its service as sleek, consumer-friendly and convenient. BAT's new buses were painted fire-engine red with a swooping bat symbol designed to capture attention. As described in a recent federal research project on transit ridership, "the result has been a revamping of previously hardened stereotypes of what public transit looks like – hip, fast, and attractive rather than dingy, smelly and old."[51] The approach has worked: 60 percent more trips were taken on the BAT in 2006 than had been taken five years earlier.[52]

New England transit agencies should seek to bolster ridership on their existing services by making transit a more comfortable, convenient and affordable option for travelers.

Comfort and Reliability

Riders are unlikely to take transit if it is uncomfortable, unsafe or unreliable. When the air conditioning in a commuter rail car is inoperable on a 90-degree day or when on-time performance degrades, travelers will be less willing to rely on transit for their transportation needs. Sound, basic maintenance of transit vehicles and tracks, as well as investments in the replacement of outdated equipment, can help improve the quality of transit service and attract riders. In addition, innovations such as electronic timetables and more comfortable buses can encourage more riders to leave their cars behind.

One of the major benefits of taking transit is that commuters do not have to pay attention to the road in front of them, enabling them to do other things. Several transit agencies across the country have begun experimenting with providing wireless internet access, providing yet another inducement for commuters to ride transit instead of driving.

Fares

As transit agencies struggle to deal with tighter budgets and increased demands, many have been tempted to raise fares. In Boston, for example, the price of a subway trip has doubled since 2000. But increasing fares can also price out transit-dependent riders and discourage others from switching to transit at a moment when high gasoline prices create an opportunity to move more drivers to transit. In addition, fare increases can sometimes be counter-productive, triggering ridership losses that erode any anticipated revenue increases.

New England states and transit agencies should seek to keep a lid on fare increases, and also to find ways to use the fare structure to bring new riders to transit. For example, several New England transit agencies are paid by local colleges to provide free or reduced-price transit service to their students. Transit agencies in Europe provide discounted fares in promotions with museums and other attractions to promote transit use during off-peak hours, which tend to have the greatest amount of spare capacity.[53]

Connectivity

In some cases, getting to transit service is the main hurdle to using it. Crowded commuter rail parking lots, poor pedestrian and bicycle access to transit stations, and long waits for connecting service can dissuade would-be transit users. Innovative ideas such as community shuttles that link residential and commercial areas with nearby transit stops, the location of car-sharing services nearby transit stops, the provision of bike racks and lockers on buses and at transit stations, improved conditions for pedestrians, better synchronized connections, and more intuitive timetables (e.g. service on the half-hour) can all increase the ability of travelers to use transit service.

Promotion

Transit agencies often do very little in the way of promotion to let consumers know about the services they offer and the advantages of taking transit. While large employers in some areas work to promote the use of transit and vanpools, transit agencies can also take an active role in promoting their services, particularly to groups like college students and new residents who may be unfamiliar with the service.

Green the Fleet

Transit agencies should also seek to operate their services with minimal impact on the environment. In an era of rising fuel prices, purchasing vehicles that use less energy per passenger mile, or that use alternative fuels, makes more economic sense than ever.

Several New England transit agencies are already pioneers in bringing cleaner vehicles to the region's roads. Boston's MBTA, for example, now operates more than 200 buses on compressed natural gas. As a result, despite the fact that the MBTA operates a fleet of large 40-foot buses, the agency's per-mile carbon dioxide emission profile is similar to that of the Worcester Regional Transit Agency, which operates a mix of large and small diesel buses.[54] Similarly, in May 2006 Greater Portland METRO added 13 compressed natural gas buses to its fleet, a move that will reduce global warming pollution from the system.[55]

CT Transit

CT Transit has experimented with hybrid-electric buses, which reduce global warming emissions from transit vehicles and save oil.

In recent years, many transit agencies in the region have moved toward the use of biodiesel fuel, which can also reduce global warming emissions. The Chittenden County Transportation Authority in Burlington, Vermont, for example, is now using 20 percent biodiesel fuel in its new fleet of low-emission buses. CT Transit in Connecticut has experimented with hybrid-electric buses, which have the potential to be over 25 percent more energy efficient than conventional diesel buses.[56]

Improvements are also possible for rail transportation. Electrification of diesel rail systems can reduce global warming emissions from rail transportation while also reducing local health impacts from particulate matter and other dangerous pollutants contained in diesel exhaust. According to data from a 2002 analysis of the environmental impacts of transit service, electric commuter rail produces about 60 percent less carbon dioxide per vehicle-mile than diesel commuter rail nationwide.[57] Electrification can deliver further global warming emission benefits if a greater share of the electricity used to power trains is derived from renewable sources of energy such as wind and solar power.

The ability to incorporate low-carbon alternative fuels such as biodiesel and electricity is one way in which transit can make a unique contribution. Unlike personal cars, transit vehicles are refueled or powered centrally, thus reducing the number of filling stations and other infrastructure needed to bring alternative or renewable energy to users. Several New England transit agencies have played pioneering roles in the use of alternative and low-carbon fuels, as well as clean sources of electricity, and more should follow suit.

Investing in vehicles that operate on low-carbon alternative fuels, however, is just one way in which transit agencies can make their fleets more environmentally responsible. Another way is by ensuring that transit vehicles are appropriately sized for the services they provide. A full vehicle is an efficient vehicle, regardless of whether it is a train, a large bus, a small bus, a van or a car. Thus, for some transit agencies – particularly those in smaller urban and rural areas – using smaller and more efficient transit vehicles could be an effective way to reduce emissions.

Some transit agencies in New England have had success with using smaller, more efficient vehicles in place of large buses. The BAT Community Connector service, for example, primarily uses smaller 20 to 32 foot buses to serve local demand, enabling the agency to produce fewer carbon dioxide emissions per passenger-mile than many other transit agencies in the region, despite average ridership well below that of larger New England urban areas.

The region should continue to identify opportunities to reduce global warming pollution from transit operations, including through the purchase of more fuel-efficient diesel buses, electrification of diesel rail operations, and purchase of more energy-efficient locomotives, and the use of smaller transit vehicles where appropriate.

Create Transit-Friendly Land Use

To maximize the global warming emission benefits of transit, New England states must also encourage transit-oriented development patterns. Many New England cities and towns are already moving in the direction of promoting the construction of mixed-use development near transit stations. Expanding transit service also creates new opportunities to revitalize existing neighborhoods, towns and cities. Transportation and land-use planners should work closely together to ensure that transportation and land-use policies are mutually supportive of the goal of reducing vehicle travel and global warming emissions from transportation.

Paying for it All

The most common objection to a major expansion of transit in New England is that it will be expensive. Many New England transit agencies are having a hard time simply maintaining current service offerings and keeping their systems in a state of good repair, let alone expanding their range of services. With transportation funding from all sources failing to keep up with the region's transportation needs, and with the federal transportation trust fund running dry, New England states will need to look to new and innovative approaches to support improved and expanded transportation services.

New England states already have the flexibility to spend more of their existing transportation revenue on transit through flexible federal transportation funding. A portion of federal transportation funds can be used by states to support either highway projects or transportation alternatives such as transit. The six New England states have "flexed" relatively little of their federal transportation funds to transit over time, with the percentage ranging from 5 percent in New Hampshire to 22 percent in Vermont over the period from fiscal year 1998 to fiscal year 2004.[58]

States can also consider new and enhanced funding sources, particularly those that would also discourage unnecessary driving. Again, the example of Europe is instructive. Whereas in the United States gasoline taxes and other highway user fees are insufficient to fund even highway maintenance and expansion, such taxes are high enough in Europe not only to meet highway needs but also to provide a steady stream of funding for public transit.[59] In New York City, bridge and tunnel tolls provide important funding for the city's transit system. Gasoline taxes, road tolling, congestion pricing schemes (in which commuters are charged tolls for traveling on certain roads during peak traffic periods), registration and title fees, and parking taxes are among the many charges that can be used to both reduce the amount of general fund revenue spent on highways and to create new funding streams for transit.

Several New England transit agencies have also worked to establish partnerships with major institutions such as hospitals and universities, bringing in much needed funds while helping to those institutions to provide for the transportation needs of their students and workers. Another option is to use tax increment financing (TIF), in which a share of increased property tax revenue along transit lines is dedicated to paying for the service, to raise funds. Public-private partnerships and TIF funding schemes are potentially important sources of new funding for transit agencies, particularly since many businesses along transit routes have much to gain from the provision of high-quality transit service. However, transit agencies and local governments must be careful in ensuring that the availability of private funding does not skew transportation priorities by letting money, rather than the potential for broad public benefits, determine when and where high-quality transit service is provided.

New England states should also advocate vigorously for changes in how the federal government funds transit projects. The federal government's process for evaluating new transit projects is commonly oversubscribed and the process for obtaining funds is cumbersome, complex and costly.[60] Proposals for transit system expansion must pass a series of difficult hurdles that are not imposed on highway projects, including extensive review of land-use impacts and cost-effectiveness and head-to-head competition against other transit projects nationwide. Moreover, while transit projects theoretically receive the same federal "match" as highways (with the federal government paying for 80 percent of the capital costs of the projects and states 20 percent), in practice the federal government has required state and local governments to cover 40 to 50 percent or more of the cost of new transit projects.[61] Changing federal transportation funding practices to direct more funding to transit projects, eliminate inequities between transit and highway project proposals, and reduce bureaucratic delays in approving transit funding could increase the availability of funding for future transit expansion in New England.

The Need for a Regionwide Plan

Transportation decision-making in New England is divided among six states, multiple metropolitan planning organizations, dozens of transit authorities and hundreds of municipalities, along with private entities such as railroad owners. The diffuse nature of transportation planning in the region ensures that various jurisdictions can advocate for and defend the interests of their residents. But it also results in a regional transportation system that is less coordinated and efficient than it can be.

Following in the footsteps of the successful effort to reduce global warming emissions from power plants through the Regional Greenhouse Gas Initiative, the New England states should initiate efforts to develop a regional plan for expansion and integration of transit service. Among the areas of discussion should be development of a blueprint for rail transportation in the region that incorporates both the need to expand inter-city and commuter rail operations as well as deficiencies in the region's freight rail system.

Regional planning efforts could also improve the coordination of transit services across state lines and transit authority boundaries. For example, transit riders might benefit from a "one-stop" source of information that would allow them to plan transit trips that begin in one transit agency's service territory and end in another, or from the ability to use the same fare card to pay for trips on various agencies' trains or buses (in the same manner as the EZ-Pass system allows for common electronic toll collection on highways throughout the Northeast.)

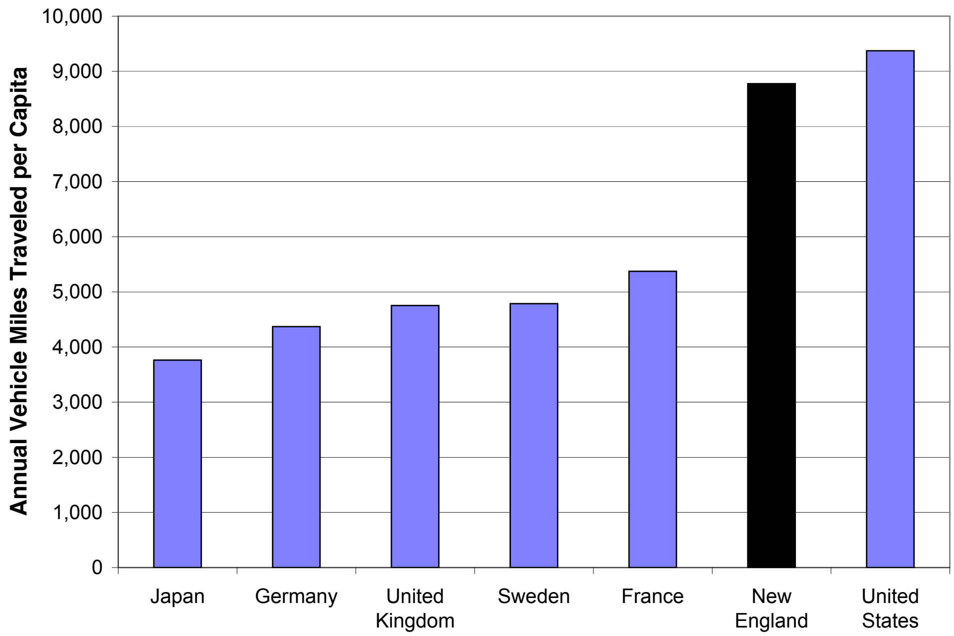
Potential Benefits from Expanded and Improved Transit

New England has a great deal to gain from improved and expanded transit service. For every 1 percent increase in ridership on the region's existing transit lines, the region can expect to reduce global warming emissions by more than 19,000 metric tons – the equivalent of taking 3,500 vehicles off the road. Using more efficient buses and alternative fuels to cut transit bus emissions by 20 percent would save the equivalent of removing 7,800 vehicles from the road. Boosting commuter rail service and ridership by 25 percent would remove the equivalent of 25,000 cars from the road.

Combining investments in transit service with better land-use practices can produce even greater results. European nations, for example, have a long history of compact urban land-use patterns and large investment in transit infrastructure (along with, in many cases, infrastructure for bicycles and pedestrians). As a result of these public policies (combined with other policies such as high gasoline taxes), per-capita vehicle travel in nations such as Germany and the United Kingdom is about half that of New England.[62] (See Fig. 4.)

To address global warming and wean New England from its dependence on foreign oil, the region must begin to plan and build a 21st century transportation system with efficient, affordable and extensive transit service at its core. By doing so, we can reduce our emissions of global warming pollutants and reap many other benefits that will improve New England's economy and our quality of life.

Fig. 4. Per-Capita Vehicle Miles Traveled in the U.S., New England and Other Countries[63]



Carbon Dioxide Emission Reductions

Carbon dioxide emission reductions from transit operations were calculated by comparing estimated emissions from transit operations with emission reductions achieved as a result of avoided driving, avoided traffic congestion, and support for more compact land-use patterns and reduced vehicle ownership that result in lower emissions from other vehicle trips.

Estimating Carbon Dioxide Emissions from Transit Operations

Estimates of transit agency energy consumption, vehicle travel, passenger miles traveled and other indicators of transit system performance are (with a few exceptions) based on the Federal Transit Administration's 2005 National Transit Database (NTD). The NTD includes energy consumption figures reported by transit agencies that directly operate their own transit vehicles as well as passenger-mile and vehicle-mile traveled data for both directly operated and paid transportation services operated under contract with private operators. We used two methods to estimate carbon dioxide emissions from transit operations – one for directly operated transit services and another for paid transportation. In a few cases, we also incorporated data from sources other than the NTD.

Method 1: Directly Operated Transit Services

For directly operated transit services, we multiplied the amount of each type of energy consumed by a carbon dioxide coefficient to estimate carbon dioxide emissions from transit operations.

Data on energy consumed in transit operations was obtained from the NTD. We then converted the energy consumption figures from their native units (gallons of diesel, etc.) into their BTU equivalents (except as described below), using heat content estimates from U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 2005*, 1 July 2006. Heat content estimates per gallon of liquefied natural gas (LNG) were based on TIAX Inc., *The Transit Bus Niche Market for Alternative Fuels: Module 4: Overview of Liquefied Natural Gas as a Transit Bus Fuel*, December 2003. Heat content estimates per "gallon" of compressed natural gas as reported to the NTD were based on the BTU content of a gallon of diesel fuel, per U.S. Department of Transportation, Federal Transit Administration, *2006 Urbanized Area Reporting Manual*, downloaded from www.ntdprogram.com/ntdprogram/pubs/ARM/2006/html/2006_Reporting_Manual_Table_of_Contents.htm, 12 July 2007.

To estimate carbon dioxide emissions per BTU of energy consumed, we multiplied energy consumption in BTU for each fuel by that fuel's carbon dioxide coefficient, which was obtained from U.S. Department of Energy, Energy Information Administration, *Documentation for Greenhouse Gas Emissions in the United States 2004*, December 2006. We assumed that ethanol and biodiesel produced no net carbon dioxide emissions, consistent with *Documentation for Greenhouse Gas Emissions in the United States 2004.* We assumed no emissions from consumption of "other fuel."

For electricity consumed in directly operated transit, we assumed that carbon dioxide emissions per kilowatt-hour were equivalent to that of the New England region as a whole. Data on carbon dioxide emissions and electricity generation were obtained from U.S. Department of Energy, Energy Information Administration, *Electric Power Annual 2005, State Data Tables*, downloaded from www.eia.doe.gov, 22 June 2007.

Emissions from the Metro-North New Haven line were calculated based on emissions from the Metro-North commuter rail system as a whole. We assumed that emissions were 47 percent of those of the entire system based on the proportion of ridership on the New Haven line to ridership on the Metro-North system as a whole, based on a 2005 mid-year forecast from Metropolitan Transportation Authority, *MTA 2006 Preliminary Budget: July Financial Plan 2006-2009*, July 2005.

Method 2: Purchased Transportation Services

Transit agencies are not required to report energy consumption statistics to the National Transit Database for transportation services they purchase from others. To estimate carbon dioxide emissions from purchased transportation services, we calculated the average amount of each fuel consumed per vehicle-mile by directly operated transit services nationally for each mode of transit, based on data from the National Transit Database. We then multiplied this figure by vehicle miles traveled by each purchased transportation service to arrive at an estimate of total energy consumption by purchased transportation service in New England.

Method 3: Exceptions

In some cases, we sought information about transit services not reporting to the National Transit Database. Estimates of emissions from the state of Massachusetts' MassRides vanpool program were based on data on average fuel economy, round-trip mileage and vanpool fleet size from the Massachusetts Executive Office of Transportation via personal communication on 28 June 2007. Estimates of emissions from the GoMaine vanpool program were based on data on average fuel economy, ridership and vanpool routes provided by GoMaine via personal communication on 27 July 2007.

Amtrak provided data on fuel consumption and passenger-miles traveled for three intercity rail routes: the Downeaster, the Springfield-New Haven line, and the Northeast Corridor service between Boston and the New York City area (personal communication, 22 August 2007). Data provided for the Vermonter, Ethan Allen and Lake Shore Limited services were insufficient to estimate carbon dioxide emissions and energy usage attributed to New England and were therefore excluded from this analysis.

Estimating Avoided Emissions from Transit Operations

We assumed that transit operations reduced global warming emissions from transportation in three ways: through direct replacement of vehicle trips, through reduced highway congestion, and by leveraging further reductions in vehicle travel as a result of more compact land-use patterns and lower per-capita vehicle ownership.

DIRECT REPLACEMENT OF VEHICLE TRIPS

Averted emissions from displaced vehicle trips were calculated based on the assumption that each passenger-mile traveled via transit replaces 0.676 miles of travel in an automobile. This replacement ratio reflects average vehicle occupancy in replaced trips of 1.479 passengers per vehicle, based on Linda Bailey, ICF International, *Public Transportation and Petroleum Savings in the U.S.: Reducing Dependence on Oil*, January 2007. We assumed average fuel economy for replaced vehicle travel of 17.85 miles per gallon. To calculate this value, we first obtained estimated on-road fuel economy for the national fleet of cars and light trucks from U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 2007*, February 2007. We then multiplied these values by the percentage of each vehicle type registered in New England from Federal Highway Administration, *Highway Statistics 2005*, November 2006. Finally, we assumed that transit service directly replaces city driving, in which vehicles achieve lower fuel economy than the mix of city and highway driving reflected in national fuel economy estimates. To adjust for the lower fuel economy of city driving, we reduced on-road fuel economy by 12 percent for cars and 11 percent for light trucks, based on the difference between city fuel economy and combined fuel economy for 2006 model year vehicles from U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2006*, July 2006.

Finally, we assumed that consumption of one gallon of gasoline produces 19.6 pounds of carbon dioxide.

AVOIDED TRAFFIC CONGESTION

To quantify carbon dioxide emissions averted through avoided traffic congestion, we assumed that transit operations averted as much gasoline use as estimated for 2003 in David Schrank and Tim Lomax, Texas Transportation Institute, *The 2005 Urban Mobility Report*, May 2005. The *Urban Mobility Report* estimates avoided gasoline consumption for 85 urbanized areas in the United States. We allocated gasoline savings (and associated carbon dioxide emission reductions) among transit agencies within an urbanized area based on the agency's share of total passenger-miles traveled on transit within the urbanized area. Transit agencies were assigned to urbanized areas based on the areas to which they were associated in the National Transit Database. Because some transit agencies and services cross urbanized area boundaries, this method likely results in some transit agencies receiving too much credit for avoided gasoline consumption and others too little. In addition, the *Urban Mobility Report* did not quantify avoided gasoline consumption for many smaller metropolitan areas in New England. As a result, no emission reductions from avoided congestion were assumed in these communities.

LEVERAGED VEHICLE TRAVEL REDUCTIONS

In addition to direct replacement of vehicle travel by transit use, we also assumed that certain transit modes "leverage" additional reductions in vehicle travel through more compact land-use patterns and reductions in per-capita vehicle ownership. For light rail and heavy rail modes, we assumed that each passenger-mile traveled leveraged additional reductions of two vehicle-miles traveled in automobiles. This is at the conservative end of VMT leverage estimates reported in the literature, based on John Holtzclaw, *Does a Mile in a Car Equal a Mile on a Train? Exploring Public Transit's Effectiveness in Reducing Driving*, 2000 and Todd Litman, Victoria Transport Policy Institute, *Rail Transit in America: A Comprehensive Evaluation of Benefits*, 31 August 2006. We assumed that commuter rail had a weaker leveraging effect, based on the notion that, while commuter rail in some locations may encourage more compact land-use patterns and reduced vehicle ownership, this impact is likely far from universal. As a result, we assumed that each passenger-mile traveled via commuter rail leveraged an additional reduction of 0.4 vehicle miles, based on the extreme low end of reported values in John Holtzclaw, *Does a Mile in a Car Equal a Mile on a Train? Exploring Public Transit's Effectiveness in Reducing Driving*, 2000. We assumed no leveraging effect from intercity rail services. These estimates – particularly for light rail and heavy rail – are likely very conservative and probably understate the actual vehicle travel reductions leveraged by transit service in the region to a significant degree.

Estimating and Attributing Carbon Dioxide Emission Savings

To arrive at a final estimate of carbon dioxide emission savings from transit, we subtracted the total amount of carbon dioxide averted through transit operations (direct replacement of vehicle travel + avoided congestion + leveraged vehicle travel reductions) from the total amount of carbon dioxide produced by transit operations.

For agencies reporting to the National Transit Database, emission savings were attributed to the state in which the transit agency is housed, even in cases in which some travel may have occurred across state lines. For intercity rail service provided by Amtrak, benefits were allocated by multiplying the number of miles traveled by the rail route within each state by the number of boardings and alightings reported for all stations along that route within each state. Benefits were allocated to each state based upon the share of this combined route-miles/boardings and alightings figure for the state versus the rail line as a whole. Given the lack of detailed data on travel between city pairs along the rail lines, this represents a very rough allocation of emission benefits among the various states. Data on boardings and alightings at Amtrak stations were obtained from Amtrak, *State Fact Sheets*, Fiscal Year 2006, downloaded from www.amtrak.com, 24 August 2007.

Gasoline Savings

Estimated gasoline savings from transit operations are based on a comparison between the total amount of diesel fuel and gasoline used by transit operations (calculated as described above) and avoided gasoline use from direct replacement of vehicle travel, avoided congestion and leveraged vehicle travel reductions. Avoided gasoline use was calculated by dividing avoided carbon dioxide emissions from transit, derived as described above, by the carbon dioxide emission factor per unit of gasoline consumed.

The estimate of gasoline savings is also likely conservative, since it assumes that one gallon of diesel fuel used in a transit vehicle is directly comparable with one gallon of gasoline used in a car or light truck. In fact, diesel fuel contains more energy per gallon of fuel than gasoline, thus understating the amount of gasoline assumed to be saved through transit operations.

Notes

1. Based on data from U.S. PIRG Education Fund, *The Carbon Boom: State and National Trends in Carbon Dioxide Emissions Since 1990*, April 2007.

2. Ibid.

3. California Air Resources Board, *Climate Change Emission Control Regulations* [fact sheet], 10 December 2004.

4. U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* series of reports, downloaded from www.fhwa.dot.gov/policy/ohpi/hss/index.htm, 16 July 2007.

5. P.C. Frumhoff, et al., Union of Concerned Scientists, *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*, Synthesis Report of the Northeast Climate Impacts Assessment, 2007.

6. Ibid.

7. See Brian Fisher, et al., "Issues Related to Mitigation in the Long-Term Context," *Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* 2007, 90.

8. Intergovernmental Panel on Climate Change, "Summary for Policy Makers," *Climate Change 2007 : The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, 2007.

9. European Environment Agency, *Atmospheric Greenhouse Gas Concentrations (CSI 013) – Assessment Published Oct 2005*, downloaded from themes.eea.europa.eu/IMS/ISpecs/ISpecification20041007131717/IAssessment1116319511425/view_content, 29 June 2007.

10. See note 4.

11. New England Climate Coalition, *Shifting Gears: 20 Tools for Reducing Global Warming Pollution from New England's Transportation System*, Spring 2006. See also: Todd Litman, Victoria Transport Policy Institute, *Win-Win Emission Reduction Strategies*, 27 April 2007.

12. "Population doubles" from City of Boston, Boston Redevelopment Authority, "Boston's Population Doubles – Every Day," *Insight*, December 1996.

13. Todd Litman, Victoria Transport Policy Institute, *Evaluating Public Transit Benefits and Costs: Best Practices Guidebook*, December 2006.

14. Based on Linda Bailey, ICF International, *Public Transportation and Petroleum Savings in the U.S.: Reducing Dependence on Oil*, January 2007. The question of how many automobile trips are avoided by transit use is a difficult one. On one hand, transit riders who are interviewed about their travel preferences often report that if they did not have access to transit, some trips would take place by walking and others by carpooling, while others simply wouldn't be taken at all. However, the results of surveys cannot be used to directly estimate the number of replacement car trips that would take place if transit service were to cease, for two reasons: 1) some communities would likely react to the end of fixed-route transit service by substituting less-efficient demand response service for transit-dependent consumers, 2) where demand response service is not provided, some trips would likely take the form of chauffeuring, in which for example, a relative might drive to take an elderly person to the doctor. Chauffeuring can also be inefficient in that it requires the driver to make an "empty" return trip or to otherwise waste valuable time. For the sake of simplicity, we assume in this analysis that each trip that would have been made via transit would be made in an automobile, with the average occupancy of private vehicles being slightly less than 1.5 passengers per mile driven.

15. David Schrank and Tim Lomax, Texas Transportation Institute, *The 2005 Urban Mobility Report*, May 2005.

16. John Holtzclaw, *Does a Mile in a Car Equal a Mile on a Train? Exploring Public Transit's Effectiveness in Reducing Driving*, 2000.

17. Studies of transit leverage have tended to focus on cities with rail transit networks. There has been comparatively little study of the potential leveraged vehicle travel reductions from bus transit, though it is unlikely that bus transit has the same degree of leveraging impact. See Todd Litman, Victoria Transport Policy Institute, *Rail Transit in America: A Comprehensive Evaluation of Benefits*, 31 August 2006.

18. Amtrak provided data sufficient to evaluate energy use and global warming emissions from several of its New England rail lines, including Acela and regional service along the Boston-New York corridor, travel along the Springfield line between Springfield, MA and New Haven, CT, and the Downeaster rail service between Portland, ME and Boston. No data were provided to evaluate energy use and emissions from the Lake Shore Limited (Boston-Albany), Vermonter or Ethan Allen rail lines and these services were excluded from this analysis.

19. Note: for transit systems that cross state borders, emission reductions are apportioned based on the state that is listed in the National Transit Database.

20. Total gasoline consumption from U.S. Department of Energy, Energy Information Administration, *Petroleum Navigator: Prime Supplier Sales Volumes*, downloaded from tonto.eia.doe.gov/dnav/pet/pet_cons_prim_dcu_R1X_a.htm, 16 July 2007. Note: we assumed that one gallon of diesel consumed in a transit vehicle offsets one gallon of gasoline. In reality, this assumption understates the oil savings resulting from transit use, since diesel contains more energy per gallon than gasoline.

21. Based on 2006 transit profiles for the various agencies from U.S. Department of Transportation, Federal Transit Administration, *National Transit Database*, downloaded from www.ntdprogram.com/ntdprogram/pubs.htm, 16 July 2007.

22. American Public Transportation Association, *Commuter Rail Transit Ridership Report: Fourth Quarter 2006*, 12 March 2007.

23. American Public Transportation Association, *Heavy Rail Transit Ridership Report: Third Quarter 2006*, 4 January 2006; American Public Transportation Association, *Light Rail Transit Ridership Report: Third Quarter 2006*, 4 January 2007.

24. Northern New England Passenger Rail Authority, *Performance Report: June 2006*, downloaded from www.amtrakdowneaster.com/documents/PerformanceReportJune2006.pdf, 13 July 2007.

25. Note: Emission reductions from the MTA Metro-North Railroad in New England are likely somewhat overstated since they also reflect emissions avoided by passengers who board the New Haven Line in New York state.

26. Based on data provided by Richard Watts, UVM Transportation Center, 5 August 2007.

27. For a comprehensive review of the benefits of transit, see Todd Litman, Victoria Transport Policy Institute, *Evaluating Public Transit Benefits and Costs: Best Practices Guidebook*, December 2006.

28. Todd Litman, Victoria Transport Policy Institute, *Evaluating Public Transit Benefits and Costs: Best Practices Guidebook*, December 2006.

29. See, for example, Roderick B. Diaz, *Impacts of Rail Transit on Property Values*, May 1999.

30. Ben Harder, "Weighing in on City Planning: Could Smart Urban Planning Keep People Fit and Trim?" *Science News*, 20 January 2007.

31. Advance Transit, like other small transit agencies, does not report to the National Transit Database, and is not included in our estimates of global warming emission reductions and energy savings from transit service in Vermont and New Hampshire.

32. Upper Valley Transportation Management Association, *Operational Impact Study of Advance Transit Fixed-Route Bus Network*, 28 July 2005.

33. Ibid.

34. Ibid.

35. See Todd Litman, Victoria Transport Policy Institute, *Rail Transit in America: A Comprehensive Evaluation of Benefits*, 31 August 2006; Center for Neighborhood Technology and Surface Transportation Policy Project, *Driven to Spend: Pumping Dollars Out of Our Households and Communities*, June 2005.

36. U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2005*, November 2006.

37. See note 15.

38. See note 36.

39. Ibid. Includes direct state spending on transit and state grants-in-aid to transit agencies. Figures include funding obtained from both state and federal sources.

40. See note 15.

41. Center for Neighborhood Technology and Surface Transportation Policy Project, *Driven to Spend: Pumping Dollars Out of Our Households and Communities*, June 2005.

42. See note 36.

43. NHPIRG Education Fund and Clean Water Fund, *Driving Global Warming: Commuting in New Hampshire and its Contribution to Global Warming*, January 2006.

44. Nashua Regional Planning Commission, *Potential Market for Passenger Rail*, downloaded from www.nashuarpc.org/rail/documents/press/survey_factsheet_ridership.pdf, 16 July 2007.

45. Nashua Regional Planning Commission, et al., *Southern New Hampshire Passenger Rail Proposal*, 23 January 2007.

46. See note 24.

47. U.S. Department of Transportation, Federal Railroad Administration, *High- Speed Rail Corridor Designations*, downloaded from www.fra.dot.gov/us/content/203, 16 July 2007.

48. U.S. Department of Transportation, Federal Railroad Administration, *Northern New England High-Speed Corridor*, downloaded from www.fra.dot.gov/us/content/654, 16 July 2007.

49. Transportation Research Board, National Research Council, *Making Transit Work: Insight from Western Europe, Canada and the United States*, National Academies Press, 2001.

50. Ibid.

51. Transportation Research Board, Transit Cooperative Research Program, *Building and Retaining Transit Ridership: The Keys to Success, An Interactive CD*, 2007.

52. Based on 2006 transit profile from U.S. Department of Transportation, Federal Transit Administration, *National Transit Database*, downloaded from www.ntdprogram.com/ntdprogram/pubs.htm, 16 July 2007.

53. See note 49.

54. Based on transit vehicle fleet rosters included U.S. Department of Transportation, Federal Transit Administration, *National Transit Database*, downloaded from www.ntdprogram.com/ntdprogram, 5 July 2007.

55. METRO Greater Portland Transit District, *Natural Gas Buses: The Future Is Riding on METRO*, downloaded from www.gpmetrobus.com/index.php?option=com_content&task=view&id=68&Itemid=134, 26 July 2007.

56. Based on evaluations of hybrid transit buses versus new diesel buses in the Seattle and New York City metropolitan areas. See, for example, K. Chandler and K. Walkowitz, National Renewable Energy Laboratory, *King County Metro Hybrid Articulated Buses: Final Evaluation Results*, December 2006.

57. Based on 1999 data from Robert J. Shapiro, Kevin A. Hassett and Frank S. Arnold, *Conserving Energy and Preserving the Environment: The Role of Public Transportation*, July 2002.

58. New England Climate Coalition, *Shifting Gears: 20 Tools for Reducing Global Warming Pollution from New England's Transportation System*, Spring 2006.

59. See note 51; NGA Center for Best Practices, *Issue Brief: State Policy Options for Funding Transportation*, February 2007.

60. U.S. Government Accountability Office, *Public Transportation: Preliminary Analysis of Changes to and Trends in FTA's New Starts and Small Starts Programs*, 10 May 2007.

61. Edward Beimborn and Robert Fuentes, *Brookings Institution Center on Urban and Metropolitan Policy, Highways and Transit: Leveling the Playing Field in Federal Transportation Policy*, December 2003; U.S. Government Accountability Office, *Public Transportation: Preliminary Analysis of Changes to and Trends in FTA's New Starts and Small Starts Programs*, 10 May 2007; William W. Millar, American Public Transportation Association, *On Public Transportation Funding for Fiscal Year 2008*, Testimony Before the U.S. Senate Appropriations Subcommittee on Transportation, Housing and Urban Development, and Related Agencies, 30 April 2007.

62. Based on data from U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2002*, 2004; U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2005*, 2007; and U.S. Census Bureau, *Annual Estimates of the Population for the United States, Regions, and States and for Puerto Rico: April 1, 2000 to July 1, 2006*, downloaded from www.census.gov, 12 July 2007. Vehicle-miles traveled estimates for other countries are for various years from 1998 and 2001; U.S. data are from 2001. Vehicle miles traveled for combination trucks were removed from the U.S. estimate in order to create a direct comparison with the European and Japanese data. For the New England data, vehicle miles traveled were reduced by the proportion of vehicle-miles traveled by combination trucks nationally to total U.S. vehicle travel.

63. Ibid.