Policy Analysis

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Does Rail Transit Save Energy or Reduce Greenhouse Gas Emissions?

by Randal O'Toole

Executive Summary

Far from protecting the environment, most rail transit lines use more energy per passenger mile, and many generate more greenhouse gases, than the average passenger automobile. Rail transit provides no guarantee that a city will save energy or meet greenhouse gas targets.

While most rail transit uses less energy than buses, rail transit does not operate in a vacuum: transit agencies supplement it with extensive feeder bus operations. Those feeder buses tend to have low ridership, so they have high energy costs and greenhouse gas emissions per passenger mile. The result is that, when new rail transit lines open, the transit systems as a whole can end up consuming more energy, per passenger mile, than they did before.

Even where rail transit operations save a little energy, the construction of rail transit lines consumes huge amounts of energy and emits large volumes of greenhouse gases. In most cases, many decades of energy savings would be needed to repay the energy cost of construction.

Rail transit attempts to improve the environment by changing people's behavior so that they drive less. Such behavioral efforts have been far less successful than technical solutions to toxic air pollution and other environmental problems associated with automobiles.

Similarly, technical alternatives to rail transit can do far more to reduce energy use and CO2 outputs than rail transit, at a far lower cost. Such alternatives include the following:

- Powering buses with hybrid-electric motors, biofuels, and—where it comes from nonfossil fuel sources—electricity;
- Concentrating bus service on heavily used routes and using smaller buses during off-peak periods and in areas with low demand for transit service;
- Building new roads, using variable toll systems, and coordinating traffic signals to relieve the highway congestion that wastes nearly 3 billion gallons of fuel each year;
- Encouraging people to purchase more fuel-efficient cars. Getting 1 percent of commuters to switch to hybrid-electric cars will cost less and do more to save energy than getting 1 percent to switch to public transit.

If oil is truly scarce, rising prices will lead people to buy more fuel-efficient cars. But states and locales that want to save even more energy and reduce greenhouse gas emissions will find the above alternatives far superior to rail transit.

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Twentieth-century streetcar companies knew what many American cities have forgotten today: buses cost less, can run on faster schedules, and are more flexible than rail service.

Introduction

Once upon a time, so the story goes, evil automobile and oil companies bought up the nation's efficient streetcar lines and dismantled the trolley systems that commuters loved in order to force people to buy cars and gasoline instead.[1] The moral of this oft-repeated fairy tale is that we should unshackle ourselves from slavery to auto dependency and petrodominance by building modern light rail, streetcar, and other rail transit lines.

The truth is that the streetcar conspiracy is a complete myth that has been frequently debunked by academic researchers.[2] In 1933, General Motors and two oil companies did purchase National City Lines, which owned a number of transit companies, in order to sell their buses and diesel fuel, not to dismantle transit systems. In 1949, General Motors was convicted of conspiring to monopolize the bus market through its investments in transit companies, so it divested itself of National City.

In 1910, streetcars served 750 American cities. By 1966, all but six of these streetcar systems had been dismantled and replaced by buses.[3] General Motors and the oil companies had an interest in fewer than 25 streetcar companies at the time they converted to buses. In many cases, National City purchased the companies in the same year they stopped running streetcars, suggesting the decision had been made before National City made its investment.[4]

In short, the General Motors "conspiracy" was involved in less than 5 percent of the conversions from streetcars to buses. The other 95 percent knew something that many cities today have forgotten: bus service costs less to start, operate, and maintain; can run on schedules that are as fast or faster than light rail; and is more flexible than rail service.

Rail advocates have used the streetcar-conspiracy myth and other myths as a part of their campaign to persuade cities to build new rail transit lines. This effort has been remarkably successful: in the last 15 years alone, American cities have spent $100 billion on new rail transit lines.[5]

Since 1980, 15 U.S. urban areas that were once served exclusively by bus transit have opened new light-rail lines. Light-rail lines are also under construction in at least two other regions, and in the planning stages in several more; and several other regions have opened or are planning commuter-rail lines that use existing tracks.

Rail advocates claimed that rail transit would cost little to build and operate, attract people out of their automobiles, relieve congestion, and restore inner cities. Although most transit agencies that built these lines claim they are successful, an objective look at the evidence reveals that these benefits are just as mythical as the streetcar conspiracy.

- A recent review of rail projects found that the average cost was 40 percent higher than the estimates made when the decision was made to build it.[6]
- The Government Accountability Office notes that bus rapid transit can cost as little as 2 percent as much to start, cost less to operate, and provide faster service than light rail.[7]
- A comparison of the cost of rail transit systems with the benefits provided by those systems found that, "with the single exception of BART in the San Francisco Bay area, *every* U.S. [rail] transit system actually reduces social welfare."[8]
- The cost of rail transit is so high that many transit agencies have been forced to raise fares and/or cut back on bus service, leading to actual losses in transit ridership in such regions as Baltimore, Los Angeles, and San Jose.[9]
- Even in regions where transit ridership has increased, those increases rarely keep up with increases in driving; so in almost every new rail region, transit carried a smaller share of passenger travel after rail service opened than before rail construction began.
- The American Public Transportation Association brags that ridership on light-rail transit is growing faster than any other form of transit.[10] But this is only because agencies are offering so much more

light-rail service. The average number of trips taken per light-rail vehicle mile declined from 7.3 in 1995 to 5.2 in 2005, indicating that light rail is suffering from a serious case of diminishing returns.

- Although Denver, Portland, San Jose, and other cities often claim that light rail stimulated economic development, such developments are almost always supported by large tax subsidies.[11] At best, the developments that result from rail transit are a zero-sum game, that is, they merely transfer developments that would have taken place anyway from one part of an urban area to another.[12]

One by one, all the original justifications for building rail transit have been discredited by the evidence. In response, rail advocates and transit agencies offer two new reasons for building rail lines: energy and global warming. Rail transit, they say, uses less energy and emits less greenhouse gases per passenger mile than buses, autos, or other forms of transportation. Cities that want to prepare for an age of scarce oil or limits on greenhouse gases, they argue, should build more rail lines.

Many people accept these statements without question. A recent National Public Radio story argued that "part of the solution (to global warming) is light rail."[13] Portland, Oregon, has been named the nation's "greenest city" mainly on the strength of the supposed reduction in greenhouse gases emitted by its light-rail lines.[14]

Is this a valid argument? Assuming we are running out of oil and/or that anthropogenic global warming is a real problem, is light rail, or any form of rail transit, an appropriate response? To answer this question, we can look at the effects of existing and new rail transit lines on energy consumption and greenhouse gas emissions in the cities that have built and maintained those lines.

Data Sources

Data needed to calculate the energy efficiency and greenhouse gas emissions of rail transit are available from a variety of federal agencies:

- The U.S. Department of Transportation's *National Transit Database* shows fuel consumption by mode for most public transit operations.[15]
- The U.S. Department of Energy's *Transportation Energy Data Book* provides factors for converting gasoline, diesel, kilowatt-hours, and other fuels into British Thermal Units.[16]
- The Energy Information Administration provides coefficients for estimating carbon dioxide (CO_2) emissions by energy source.[17] It also provides data on the mix of energy sources used to produce electricity in each state.[18]
- For comparison, information about auto energy efficiency is available in the *Transportation Energy Data Book*.[19] Information about specific brands of autos is available from the Environmental Protection Agency's new measure of fuel economy for 2008 automobiles.[20]

These data can be used to calculate energy use and emissions for most of the transit systems in the United States. However, there are a few limits. The *National Transit Database* only includes fuel numbers for transit lines that are directly operated by transit agencies. Agencies that contract out their operations to private companies such as Laidlaw or First Transit do not report the fuel those companies use. This means there are no results for many of the new commuter rail lines, including those in Dallas, Ft. Lauderdale, Los Angeles, San Diego, San Jose, Seattle, and the Washington, D.C., area.

Still, data are available for almost every heavy-rail system, most light-rail systems, and several commuter-rail systems, not to mention hundreds of bus systems and the handful of trolley buses, ferry systems, and other forms of transit that still operate. For each of these systems we can calculate BTUs and pounds of CO_2 emissions per passenger mile.

Calculations of CO_2 emissions by electrically powered transit are complicated by the fact that

Now that all the original justifications for building rail transit have been discredited by the evidence, rail advocates offer two new reasons: energy and global warming.

On average, light rail uses as much energy per passenger mile as passenger automobiles.

different sources of electricity are used in different regions of the country. Three-fourths of the electricity used in Washington state comes from hydroelectric dams, while all of the electricity used in Washington, D.C., comes from burning oil. The Energy Information Administration publishes an annual report showing the sources of electrical power by state.[21]

As used in this paper, *automobile* denotes four-wheeled passenger-carrying vehicles including *passenger cars* and *light trucks*. Light trucks, in turn, include pickups, sport utility vehicles, and vans.

Light rail includes self-powered rail transit cars that sometimes operate in their own exclusive rights of way and sometimes run in streets. *Heavy rail*, also known as subways or elevateds, always run in exclusive rights of way. *Commuter rail* usually consists of a locomotive pulling unpowered passenger cars on tracks that are often shared with freight trains. These tracks may cross streets at grade but usually do not operate in streets.

A number of rail lines that the *National Transit Database* classifies as light rail are actually *streetcars*, which tend to be smaller vehicles than light-rail cars, run on shorter routes, and run almost exclusively in streets. *Automated guideways*, sometimes called *people movers*, are self-powered vehicles that run without drivers, usually elevated above street level. *Motor buses* are powered by internal combustion engines whereas *trolley buses* are powered by electricity.

Modal Averages

Table 1 shows the average number of BTUs and pounds of CO_2 per passenger mile for various modes of transit and types of automobiles. Ferries and automated guideways are far worse, on both counts, than any other form of passenger travel. Motor buses and light trucks are comparable to one another, while light rail uses the same energy as passenger cars but emits less CO_2.

Table 1
Modal Energy Consumption and CO_2 Emissions per Passenger Mile

	BTUs	Pounds CO_2
Ferry Boats	10,744	1.73
Automated Guideways	10,661	1.36
Light Trucks	4,423	0.69
Motor Buses	4,365	0.71
Trolley Buses	3,923	0.28
All Automobiles	3,885	0.61
Light Rail	3,465	0.36
Passenger Cars	3,445	0.54
All Transit	3,444	0.47
Heavy Rail	2,600	0.25
Commuter Rail	2,558	0.29
Toyota Prius	1,659	0.26

Source: Calculations based on data in Federal Transit Administration, "Energy Consumption," *2006 Provisional National Transit Database* (Washington: U.S. Department of Transportation, 2007), tinyurl.com/3cdn6k; Stacy C. Davis and Susan W. Diegel, *Transportation Energy Data Book: Edition 26* (Oak Ridge, TN: U.S. Department of Energy, 2007), pp. B-4, B-6, Table 2.13; Energy Information Administration, "Fuel and Energy Emission Coefficients," (Washington: Department of Energy), tinyurl.com/smdrm; Energy Information Administration, *State Electricity Profiles 2006* (Washington: Department of Energy, 2007), Table 5; Environmental Protection Agency, *Model Year 2008 Fuel Economy Guide* (Washington: EPA, 2007), tinyurl.com/25y3ce.

Table 2
Household Size and Average Auto Occupancy

	Household Size	Occupancy
1969	3.27	1.90
1977	2.86	1.90
1983	2.73	1.75
1990	2.63	1.64
1995	2.65	1.59
2001	2.58	1.63

Source: Census Bureau, "Average Population by Household and Family: 1940 to Present" (Washington, 2004), tinyurl.com/2hpgbx; and Pat S. Hu, *Summary of Travel Trends: 2001 National Household Travel Survey* (Washington, US DOT, 2004), table 15.

The Toyota Prius, the most fuel-efficient auto sold in the United States, is also shown as an example of the potential for energy-efficient autos.[22] The Prius uses less energy than other forms of travel, but generates about the same CO_2 as heavy rail and commuter rail.

Emissions from electrically powered transit depend on local sources of electricity. Massachusetts and Ohio, for example, rely heavily on fossil fuels for electrical power, so trolley buses in those states emit more greenhouse gases than diesel buses. But Washington and California rely more heavily on hydroelectric power, so trolley buses in those states emit less greenhouse gases than diesel buses.

All of these numbers are very sensitive to load factors. Because the vehicles themselves tend to weigh far more than the passengers being carried, doubling the number of people on board any vehicle will cut the energy consumption and emissions per passenger almost in half. Using estimates from the *2001 National Household Travel Survey*, Table 1 assumes that passenger autos carry an average of 1.57 people, while light trucks carry an average of 1.73 people.[23] Transit loads are from the *National Transit Database* (passenger miles divided by vehicle revenue miles).[24]

One obvious way to reduce energy consumption and emissions is to increase vehicle occupancies. Increasing auto occupancies is easier said than done, however. As Table 2 shows, average auto occupancies roughly equal average household size minus one. Efforts to increase occupancies with carpool lanes have mostly failed. Indeed, most carpools are really "fampools," that is, family members traveling together to work or other destinations.

Transit loads are easier to manipulate by directing transit service to areas where demand is high and avoiding or providing smaller vehicles in areas where demand is low. Most transit agencies fail to do this for political reasons. Since transit agencies rely heavily on tax dollars, they try to provide at least some service to all taxpayers in a region. Because a large share of their capital costs is funded by federal grants, they also tend to buy buses that are larger than they really need. The result is that they often run buses that are nearly empty.

Modal Trends

Not only are passenger autos competitive (at least in terms of energy efficiency) with public transit, autos are becoming more energy efficient each year, whereas transit's efficiency is stagnant or declining. The energy efficiency of passenger cars per vehicle mile has grown by an average of 1.5 percent per year, and when fuel prices have been high, it has grown by as much as 3.0 percent per year. Since auto occupancies have been declining, efficiencies per passenger mile have only grown at an average

Automobiles are becoming more energy efficient each year, whereas transit's efficiency is stagnant or declining.

Automobiles will continue to become more energy efficient by 2 percent per year, which means that new rail transit lines must be more efficient than future autos to achieve any savings at all.

of 0.9 percent per year; but they have grown as fast as 2.5 percent per year when fuel prices were highest.[25]

The fuel efficiencies of light trucks have grown faster than cars, partly because light truck occupancies have increased. In 1970, the vast majority of light trucks were pickups. Today, most are vans or sport utility vehicles, which tend to have much higher occupancies than pickups.[26]

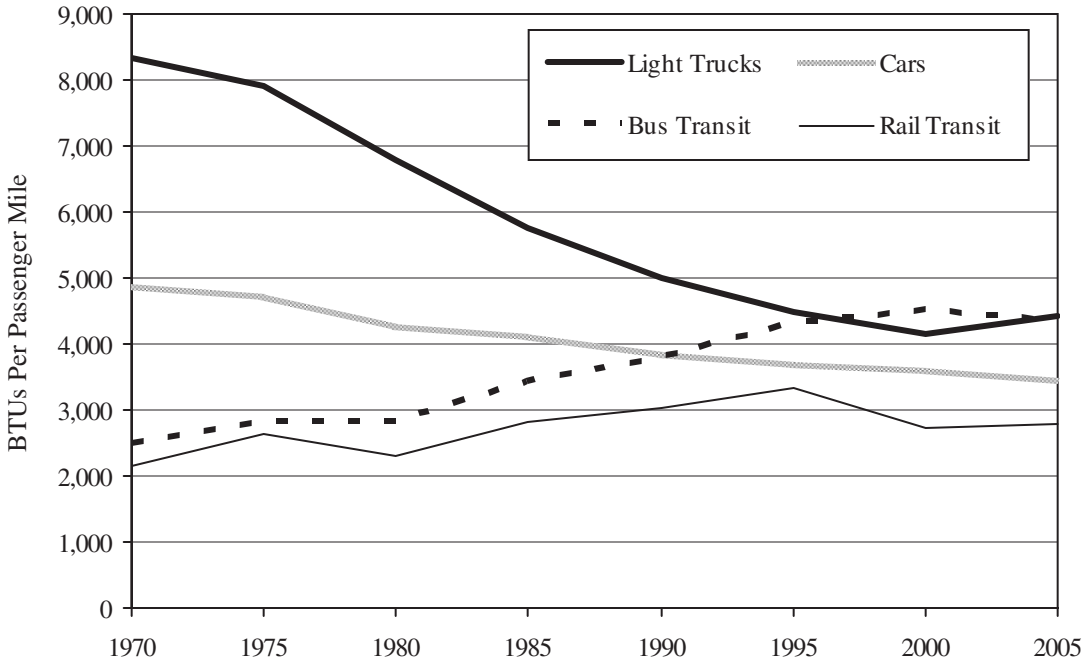
These trends will be accelerated by the Energy Independence and Security Act of 2007, which requires that corporate average fuel economy (CAFE) increases from 27.5 miles per gallon today to 35 miles per gallon by 2020. The law also requires that production of biofuels (which produce only one-third the net greenhouse gas emissions of fossil fuels) increase from 4 billion gallons today to 36 billion by 2022.[27]

The net effect of this law will be to increase fuel economies by close to 2 percent per year. By 2020, the average automobile on the road will consume little more than 3,000 BTUs per passenger mile. By 2035, even if new-car efficiencies do not improve after 2020, the average auto will consume just 2,500 BTUs per passenger mile.[28]

Projections of the energy efficiency of rail transit must take into account the growing energy efficiency of automobiles. A proposed light-rail line that promises to save energy not only needs to be more efficient than today's autos, it must be more efficient than future autos. Since rail lines typically take 10 years to plan and construct, and have an operational life (before they need reconstruction and rehabilitation) of 30 to 40 years, they would have to be more efficient than the average auto 25 to 30 years from now to achieve any savings at all.

Suppose a light-rail line is projected to open in 2015 and operate until 2055. If the average auto consumed 3,885 BTUs per passenger mile in 2005, and auto energy efficiency is growing at 2.7 percent per year, then when the rail line opens, autos will be using less than 3,400 BTUs per passenger mile. At the light-rail line's mid-life in 2035, autos will

Figure 1
Energy Intensity of Passenger Transport



Source: Davis and Diegel, *Transportation Energy Data Book*, Tables 2.13 and 2.14.

consume only 2,500 BTUs per passenger mile. Since only one light-rail line operating today consumes significantly less than that, new light-rail lines are not likely to achieve any savings.

Production of carbon dioxide (CO_2) by petroleum-fueled motor vehicles is almost exactly proportional to their energy efficiency. CO_2 emissions from motor vehicles can be reduced, however, by using biofuels, which offset the CO_2 emissions by obtaining energy from plants taking carbon out of the atmosphere. The biofuel requirement in the 2007 Energy Act means that greenhouse gas emissions per passenger mile will decline even faster than fuel consumption.

In contrast to autos, fuel economies for bus transit have declined in almost every five-year period since 1970. This is partly because transit agencies have purchased larger vehicles and increasingly supplied them with air conditioning and other energy-intensive features, and partly because the number of people riding the average bus has declined. In 1982 (the earliest year for which data are available), the average number of bus occupants (passenger miles divided by vehicle revenue miles) was 13.8; by 2006, it was only 10.7.[29]

Rail transit's energy intensity has been flat or trending upwards.[30] But the New York urban area heavily skews rail numbers. New York provided more than 65 percent of rail transit passenger miles in 1980 and even today accounts for 55 percent of rail passenger miles.[31] New York rail ridership dropped dramatically in the 1980s, bottoming out in 1993. Since then, it has recovered. The trend for rail in Figure 1 largely reflects what happened in New York and says little about the energy efficiency of rail transit in other regions.

In general, the trends for CO_2 emissions for bus and rail transit probably roughly follow the trends for energy efficiency. Detailed calculations are complicated because so many different fuels are used to power these modes, and data are not available before 1982. Most buses rely on diesel fuel, but many use gasoline, some use compressed natural gas or other fuels, and a few (separately classified as "trolley buses") are electric. Some rail transit is diesel powered, but most rail transit is electrically powered. The sources of that electricity include some greenhouse gas emitters, such as coal and oil, and some non-emitters, such as nuclear and hydro.

Urban Area Modal Data

Table 3 lists the energy efficiency and CO_2 emissions for most of the nation's light-rail, heavy-rail, and commuter-rail lines in 2006. Also listed are streetcars, ferryboats, and trolley buses, each of which is being considered by some cities. For good measure, the table also includes automated guideways and cable cars, even though these are not being seriously considered by any major cities.

Commuter rail. Two commuter-rail systems —New Jersey Transit and the Northern Indiana Commuter District—are the only transit systems that use less energy per passenger mile than a Toyota Prius. All other commuter-rail lines, except for the SEPTA system in Philadelphia, use less energy than the average passenger auto.

The commuter-rail systems shown in Table 3 are electrically powered, while most of the commuter-rail systems for which there are no data are diesel-powered. So the missing systems may produce more greenhouse gases per passenger mile than the systems shown in the table.

Heavy rail. As Figure 2 shows, most heavy-rail systems are less energy efficient than an average passenger car, and none are more energy efficient than a Toyota Prius. As Table 3 shows, two of them—New York subways and San Francisco BART—emit less CO_2 than a Prius, but several emit more CO_2 than the average passenger car.

Light rail. Most light-rail systems use as much or more energy per passenger mile as the average passenger car, several are worse than the average light truck, and none is as efficient as a Prius (see Figure 3). Three emit less greenhouse gases than a Prius, but several emit more greenhouse gases than light trucks (see Table 3).

Most light- and heavy-rail lines are less energy efficient than the average passenger car, and none are as efficient as a Prius.

Table 3
Transit Line Energy Consumption and CO_2 Emissions per Passenger Mile

Urban Area	BTUs	Pounds CO_2
	Commuter Rail	
Chicago (NW IN)	1,587	0.33
Newark (NJT)	1,599	0.19
Boston	2,209	0.36
New York (LIRR)	2,681	0.24
Chicago (RTA)	2,693	0.40
New York (Metro-North)	3,155	0.28
Philadelphia	4,168	0.53
	Heavy Rail	
Atlanta	1,983	0.29
New York (MTA)	2,149	0.16
San Francisco (BART)	2,299	0.14
New York (PATH)	2,953	0.20
Washington	3,084	0.62
Chicago	3,597	0.37
Boston	3,631	0.44
Baltimore	3,736	0.50
Philadelphia (SEPTA)	3,745	0.48
Los Angeles	4,233	0.26
Philadelphia (PATH)	5,077	0.35
Cleveland	5,494	1.02
Miami	6,756	0.89
Staten Island	8,039	0.60
	Light Rail	
San Diego	2,102	0.13
Boston	2,473	0.30
Portland	2,482	0.08
Minneapolis	2,498	0.35
St. Louis	2,613	0.48
Salt Lake City	2,830	0.56
Houston	2,849	0.39
Los Angeles	2,884	0.18
Denver	4,400	0.78
Dallas	4,466	0.60
San Francisco	4,509	0.27
Newark	4,564	0.31
Sacramento	4,821	0.29
Philadelphia	5,459	0.69
Cleveland	5,585	1.03
Buffalo	5,774	0.43
San Jose	6,174	0.38
Baltimore	8,128	1.09
Pittsburgh	9,265	1.18

Urban Area	BTUs	Pounds CO_2
	Streetcars/Vintage Trolleys	
New Orleans	3,540	0.40
Tacoma	4,396	0.09
Charlotte	5,438	0.71
Tampa	7,941	1.04
Little Rock	12,948	1.54
Memphis	17,521	2.42
Kenosha	32,910	4.94
Galveston	34,325	5.58
	Trolley Bus	
San Francisco	3,341	0.21
Seattle	3,912	0.08
Dayton	6,377	1.12
Boston	7,589	0.88
	Ferry Boat	
New York	4,457	0.72
San Francisco	10,173	1.65
Portland	11,464	1.86
Seattle	13,118	2.13
Savannah	38,864	6.31
San Juan	60,582	9.84
New Orleans	71,784	11.66
	Automated Guideway	
Miami	7,649	1.00
Detroit	15,058	2.11
Jacksonville	54,054	7.09
	Cable Car	
San Francisco	4,629	0.28

Source: Calculations based on data from Federal Transit Administration, "Energy Consumption," *2006 Provisional National Transit Database* (Washington: U.S. Department of Transportation, 2007), tinyurl.com/3cdn6k; Stacy C. Davis and Susan W. Diegel, *Transportation Energy Data Book: Edition 26* (Oak Ridge, TN: U.S. Department of Energy, 2007), pp. B-4, B-6; Energy Information Administration, "Fuel and Energy Emission Coefficients," (Washington: Department of Energy), tinyurl.com/smdrm; Energy Information Administration, *State Electricity Profiles 2006* (Washington: Department of Energy, 2007), table 5.
Note: Salt Lake City data adjusted for ridership overcounts revealed by local transit agency.

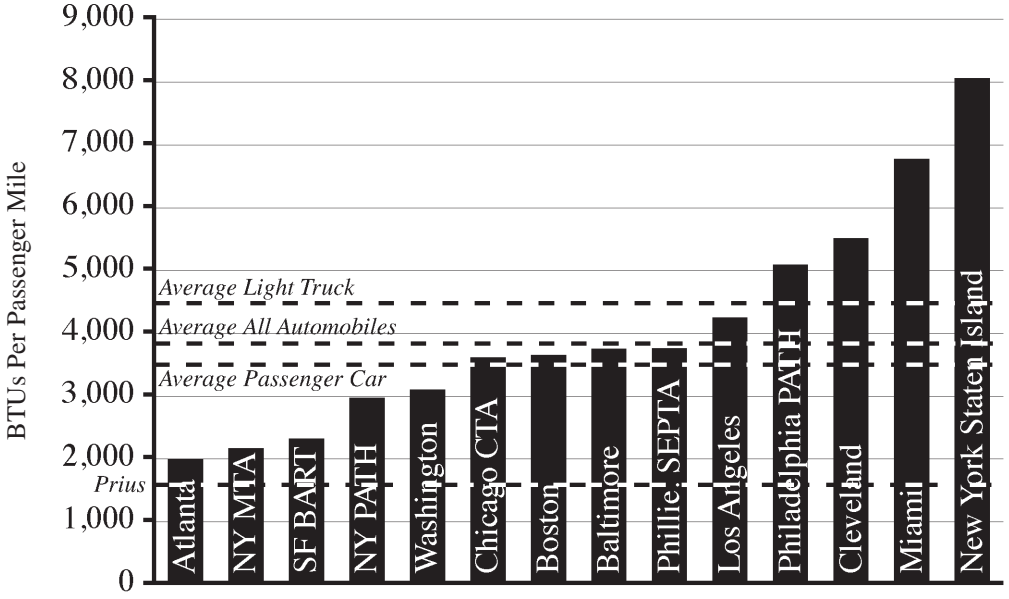
Streetcars. Streetcars and vintage trolleys consume lots of energy and, for the most part, emit lots of greenhouse gases per passenger mile. The poor performance of these systems results from low passenger loads, as many carry average loads of just two to six riders.

Trolley Buses. Trolley buses in Seattle and San Francisco use somewhat less energy than buses, probably because they are concentrated in the inner cities while most bus lines serve many suburban areas. In regions where much if not most electricity comes from hydro or other non-fossil-fuel sources, trolley buses can reduce greenhouse gas emissions, but otherwise they are not effective.

Ferryboats. If saving energy and reducing greenhouse gases are the goals, ferryboats are a very poor choice of transit.

Streetcars and ferryboats tend to use the most energy and generate the most greenhouse gases per passenger mile of any form of transit.

Figure 2
Heavy-Rail Energy Consumption



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Automated Guideways. The "people movers" in Florida and Detroit have mostly been disappointments. One in Tampa was even torn out because ridership was so low. Not surprisingly, they require large amounts of energy per passenger mile.

Cable Cars. The San Francisco cable cars use a lot of energy. But California gets nearly half its electricity from renewable sources that emit little or no CO_2, so they are relatively greenhouse friendly.

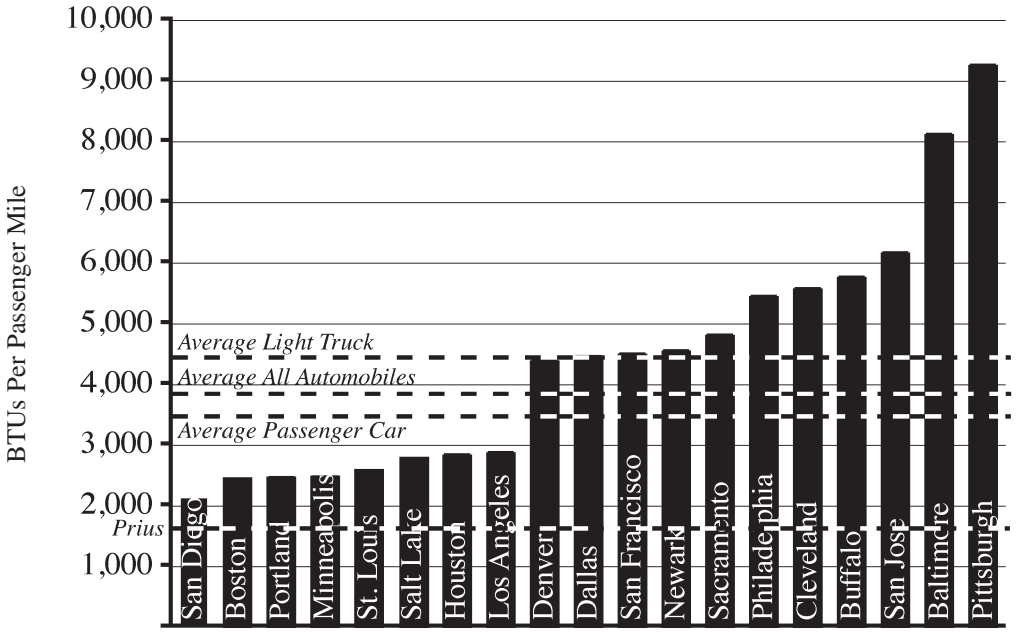
National Transit Database numbers for Salt Lake City indicate that it has an extraordinarily efficient light-rail line, equal in energy performance to the San Diego line. However, the Utah Transit Authority recently revealed that it has systematically overestimated light-rail ridership by 20 percent or more for several years. The agency installed automated passenger counters in all its rail vehicles, whereas previously it had relied on a sampling system. The new counters reveal light rail carries about 22 percent fewer riders than the transit authority had previously reported.[32] The numbers in Table 3 have been adjusted to account for this overcount.

Rail systems do poorly partly because rail cars weigh around 60 percent more, per passenger, than buses.

Only a handful of rail systems are more environmentally friendly than a Toyota Prius, and most use more energy per passenger mile than the average automobile. Steel wheels on steel rails require far less friction to turn than rubber tires on pavement. So why do rail systems have such mediocre performances?

One reason is that, for the safety and comfort of passengers, rail cars tend to be heavier per passenger than buses. A typical light-rail car, for example, weighs about 100,000 pounds compared with 27,000 pounds for a typical bus. Light-rail loads and capacities are around two-and-one-half times those of buses, so light-rail cars weigh around 60 percent more per passenger.[33]

Figure 3
Light-Rail Energy Consumption



Source: Calculations based on data in Federal Transit Administration, "Energy Consumption," 2006 Provisional National Transit Database (Washington: U.S. Department of Transportation, 2007), tinyurl.com/3cdn6k; Stacy C. Davis and Susan W. Diegel, Transportation Energy Data Book: Edition 26 (Oak Ridge, TN: U.S. Department of Energy, 2007), pp. B-4, B-6, Table 2.13; Energy Information Administration, "Fuel and Energy Emission Coefficients," (Washington: Department of Energy), tinyurl.com/smdrm; Energy Information Administration, State Electricity Profiles 2006 (Washington: Department of Energy, 2007), table 5; Environmental Protection Agency, Model Year 2008 Fuel Economy Guide (Washington: EPA, 2007), tinyurl.com/25y3ce.

A second problem is that electrically powered systems suffer significant losses in generation and transmission. A kilowatt-hour provides users with about 3,400 BTUs of energy. But the electricity producer must use more than 10,300 BTUs to deliver that kilowatt-hour to the user.[34] Trolley buses in Boston, Dayton, and Seattle, for example, consume more energy per passenger mile than diesel buses in those same cities even though the trolley buses carry the same or greater loads.[35]

A third problem is that rail lines cost a lot to build, so they are largely limited to major corridor routes. To justify the large investment, transit agencies operate light- and heavy-rail lines at greater frequencies than buses. Where buses can run frequent service in busy corridors and then diverge into various neighborhoods at the ends of the corridors, trains are confined to the rails. The result is that the train cars are substantially empty at the ends of their corridors and during much of the day.

All of these factors counteract rail's inherent efficiency advantage. The result is that rails are energy efficient only in extremely high-use corridors, and electrically powered rail lines are greenhouse friendly only in regions that use alternatives to fossil fuels to generate half or more of their electricity.

Even rail lines that use significantly less energy than autos will not save much energy unless they attract a significant number of people who would otherwise drive their cars. Table 4 shows that no region with rail transit has been able to persuade more than 0.5 percent of travelers to switch from cars to transit in the past 20 years. Transit's share of travel has actually declined since rail service began (or since 1985 for regions that had rail service before 1985) in 14 out of 25 regions with rail transit.

Electrically powered transit loses two-thirds of its energy in electrical generation and transmission.

Table 4
Transit's Share of Motorized Passenger Travel (percent)

	1985	1990	1995	2000	2005	Rail Began
Atlanta	1.9	1.8	1.3	1.4	1.1	1979
Baltimore	1.9	1.8	1.5	1.6	1.4	1983
Boston	2.6	2.8	3.0	3.4	3.1	1888
Buffalo	1.2	0.9	0.8	0.7	0.6	1986
Chicago	5.7	4.8	3.6	3.7	3.7	1892
Cleveland	2.3	1.5	1.2	1.3	1.3	1884
Dallas–Ft. Worth	0.8	0.6	0.5	0.6	0.6	1996
Denver	1.4	1.3	1.2	1.3	1.4	1994
Houston	1.0	1.0	1.0	1.0	1.0	2004
Los Angeles	1.9	1.4	1.3	1.4	1.8	1988
Miami–Ft. Lauderdale	1.2	1.1	1.1	1.0	1.0	1984
Minneapolis–St. Paul	1.4	1.1	0.8	1.0	1.0	2004
New Orleans	3.1	2.9	2.4	1.9	1.4	1892
New York	12.7	10.4	9.9	10.4	9.6	1905
Philadelphia	3.4	3.3	2.5	2.6	2.5	1890
Pittsburgh	2.2	2.1	1.5	1.5	1.3	1890
Portland	2.1	1.8	2.0	2.1	2.2	1986
Sacramento	0.9	0.7	0.7	0.9	0.7	1987
Salt Lake City	1.1	1.7	1.1	1.0	1.2	1999
San Diego	1.1	1.2	1.0	1.4	1.1	1981
San Francisco–Oakland	5.3	4.3	3.9	4.2	4.1	1972
San Jose	0.9	1.0	0.9	1.1	0.9	1988
Seattle	1.8	1.5	1.4	1.6	1.9	2000
St. Louis	1.0	0.7	0.6	0.8	0.7	1994
Washington	3.9	4.4	3.9	4.0	4.0	1976

Sources: Transit passenger miles from Federal Transportation Administration, *National Transit Database*, compared with motor vehicle miles (multiplied by 1.6 to get passenger miles) from Federal Highway Administration, *Highway Statistics* (years indicated in table).

Rather than attract people out of their cars, transit's share of commuting has declined in 20 out of 25 rail regions.

The same tale of woe is told by commuting data (see Table 5). Twenty out of 25 rail regions saw a decline in transit's market share of commuters since they began rail service (or 1970, in the case of regions that have had rail service since before 1970). Among the few that increased, Seattle's increase was the greatest, with transit's share rising from 7.1 percent in 1990 to 8.1 percent in 2006. Very little of that increase, however, was due to the region's trivial rail transit projects, which carried less than 2 percent of the region's transit trips in 2006.

Transit's loss of market share in most rail cities is not just a case of bad luck. Rail transit agencies must go heavily in debt to cover the high cost of building rail transit lines, and once that debt is paid off they have to go in debt again to reconstruct and rehabilitate worn out rail lines. To keep its rail system running, for example, Boston has incurred a $5 billion debt and must dedicate one-third of its operating budget just to pay the interest on that debt.[36]

Such indebtedness—which is not needed to operate a bus system—leaves transit riders vulnerable to economic downturns that reduce the tax revenues transit agencies rely on to both repay their debts and operate their sys-

Table 5
Transit's Share of Commuting (percent)

	1970	1980	1990	2000	2006	Rail Began
Atlanta	10.4	9.1	5.9	4.1	4.4	1979
Baltimore	16.9	12.3	9.3	7.4	8.1	1983
Boston	18.2	13.5	12.7	12.5	12.3	1888
Buffalo	12.3	16.4	5.5	4.0	4.9	1986
Chicago	24.4	18.7	15.8	12.6	12.2	1892
Cleveland	14.0	11.5	6.8	5.0	4.6	1884
Dallas–Ft. Worth	5.7	4.0	2.7	2.2	2.1	1996
Denver-Boulder	4.6	6.6	4.8	5.1	5.3	1994
Houston	6.0	3.5	4.5	3.8	3.2	2004
Los Angeles	4.8	5.9	5.6	6.0	6.3	1988
Miami–Ft. Lauderdale	6.2	4.3	3.7	3.3	4.0	1984
Minneapolis–St. Paul	9.5	10.0	6.2	5.5	5.1	2004
New Orleans	21.5	11.5	8.3	7.1	2.9	1892
New York	39.0	30.7	29.3	28.9	30.8	1905
Philadelphia	23.0	15.1	12.4	10.1	9.8	1890
Pittsburgh	17.7	13.8	10.2	8.1	8.0	1890
Portland	7.0	9.8	6.7	7.7	7.6	1986
Sacramento	2.7	4.1	2.8	2.9	2.9	1987
Salt Lake City	2.3	5.5	3.5	3.6	4.2	1999
San Diego	4.8	3.5	3.5	3.6	3.3	1981
San Francisco–Oakland	16.0	16.8	14.5	14.3	13.1	1972
San Jose	2.4	3.1	3.1	3.6	3.6	1988
Seattle	6.6	9.1	7.1	7.9	8.1	2000
St. Louis	9.2	6.9	3.5	2.9	3.1	1994
Washington	17.6	16.7	15.6	13.7	16.9	1976

Sources: Census Bureau, *Decennial Census, 1970 through 2000*, and *American Community Survey for 2006* (Washington: Census Bureau).

tems. When tax revenues decline, debt holders will not accept lower payments, so transit agencies must make much larger cuts to their transit systems than if they had no debt.

San Jose, for example, went into debt building new light-rail lines in the 1990s. When the 2001 recession hit, it was forced to cut transit service by nearly 20 percent and lost more than a third of its transit riders.[37]

So, even though some systems report that their rail lines generate less greenhouse gases than automobiles, they are not saving energy if they are losing market share to the auto. At best, agencies might brag that rail transit saves energy by carrying people who would otherwise ride an energy-intensive and CO_2-emitting bus. But, as the next section will show, new rail transit lines do not reduce energy use by buses.

Urban Transit Network Data

Table 6 lists the average energy efficiency and CO_2 outputs for all transit agencies for which data are available in 50 major urban areas in the country. A few regions are not listed because most or all of their transit systems are contracted out and so representative data are not available.

Unlike bus transit, the high cost of rail transit forces transit agencies into debt that leaves them especially vulnerable to recessions.

Table 6
Urban Area Transit Energy Consumption and CO2 Emissions per Passenger Mile

Urban Area	BTUs	Pounds CO2	Urban Area	BTUs	Pounds CO2
New York	2,639	0.29	Columbus	4,643	0.50
Atlanta	2,865	0.45	Cleveland	4,703	0.79
San Francisco–Oakland	3,003	0.30	Austin	4,985	0.80
Portland	3,008	0.36	Miami–Ft. Lauderdale	5,037	0.76
Boston	3,201	0.45	Indianapolis	5,059	0.82
Chicago	3,357	0.46	Tampa–St. Petersburg	5,218	0.84
Minneapolis–St. Paul	3,722	0.56	San Antonio	5,351	0.84
Houston	3,528	0.57	Pittsburgh	5,357	0.82
Denver	3,596	0.59	Dallas–Ft. Worth	5,414	0.85
Washington	3,646	0.63	Memphis	5,502	0.87
Orlando	3,670	0.59	Louisville	5,521	0.89
Hartford	3,670	0.59	San Jose	5,549	0.74
Los Angeles	3,674	0.56	Buffalo	5,602	0.81
Salt Lake City	3,837	0.66	Sacramento	5,613	0.69
San Diego	3,893	0.54	Seattle	5,805	0.91
Cincinnati	3,938	0.48	Kansas City	6,106	0.97
Detroit	3,998	0.64	Riverside–San Bern.	6,121	1.11
Providence	4,076	0.66	Richmond	6,193	1.00
Norfolk	4,133	0.66	Tucson	6,275	1.00
Philadelphia	4,305	0.57	Jacksonville	6,278	1.00
St. Louis	4,345	0.74	Dayton	6,379	1.05
Charlotte	4,488	0.72	Oklahoma City	6,626	1.07
Baltimore	4,497	0.67	Norwalk	7,243	1.17
Milwaukee	4,572	0.74	New Orleans	8,674	1.40
Nashville	4,596	0.74			

Source: Calculations based on data from Federal Transit Administration, "Energy Consumption," *2006 Provisional National Transit Database* (Washington: U.S. Department of Transportation, 2007), tinyurl.com/3cdn6k; Stacy C. Davis and Susan W. Diegel, *Transportation Energy Data Book: Edition 26* (Oak Ridge, TN: U.S. Department of Energy, 2007), pp. B-4, B-6; Energy Information Administration, "Fuel and Energy Emission Coefficients," (Washington: Department of Energy), tinyurl.com/smdrm; Energy Information Administration, *State Electricity Profiles 2006* (Washington: Department of Energy, 2007), table 5.

Transit systems in Baltimore, Dallas, Miami, San Jose, and Sacramento are less environmentally friendly than SUVs.

The most energy-efficient transit network is in New York City. New York's transit network is efficient not just because it has rail transit, but because its buses average 60 percent greater loads than the rest of the country (more than 17 passengers versus fewer than 11).

Other than the top six or seven systems, U.S. transit networks use as much or more energy and emit as much or more CO_2 per passenger mile as the average passenger car. Many regions with rail transit, including Baltimore, Dallas, Miami, San Jose, and Sacramento, are less environmentally friendly than light trucks.

One reason why many rail regions do so poorly is that new rail lines cannibalize bus systems by taking their most popular—and therefore most energy-efficient—routes. Moreover, after opening a new rail line, transit agencies typically offer their customers more bus service, not less, as corridor bus routes are turned into feeder buses for the rail corridor. Since many people who have access to autos will drive to the rail stations, those feeder bus-

es tend to operate with much smaller average loads than the corridor buses they replaced.

Many regions that build new rail transit lines end up using more fuel on buses carrying smaller average loads than before they built those lines. For example, in 1991, before St. Louis built its first light-rail line, St. Louis buses averaged more than 10 riders and consumed 4,600 BTUs per passenger mile. In 1995, after opening the light-rail line, average bus loads declined to fewer than 7 riders and energy consumption increased to 5,300 BTUs per passenger mile. CO_2 emissions also climbed from 0.75 pounds to 0.88 pounds per passenger mile.[38]

Other cities experienced similar declines in energy efficiencies after opening light-rail lines. Sacramento's bus loads, for example, declined from around 14 before the region's first light-rail line opened to under 10 afterwards. Overall energy consumption thus increased from around 3,000 to 4,300 BTUs per passenger mile while CO_2 emissions increased from 0.48 pounds to 0.58 pounds per passenger mile.[39] By 2004, Sacramento had opened a new light-rail line, but bus loads fell below 8 while overall energy consumption and CO_2 emissions grew to nearly 4,600 BTUs and 0.64 pounds per passenger mile.[40]

Similarly, Houston's light-rail line boosted energy consumption and CO_2 emissions per passenger mile by 8 to 10 percent.[41] Portland's eastside light-rail line, which opened in 1986, increased energy use and CO_2 production by 5 to 13 percent per passenger mile.[42] Its westside line, opened in 1998, increased energy use and CO_2 production by 7 to 11 percent per passenger mile.[43]

Not every transit system suffers a decline in energy efficiency after opening a rail line. Before opening the Hiawatha light-rail line in 2004, the Twin Cities' transit system used about 4,000 BTUs and emitted about 0.65 pounds of CO_2 per passenger mile. The light rail improved the 2006 systemwide average to 3,722 BTUs and 0.56 pounds of CO_2 per passenger mile.[44] But as the next section suggests, this small savings probably does not make up for the huge energy and CO_2 cost of building the line.

Construction

Even if a new rail line could save energy or reduce greenhouse gases compared with buses or autos, the energy costs and CO_2 emissions from constructing rail lines are huge and may never be recovered by the savings. Rail transit requires significant amounts of steel and concrete, for example, the production of both of which is energy intensive and emits large volumes of CO_2.

The environmental impact statement for Portland's North Interstate light rail estimated that the line would save about 23 billion BTUs per year but that construction would cost 3.9 trillion BTUs.[45] Thus, it would take 172 years for the savings to repay the construction cost. In fact, long before 172 years, automobiles are likely to be so energy efficient that light rail will offer no savings at all.

Similarly, the North Link light-rail line in Seattle is estimated to save about 346 billion BTUs of energy in 2015, declining to 200 billion in 2030.[46] Construction is estimated to require 17.4 trillion BTUs.[47] If the savings remains constant at 200 billion BTUs after 2030, the savings will not repay the cost until 2095. The Federal Transit Administration says that it is satisfied with this savings, because "the light rail project is expected to have about a 100 year life."[48]

In reality, rail projects have an expected lifespan of only about 30 to 40 years, after which most of the rail line must be substantially rebuilt or replaced. Washington's Metrorail needs $12.2 billion to reconstruct and rehabilitate its rail system over the next decade, none of which is funded—and the oldest parts of the system are about 30 years old.[49] The San Francisco Bay Area Rapid Transit District, which is slightly older than Washington's Metrorail, needs $11 billion for rehabilitation, only half of which is funded.[50] No matter where the money comes from, such reconstruction will require lots of energy and emit lots of CO_2, all of which must be counted against any operational savings that the systems claim to provide.

These examples show that any claims that rail transit will reduce energy consumption

Even if rail operations did save energy, it could take hundreds of years for that savings to repay the energy cost of constructing rail transit.

must be met with skepticism unless they are accompanied by evidence that the operational savings will quickly repay the construction cost. Transit agencies are often reluctant to provide that evidence even when they are required to do so by law. In the environmental impact statement for Dallas' Southeast Corridor light-rail line, the chapter on environmental consequences, for example, never once mentions the words "energy," "greenhouse," or "carbon dioxide," much less estimates the energy or CO_2 costs of constructing the line.[51]

Highway construction also uses energy and emits CO_2, but each mile of urban highway typically carries far more passenger miles and freight ton miles of travel than a mile of rail transit line. In 2005, for example, the average mile of U.S. light-rail line moved only 15 percent as many passenger miles as the average lane mile of urban freeway in rail regions.[52] Highways also move millions of tons of freight that can share the cost of construction. This means the energy and CO_2 costs of highway construction, per passenger mile or ton mile, are far lower than for rail transit construction.

Behavioral solutions to toxic air pollution have failed miserably, so it is no surprise that behavioral solutions to greenhouse gases are also failing.

Alternatives to Rail Transit

Since the 1960s, when Americans became alarmed about toxic air pollution, we have used two very different techniques to reduce the pollution generated by automobiles. First, we applied *technical solutions*, such as increasing traffic speeds (because cars pollute more at slower speeds) and reducing tailpipe emissions. Second, we tried *behavioral solutions* aimed at getting people to drive less.

Technical solutions have been fantastically successful. Americans drive four times as many miles as they did four decades ago, yet total automotive air pollution has been reduced by more than 50 percent.[53] New cars on the road typically pollute less than 5 percent as much as cars made in 1970, and some pollute less than 1 percent as much. Because new cars are getting cleaner every year, the air pollution problem is rapidly disappearing.[54]

In contrast, the behavioral solutions have failed miserably. Per capita driving in urban areas has more than doubled since the 1970s, and no city has managed to reduce per capita driving by even 1 percent except for short periods of time when gas prices were high. Americans respond to high fuel prices with a short-term reduction in driving, but their long-term response is to buy more fuel-efficient cars and then continue to drive more each year.

Despite the failure of behavioral solutions in the past, history is repeating itself today with cities planning rail transit lines, high-density housing projects, mixed-use developments, and other techniques aimed at changing people's travel behavior in order to reduce energy use and greenhouse gas emissions. Once again, the reality is that technical solutions cost less and do more to address these issues, while there is little evidence that the behavioral solutions will have any measurable effect at all.

Construction of new rail lines, or reconstruction of existing ones, is very expensive in dollars, energy, and greenhouse gas emissions; yet the most successful lines have attracted only a tiny percentage of motorists out of their automobiles. Even the best rail transit lines provide only small energy and greenhouse benefits relative to the most efficient automobiles. And most rail transit lines in the United States actually consume more energy per passenger mile than the average passenger car.

Rail transit may use less energy, per passenger mile, than buses. But the introduction of rail transit rarely leads to a reduction in bus operations. Instead, buses that once followed the rail corridors are converted to feeder bus routes. So the incremental effect of rail transit on a transit system's overall energy use can often be to increase consumption per passenger mile.

Transit officials and other urban leaders who have a genuine desire to reduce energy usage and greenhouse gas emissions from their regions should consider alternatives that are far more cost effective at achieving these goals than building rail transit. Four

potential alternatives are these:

- Promoting alternative transit fuels and technologies;
- Increasing average bus loads;
- Reducing fuels wasted on highways and streets; and
- Improving automotive efficiencies.

Alternative Transit Fuels and Technologies

Transit agencies wishing to reduce greenhouse gas emissions have two options, neither of which involves building rail transit. First, they can use alternative fuel sources and technologies. Second, they can improve their loadings by increasing the average number of people using each transit vehicle or reducing vehicle sizes.

Minneapolis–St. Paul is one of the few regions where a new light-rail line saved energy. In addition to building this line, the region has also reduced greenhouse gas emissions by purchasing hybrid-electric buses and converting to biodiesel fuel for its buses. Hybrid-electric buses are 22 percent more fuel-efficient than regular buses. Biodiesel's net CO_2 emissions are two-thirds less than petroleum-based diesel fuel. In 2006, Minneapolis–St. Paul used a fuel mixture of 10 percent biodiesel and plans to increase this to 20 percent in 2008.[55]

Hybrid buses cost more than regular buses, and biodiesel costs more than regular diesel. But they are far more cost-effective at reducing greenhouse gas emissions than building light rail. Minneapolis–St. Paul spent $715 million building its light-rail line.[56] Amortized at 7 percent over 40 years, this is equal to a $53 million annual payment. The transit agency estimates that the light rail saves it $18 million per year in operating costs, so the net cost is $35 million per year.[57] Operating the light rail instead of carrying the same passengers on buses saved about 16 million pounds of CO_2, at a cost of more than $2.20 per pound.

In contrast, Minneapolis–St. Paul is purchasing 172 hybrid-electric buses, each costing $200,000 more than a regular bus. Amortizing this cost over 10 years results in an annual cost of about $28,000. The transit agency estimates that each bus will save nearly 2,000 gallons of fuel per year, which would otherwise have generated nearly 44,000 pounds of CO_2.[58] This represents a cost of about 60 cents per pound. Hybrid-electric buses are thus 3.5 times more cost-effective at reducing greenhouse gases than light rail. The Minneapolis–St. Paul experience indicates that, even where light-rail operation saved greenhouse gas emissions (not counting construction costs), other methods of reducing CO_2 are far more cost effective (see Figure 4).

Biodiesel is even more cost effective. Converting from petroleum diesel to a 20-percent biodiesel mixture saves Minneapolis–St. Paul about 22 million pounds of CO_2 per year.[59] The 20-percent biodiesel mixture costs about 20 cents more per gallon and yields about 2 percent less BTUs per gallon than pure petroleum diesel, for a total net cost of less than $2 million per year.[60] Biodiesel thus costs less than 10 cents per pound of CO_2 saved, making it more than 25 times as cost-effective at reducing greenhouse gases as light rail.

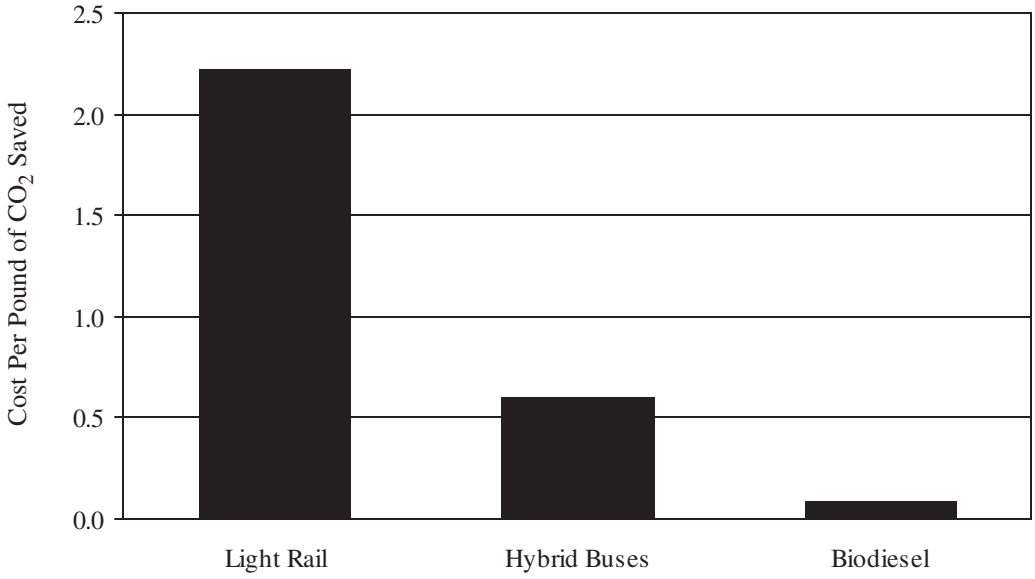
Increasing Transit Loads

Transit agencies can also save energy by increasing load factors—that is, the percentage of seats and standing room on transit vehicles used in the course of a day. The average transit bus has 39 seats and room for 20 more people standing, yet it carries on average fewer than 11 people. As Figure 5 shows, some transit agencies average more than 20 passengers per bus and consume far less energy per passenger mile.

Regions that rely heavily on non-fossil-fuel sources of electricity have a third option for reducing CO_2: electric trolley buses. While trolley buses are not as energy-efficient as diesel buses, they can be greenhouse friendly. Seattle's trolley buses, for example, produce just one-seventh as much CO_2 per passenger mile as Seattle's diesel buses.[61] Installing and maintain-

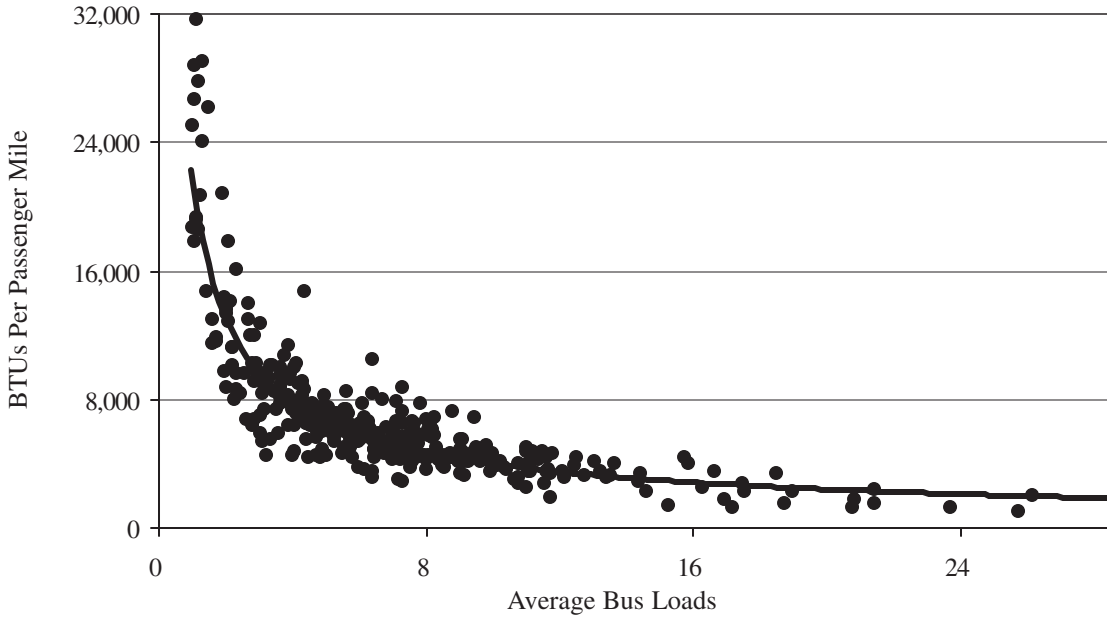
Hybrid buses and biofuels can reduce one pound of greenhouse gas emissions at a small fraction of the cost of light rail.

Figure 4
Alternative Greenhouse Gas Strategies



Source: Caluclations based on data in Peter Bell, "Message from the Council Chair" (St. Paul, MN: Metropolitan Council, 2007), tinyurl.com/2nlxur; Dantata, Touran, and Schneck, "Trends in U.S. Rail Transit Project Cost Overrun," Table 3; Federal Transit Administraion, "Operating Expenses," *2006 Provisional National Transit Database*; Jim Foti, "Hybrid Buses Thunder Down Nicollet Mall—Quietly," Minneapolis Star-Tribune, November 15, 2007, tinyurl.com /2c33mj; Federal Transit Administration, "Fuel Consumption," *2006 Provisional National Transit Database*; and Davis and Diegel, *Transportation Energy Data Book*, Table A.3.

Figure 5
Energy Efficiency of Bus Transit



Source: Federal Transit Administration, "Energy Consumption," *2006 Provisional National Transit Database* (Washington: U.S. Department of Transportation, 2007), tinyurl.com/3cdn6k.

ing trolley wires is costly, though nowhere near as costly as building rail transit lines.

One way to increase passenger loads is to focus bus service in areas where ridership is highest. Such a market orientation is foreign to transit agencies that are politically pressured to provide service to all taxpaying neighborhoods, even if those neighborhoods offer few riders.

Still, some bus operations are remarkably energy efficient. Several commuter bus lines in the New York metropolitan area consume less than 2,000 BTUs per passenger mile by focusing their services on routes and times that serve large numbers of passengers. Golden Gate Transit in San Francisco–Marin County as well as transit systems in such varied cities as Cumberland, Maryland; Rome, Georgia; Brownsville, Texas; and Santa Barbara, California; all consume less than 3,000 BTUs per passenger mile.

Transit agencies that focus on corridor or commuter routes can save energy while serving suburban neighborhoods or off-peak times by using smaller buses. Transit agencies typically buy buses large enough to meet peak-hour demand and then operate those buses throughout the day. Moreover, federal funding for transit capital purchases gives agencies incentives to buy buses that are larger than they really need even during peak hours. In any case, buying two separate fleets of buses—one for corridors and peak periods and one for suburban routes and off-peak periods—would do more to reduce energy use and CO_2 emissions than building rail transit.

Portland's TriMet transit agency, for example, has a fleet of 545 buses in fixed-route service, 90 percent of which have 39 seats or more. TriMet could supplement these buses with 500 15- to 25-passenger buses costing $50,000 to $75,000 each.[62] This would total $25–37 million—about the cost of one mile of light-rail line. Amortized over 10 years, this is about $5 million per year.

The smaller buses consume only about 40 percent as much fuel and emit 40 percent as much CO_2 as full-sized buses. TriMet buses produced 129 million pounds of CO_2 in 2006, so operating smaller buses for even one-third of vehicle-hours of service would save 25 million pounds of CO_2. Savings on fuel would offset at least $1 million of the $5 million amortized cost of buying these buses. Thus, the reductions in CO_2 levels would cost only about 16 cents per pound.

Saving Energy on Highways and Streets

The Texas Transportation Institute estimates that more than 2.9 billion gallons of fuel are wasted in congested traffic each year.[63] Relieving the congestion by fixing bottlenecks, using congestion tolls, and adding new capacity will do far more to reduce energy than rail transit can. Moreover, new highways largely pay for themselves, especially if tolls are used, while rail transit requires huge subsidies.

Some people fear that relieving congestion will simply induce more driving, and the energy costs of that driving will cancel out the savings from congestion relief. The induced-demand story is as much a myth as the claim that General Motors shut down streetcar systems in order to force people to buy cars.

Not building roads out of fear of induced demand is "wrongheaded," says University of California planning professor Robert Cervero. "The problems people associate with roads—for example, congestion and air pollution—are not the fault of the road investments," he adds. They result "from the *use* and *mispricing* of roads."[64]

Historically, gasoline taxes and other highway user fees have paid nearly 90 percent of all the costs of building, maintaining, and policing American roads and streets.[65] (In contrast, transit fares cover only about 40 percent of transit operating costs and none of transit capital costs.) The problem with gas taxes as a user fee, however, is that they do not signal users about the costs of the services they are consuming. Building a system that can meet peak-period demand costs more, yet peak-period users pay about the same user fee as off-peak users.

Relieving traffic congestion by fixing bottlenecks, using congestion tolls, and coordinating traffic signals will do far more to save energy than rail transit.

There may be reasons to build rail transit, but saving energy and reducing greenhouse gas emissions are not among them.

The solution is to charge tolls for new highway capacity, and vary the tolls by the amount of traffic so that new highway lanes never become congested. Existing high-occupancy vehicle lanes, which often have surplus capacity, can also be converted to high-occupancy toll (HOT) lanes, as has been successfully done in Denver.[66] Toll revenues will cover the costs of new roads, but higher tolls during peak periods will reduce the need for more roads.

So far, tolls have been applied only to limited-access highways. But traffic engineers can do much to reduce CO_2 emissions on unlimited access roads by improving traffic signal coordination.

San Jose coordinated 223 traffic signals on the city's most-congested streets at a cost of about $500,000. Engineers estimate that this saves 471,000 gallons of gasoline each year, which translates to a 9.2-million pound reduction in CO_2 emissions.[67] That works out to a cost of just 5.4 cents per pound. Not only were greenhouse gases reduced, but motorists saved time, safety improved, and toxic air pollution was reduced as well.

According to the Federal Highway Administration, three out of four traffic signals in the nation are obsolete and poorly coordinated with other signals.[68] The National Transportation Operations Coalition says that deficiencies in signal coordination "are remarkably similar across the country and across jurisdictions."[69] Cities that have not budgeted the funds to improve traffic signal coordination have no business spending hundreds of millions of dollars building light-rail lines in the forlorn hope that rail transit will reduce CO_2 emissions.

Improving Automobile Efficiencies

The Energy Independence and Security Act of 2007 requires that the average new car sold in 2020 get 35 miles per gallon. Yet even under this law, the average car on the road in 2020 will get only about 25 miles per gallon. Cities that want to accelerate this process are likely to find that giving people incentives to buy fuel-efficient cars will be a more cost-effective way of reducing energy consumption and greenhouse gas emissions than building rail transit.

Since 1992 American cities have invested some $100 billion in urban rail transit.[70] Yet no rail system in the country has managed to increase transit's share of urban travel by even 1 percent.[71] Between 1990 and 2005, the only rail region that managed to increase transit's share of commuting by more than 1 percent was New York, and it did so mainly by lowering transit fares. Meanwhile, transit actually lost a share of passenger travel and commuters in most rail regions.[72] Thus, rail transit promises, at best, tiny gains for huge investments.

Considering rail transit's poor track record, persuading 1 percent of auto owners to purchase a car that gets 30 to 40 miles per gallon or better the next time they buy a car will do more to reduce energy consumption and CO_2 emissions than building rail transit. Only minimal incentives might be needed to achieve this, making such incentives far more cost effective than building rail transit.

Conclusion

There may be places in the world where rail transit works. There may be reasons to build it somewhere in the United States. But saving energy and reducing greenhouse gas emissions are not among those reasons. Regions and states that want to be green should find cost-effective alternatives such as the ones described here.

Notes

1. Bradford C. Snell, "American Ground Transport, A Proposal for Restructuring the Automobile, Truck, Bus, and Rail Industries," Part 4A, Appendix to Part 4, Testimony before the Subcommittee on Antitrust and Monopoly of the Senate Committee on the Judiciary, 93rd Cong., A-1–A-103, February 26, 1974.

2. For examples, see Scott Bottles, *Los Angeles and the Automobile: The Making of the Modern City* (Berkeley,

CA: UC Press, 1987), pp. 3–4; Christine Cosgrove, "*Roger Rabbit* Unframed: Revising the GM Conspiracy Theory," *ITS Review Online* 3, no. 1 (Winter 2004–Spring 2005), tinyurl.com/2bcg2t; and Martha J. Bianco, *Kennedy, 60 Minutes, and Roger Rabbit: Understanding Conspiracy-Theory Explanations of the Decline of Urban Mass Transit*, Portland State University Center for Urban Studies Discussion Paper 98-11, November 1998.

3. "List of Town Tramway Systems—United States," Wikipedia, tinyurl.com/2ehcck.

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