Conserving Energy and Preserving the Environment: The Role of Public Transportation

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The role of transportation in our nation's energy consumption and environmental quality is immense. Americans use more energy and generate more pollution in their daily lives than they do in the production of all the goods in the economy, the operations of all commercial enterprises, or the running of their homes. Any serious effort to reduce our dependence on foreign oil and make significant environmental progress must address the way Americans travel.

The vital role of public transportation in improving energy efficiency and the environment is often under-appreciated. With its fuel and pollution advantages, increased use of transit offers the most effective strategy available for reducing energy consumption and improving the environment without imposing new taxes, government mandates, or regulations on the economy or consumers.

Public transportation needs to be an essential element in sound national energy and environmental policies. Potential threats to the supply and price of foreign oil as a result of terrorism, conflicts in the Middle East, and OPEC decisions underscore the need for a public transportation strategy that reduces our nation's dependence on imported oil. Likewise, ongoing efforts to reduce harmful emissions from our air can be more effective when they include ways to increase use of public transportation.

"Conserving Energy and Preserving the Environment: The Role of Public Transportation" demonstrates that traveling by transit, per person and per mile, uses significantly less energy and produces substantially less pollution than comparable travel by private vehicles. The findings provide clear and indisputable evidence that public transportation is saving energy and reducing pollution in America today -- and that increased usage could have an even greater impact in the future.

Current Benefits

At our current levels of use, the study found public transportation is reducing Americans' energy bills and keeping the air cleaner. For example:

Energy savings from public transportation contribute to our national and economic security by making America less dependent on foreign oil or on new sources for drilling.

- Public transportation saves more than 855 million gallons of gasoline a year, or 45 million barrels of oil. These savings equal about one month's oil imports from Saudi Arabia and three months of the energy that Americans use to heat, cool and operate their homes, or half the energy used to manufacture all computers and electronic equipment in America.

- For every passenger mile traveled, public transportation uses about one-half the fuel of private automobiles, sports utility vehicles (SUVs) and light trucks.

Even at current rates of usage, public transportation produces large environmental benefits.

- For every passenger mile traveled, public transportation produces only a fraction of the harmful pollution of private vehicles: only 5 percent as much carbon monoxide, less than 8 percent as many volatile organic compounds, and nearly half as much carbon dioxide and nitrogen oxides.

- Compared to private vehicles, public transportation is reducing annual emissions of the pollutants that create smog, volatile organic compounds (VOCs) and nitrogen oxides (NOx), by more than 70,000 tons and 27,000 tons respectively. These reductions equal:

  -- nearly 50 percent of all VOCs emitted from the dry cleaning industry, a major source of this pollutant;
  -- 45 percent of VOCs emitted from the industrial uses of coal;
  -- 50 percent of NOx from the industrial uses of coal;
  -- more than 33 percent of the NOx emitted by all domestic oil and gas producers or by the metal processing industry.

- The reduced VOC and NOx emissions that result from public transportation use save between $130 million and $200 million a year in regulatory costs.

- Public transportation is reducing emissions of carbon monoxide (CO) by nearly 745,000 tons annually. This equals nearly 75 percent of the CO emissions by all U.S. chemical manufacturers.

- Public transportation is also reducing emissions of carbon dioxide (CO2), which contributes to global warming, by more than 7.4 million tons a year.

Potential, Achievable Benefits

As great as the current advantages are, far greater energy and environmental benefits could be derived through increased use of public transportation. Based on our findings, the study concludes that greater use of public transportation offers the single most effective strategy currently available for achieving significant energy savings and environmental gains, without creating new government programs or imposing new rules on the private sector.

If Americans increase their use of public transportation, the study found dramatic benefits in energy conservation and a healthier environment.

For example, if Americans used public transportation at the same rate as Europeans -- for roughly **ten percent** of their daily travel needs -- the United States would:

- Reduce its dependence on imported oil by more than 40 percent or nearly the amount of oil we import from Saudi Arabia each year;

- Save more energy every year than all the energy used by the U.S. petrochemical industry and nearly equal the energy used to produce food in the United States.

- Reduce carbon dioxide emissions by more than 25 percent of those directed under the Kyoto Agreement.

- Reduce CO pollution by three times the combined levels emitted by four high polluting industries (chemical manufacturing; oil and gas production; metals processing; and industrial use of coal).

- Reduce smog across the country by cutting NOx emissions by 35 percent of the combined NOx emissions from the four industries cited above, and cut VOC pollution by 84 percent of the combined VOC emissions from these four industries.

If Americans used public transportation at the same rate as Canadians -- for roughly **seven percent** of their daily travel needs -- the United States would:

- Reduce its oil dependence by an amount equal to more than a half year's oil imports from Saudi Arabia.

- Save nearly the amount of energy used by the entire petrochemical industry every year.

- Reduce CO pollution by twice the combined levels emitted by the four high polluting industries (chemical manufacturing; oil and gas production; metals processing; and industrial use of coal).

- Reduce NOx emissions by 25 percent of the combined NOx emissions from the four industries cited above, and cut VOC pollution by almost 60 percent of the combined VOC emissions from these four industries.

- Help prevent global warming by cutting CO2 emissions by amounts equal to nearly 20 percent of the CO2 emitted from fuel burned for residential uses or more than 20 percent of all CO2 emitted by commercial enterprises.

Even modest increases in the use of public transportation would produce great reductions in hazardous pollution in congested areas where pollution now poses the greatest risk.

- For example, almost half of the 35 largest public transportation systems, serving 26 metropolitan areas, are located in areas currently failing to meet EPA air-quality standards for CO or smog. In these highly-populated, urban and suburban "non-attainment areas," the pollution reductions that public transit can deliver would go directly to the environmental bottom line.

Achieving a genuine measure of energy independence and cleaner air by investing in our public transportation systems has significant economic advantages. While this study measured current and potential benefits of public transportation, the findings lead us to believe that achieving greater energy savings and environmental gains by significantly increasing the passenger loads would be less costly than continuing to expand the fleet of private vehicles, build and maintain more roads and highways to accommodate them, and absorb the rising energy, environmental and congestion expenses of this approach.

An Attainable Goal for Americans

Increasing Americans' use of public transit is an achievable goal. In the early 20th century, America led the world in mass transit development and use. Recent data suggest that a transit renaissance may be underway in the United States. Specifically, the study points to the following facts: 1) since 1995, use of public transportation has grown sharply and faster than the use of private vehicles; 2) passenger miles ridden on public buses and rail systems have grown faster than the passenger miles ridden in private automobiles, SUVs and light trucks; and 3) public transportation ridership has grown at a faster rate than air travel in recent years.

"*Conserving Energy and Preserving the Environment: The Role of Public Transportation*" concludes that making much greater use of public transportation may be the most effective strategy to sharply reduce our dependence on foreign oil and make historic strides in environmental quality. The study argues that these results can be achieved if we make public transportation a vital part of our nation's energy and environmental policies.

Conserving Energy and Preserving the Environment: The Role of Public Transportation

I. Introduction

As the United States strives to achieve greater energy efficiency and independence and to improve the environment, the role of transportation has become paramount. America consumes more energy and produces more pollution in mobility and travel than in any other activity. It follows that any serious effort to reduce our dependence on foreign oil and make significant additional progress on the environment must address the way Americans travel. This study examines the role of public transportation in conserving energy and reducing pollution. The data show that traveling by public transportation, per person and per mile, uses significantly less energy and produces substantially less pollution than comparable travel by private vehicles. We find that increasing the role of public transportation can provide the most effective strategy available for reducing energy consumption and improving the environment *without* imposing new taxes and government regulations on the economy or consumers.

Americans highly value their mobility and with good reason. Our communities, the economy and much of our lives are organized around our ability to travel easily and efficiently from home to work or school, to shop or play, to receive medical care or just for the sheer pleasure of traveling. This freedom has certain costs that accompany its many benefits. Vehicles, public and private, have to be purchased and operated; roads must be built and maintained; laws must be enforced so many people can travel at the same time; and hundreds of thousands of accidents inevitably occur.

The most fundamental costs of mobility, however, involve the energy required to move people and goods over any distance, and the pollution released as this energy is burned. As shown in Table 1, in 2000 Americans consumed more energy moving from place to place than industry used to produce all of its goods. All forms of transportation also consumed almost four times the energy of all residential uses and more than six times the energy of all commercial uses. Moreover, petroleum products provide virtually all of the fuel used for transportation, while other sectors use more diverse, efficient, and environmentally friendly sources of energy.

Table 1. Primary Energy Consumption by Sector and Source, 2000[1]

Transportation	**Industrial**	**Residential**	**Commercial**
26,580 trillion Btu	24,477 trillion Btu	7,053 trillion Btu	4,310 trillion Btu
97.5% petroleum	43.1% petroleum	20.4% petroleum	20.4% petroleum

[1] Energy Information Administration, Department of Energy, *Annual Energy Review*, Table 2.1a, "Energy Consumption by Sector, 1949-2000," www.eia.doe.gov/emeu/aer/txt/tab0201a.htm. *National Transportation Statistics, 2000*, Bureau of Transportation Statistics, U.S. Department of Transportation, April 2001, Table 4-2, p. 232.

Energy and environmental costs are built into all forms of mobility by mechanical means, but personal and political choices can reduce the fuel and pollution "overhead" associated with a given level of mobility. The primary approach for lowering these costs involves developing and using technologies that reduce either the fuel required to move people and goods, or the amount of pollution associated with burning that fuel. The most prominent regulatory strategies developed to advance this approach are the Corporate Average Fuel Efficiency (CAFÉ) and auto-emission standards for private automobiles. The *non-regulatory* strategy with the greatest potential for achieving the same results is greater use of public transportation, because on a per-person, per-mile basis, public transportation is much more energy efficient and much less polluting than private automobiles.

A Note about Categories and Years

In comparing public and private transportation, we include vehicle travel within metropolitan areas; we do not include trips between metropolitan areas. The category of public transportation used here covers all buses, commuter rail and light and heavy rail within a metropolitan area; it does not include taxicabs, other "demand response" vehicles such as vans for handicapped people, ferry boats, or trolley buses, nor inter-city train, bus or air service. The category of private vehicles used here includes passenger cars and "other 2-axle 4-tire vehicles," which covers SUVs and light trucks; it does not include motorcycles and trucks with six or more tires.

In each case, we use the most recent and comprehensive data available. The energy section draws on 1998 data on travel by private and public transportation, because 1998 is the latest year for which data on energy consumption by private vehicles is available (1999 data on energy use by public transportation systems is available). The analysis of public transportation and the environment draws on 1999 data, because that is the most recent data available on pollution emissions by public and private vehicles.

The most recent data show that the current use of public transportation is a major source of energy savings.

> *Moving a person over a given distance by public transportation consumes, on average, about half the energy of moving a person the same distance by private automobile, sports-utility vehicle (SUV), or light truck.*

Over the 42.5 billion passenger miles traveled on public transportation in 1998, the energy benefits add up to nearly than 107 trillion British thermal units (Btus).[2] As we will show, these energy benefits are comparable to the energy consumed by various manufacturing industries. For example, the energy saved through the use of public transportation is equivalent to half of the energy used to manufacture computers and electronic equipment in America. These energy savings are also equal to 99 percent of the energy used by the beverage and tobacco industries, and more than four times all the energy used to manufacture apparel. Finally, these energy benefits are equivalent to about one-fourth of the energy used to heat American homes in 1997 (the most recent data).[3]

These savings carry clear significance for our national and economic security. The United States is increasingly dependent on oil from the Middle East, at a time when dangers from Saddam Hussein, the war against terrorism, and the Israeli-Palestinian conflict all threaten to interrupt the supply of OPEC oil or sharply increase its price. Greater use of public transportation can offer a powerful conservation strategy that could substantially reduce our dependence on imported oil. There is no other technology or approach other than increased use of public transportation that, for every trip it is used, has the energy impact of nearly doubling the fuel efficiency of automobiles.

Table 2 shows that the energy savings attributable to public transportation in 1998 are equivalent to almost 860 million gallons of gasoline, or more than 45 million barrels of imported oil; the energy saved by the use of public transit in 1999 was equal to almost 890 million gallons of gasoline and nearly 47 million barrels of oil.

Table 2. Public Transportation Use and Implicit Energy Savings, 1998 and 1999

Year	Vehicle Miles	Passenger Miles	Energy Benefits (Btus)	Equivalent Gasoline Saving	Equivalent Oil Imports Saved
1998	3.043 billion	42.476 billion	106.8 trillion	855.3 million gallons	45.0 million barrels
1999	3.164 billion	44.079 billion	110.8 trillion	887.5 million gallons	46.7 million barrels

Put another way, the current use of public transportation reduces our energy dependence by the equivalent of nearly one month's imports from Saudi Arabia, which ran a little less than 1.5 million barrels per day in 1998 and 1999, and currently run about 1.6 million barrels per day.

[2] As noted earlier, the analysis of public transportation includes all bus, commuter rail and light and heavy rail trips within a metropolitan area; it does not include taxicabs, ferry boats or trolley buses, nor inter-city train, bus or air service. The analysis of private vehicle travel includes automobiles, sports utility vehicles and light trucks; it does not include motorcycles or trucks with six or more tires.

[3] Energy Information Administration, U.S. Department of Energy, www.eia.doe.gov/emeu/aer/txt/tab0205.html, also, *Monthly Energy Review*, www.tonto.eia.doe.gov/mer/.

These energy savings from public transit are also equal to two-to-three weeks of imports from the entire Persian Gulf.

A Note About Terms

Vehicular travel is measured in several ways. "Vehicle Trips" refers to the number of single, one-way trips from one point to another by public transportation or private vehicle. "Passenger Trips" refers to the number of person(s) traveling from one point to another on public transportation; "Person Trips" refers to the number of persons traveling from one point to another in a private vehicle. Here, we will use "passenger trips" to refer to both. "Vehicle Miles" or "Miles Driven" refers to the distance traveled on a single vehicle trip. "Passenger Miles" refers to the total distance traveled by all passengers in a public-transit vehicle on a single passenger trip, and "Person Miles" refers to the combined distance traveled by the driver and all passengers in a private vehicle. Again, here we will use "passenger miles" to refer to both. A 10-mile automobile trip with one driver and two passengers would constitute one vehicle trip, three passenger trips, 10 vehicle miles or miles driven, and 30 passenger miles. Similarly a five-mile commuter train trip with a driver and 50 passengers would constitute one vehicle trip, 50 passenger trips, five vehicle miles or miles driven, and 250 passenger miles.

The environmental benefits from using public transportation, compared to private automobiles (including SUVs and light trucks), are also highly significant. Here, we will examine the impact of public transportation, versus private automobiles, on emissions of four major air pollutants.[4] The first two are volatile organic compounds (VOCs) and nitrogen oxides (NOx), which combine with sunlight to form ozone, or smog. Smog is a serious irritant that can cause coughing, choking, and stinging eyes, damage lung tissues, and exacerbate respiratory illnesses. Children are especially susceptible to the harmful effects of VOCs and NOx in smog, and even healthy adults usually feel its effects over time. Another important pollutant examined here is carbon monoxide (CO), a poisonous gas that reduces the body's ability to transport

[4] Sulfur dioxide (SO2) is also emitted in substantial quantities by electric utilities and in very small amounts by automobiles. This pollutant is not included in the analysis because its nationwide emissions are capped at a given level, and the fixed amount allowed is distributed based on an emission allowance trading system. Thus, total SO2 emissions (due to the use of electricity by rail systems) will not change whether public transportation exists or not. In light of this, omitting the small SO2 emissions from automobiles means that the environmental benefits of public transportation are understated in this analysis.

oxygen to organs and tissues, and interferes with learning. Elderly people, children and adults with respiratory conditions are particularly vulnerable to the effects of CO exposure. These three pollutants pose the greatest risks to people living in urban and close-in suburban areas, where smog and CO concentrations are highest and public transportation systems are most highly developed. Greater use of public transportation, therefore, would reduce hazardous pollution in precisely those areas where it now presents the greatest risks. In addition to these three pollutants, the analysis also covers the impact of public transportation on emissions of carbon dioxide (CO2), a major greenhouse gas that contributes to climate change.

The data in Table 3 show that travel on public transportation produces much less dangerous pollution than comparable travel by private automobile, SUV, and light truck.

Table 3. Emissions by Public Transit and by Replacement Use of Private Vehicles
Metric Tons, 1999

Mode of Travel	VOCs	CO	NOx	CO2
Public Transit	6,318	38,079	29,838	9,120,489
Private Vehicles	76,748	783,006	57,002	16,526,345
Environmental Savings	70,431	744,927	27,164	7,405,856

Moving a person a given distance by public transportation produces, on average, only about five percent as much carbon monoxide, less than ten percent as much volatile organic compounds, and nearly half as much carbon dioxide and nitrogen oxides, as moving a person the same distance by private automobile, SUV, or light truck. Put another way, travel by public transportation produces, on average, 95 percent less carbon monoxide, 90 percent less volatile organic compounds, and about 45 percent less carbon dioxide and nitrogen oxide, per passenger mile, as travel by private vehicles.

This environmental impact equals or exceeds the dimensions used under Federal guidelines to identify major regulations. The Office of Management and Budget (OMB) currently defines as a "major rule" any environmental (or other) regulation that imposes a cost of $100 million or more a year. The Environmental Protection Agency (EPA) estimates that under its current emission standards regulation, it costs business and consumers between $1,300 and $2,000 per metric ton to reduce NOx and VOCs.[5] In 1999, for example, the use of public transportation reduced NOx and VOC emissions by nearly 100,000 metric tons, implicitly saving between $130 million and $200 million a year in regulatory costs.

The environmental benefits from the use of public transportation compare favorably with the results of decades of regulation of once highly polluting industries. As this report will show, the reductions in CO emissions attributable to the use of public transit are equal to nearly three-

[5] U.S. Environmental Protection Agency, Office of Air and Radiation, "Regulatory Impact Analysis – Control of Air Pollution from Motor Vehicles: Tier 2 Motor Vehicle Emission Standards and Gasoline Sulfur Control Requirements," December 1999, Table IV-9.

fourths of all CO emissions by chemical manufacturers. These reductions in CO emissions are also equal to more than half the CO produced by the metal processing sector, and 60 percent *more* than the CO emissions by the electric utility industry.[6] The NOx benefits of public transportation are also equal to more than one-third of the NOx emissions of American oil and gas producers, and nearly half of the NOx emissions from all industrial uses of coal.[7] Similarly, the reductions in VOCs attributable to the use of public transportation are equal to about half of all VOC emissions from the dry cleaning industry, a major source of this pollutant, and just under 45 percent of the VOCs emitted by the industrial use of coal.

The energy savings and environmental benefits derived from public transportation could be much greater, if Americans used public transit more frequently. In the early 20th century when cities were growing rapidly, public and private streetcar and bus lines were established across the country, and America led the world in mass-transit development and use.[8] Since World War II, private automobiles have become the dominant means of short-distance travel, even as public transit assumed a larger role many other countries. Over the last several decades, for example, the number of privately-owned vehicles has grown more than twice as fast as the population.[9]

As shown in Table 4, in 1998 public transportation logged 42.7 billion passenger miles, compared to nearly 3.9 *trillion* passenger miles in private automobiles, SUVs, and light trucks.

Table 4. Passenger Miles and Shares by Mode of Transportation, 1998[10]

Transport Mode	**Passenger Miles**	**Percentage of Total**
Automobiles	2,464 billion	62.7 percent
SUVs and light trucks	1,424 billion	36.2 percent
Total Private	**3,888 billion**	**98.9 percent**
Buses	20.6 billion	0.52 percent
Rail	22.1 billion	0.56 percent
Total Public	**42.7 billion**	**1.08 percent**

6 Environmental Protection Agency, *National Emissions (1970 to 1998) by Tier 3 Source Category and Pollutant,* Appendix A, Table A.1 www.epa.gov/ttn/chief/trends98/appendix_a.pdf. See Table 20a below.

7 *Ibid,* Tables A.2 and A.3. See Tables 20b and 20c below

8 "Milestones in Public Transportation History," American Public Transportation Association, www.apta.com/stats/history/mileston

9 *Public Transit in America: Findings from the 1995 Nationwide Personal Transportation Survey*, Center for Urban Transportation Research, University of South Florida, September 1998.

10 *National Transportation Statistics, 2000*, Bureau of Transportation Statistics, U.S. Department of Transportation, April 2001, Table 1-31, p. 48. *Public Transportation Fact Book,* American Public Transportation Association, March 2001, Table 30, p. 70.

After more than a decade in which the total number of passenger miles traveled in private vehicles grew significantly faster than public transportation passenger miles, the most recent data indicate a turn-around: Since 1995, the use of public transit has grown both sharply and faster than the use of private vehicles. As shown in Table 5, use of public rail systems has increased even faster than the use of SUVs and light trucks, the vehicles that dominated the growth in transportation in the 1980s and early 1990s. Moreover, public bus use has grown faster than automobile use, and nearly as fast as SUV and light-truck use.

Table 5. Changes in Passenger Miles, 1980-1990, 1990-1995, and 1995-1998 [11]

Transport Mode	**1980-1990**	**1990-1995**	**1995-1998**
Automobiles	+ 13.4 percent	- 0.004 percent	+ 8.5 percent
SUV/light trucks	+ 92.0 percent	+ 29.6 percent	+ 9.9 percent
Total Private	**+ 29.5 percent**	**+ 8.7 percent**	**+ 9.0 percent**
Buses	- 3.7 percent	- 10.3 percent	+ 9.5 percent
Rail	+ 9.6 percent	+ 2.8 percent	+ 12.5 percent
Total Public	**+ 2.2 percent**	**- 4.1 percent**	**+ 11.0 percent**

Public transportation has also grown at a faster rate than air travel in recent years. From 1995 to 1998, the number of trips taken on public buses grew 11.4 percent, and the number of trips taken on public-rail systems increased 16.1 percent: Together, the number of trips on public transportation increased 13 percent from 1995 to 1998.[12] Over the same period, the number of domestic airline passengers increased 11.9 percent, and the number of airline departures grew only 2.7 percent.[13]

Given its high energy efficiency and low polluting, public transportation offers the single largest untapped source of energy savings and environmental gains available to the United States. Throughout much of Europe, people use public transportation for about 10 percent of their daily travel needs.[14] There, governments have long used tax, planning, and regulatory policies to encourage the use of public transportation and protect their urban centers from automobile congestion. Virtually all European governments have also long provided extensive capital and operating assistance to their bus and rail systems. We will see that if Americans used public transportation at the same rate as Europeans – if a little more than ten percent of those

[11] *National Transportation Statistics, 2000,* Bureau of Transportation Statistics, U.S. Department of Transportation, April 2001, Table 1-31, p. 48.

[12] American Public Transportation Association, *Public Transportation Fact Book, 2001*, Table 26, p. 66.

[13] *National Transportation, Statistics, ibid*., Table 1-35, p. 56.

[14] *Making Transit Work: Insight from Western Europe, Canada and the United States*, Transportation Research Board, Committee for an International Comparison of National Policies and Expectations Affecting Public Transit, National Research Council, Special Report 257, Washington DC: 2001, p. 1

who currently use private automobiles shifted to public transportation, or everyone used public transit for about ten percent of their daily travel needs -- the United States could be virtually energy independent from Saudi Arabia. The energy savings at that level of public-transit use would be equal to one-quarter of all energy use in the commercial sector in 2000.[15]

This report shows that if just five percent of Americans left their cars at home and used public transportation, or if everyone used public transit five percent of the time, it would reduce CO pollution by more than all of the CO emitted by the chemical manufacturing sector and all metal processing plants.[16] If ten percent of Americans switched to public transit or everyone used public transit for ten percent of their daily travel needs, the United States would achieve more than one-quarter of the CO2 reductions mandated by the Kyoto Treaty, without increasing gas taxes or imposing regulatory restrictions on business. It would also reduce NOx pollution by more than the NOx produced by all industrial uses of coal, and produce environmental benefits equivalent to more than all the VOCs emitted by the chemical manufacturers and all oil and gas production.[17]

At one time, such levels of transit use, or even greater, were common. In 1920, the average person in an American city used public transportation about 250 times a year.[18] This widespread reliance on public transport declined with the rapid increase in automobile ownership in the 1940s and 1950s. With growing use of faster and more flexible means of private transportation, residential and commercial development spread farther from the established transit lines along which center cities and many early suburbs had formed. Today, with local land use planning generally uncoordinated with regional transportation planning, development continues to unfold even farther from existing public transportation corridors.[19]

Achieving much greater energy savings and environmental benefits by significantly increasing the passenger loads of existing public transportation systems would require modest new investments, at a much lower cost than would be required to produce comparable energy and environmental benefits by other means. Achieving a genuine measure of energy independence and markedly cleaner air by raising our public transportation use to European levels would require significant financial commitments, as well as changes in other areas such as land-use planning and the way many public transportation systems operate. The long-term price tag for substantially expanding the country's public transportation infrastructure, especially rail systems, would be less than the cost of continuing to expand the country's fleet of private vehicles, build and maintain more roads and highways to accommodate them, and absorb the

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[15] Energy Information Administration, U.S. Department of Energy, www.eia.doe.gov/emeu/aer/txt/tab0201a.html.

[16] Environmental Protection Agency, Appendix A, *National Emissions (1970 to 1998) by Tier 3 Source Category and Pollutant*, Table A.1, www.epa.gov/ttn/chief/trends98/appendix_a.pdf. See Table 21b below.

[17] *Ibid.*, Tables A.2 and A.3. See Tables 21a and 21c below.

[18] *Making Transit Work: Insight from Western Europe, Canada and the United States, op. cit*., pp. 1-2.

[19] *Op. cit*., pp. 3-10.

rising energy, environmental, and congestion costs of this approach. Given the limits and risks to our energy supply and the threats to the environment, relying for the long-term on private cars, SUVs, and light trucks for 99 percent of all daily transportation needs will be unsustainable.

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II. The Energy Savings from the Use of Public Transportation

The consumption of energy by private automobiles in the United States truly dwarfs energy consumption by public transportation systems, as would be expected based on their relative use. In 1998, public transit consumed about 800 million gallons of gasoline, diesel and other fossil fuels, plus about 5.1 billion kilowatt-hours (kWh) of electrical power. By contrast, private cars consumed about 123 *billion* gallons of gasoline, diesel, and other fuels.[20] Converting these various forms of fuel to Btus makes the comparison clear, shown in Table 6.

Table 6. Energy Consumption, Private and Public Transportation, Btus, 1998[21]

Private Cars	SUVs/Light Trucks	Total Private	Public: Elec. Power	Public: Motor Fuel	Total Public
9,052 trillion	6,322 trillion	15,374 trillion	18 trillion	107 trillion	125 trillion

While private automobile use is powered almost exclusively by gasoline fuel, a detailed analysis of fuel consumption by public transit, presented in Table 7, demonstrates a significant range of sources, with diesel fuel and electrical power extremely dominant.

Table 7. Fuel Consumption by Mode of Public Transport, 1998 [22]

Transit Mode	Fossil Fuel, Gallons	Electric, kWh	Btus
Bus – Diesel	606,631,000		84,139,719,700,000
Bus – CNG	32,561,802		4,516,321,944,000
Bus – Gasoline	1,077,830		134,603,771,000
Bus – LNG	4,893,617		678,744,695,000
Bus – Propane	583,715		55,744,762,000
Bus – Other	3,859,412		368,573,824,000
Commuter rail –Diesel	69,200,000		9,598,040,000,000
Commuter rail – Elec		1,299,000,000	4,433,487,000,000
Heavy rail – Elec		3,280,000,000	11,194,640,000,000
Light Rail – Elec		381,000,000	1,300,353,000,000

[20] *National Transportation Statistics*, op. cit., Table 4-5, p. 238.

[21] *Ibid*., Table 4-6, p. 240.s

[22] *Public Transportation Fact Book, 2001,* American Public Transportation Association, Table 65, "Fossil Fuel Consumption by Mode," p. 112; Table 66, "Non-Diesel Fossil Fuel Consumption by Mode," p. 113 distributing the bus total using Table 50, "Passenger Vehicle Power Sources", p.90, and Table 51, "Bus Power Sources", p. 91; Table 67, "Electric Power Consumption by Mode, Table 67, p. 114.

As these data suggest, buses that run on diesel fuel and electric commuter and heavy rail systems dominate the daily use of public transit. Of the more than 3.0 billion vehicle miles operated by public transit in 1998, diesel buses and electric commuter and heavy rails accounted for more than 2.9 billion of those miles, as shown in Table 8.[23] Similarly, public transit recorded roughly 42.5 billion passenger miles in 1998; diesel buses accounted for 19 billion of those passenger miles, and electric commuter and heavy rail accounted for another 20 billion passenger miles.[24]

Table 8. Vehicle Miles and Passenger Miles, By Mode of Public Transport, 1998[25]

Transit Mode	**Miles Traveled**	**Passenger Miles**
Bus – Diesel	2,033,512,011	19,039,043,749
Bus – CNG	92,593,034	866,915,377
Bus – Gasoline	10,776,657	100,897,972
Bus – LNG	14,914,893	139,642,793
Bus – Propane	517,280	4,843,103
Bus – Other	22,286,126	208,657,006
Commuter rail –Diesel	51,900,000	1,740,800,000
Commuter rail – Electric	207,600,000	6,963,200,000
Heavy rail – Electric	565,700,000	12,284,000,000
Light Rail – Electric	43,800,000	1,128,000,000
Total	3,043,600,000	42,476,000,000

One reason that public transportation is nearly twice as energy-efficient as private automobiles is that public transit on average carries many more passengers at once than private automobiles. We can determine the average passenger load of both public transportation systems and private vehicles by dividing the total passenger miles for each mode of transportation by its

[23] *Ibid*, Table 42, “Vehicle Miles Operated by Mode,” p. 78; and Table 51, “Bus Power Sources,” p. 91.

[24] *Ibid*, Table 30, “Passenger Miles by Mode,” p. 70; and Table 51, “Bus Power Sources,” p. 91.

[25] *Public Transportation Fact Book, 2001,* American Public Transportation Association, Table 30, “Passenger Miles by Mode”, p. 70; Table 42, “Vehicle Miles by Mode”, p. 78; distributing the commuter rail vehicle and passenger miles according to Table 50, “Passenger Vehicle Power Sources”, p.90 - 80% are assumed to be electrically-powered and the remaining 20% diesel powered. Bus vehicle and passenger miles were distributed using Table 50 and Table 51, “Bus Power Sources”, p. 91. Note that this method of distributing the total bus vehicle and passenger miles assumes that the same number of miles are driven per bus fuel type. This is probably not precisely the case, but the data are not sufficiently disaggregated to make the appropriate adjustments. The error introduced due to this simplification is minor because diesel-powered buses constitute the vast majority of this mode of public transportation.

total vehicle miles. The results reported in Table 9 show that for every mile traveled, public transportation carries on average about ten times more passengers than private vehicles.

Table 9. Average Passenger Load for Public and Private Vehicle Transportation, 1998[26]

Buses	Rail	Total Public	Automobiles	SUVs/lt trucks	Total Private
9	25	16	1.59	1.64	1.61

Increasing the average passenger loads of buses, trains or private vehicles would directly raise energy efficiency, because carrying additional passengers would increase the energy consumed only marginally, if at all. One difference which points to public transportation's greater potential for energy savings, compared to private vehicles, is that shifting passengers from private vehicles to public transportation would not require additional trips by public transit, while shifts in the other direction often would mean more automobile trips.

Another reason public transportation is nearly twice as energy efficient as private automobiles is that about half of the public transportation vehicle miles are traveled using trains, which not only carry many people, but also use more efficiently provided electricity for power. As shown in Table 10, the average energy use for public transportation is 2,740.8 Btus per passenger mile, which about half the some 6,348.2 Btus per passenger mile used by automobiles. The most energy-efficient mode of public transportation, electrically powered trains, requires only about 1,000 Btus per passenger mile.

Table 10. Energy Efficiency of Public Transportation, by Fuel Source Per Mile and Per Passenger Mile, 1998

Transit Mode by Fuel	Btu/ Vehicle Mile	Btu/ Passenger Mile
Bus Total	41,338	4,415.2
Commuter Rail Total	54,071	1,612.1
Heavy Rail– Electric	19,789	911.3
Light Rail– Electric	29,688	1,152.8
TOTAL (weighted average)	**38,251**	**2,740.8**

One key element for increasing the energy efficiency of American transportation overall is to alter the mix of fuels and transportation modes used, toward more efficient ones and away from gasoline-powered cars. The least expensive and most direct way to accomplish this is to increase the use of public transportation, which already relies predominantly on more energy-efficient fuels and modes. Using these fuels, public transportation consumes an average of 2,741 Btus per passenger mile.

[26] *National Transportation Statistics, 2000, op. cit.*, Tables 1-29 and 1-31, pp. 45 and 48.

The most accurate way to calculate the precise energy savings from the use of public transportation involves a number of steps. Having determined the distance traveled and fuel consumed by each mode of public transit (Tables 7 and 8), and the marginal fuel efficiency or Btu per vehicle mile and Btu per passenger mile (Table 10), we perform a simple thought experiment. We hypothesize that public transportation is no longer available, and the 42.5 billion passenger miles that occurred on public transit in 1998 have to take place in private automobiles. We calculate how many *vehicle miles* in private automobiles, SUVs and light trucks it would take to replace the 42.5 billion *passenger miles* provided by public transportation. Next, we determine how much fuel these private vehicles would use to meet the travel needs served by public transit. The difference between that fuel and the fuel used by public transportation gives us an accurate measure of the net energy and conservation benefits of public transportation.

The first step in running this thought experiment involves calculating how many additional vehicle miles would have to be traveled in private vehicles, to account for the 42.5 billion passenger miles traveled on public transportation in 1998. As just noted, one critical difference between private automobiles and public transportation is their different passenger loads. According to the most recent Nationwide Personal Transportation Survey,[27] driving in America remains a fairly solitary activity: Roughly 70 percent of all automobile trips involve a driver and no passengers, and about 19 percent more involve the driver and only one passenger. Of the remaining 11 percent of automobile trips, just over six percent involve a driver and two passengers, and less than five percent involve a driver and three or more passengers.

Using these data, we can distribute the 42.5 billion passenger miles from public transportation to the four different passenger-load categories, and calculate the additional private vehicle miles that would have to be traveled if there were no public transportation. If private vehicles replaced all public transportation, and its passengers were distributed according to current passenger loads in private automobiles, the 42.5 billion passenger miles on public transportation would require 35.1 billion vehicle miles in private automobiles.

Table 11. Private Vehicle Miles Driven in Shift from Public to Private Transportation

Private Vehicle Occupants	**Share**	**Passenger Miles-Number of People**	**Vehicle Miles Driven**
Driver	70 percent	29,733,200,000	29,733,200,000
Driver + 1 passenger	19 percent	8,070,440,000	4,035,220,000
Driver + 2 passengers	6 percent	2,548,560,000	849,520,000
Driver + 3 or more	5 percent	2,123,800,000	471,955,556
Total	**100.0 percent**	**42,476,000,000**	**35,089,895,556**

[27] *Nationwide Personal Transportation Survey*, www.cta.ornl.gov/npts/1995/Doc/index.shtml.

To calculate how much energy would be consumed in the hypothetical 35.1 billion private-vehicle "replacement" miles, we begin with the fuel efficiency of automobiles, SUVs and light trucks, based on the number of miles driven and fuel consumed, shown in Table 12.

Table 12. Vehicles Miles and Fuel Efficiency of Private Vehicles, 1998

Private Vehicle	**Miles Driven**	**Fuel Consumed (gallons)**	**Gallons of Fuel per Vehicle Mile**	**Btus per Vehicle Mile**
Automobiles	1,546,000,000,000	72,209,000,000	0.046707	5833.0
SUVs & lt trucks	866,000,000,000	50,579,000,000	0.058405	7293.9

Based on the number of automobiles and the number of SUVs and light trucks actually on the road, and the Btus burned per mile by each category, we calculate a weighted average that represents the average energy consumed every mile by all private vehicles: 6,348.2 Btus per vehicle mile. Using this value, we can easily calculate the total energy needed to travel 35.1 billion vehicle miles: Transporting all the passengers from public transportation in private vehicles, in the same proportions and passenger loads as everyone else, would consume about 223.2 trillion Btus. Now we can determine the energy consumed per passenger mile by the private vehicles that replace public transit in our thought experiment: 5,254.8 Btus per passenger mile.

Table 13. Values for Determining the Energy Benefits of Public Transportation, 1998

Btus per private-vehicle mile: Weighted Average	6,348.2
Miles driven by "replacement" vehicles	35,089,895,556
Total Btus consumed by "replacement" vehicles	223,203,124,495,867
Passenger miles for "replacement" vehicles	42,476,000,000
Btus per passenger mile for "replacement" vehicles	5,254.8

Now we can calculate the net energy savings from the use of public transportation: It is the difference between the average energy efficiency for the private vehicles that would replace public transit (5,254.8), and the energy efficiency of public transportation. We determined earlier that public transportation consumes, on average 2,740.8 Btus per passenger mile (Table 10). The difference between these two values is 2,514.0 Btus per passenger mile.

Every passenger mile traveled on public transportation saves 2,514 Btus. Based on 1998 data, public transportation saves more than 105 trillion Btus (106,782,895,800,499) per year.

Even though public transportation currently accounts for just 1.1 percent of all the passenger miles traveled in America, its energy benefits are large. The 106.8 trillion Btus in energy savings in 1998 are equivalent to more than 855 million gallons of gasoline, or more than 45 million barrels of oil -- a half-month's supply of oil imports from the Persian Gulf. As noted earlier, the energy savings by 1999 amounted to the equivalent of almost 890 million gallons of gasoline or nearly 47 million barrels of oil.

These benefits compare favorably with energy use by various energy-intensive industries. For example, the energy savings from public transportation are equal to more than twice the energy consumed by the apparel industry, and half the energy burned by the paper pulp industry or by all manufacturers of computer and electronic equipment.

Table 14. Energy Savings from the Use of Public Transportation versus Energy Consumed by Various Industries, 1998, Trillion Btus[28]

	Public Transportation Energy Savings and Energy Use by Industry	**Public Transportation Energy Savings as Share of Industry Energy Use**
Public Transportation Savings	106.8	--
Apparel	48	222.5 percent
Beverage and Tobacco Products	108	98.9 percent
Paper Pulp	198	53.9 percent
Computers and Electronics	205	52.1 percent
Plastics and Rubber Products	328	32.6 percent
Petrochemicals	723	14.8 percent

Public transportation would produce much greater energy savings if Americans used public transportation at the rates they did once, or at the rates that people in other countries currently do. Canadians travel on public transportation about seven times more often, on a passenger mile basis, than Americans, and Europeans use buses and trains about ten times as frequently as Americans.[29] If we emulated Canadians in our use of public transportation, it would save almost as much energy as the entire petrochemical industry burns every year, or more than a half-year's supply of oil imports from Saudi Arabia. If Americans used public transportation at the rate that Europeans do, the energy savings would equal nearly all the energy used to produce all the food in the United States, and the United States could reduce its oil dependence on the Persian Gulf by more than 40 percent.

* * *

[28] Energy Information Administration, Department of Energy, *1998 Manufacturing Energy Consumption Survey*, Table N1.2, www.eia.gov/emeu/mecs/mecs98/datatables/contents.html.

[29] Jeffrey Kenworthy and Felix Laube, "A Global View of Energy Use in Urban Transport Systems and its Implications for Urban Transport and Land-use Policy," *Transportation Quarterly*, Vol. 53, No. 4, Fall 1999, pp. 23-48; *Transport Fact Book*, www.publicpurpose.com/tfb-cheujpus98-pkm.htm.

III. The Environmental Benefits from the Use of Public Transportation

Public transportation also offers the largest opportunity and the most efficient means for making major strides in environmental quality without direct government regulation, especially in the urban and densely populated suburban areas with the worst pollution. The direct environmental benefits of public transportation come primarily from two factors. First, as we have now established, public transportation systems burn less fuel on a per person/per mile basis and therefore produce less pollution. Second, the diesel fuel and electrical power used in public transportation systems are less polluting, unit-by-unit, than the gasoline used in most private automobiles, SUVs, and light trucks.

As noted earlier, this analysis focuses on four major pollutants. The first two are volatile organic compounds (VOCs) and nitrogen oxides (NOx), which combined with sunlight produce ozone or smog. Ozone can irritate people's respiratory systems and eyes, damage their lungs, and exacerbate many respiratory conditions. In addition to VOCs and NOx, this analysis examines emissions of carbon monoxide (CO), a poisonous gas that hampers the body's ability to transfer oxygen to organs and tissues, and carbon dioxide (CO2), a greenhouse gas that is a major contributor to climate change.

As before, the focus here is on buses and rail systems within metropolitan areas. Of more than 3.1 billion vehicle miles covered by public transportation systems in 1999, just about two-thirds occurred on buses, which run primarily on diesel fuel. The remaining one-third occurred on commuter, light and heavy rail systems, mostly powered by electricity.

Table 15. Public Transportation Vehicle Miles by Mode, 1999[30]

Public Transportation Mode	**Vehicle Miles**
Bus-Diesel	2,096,103,900
Bus-Compressed Natural Gas	129,726,300
Bus-Gasoline	9,103,600
Bus-Liquefied Natural Gas	34,138,500
Bus-Propane	2,275,900
Commuter Rail-Diesel	53,180,000
Commuter Rail-Electric	212,720,000
Heavy Rail-Electric	577,700,000
Light Rail-Electric	48,700,000
Total	3,163,648,200

The next step in calculating the environmental benefits of public transportation draws on data collected and issued by the Environment Protection Agency (EPA) and the Department of Transportation. First, we use the emissions per mile produced by fossil-fuel powered vehicles,

[30] *Public Transportation Fact Book, op. cit.*, Tables 30, 42, 50, and 51.

including buses and diesel-powered trains. Diesel-powered rail systems produce roughly four times as much emissions per *mile* as diesel buses, only because they require much larger engines to carry many more passengers.

Table 16a. Emissions by Buses and Diesel-Powered Trains, Grams/Vehicle Mile, 1999[31]

	Volatile Organic Compounds (VOCs)	Carbon Monoxide (CO)	Nitrogen Oxides (NOx)	Carbon Dioxide (CO2)
Buses	2.3	11.6	11.9	2,386.9
Diesel Rail	9.2	47.6	48.8	9,771.0

Next, we calculate the emissions produced by electricity-powered rail systems, in grams per million-kilowatt-hour (MKWH). We start with all the pollution in grams produced by electric utilities, divide that by the million-kilowatt-hours generated by utilities, to arrive at electric utility pollution in grams/MKWH, and multiply that result by the million-kilowatt-hours used by public rail systems. The result is presented in Table 16b:

Table 16b. Emissions by Electricity-Powered Rail Systems, Grams/MKWH, 1999[32]

VOCs	CO	NOx	CO2
137,987	1,772,125	17,365	618,499,055

Now, we can easily calculate the total pollution produced by public transportation in 1999: It is the sum of the emissions per-vehicle-mile in grams for fossil-fuel powered systems (Table 16a), times the vehicle miles traveled by these systems (Table 15), plus the emissions per-vehicle-mile for electrically-powered systems, in grams per MKWH (Table 16b), times the MKWH of electricity consumed by these public transit systems. The results have been converted to a common measure, metric tons, and presented in Table 17:

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[31] Data for VOCs, CO and NOx emissions by buses from *National Transportation Statistics, op. cit.*, Table 4-38. Data for CO2 emission by buses scaled from car emissions, in "Emission Facts: Average Annual Emissions and Fuel Consumption for Passenger Cars and Light Trucks," U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Transportation and Air Quality, EPA 420-F-00-013, April 2000. Scaling based on relative fuel efficiencies for buses and automobiles; see *National Transportation Statistics, op. cit.*, Tables 4-22 and 4-24. Data for diesel-driven trains derived by scaling bus emission factors by fuel use per mile; see *Public Transportation Fact Book, op. cit.*, Tables 42, 65.

[32] Electricity production: Department of Energy, *Electric Power Annual*, 1999; emissions for all pollutants except carbon dioxide: Environmental Protection Agency, *National Pollutant Emission Estimates for 1999*, Clearinghouse for Inventories and Emissions Factors, www.epa.gov/ttn/chiief/trends99/Tier3_1999EmisFeb5_forWeb.xls. Carbon dioxide emissions: www.epa.gov/globalwarming/emissions/national/CO2.html, paragraphs after Table ES-15. Note that sulfur dioxide (SO2) emissions are not included, because total SO2 emissions are capped nationally.

Table 17. Pollution Emissions by Public Transportation, by Mode, Metric Tons, 1999

	VOCs	CO	NOx	CO2
Buses	5,121	26,469	27,151	5,432,295
Commuter Rail-Diesel	490	2,532	2,597	519,624
Commuter Rail-Electric	182	2,343	23	817,656
Heavy Rail	467	5,999	59	2,093,619
Light Rail	57	737	7	257,296
Total	**6,318**	**38,079**	**29,838**	**9,120,489**

As in our analysis of the energy savings produced by use of public transportation, we next hypothesize that public transit is unavailable and all the passenger miles traveled on public transportation must instead be satisfied by travel in private automobiles, SUVs, and light trucks. The difference between the pollution produced by public transportation and the pollution that would be produced if all public transportation riders used private vehicles provides an accurate measure of the environmental benefits of public transportation.

To calculate this benefit, we next turn to data from the EPA and the Department of Transportation on the pollution produced, per mile, by private automobiles, SUVs and light trucks. Using other data on the total numbers of private vehicles on the road in each of the two categories (automobiles and SUVs/light trucks), we ascertain a weighted average for the pollution emitted by private vehicles, overall:

Table 18. Pollution Emissions by Private Vehicles, Grams Per Vehicle Mile, 1999[33]

	VOCs	CO	NOx	CO2
Automobiles	1.88	19.36	1.41	415.49
SUVs, light trucks	2.51	25.29	1.84	521.63
Weighted Average	2.10	21.45	1.56	452.92

These data illustrate the serious environmental consequences of Americans' increasing preference for SUVs and light trucks, compared to automobiles, and the consequent growing importance of public transportation in improving environmental quality. Compared to automobiles, these larger vehicles emit, per-mile, 33 percent more volatile organic compounds, 24 percent more carbon monoxide, 30 percent more nitrogen oxides, and 26 percent more carbon dioxide. While SUVs and light trucks, on average, do carry marginally more passengers than automobiles – 1.64 people, compared to 1.59 for conventional automobiles -- the larger vehicles produce nearly 30 percent more smog and 26 percent more global-warming gases than automobiles.

[33] The weighted average is based on vehicle registration data, U.S. Department of Transportation, *National Transportation Statistics, op. cit.*, Tables 4-11 and 4-12. Emission Factors, *ibid.*, Tables 4-38 and 4-39.

Our next step involves calculating the number of *vehicle miles* that would have to be driven in automobiles and the larger passenger vehicles to accommodate the 44.1 billion *passenger miles* traveled on public transportation in 1999. To distribute the riders on public transportation to private vehicles, we begin with the distribution of occupants, or passenger load, for private vehicle trips -- the percentages of all private-vehicle miles driven by drivers alone, drivers with one passenger, drivers with two passengers, and drivers with three or more passengers. Multiplying these percentages by the total passenger miles distributes the passenger miles by passenger load, and dividing those results by the number of occupants in each category produces the number of private-vehicle miles needed required to replace the passenger miles ridden on public transportation. If public transportation was unavailable, its riders would have to drive or be driven 36.4 billion miles in private vehicles, in order to replace the 44.1 billion passenger miles traveled on public buses and rail systems in 1999:

Table 19. Private Vehicle Miles Driven in Shift from Public Transportation, 1999[34]

Private Vehicle Occupants	**Share**	**Passenger Miles – Number of People**	**Vehicle Miles Driven**
Driver	70 percent	30,855,300,000	30,855,300,000
Driver + 1 passenger	19 percent	8,375,010,000	4,187,505,000
Driver + 2 passengers	6 percent	2,644,740,000	881,580,000
Driver + 3 or more	5 percent	2,203,950,000	489,766,667
Total	**100.0 percent**	**44,079,000,000**	**36,414,151,667**

To determine how much pollution is produced by private vehicles driving 36.4 billion miles, we once again distribute those vehicles miles between the two classes of private vehicles, because they emit different amounts of pollution per-mile (Table 18). We apply the weighted average of pollution by both classes of vehicles to the first three categories of occupancy – trips taken by drivers alone, by a driver plus one passenger, and by a driver plus two passengers – and the pollution values for SUVs and light trucks to trips taken by a driver and three or more passengers. The rest is simple arithmetic: Multiplying the pollution per-mile by the vehicle miles driven in each class of occupancy. The result tells us how much pollution would be produced if everyone currently riding on public transportation had to use private vehicles instead.

The difference between that pollution produced by the current use of public transportation (Table 17), and the pollution produced by private vehicles traveling the 36.4 billion miles required to replace the current use of public transit, presented in Table 20, provides an accurate measure of the environmental benefits of public transportation.

[34] *Nationwide Personal Transportation Survey, 1999, op. cit.*, Tables 4.18 and 7.3.

Table 20. Environmental Benefits of Public Transportation: Pollution Produced by Private Vehicles and Public Transportation Over the Vehicle Miles Traveled on Public Transportation, Metric Tons, 1999

	VOCs	CO	NOx	CO2
Private Vehicles	76,748	783,006	57,002	16,526,345
Public Transportation	6,318	38,079	29,838	9,120,489
Difference: Benefits	70,430	744,927	27,164	7,405,856

Public transportation produces about 90 percent less volatile organic compounds, more than 95 percent less carbon monoxide, and almost 50 percent less nitrogen oxides and carbon dioxide than private vehicles would if all the people who currently ride public transportation had to use automobiles, SUVs, and light trucks for the same travel.

Even though public transportation accounts for a small share of all the passenger miles traveled in America, it produces large environmental benefits. The reductions in the emissions of volatile organic compounds from the use of public transportation, for example, are equal to roughly half the VOCs emitted by all dry cleaning operations in the country, and the carbon monoxide reductions are about 60 percent greater than the CO emitted by all electric utilities. The use of public transportation also reduces pollution by amounts that compare favorably with the pollution emitted by four high-polluting industries.

As Table 21a shows, public transportation reduced potential VOC emissions in 1999 by more than 77,000 tons, equivalent to 10.4 percent of the combined VOC emissions from the four industry groups. The reductions in VOCs attributable to public transportation also exceeded the VOCs emitted by the metals processing industry and were equivalent to more than 11 times the VOCs produced by the industrial use of coal.

Table 21a. Emissions of Volatile Organic Compounds (VOCs): Benefits of Public Transportation versus Emissions by Industries, 1999, Short Tons[35]

	Emissions Benefits from Public Transportation and Emissions by Industry	Public Transportation Savings as Share of Industry Emissions
Public Transportation Benefits	77,635	---
Industrial Use of Coal	7,000	1109.1 percent
Chemical Manufacturing	395,000	19.7 percent
Oil and Gas Production	271,000	28.7 percent
Metals Processing	77,000	101.0 percent

[35] Environmental Protection Agency, *National Pollutant Emission Estimates for 1999*, Clearinghouse for Inventories and Emissions Factors, www.epa.gov/ttn/chief/trends99/Tier3_1999EmisFeb5_forWeb.xls.

Similarly, public transportation reduced potential CO emissions in 1999 by more than 820,000 tons, or the equivalent of nearly 30 percent of the total CO emissions from all four industry groups. The reductions in CO emissions attributable to public transportation are also equal to more than 75 percent of the CO produced by U.S. chemical manufacturers, and thirty times the CO emissions of oil and gas producers (see Table 21b, below).

Table 21b. Emissions of Carbon Monoxide (CO): Benefits of Public Transportation versus Emissions by Industries, 1999, Short Tons[36]

	Emissions Benefits from Public Transportation and Emissions by Industry	Public Transportation Emission Benefits as Share of Industry Emissions
Public Transportation Benefits	821,128	---
Industrial Use of Coal	109,000	753.3 percent
Chemical Manufacturing	1,081,000	76.0 percent
Oil and Gas Production	27,000	3,041.2 percent
Metals Processing	1,678,000	48.9 percent

As Table 21c shows, the use of public transportation also cut potential NOx emissions in 1999 by nearly 30,000 tons, or the equivalent of more than one-third of the NOx emissions generated by the metals processing industry or by all oil and gas producers.

Table 21c. Emissions of Nitrogen Oxides (NOx): Benefits of Public Transportation versus Emissions by Industries, 1999, Short Tons[37]

	Emissions Benefits from Public Transportation and Emissions by Industry	Public Transportation Savings as Share of Industry Emissions
Public Transportation Benefits	29,943	---
Industrial Use of Coal	542,000	5.5 percent
Chemical Manufacturing	131,000	22.9 percent
Oil and Gas Production	88,000	34.0 percent
Metals Processing	88,000	34.0 percent

Industry comparisons are less useful in evaluating the impact of public transportation on CO2 emissions. Virtually all CO2 pollution in the United States, or 98 percent, comes from burning fossil fuels – roughly one-third from fuel used by industry; a little less than one-third from fuel consumed in transportation; nearly 20 percent from the fuel American use to heat, cool and operate their homes; and the remaining 15 percent from fuel used by commercial

[36] *Ibid.*

[37] *Ibid.*

enterprises.[38] Since more than 30 percent of CO2 emissions come from transportation, and public transit accounts for only about one percent of vehicular transportation, its benefits as measured by CO2 reductions may appear modest. Nevertheless, as Table 22 shows, public transportation measurably reduces CO2 pollution, as a proportion of all the CO2 produced by driving, as well as VOCs, CO and NOx.

Table 22. Environmental Benefits of Public Transportation As a Share of All Pollution Produced by Driving, 1999, Metric Tons

	VOCs	CO	Nox	CO2
Reductions from Use of Public Transportation	**70,431**	**744,927**	**27,164**	**7,405,856**
Total On-Road Emissions	**5,213,326**	**49,199,350**	**8,454,308**	**1,349,200,000**
Percentage Benefit	**1.35%**	**1.5%**	**0.3%**	**0.5%**

Virtually all public transportation systems in the United States are located in major metropolitan areas, and this concentration in dense urban and near-suburban areas increases public transportation's potential for providing greater environmental benefits. In most urban areas, almost all sources of pollution other than transportation are already tightly regulated. The only significant approach that remains for achieving major reductions in pollution is to focus more on emissions produced by driving, and therefore increasing the use of public transportation is the only strategy currently available that could achieve this without more regulation.

The greatest environmental and economic benefits would be derived from greater use of public transportation, especially rail, in those areas where the air quality is poorest and the population density is greatest.[39] Almost half of the 35 largest public transportation systems, serving 26 metropolitan areas, are located in areas that currently fail to meet EPA air-quality standards for ozone (produced when VOCs and NOx combine with sunlight) or CO.[40] The nation's two largest metropolitan areas, New York and Los Angeles, fail to meet these standards in both ozone and CO. For all the highly-populated, urban and suburban "non-attainment areas," the major reductions in pollution that public transportation can deliver, compared to private vehicles, would directly go to the environmental bottom line.

[38] Environmental Protection Agency, *Carbon Dioxide Emissions*, Table ES-8: "C02 Emissions from Fossil Fuel Consumption by End Use Sector," www.epa.gov/globalwarming/emissions/national/co2.html.

[39] While public buses reduce pollution per passenger mile, compared to automobiles, electrically-powered rail systems often not only reduce the per-passenger-mile emissions, but also remove them physically from these highly populated urban areas. Hence, reducing pollution in these regions could provide health and other benefits far greater than what might be inferred from the estimated emissions reductions calculated above.

[40] In addition to New York and Los Angeles, the following metropolitan areas fail EPA tests for ozone (VOCs and NOx): Washington, D.C., San Francisco, Atlanta, Baltimore, Houston, San Diego, Pittsburgh, Milwaukee, Dallas, San Jose, St. Louis and Hartford. In addition, Minneapolis and Las Vegas fail to meet EPA standards for CO. *Public Transportation Fact Book, op. cit.*, Table 2; *National Transportation Statistics*, *op. cit*., Table 4-48.

There is no simple formula to determine the energy savings and environmental benefits from the use of public transportation in a particular local or metropolitan area. Local authorities can estimate the savings and benefits of their own public transportation systems by adapting the approach of this study to their own communities.

1. Gather data on the number of passenger miles and vehicle miles traveled in the local or metropolitan area by each mode of public transit.

2. Calculate the energy use by the area's public transportation systems: Multiply the vehicle miles for each mode of public transit by the Btus per-vehicle-mile for that mode provided in Table 10. Add the results to determine total energy use by the locality's public transit.

3. Calculate the pollution produced by public transportation: Multiply the vehicle miles for buses and diesel-powered rail public transit in the area by the mode's emissions in grams-per-vehicle-mile provided in Table 16a, and multiply the total energy used by electrically-powered rail public transit systems in the area by the emissions per MKWH in Table 16b. Add the results to determine the total pollution produced by the locality's public transit.

4. Calculate how much fuel would be used if private vehicles replaced public transit: Multiply the locality's total public transportation passenger miles by 5,254.8, the Btus per-passenger-mile for "replacement" vehicles from Table 13.

5. Calculate how much pollution would be produced if private vehicles replaced public transit: Multiply the locality's total public transportation passenger miles by 0.826 (the ratio of the private vehicle replacement miles to the public-transit passenger miles being replaced, from Table 19), and multiply by the weighted-average pollution emissions for private vehicles, in grams/vehicle mile, from Table 18.

6. Estimate the energy savings from the use of public transportation: Subtract the energy used by public transit (step 2) from the energy needed if private vehicles replaced public transit (step 4).

7. Estimate the environmental benefits of public transportation: Subtract the pollution produced by public transit (step 3) from the pollution that would be produced if private vehicles replaced public transit (step 5).

Public transportation would produce much greater environmental benefits, if more Americans left their cars at home and used the transit systems already in place. Canadians use public transportation at seven times the American rate, and Europeans use buses and trains ten times as much as Americans.[41] If we matched Canadians in the use of public transportation, it would reduce potential CO pollution by nearly twice the combined levels emitted by four high-polluting industry groups (chemical manufacturing, oil and gas production, metals processing, and industrial uses of coal). It also would cut potential NOx pollution by one-fourth of the combined NOx emissions from the four industries, and the reductions in VOC pollution would be equivalent to almost 60 percent of the combined VOC emissions of the four industries.

Similarly, if Americans used public transportation at the same rate as Europeans, it would reduce CO emissions by almost three times the combined CO output of the four industries identified above, and cut NOx emissions by more than one-third of the combined NOx pollution from these four industries. The reductions in VOC pollution would be equal to more than 84 percent of the total VOC emissions from these industries.

Turning to global warming, the use of public transportation reduces potential CO2 emissions by 7,405,856 metric tons. If we used public transit at the rate Canadians do, we would save more than 50 million metric tons of CO2; and if we matched the Europeans, we could cut CO2 emissions by about 74 million metric tons. At the Canadian rate, the benefits for global warming in the United States would equal nearly 20 percent of all CO2 emitted from fuel burned for residential uses and more than 20 percent of the CO2 emitted by commercial enterprises. If we used public transit as often as Europeans do, the gains for climate change would equal nearly one-fourth of the reductions mandated by the Kyoto agreement.[42]

Table 23. Emissions of Carbon Dioxide (CO2):
Benefits of Public Transportation as a Share of Emissions By Sector, 1999[43]

End-Use Sector	Sector CO2 Emissions (Metric Tons)	Public Transit CO2 Benefits, as a Share of Sector Emissions	Public Transit Benefits at the Canadian Rate of Use, as a Share of Sector Emissions	Public Transit Benefits at the European Rate of Use, as a Share of Sector Emissions
Industrial	486,518,200	1.5 percent	10.6 percent	15.2 percent
Transportation	468,109,100	1.6 percent	11.1 percent	15.8 percent
Residential	283,490,900	2.6 percent	18.3 percent	26.2 percent
Commercial	235,636,400	3.1 percent	22.0 percent	31.4 percent

[41] Jeffrey Kenworthy and Felix Laube, "A Global View of Energy Use in Urban Transport Systems and its Implications for Urban Transport and Land-use Policy," *Transportation Quarterly*, Vol. 53, No. 4, Fall 1999, pp. 23-48; *Transport Fact Book*, www.publicpurpose.com/tfb-cheujpus98-pkm.htm.

[42] Whether such gains could be achieved on a cost-effective basis is an important focus for future research.

[43] The EPA now reports CO2 emissions using the new measure, "Teragram CO2 Equivalents" or TgCO2Eq. TgCO2Eq = 1 million Metric Tons of Carbon Emitted (MMTCE) times (44/12). Emission by sector: EPA, *Carbon Dioxide Emissions*, Table ES-8, *op. cit.*

IV. Conclusion

Greater reliance on more fuel-efficient means of travel, especially use of public transportation is the key to the United States achieving greater energy independence and environmental progress.

The facts are clear and indisputable. For every passenger mile traveled by Americans, public transportation consumes about one-half the fuel and energy of private automobiles, SUVs and light trucks. For every passenger mile traveled by Americans, public transportation produces only five percent as much carbon monoxide, less than ten percent as much volatile organic compounds, and little more than half as much carbon dioxide and nitrogen oxides. Greater use of public transportation offers the most effective strategy available for achieving significant energy savings and environmental gains without imposing new taxes, government mandates or regulations.

At our current levels of use, every year public transportation saves close to one billion gallons of gasoline and reduces harmful emissions by millions of tons. Increasing Americans' use of public transit would produce even greater benefits for our nation's economy, security and environment.

This is an achievable goal – and one that Americans had formerly attained. In the early 20th century, America led the world in mass transit development and use. Today, there are signs of a transit renaissance. Since 1995, use of public transportation has grown faster than the use of private vehicles. Passenger miles ridden on public buses and rail systems have grown faster than the passenger miles ridden in private automobiles, sports utility vehicles (SUVs) and light trucks. As ridership increases, so will the energy savings and environmental benefits.

Both pragmatism and patriotism can become catalysts for much greater use of public transportation. As a practical matter, increasing transit use may be one of the most feasible -- and desirable -- strategies for sharply reducing our dependence on foreign oil and making historic strides in environmental quality. As a act of civic commitment, many Americans may view riding public transportation, even on a limited basis, as a small but important contribution to our country's well being. As this study demonstrates, if one out of ten people shifted his or her daily transportation from private vehicle to transit, or if the general public used transit for only 10 percent of its daily transportation needs or used public transportation for three days every month, the energy savings and environmental benefits would be enormous: the United States would no longer need to import oil from Saudi Arabia, every metropolitan area in the country would meet EPA air quality standards for smog and carbon monoxide, and America would achieve more than one-fourth of the reductions in global-warming emissions directed under the Kyoto Agreement.

Realizing these benefits does not depend on technology or new regulatory schemes, but rather on a political and economic commitment. By making public transit a key element of our nation's long-term transportation, energy and environmental policies, we can attain conservation and clear air goals that strengthen America.

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V. Methodology: A Review

The technical approach employed in this study to estimate the energy and environmental effects of public transportation is designed to be conceptually transparent and rely on readily available data. This ensures that the results can be easily understood and verified. In essence, we postulate a world without public transportation and estimate how much additional fuel consumption and pollutant emissions would occur if current users of public transit had to rely instead on private automobiles.

To do this, we first estimated the energy used and the pollution caused by public transportation. Buses account for roughly half of the more than 42.5 billion passenger miles that public transit systems provided in 1998; commuter rail, light rail, and heavy rail systems account for almost all of the other half of public-transit passenger miles. Public buses use primarily diesel fuel, with relatively modest amounts of other fossil fuels, while electricity powers most of the rail systems. The amount of fuels used in public transportation is determined by calculating the distance traveled by each mode of public transit and the fuel consumed by each mode to traverse those miles. The aggregate fuel consumption of each of the modes of public transit is converted to British thermal units (Btus) to arrive at the total energy consumed by public transportation systems.

Both public transit and private automobiles emit four major classes of pollutants into the environment: volatile organic compounds, nitrogen oxides, carbon monoxide, and carbon dioxide. For diesel-powered buses and commuter-rail locomotives, emissions are determined on a grams-per-vehicle-mile-traveled basis, which then is multiplied by the total miles traveled by these modes of public transit to calculate the total pollution produced by them. The emissions associated with electrically-powered light-rail and heavy-rail systems are calculated by determining the total emissions produced by utilities, in grams per million kilowatt hours (MKWH), which is then multiplied by the electric power in MKWH used by public transportation systems.

Once we calculate the energy needs and environmental costs associated with public transportation, we perform a thought experiment in which public transportation is no longer available and the passenger miles currently traveled on public transit occur instead in private automobiles, SUVs and light trucks. We do *not* assume that in a world without public transportation, all those currently using it would become lone drivers of private vehicles. Commuting to work or to school accounts for a majority of current passenger miles on public transportation, and a significant share of these trips involves at least two people in one vehicle (a driver and passenger). To accurately distribute the passenger miles from public transportation to private automobiles, we use the four-category distribution for private automobile travel from the 1995 Nationwide Personal Transportation Survey -- single driver with no passengers; driver plus one passenger; driver plus two passengers; and driver plus three or more passengers. Based on this distribution, we calculated the total number of automobile *vehicle miles* required to replace all the public transportation *passenger miles*. We multiply those vehicle miles by the average fuel consumption and pollution emissions, per mile, for passenger cars, SUVs, and light-duty trucks, in the appropriate proportions, to determine the fuel consumed and pollution emitted if current public transportation needs had to be met by private automobiles.

The difference between the fuel consumption and pollution levels associated with the current use of public transportation, and the higher levels of energy consumed and pollution emitted by the automobile trips required to replace public transit, provides an accurate measure of the net energy and environmental benefits of public transportation. These differences are expressed in a variety of ways to illustrate the dimensions of the current energy and environmental benefits of public transportation.

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Appendix

TABLES