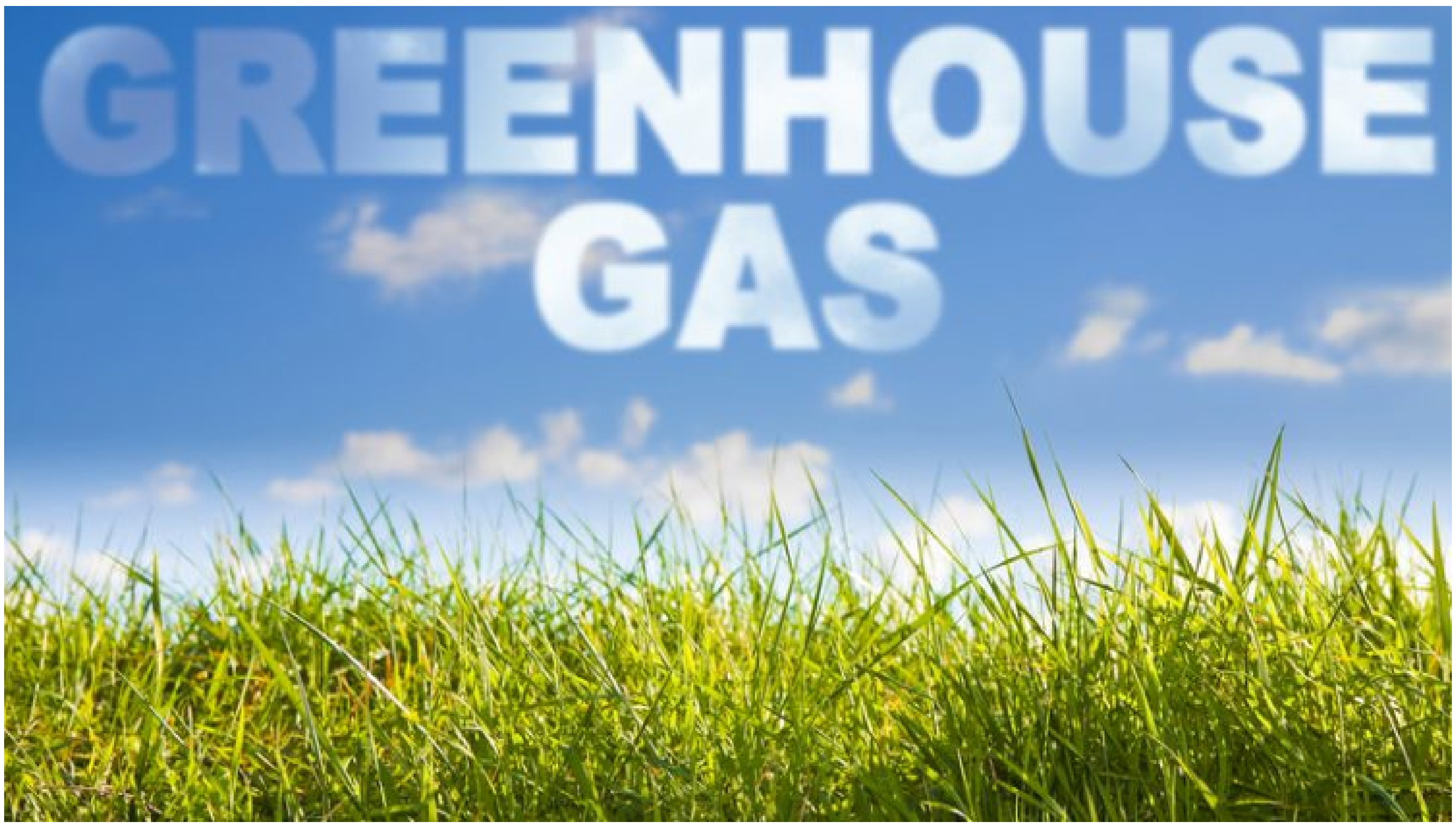

COMMENTARY

Does Bus Transit Reduce Greenhouse Gas Emissions?

Thomas Rubin, Marcy Lowe, Bengu Aytekin and Gary Gereffi Debate Public Transit Buses: A Green Choice Gets Greener

April 5, 2010

The American Public Transit Association claims that public transit saves an estimated 1.4 billion gallons of gas annually, which translates into about 14 million tons of CO2. *Time*'s Global Warming Survival Guide says "Ride the Bus." But does bus transit really reduce greenhouse gas emissions?

The latest major study in this debate says yes. Last October the Center on Globalization, Governance & Competitiveness, an affiliate of the Social Science Research Institute at Duke University, released the latest in a series of papers on climate change issues, *Public Transit Buses: A Green Choice Gets Greener*, by Marcy Lowe, Bengu Aytekin and Gary Gereffi. Public Transit Buses argues that bus transit dramatically reduces Green House Gas (GHG) emissions.

But Thomas Rubin, a mass transit consultant in Oakland, California, disagrees. He says the Duke University team has seriously distorted their analysis and that bus transit today is not greener than driving a car. Rubin was the Controller-Treasurer of the Southern California Rapid Transit District from 1989 until 1993 and has written many research reports on transit issues.

You can follow the link to read *Public Transit Buses*. Below, we present Tom Rubin's critique of that report, followed by a reply from the authors, and then a final response from Tom Rubin. – *Adrian Moore, Vice President of Research at Reason Foundation*

Part 1: A Critique of *Public Transit Buses: A Green Choice Gets Greener*
By Thomas A. Rubin

Which is "greener" – uses less energy and produces fewer emissions – riding in a transit bus or driving a car? While the results will vary depending on the particulars of the bus, the car, and how they are utilized, on average in the U.S., moving a passenger one mile in an auto uses less energy, and produces less emissions, per passenger-mile (one person traveling one mile) than carrying that person one mile in an urban transit bus.

However, researchers based at Duke University have reached a very different conclusion – but they have done so by assuming a bus passenger load over seven-and-one-half times the U.S. average and an auto passenger load 63% of the average, and prominently displayed the results produced by this extremely unrealistic mixture of assumptions in the first paragraph of their paper to produce maximum impact for their badly flawed hypothesis. This improper representation of the greenery of urban transit buses vs. the private autos must not be allowed to stand unopposed, for it could be utilized to justify very contraindicated governmental transportation decisions.

The Center on Globalization, Governance & Competitiveness (CGGC), an affiliate of the Social Science Research Institute at Duke University, has prepared a number of papers under the general title of *Manufacturing Climate Solutions – Carbon-Reducing Technologies and U.S. Jobs*. For the Environmental Defense Fund, it recently issued the latest component, Chapter 12, "Public Transit Buses: A Green Choice Gets Greener1."

The main message of the CGGD paper is that using transit buses to move people is very energy efficient and "green" compared to auto usage. Unfortunately, this conclusion is reached through the use of vehicle occupancy assumptions that are far removed from actual "real world" experience.

The central premise of the paper is stated in the Summary, first paragraph, first page:

Public transit substantially reduces fuel use and greenhouse gas emissions, making it a wise public investment in a new, carbon-constrained economy. A typical passenger car carrying one person gets 25 passenger miles per gallon, while a conventional bus at its capacity of 70 (seated and standing) gets 163 passenger miles per gallon. These fuel savings yield commensurate cuts in CO_2 emissions. A passenger car carrying one person emits 89 pounds of CO_2 per 100 passenger miles, while a full bus emits only 14 pounds. In addition, these benefits of conventional transit buses are further enhanced by a growing number of alternative options known as "green buses," including electric hybrid, all-electric, and other advanced technologies.

In the U.S., the average passenger load in a "conventional bus" in 2006 was 9.22 – slightly over one-eighth of the 70 factor used in the paper. Using the 2.33 bus miles/gallon (mpg) value on page two of the paper, this translates to 21.4 passenger-miles per gallon.

The average load in a "typical passenger car" in the U.S. was 1.58 in 20063. Using the 25 mpg in the CGGC paper above4, at 1.58 passengers/vehicle, that's 39.5 passenger-miles per gallon.

(I will not go into detail as to emissions per passenger-mile of CO_2 or other pollutants; simplifying greatly, in general, particularly for CO_2, emissions are proportional to energy usage.)

paggenger load factors

Now, to be fair, if we actually go to the energy use data from the National Transit Database (NTD) for 2006 (Table 17, Energy Consumption), and add up the diesel gallon equivalents of all the energy utilized to power (non-catenary electric) buses, the result is 3.91 mpg and, applying that, the result is 36.0 passenger-miles per gallon, which is fairly close to the result above for automobiles.

So, by CGGC's math, a transit bus loaded with an unusually high load provides 6.52 times the energy productivity of a passenger car with the absolute minimum possible passenger load.

By my calculations – which I will refer to, without any fear of being called to task, as "real world" – it was .54.

Which works out to an overstatement of right about a dozen times.

(If we utilized the actual 2006 average bus mileage factor of 3.91 mpg, versus the 2.33 mpg assumption of CGGC, the ratio would be approximately .89, with the auto producing about 12% more passenger miles per gallon of fuel than bus.)

My use of annual averages is somewhat unfair to buses for a variety of reasons. First, for autos, there is a significant amount of freeway driving, urban, rural, and inter-city, where high, constant speeds and high mileage factors are achieved – this type of travel is a relatively rare portion of urban transit bus usage.

Also, autos and buses are used very differently. Autos generally have their lowest load factors during peak periods, with most urban areas reporting statistics in the 1.10-1.15 range. There is far more peak hour utilization of bus than of auto as a percentage of total seat availability.

Auto mpg, like that of buses, is also lower during peak periods than the annual average. Also, most transit buses are diesel powered, and those that are not generally report their energy usage in diesel fuel Btu's equivalents, and diesel motor fuel has approximately 11% more Btu's per gallon than gasoline5.

Therefore, by using annual average statistics, I am working away from the situation where bus transit actually performs best. However, even if we assume that what CGGC was actually going for was peak hour auto usage, their assumptions are still far outside of the range of what has ever been actually achieved in the U.S. – particularly when one considers that, during the peak period, while buses are generally operating with their highest load factors on the *in*-bound trips in the morning and the *out*-bound trips in the evening, when these buses then return for their next peak hour, peak direction load, they are generally carrying far fewer passengers than in their peak direction trips.

While 70 passengers on a "standard" 40-foot, 102-in wide bus, is certainly not unheard of in the transit industry, this is hardly a typical load, even on most crowded bus lines for most transit agencies, even for peak hour in-bound trips. Street-running urban buses – unlike, for example, an airliner flying between New York City and Washington, D.C. – make many stops along their routes. Typically, a bus has a very small passenger load when it begins a route, picks up passengers more-or-less constantly as it approaches its peak load point, most commonly the leading edge of the central business district, and then has a steadily decreasing passenger load as it nears the end of the route. Therefore, unlike a NYC-DC airline flight, which can often have a 100% seated load (a passenger in every seat), even though buses can have standees, it is unusual for a local, street-running bus route to approach a 50% average seated load even during rush hour. Annual average seated load factors over one-third are achieved only by a small handful of urban bus operators in the U.S., chiefly those in the largest cities.

The 70 passenger load used by CGGC above is almost certainly the "peak" load, or at least close to it, which means that it is reached and maintained only for a fairly short portion of the line, and then only during the peak hours. Given that most modern "low-floor" 40-footers have around 39/40 seats, the previous generation perhaps around 43, and the maximum number of seats on a 40-footer being 51 (and that for buses that were operated decades ago), CGGC's 70 passenger load is a *very* large factor, even before considering the low-load return trips during peak hour operations.

For example, the Los Angeles County MTA operates to a 120% load factor, which means scheduling for a maximum of 48 passengers on its 40-seat 40-foot buses – and that is at the peak load point. It is rare for even the transit operators in the largest cities to have maximum load point factors over 150%6, which would be 60 total passengers on a 40-seat bus – and these are the projected maximums at the peak load point, not anything remotely close to a load factor for an entire bus trip.

For the past thirty years, there have been two big city local transit bus operators (as opposed to long-haul commuter express operators, such as those operated into the Port Authority Bus Terminal by several contractors for NJTransit) that have had the highest average passenger loads (passenger miles/vehicle miles) almost every one of those years, MTA-New York City Transit and Los Angeles County MTA. For the 2007 NTD reporting year, MTA-NYCT reported 15.6, and LACMTA reported 14.0 – neither of these is remotely close to the 70 passenger load factor assumption that CGGC utilizes so prominently7.

In my experience of well over three decades in the transit industry, it is extremely rare for even the most heavily utilized local bus lines to achieve a working weekday load factor of 25.

A 70 load factor, as an annual average, is something that, in the transit industry, cannot be found on any type of rubber tire, or even rail vehicle, *period*; even commuter rail, which operates very large cars for very long trips, doesn't average half of that on an industry-wide annual basis.

The use of a bus load factor of 70 in the CGGC publication, *for any purpose what-so-ever, particularly when presented as something that is actually reasonable to contemplate*, is totally without justification; it is so far divorced from any kind of reality to call into question if CGGC lacks the technical competence to publish such a report – or, perhaps, worse.

On page 2, the paper discusses how a bus with a passenger load of eleven was approximately "breakeven" on fuel economy with a single-passenger car, but:

1. Prominent place to the 70 load in the very first paragraph.
2. The passenger load of eleven is actually well above the U.S. bus transit industry average of 9.2 for 2006 (although there are many large-city bus operators who exceed this mark on a regular basis)
3. The comparison is still to a single-passenger – 1.00 passengers – automobile, which is far under the actual U.S. average.

Overall, the impact of the eleven load factor example was to appear to present a "worst case" bus comparison to the automobile, where, in fact, the bus utilization factor was still significantly overstated and the auto factor was significantly understated.

Even if the analysis is limited to peak hour transit, when auto passenger loads are far lower than the all-day, full-year average, the 1.00 factor is still unrealistically low – and, I submit, a comparison of only peak-to-peak can be done only with extreme care, as this is a minority of the usage of both autos and buses and, therefore, unlikely to be representative of the whole for either.

The historical trend also does not favor bus transit. From 1977 to 2007, bus average passenger load fell over 25%, from 12.2 to 9.1. From 1984 through 2007, bus miles per gallon first rose slightly, from 3.65 in 1984 to 3.84 in 1993, but, as the utilization of alternative fuels increased, fell to 3.43 in 2007, an overall decrease of 6% from 1984 to 2007. When the combined effects of lower average passenger loads and lower miles per gallon are combined, passenger-miles per gallon fell 27%, from 42.8 in 1984 to 31.3 in 20078.

From 1970 to 2007, U.S. auto fuel economy increased 67%, from 13.5 mph in 1970 to 22.5 mph in 20079.

In fact, with the exception of a few U.S. transit operators, including MTA-NYCT, there is considerable question if transit has *any* energy and emissions advantages over automobiles *at all* at the present time – and, given the historical trend, and that there appears to be very significant likelihood for major progress being made for automobiles in both regards over the upcoming years, I am not prepared to concede that buses can get "greener" faster than automobiles in the foreseeable future10.

While the paper's endorsement of newer vehicle technologies is somewhat less objectionable, these cover a wide range of technologies and, at the present time, practicalities. Compressed natural gas (CNG) and liquefied natural gas (LNG) have become very prominent in the transit bus industry, even to the point of some old-time vehicle maintenance supervisors expressing a preference for them. However, other modes mentioned in the DGGC paper – particularly hydrogen fuel cell – are so far away from practical use that, when the California Air Resources Board was (again) considering actually implementing its long-planned zero-emission-bus rule, it was widely opposed – including by the California Sierra Club.

The purpose of this critique is *not* to attempt to show that buses are bad for energy use, air quality, or the economy. It is, rather, to show that any proposal to achieve improvements in any of these through transit, including bus transit, must be based on a realistic presentation of the current situation, the historical trend, and the *practical* potential for improvement. Any evaluation based on wholly ridiculous bus load factors and misstatements of auto load factors, using this analysis as the basis for future promises of improvements, fails this test badly.

Thomas A. Rubin, CPA, CMA, CMC, CIA, CGFM, CFM has over three decades of transit industry experience as the chief financial officer of two of the largest transit operators in the U.S., including the Southern California Rapid Transit District in Los Angeles, and as a consultant and auditor to well over 100 transit operators, metropolitan planning agencies, state departments of transportation, the U.S. Department of Transportation, and industry suppliers. He has presented well over 100 papers on a variety of topics at industry conferences.

Part 2: A Response to Thomas Rubin's Critique Of
Public Transit Buses: A Green Choice Gets Greener
By Marcy Lowe, Bengu Aytekin and Gary Gereffi

The report in question, released in October 2009, is a value chain analysis of the U.S. transit bus manufacturing industry. Its main purpose is not to analyze fuel efficiency, but rather to map out the U.S. supply chain for the manufacture of transit buses. We identify the lead firms across the bus supply chain, including original equipment manufacturers, system builders, and producers of components ranging from engines to interior lighting, along with a large after-market segment. Our purpose is to highlight how many U.S. jobs are involved in this supply chain, what types of jobs they are, and where they are located.

The main message of our report is that although the U.S. transit bus manufacturing industry is small, these jobs are widely dispersed throughout the Eastern United States and California-and there is plenty of opportunity to fill increasing bus orders with domestic production if U.S. transit policy were to shift to a greater emphasis on public transit. Our study places special emphasis on electric hybrids and other "green buses," that is, those that run on alternatives to diesel or gasoline, because we believe these vehicles offer sustainable growth potential for the industry.

Throughout the report we emphasize that public transit is an underused option in the United States. As we note in the report, the 70-person figure cited in our fuel comparison does not refer to actual bus occupancy in average U.S. conditions, but rather to the capacity of the standard bus type we focus on in our supply chain. The actual number of occupants per bus in the U.S. varies widely, of course, ranging from a full bus in New York City during rush hour to a little-used bus operating in a small urban area during off-peak hours. Because our focus is U.S. jobs linked to the domestic manufacture of buses, our report does not attempt to calculate vehicle occupancy figures that would reflect the wide range of actual U.S. conditions.

We appreciate your interest in our report. We hope it adds a useful perspective to the ongoing discussion concerning the most promising public transit options and their job creation potential in the United States.

Part 3: Thomas A. Rubin's Response

The reply makes it clear that the "… main purpose [of the paper] is not to analyze fuel efficiency." As there is no response to, or exception taken to, the data cited in our original critique, which utilized actual vehicle occupancy and fuel mileage data, nor the calculations deriving there from, it appears that our conclusion – that the private auto is superior to transit buses in fuel efficiency and emissions per passenger mile, for the national as a whole and for most specific travel situations, is not disputed by CGGC.

Since the focus of the report is on "U.S. jobs linked to the domestic manufacture of buses," it would appear reasonable for the paper to discuss and compare the creation of jobs from the manufacture of passenger cars in the same manner as the paper compared fuel efficiency of buses vs. automobiles (which resulted in conclusions regarding "greenness" that CGGC now appears to have abandoned). However, this was not a part of the paper.

A detailed calculation of comparative job creation is far beyond what we have the space to get into in this short paper. However, let us see what we can come up with by making a number of admittedly very simplistic assumptions.

As was cited in the first posting, the average vehicle occupancy for transit buses in the U.S. was 9.21, and for passenger car vehicles, 1.58 in 2006. This means it takes an average of approximately 5.83 passenger cars to carry the average load of a bus (9.21/1.58).

Using the average price per 40-foot bus of $342,55811 in 2006, the year for these occupancy figures, that would mean that, to achieve equivalent cost per average passenger load, the cost of the passenger cars would be approximately $58,766, prior to adjustment for the lifetime utilization of buses and passenger cars. I will arbitrarily adjust this by a factor of 2, representing my approximation of the ratio of lifetime bus vs. passenger cars miles12, resulting in an average "equivalency" cost per auto of $29,383 (not adjusting for the time value of money).

The actual average cost per new car in 2006 was $22,65113, approximately 77% of the calculated equivalency price above. If we make one more assumption – that the labor component per dollar of price for buses and passenger cars are equal – then it would appear that building buses to create passenger-miles does generate more jobs than does building passenger cars. While, admittedly, there are a large number of assumptions in the above calculation, the 1.3:1 ratio of the end calculation does appear to leave a "fudge factor" of some size.

However, one might ask, is the purpose of transportation to create jobs manufacturing vehicles? Or is it to move more people, and to move them further (leaving aside goods movement for the current discussion)? Which is more important, creating jobs or using taxpayer subsidies as cost-effectively as possible – particularly when this means moving people will mean lower taxes, or that more people can be moved further for the same number of taxpayer dollars? (For now, let us not get into discussions of transportation policy as a means of achieving "superior urban form," or of transit to actually contribute meaningfully to the achievement of such objectives; as for energy efficiency and "greenness," these were discussed in the first critique, resulting in the passenger car being shown as superior, which has not been challenged by CGGC).

Perhaps one answer to this conundrum may be found in 49 USC 5323(j)(2)(C), formerly know as the Urban Mass Transportation Act of 1964, as Amended, which requires that for Federally funded "rolling stock" procurements (including buses), "… the cost of components and subcomponents produced in the United States is more than 60 percent of the cost of all components of the rolling stock; and … final assembly of the rolling stock has occurred in the United States" unless "including domestic material will increase the cost of the overall project by more than 25 percent."

From this provision, it does appear clear that creating U.S. jobs is a higher priority for public transportation in the U.S. than more cost-effective utilization of taxpayer funds, as so determined by the U.S. Congress.

Which is not necessarily the same thing as saying as this is the preference of the taxpayers and transit users of this nation.

And it does make one wonder a bit about the intended meaning of "competitiveness" in the name, Center on Globalization Governance and Competitiveness.

Footnotes

1 Marcy Lowe, Bengu Aytekin and Gary Gereffi,
http://www.cggc.duke.edu/environment/climatesolutions/greeneconomy_Ch12_TransitBus.pdf
October 26, 2009, Center on Globalization, Governance & Competitiveness, Duke University, accessed January 18, 2010.

2 U.S. Department of Transportation, Federal Transit Administration, National Transit Database (NTD), 2006, Table 19, "Transit Operating Statistics: Service Supplied and Consumed," total of directly operated + purchased transportation services passenger miles of 20,390,185,933, divided by total of directly operated + purchased transportation services vehicle total miles of 2,214,041,933.

Note utilization of vehicle total miles for the denominator, vice vehicle revenue miles. The primary difference between these two statistics is "deadhead" miles, such as driving a bus from the operating yard to the beginning of the first trip in the morning, and then back at the end of the day. Even though the buses are not carrying any passengers while deadheading from operating yards to/fm the beginnings and ends of bus lines and otherwise not in service to passengers, they are using fuel for such movements, which must be accounted for in the calculation of energy usage to produce human mobility.

http://www.ntdprogram.gov/ntdprogram/data.htm

3 (U.S. Department of Transportation, Research & Innovative Technology Administration, Bureau of Transportation Statistics, *Pocket Guide to Transportation 2009 (Pocket Guide)*, Passenger Car Passenger-Miles, 2006, 2,658,621 million, Table 4-3, "Passenger-Miles: 1990-2006, page 19; divided by Passenger Car Vehicle Miles, 2006, 1,682,671 million, Table 4-1, "Vehicle-Miles: 1990-2006," page 17:
http://www.bts.gov/publications/pocket_guide_to_transportation/2009/pdf/entire.pdf
Accessed January 19, 2009.

4 *Ibid*., Table 6-1, "New Passenger Car and Light Truck Fuel Economy Averages, Model Years 1985-2008," auto miles/gallon increases from 27 to 30 mpg over this period.

5 Stacy C. Davis, Susan W. Dielgel, and Robert G. Boundy, *Transportation Energy Data Book – Edition 28 (Transportation Energy)* (ORNL-6984), U.S. Department of Energy, Oak Ridge National Laboratory, 2009, Table B.4, "Heat Content for Various Fuels," page B-4, accessed February 1, 2010:
http://cta.ornl.gov/data/tedb28/Edition28_Full_Doc.pdf

The values shown are 125,000 Btu/gallon for conventional (non-aviation) gasoline and 138,700 for diesel motor fuel.

Emission factors are also very different between automobiles, which are primarily gasoline powered at this time, and buses, which, at the present time, are primarily diesel powered (74.5% of the motor [non-electric] bus diesel fuel equivalent energy use was diesel in 2006), NTD 2006, Table 17. CO2 emissions per gallon of diesel are approximately 15% higher than that of gasoline (*Transportation Energy*, Table 11.11, "Carbon Dioxide Emissions from a Gallon of Fuel," page 11-15). Other factors – CO, NOX, PM, etc. – vary in ways more complex that can be approached in this paper.

6 Prior to MTA agreeing to reduce its load factors to 120% as part of its settlement of the Federal Title VI (discrimination in the utilization of Federal funding) lawsuit, Labor/Community Strategy Center v MTA, MTA utilized a 150% load factor for its surface bus routes serving the Los Angeles central business district during peak hours.

NTD, Table 19, 2007.

American Public Transportation Association, *2009 Public Transportation Fact Book – Appendix A: Historical Tables*, author's calculations from Table 2: Passenger Miles by Mode, Table 6: Vehicle Total Miles by Mode, Table 30: Fossil Fuel Consumption by Mode, and Table 32, Bus Fuel Consumption. Accessed February 1, 2010:
http://www.apta.com/resources/statistics/Documents/FactBook/2009_Fact_Book_Appendix_A.pdf

APTA's *Transit Fact Book* series uses, primarily, the same data as reported to U.S. DOT for NTD; however, for the motor bus mode, it includes some operators not reporting to NTD, so there are often minor variations between NTD and APTA bus data.

9 *Transportation Energy*, Table 4.1, "Summary Statistics for Cars, 1970-2007," page 4-2. Note that this report is on the average fuel mileage for all cars on the road in the year being reported, as opposed to the miles per gallon data from the *Pocket Guide*, which reports mpg for new vehicles only for the year being reported upon.

10 For a more factually driven analysis of transit vs. automobile energy utilization and emissions, I recommend Randal O'Toole, *Does Rail Transit Save Energy or Reduce Greenhouse Gas Emission?"* Cato Institute, Policy Analysis 615, April 14, 2008:

http://www.cato.org/pub_display.php?pub_id=9325

(Despite the title, the paper includes data for many transit modes, including buses.)

11 Dana Lowell, William P. Chernicoff, and F. Scott Lian, MJ Bradley & Assoc., for U.S. Department of Transportation, *Fuel Cell Life Cycle Cost Model: Base Case and Future Scenario Analysis* (DOT-T-01), June 2007, Table 8, "Weighted Average Bus Prices (2006 APTA Transit Vehicle Database)," page 13, accessed February 15, 2010: http://hydrogen.dot.gov/projects_across_dot/publications/fuel_cell_bus_life_cycle_cost_model/report/pdf/entire.pdf

12 This calculation is the best I can do for an adjustment factor for the useful lives of auto's vs. buses. Unfortunately, it is difficult to come up with comparable data.

For 2006, the median age of passenger cars in the U.S. was 9.2 years (U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 2008*, Table 1-25, "Median Age of Automobiles and Trucks in Operation in the U.S.," accessed February 15, 2010: http://www.bts.gov/publications/national_transportation_statistics/2008/html/table_01_25.html)

For 2006, the average age of full-sized transit buses was 7.6 years, (*National Transportation Statistics 2008*, Table 1-28a, "Average Age of Urban Transit Vehicles.," accessed February 15, 2010: http://www.bts.gov/publications/national_transportation_statistics/2008/excel/table_01_28a.xls)

(Of course, the median value is not usually the same as the average value.)

As to average annual mileage per vehicle, for buses, for the 2006 reporting year, it was 30,030 (American Public Transportation Association, *2008 Public Transportation Fact Book*, "Table 51:Bus and Trolleybus National Totals, Fiscal Year 2006, 2,494.9 million Vehicle Total Miles divided by 83,080 Bus Revenue Vehicles Available for Maximum Service: http://www.apta.com/resources/statistics/Pages/transitstats.aspx

For passenger cars for 2006, the average was 12,427 miles (U.S. Department of Transportation, Bureau of Labor Statistics, *Pocket Guide to Transportation 2009*, 1,682,671 million passenger car vehicle miles (Table 4-1, "Vehicle-Miles, 1990-2006), divided by 135,399,945 automobiles (Table 4-2. "Number of Aircraft, Vehicles, Railcars, and Vessels: 1990-2006" – the notes to these table makes it clear that "automobiles" in Table 4-2 has the same meaning as "passenger cars" in Table 4-1).

If we assume that median age is the same as average age, and that miles driven are constant over the vehicle life, and that average/median age is directly proportional to total useful life for both buses and passenger cars (all admittedly questionable assumptions), then the bus miles to median life are 228,.228 (7.6 years x 30,030 miles/year), and, for passenger cars, 114,328 miles (9.2 years x 12,427), or a ratio of 1.996:1 – which we shall round to 2:1

13 U.S. Department of Energy, "Fact #520: May 26, 2008, Average Price of a New Car, 1970-2006, accessed February 15, 2010: http://www1.eere.energy.gov/vehiclesandfuels/facts/printable_versions/2008_fotw520.html