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Rail Efficiencies

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Tags: air travel, energy efficiency, rail, railroad [list all tags]

This is a guest post by Hans Noelder, a mechanical engineer and cofounder of the Madison Wisconsin Peak Oil Group. This is a link to Hans' blog, where this originally was posted.

Having recently traveled from my home near Madison, Wisconsin to Pontiac, Michigan using rail as much as possible (Metra commuter rail from Harvard, Illinois to Chicago and thence Amtrak to Pontiac) it is clear to me that investments in rail-based transportation could yield substantial environmental and social benefits in this region of the United States – primary among them a massive reduction in automobile-centric sprawl. The synergy between rail transit and dense, pedestrian-oriented urban habitat is especially clear in the Chicago heartland. Her leaders – God bless them! – never allowed their transit system to collapse, much less be systematically dismantled by transit-averse business interests.

However, I am troubled by the various claims I've seen over the years regarding energy consumption and CO_2 emissions per passenger-mile for trains/streetcars versus automobiles versus airplanes.

Table 2.12
Passenger Travel and Energy Use, 2006

	Number of vehicles (thousands)	Vehicle-miles (millions)	Passenger-miles (millions)	Load factor (persons/ vehicle)	Energy intensities (Btu per vehicle-mile)	Energy intensities (Btu per passenger-mile)	Energy use (trillion Btu)
Cars	**135,399.9**	**1,682,671**	**2,641,793**	**1.57**	**5,514**	**3,512**	**9,277.7**
Personal trucks [a]	**87,223.1**	**910,229**	**1,565,595**	**1.72**	**6,785**	**3,944**	**6,175.5**
Motorcycles	**6,686.1**	**12,401**	**14,881**	**1.2**	**2,226**	**1,855**	**27.6**
Demand response [b]	**42.0**	**978**	**930**	**1.0**	**13,595**	**14,301**	**13.3**
Vanpool	**6.6**	**99**	**605**	**6.1**	**8,048**	**1,322**	**0.8**
Buses	[c]	[c]	[c]	[c]	[c]	[c]	**196.0**
Transit	83.0	2,498	21,998	8.8	37,310	4,235	93.2
Intercity [d]	[c]	[c]	[c]	[c]	[c]	[c]	29.8
School [d]	669.2	[c]	[c]	[c]	[c]	[c]	73.0
Air	[c]	[c]	[c]	[c]	[c]	[c]	**2,139.9**
Certificated route [e]	[c]	6,003	577,620	**96.2**	**313,776**	3,261	1,883.6
General aviation	221.9	[c]	[c]	[c]	[c]	[c]	256.3
Recreational boats	**13,080.0**	[c]	[c]	[c]	[c]	[c]	**247.7**
Rail	**19.5**	**1,282**	**31,000**	**24.2**	**68,097**	**2,816**	**87.3**
Intercity (Amtrak)	0.3	264	5,410	20.5	54,167	2,650	14.3
Transit (light & heavy)	12.8	715	16,117	22.5	62,797	2,784	44.9
Commuter	6.4	303	9,473	31.3	92,739	2,996	28.1

Table 2.12 from Department of Energy's Transportation Energy Data Book #27 Click for larger image.

Environmental organizations and sustainability advocates routinely assert that energy consumption for passenger rail is much "greener" than driving or flying. But Tables 2.13 and 2.14 (summarized in 2.12, above) in the Department of Energy's Transportation Energy Data Book #27 indicate that existing Amtrak intercity passenger rail is only 25% more efficient than the fleet average for cars; furthermore, Amtrak is only 19% more efficient than air travel!

Given the greater-than 80% reductions in GHG emissions we need to achieve in the coming decades, and given the fact that new CAFÉ standards mandate a 40% improvement in the mileage of cars ***and*** SUVs by 2020, efficiency gains from passenger rail of 19% to 25% seem paltry. Moreover, due to basic laws of aerodynamics, the efficiency of high speed rail (i.e. trains moving at 150-300 mph) will inevitably be less than trains moving at 50-100 mph. While I cannot recall the source at present, I am quite sure I have seen credible data within the last five years which indicated that Bullet Trains in Japan were no more energy-efficient on a passenger-mile basis than airplanes.

Of course the real issue vis a vis energy and CO_2 is the ***practical*** potential for these transportation modes in the future, not the ***existing*** efficiencies of each as currently deployed. During the past half-century, aerospace companies (with lavish financial support from the Department of Defense) have pursued the most ambitious research and development programs by far of any “transportation” industry in the United States. Along the way, improvements in engines, aerospace materials, and aircraft designs have yielded astonishing increases in the efficiency of air transport (almost ten-fold). And even though they vigorously marketed absurdly inefficient cars in the '60's and then gas-guzzling SUVs and pickup trucks more recently, automobile companies also made notable investments in R&D during the same time period; consequently the energy efficiency of engines and transmissions were substantially improved. (It is the sheer size and weight of SUVs and pickup trucks which make them gas hogs, not their drive-trains.)

Meanwhile, passenger rail locomotives and rolling stock in our nation changed very little even as ridership plummeted (until recently) and domestic engineering activity all but ground to a halt. Thus we must ask how efficient our passenger trains ***could be*** if they were constructed with aerospace materials, up-to-date engineering, etc. What if hybrid drives and regenerative braking were widely deployed? What if more trains were electrified? What if the expansion of electrified rail were coordinated with upgrading the national electrical grid? Having languished for so long, surely our passenger railroads are ripe for major improvements!

And there are sound reasons to believe that investing in rail technologies rather than airplanes or automobiles is likely to produce the biggest efficiency gains overall. Thanks to many decades of top-notch engineering, aircraft have already approached their theoretical efficiency limits; thus spending billions more on R&D probably won't change efficiencies by more than a percent or two. Similar logic applies to automobile R&D generally, although electric cars and battery technologies might prove to be an excellent gamble. Even so, such breakthroughs in "automotive" technology might be used to equal or greater advantage in trains rather than cars. Given the nature of "fixed costs", it is usually much cheaper to install a particular technological improvement in a single unit – say, a locomotive that moves 250 people – than to install that improvement in many units – say, 250 cars that move 250 people.

Usage factors must be carefully considered also; the percentage of empty seats makes an

enormous difference in passenger-miles per unit of energy or pound of CO_2. (While the vehicle occupancy of automobiles cannot (yet!) be less than one, trains and airplanes often travel with relatively few passengers – and sometimes with none at all.) How much more usage-efficient is existing Amtrak service along the heavily-used Washington-Boston corridor versus lightly traveled routes in the "hinterlands"? How efficient is the best existing passenger rail in Europe? Japan? Practically speaking, what kind of usage factors could we expect for high-speed service along a Chicago-Milwaukee-Madison-Minneapolis route?

Given our worsening ecological circumstances, our unsustainable consumption of natural resources, and the prospects for a long and severe recession, America desperately needs ***facts*** rather than urban myths and "green-washing"; we need ***reality***-based planning rather than cheerleading and poorly conceived, hastily-approved public works projects. We must thoroughly analyze the efficiencies of our existing transportation modes, soberly review existing and practically-achievable alternatives, and then responsibly choose those transportation arrangements our heirs can afford in the future. This is not the time to shoot from the hip, "wish upon a star", or print our money into hyperinflation!

And throughout it all we must never forget this elemental fact: proximity is the most efficient form of "transportation" that will ever exist. There is nothing like already being within a short stroll, a flight of stairs, or a quick bicycle ride from where we want to be. Our greatest challenge is to stop manufacturing so many "needs" for more complex, ecologically-disruptive forms of transportation in the first place!