US Railroad Passenger Miles Per Gallon

by David S Lawyer

Introduction

This paper, under the title "US Railroad Passenger Miles Per Gallon", originally researched in 1973 and first written in 1998, examines the fuel consumption characteristics in terms of passenger miles per gallon on US railroads between 1936 and 1963. The author describes the basis of the calculations and how the data must be modified to account for statistical errors to obtain realistic figures. This is Version 1.4, dated July, 2000 and edited. David has a website with further articles here

Contents

Background

Between 1936 and 1963 the Interstate Commerce Commission (ICC) collected statistics from all class I railroads in the United States related to energy efficiency. From this information one may estimate the passenger-miles per gallon (pass-mi/gal) of fuel used on diesel-powered passenger trains. The key statistical publication which permits this is entitled "Fuel and Power ..." (see Appendix 1) which was first published in 1936 and ceased publication in 1963. To the authors knowledge, no one else has published such estimates. Obtaining these estimate was not straightforward. One difficulty is that the ICC did not publish a retrospective compilation covering several years. Furthermore, there are 3 different documents that one should check for each year between 1936 and 1963. But there are many more serious difficulties.

Methodology

One might think that it's simple to find pass-miles/gallon. Just divide pass-miles by the gallons used. This can't be done for two reasons:

1. A substantial percentage of passenger train fuel was used for the transport of "freight", mainly mail and express. In 1963 one may estimate that almost 40% of passenger train fuel was used to transport such "freight". There were many mail trains which carried only mail (or sometimes a small number of passengers as well).
2. Passenger-miles were not differentiated by fuel. In 1936, coal predominated as a fuel so one could not just divide passenger-miles on mostly coal-powered trains by gallons of diesel fuel. In addition, electric energy was used by some railroads in the NE U.S. as well as for several hundred miles in the West from Montana to the Pacific.

There is a way around this problem. Statistics were kept of both miles per gallon for rail passenger cars and passenger-miles per passenger-car-mile (the average number of passengers per car; see Appendix 2). Unfortunately the number of passenger per car was not differentiated by fuel. But these figures still may be used if one assumes the number of passengers per rail-car was roughly the same for steam-powered and diesel-powered trains. Since the ICC did publish gallons per car-mi all that (seemingly) is needed is to divide the average number of passengers per car by gallons per car-mi. The results is in units of passenger-miles per gallon. Note that since the passengers-per-car statistic only counted real passenger cars (with seats for revenue passengers), the problem regarding cars used for "freight" is seemingly solved. But such a calculation is also fatally flawed.

Why is this wrong, after all, the units come out correct in pass-mi/gal? One might at first guess that the error is because the energy content of diesel fuel is about 10% higher than that for gasoline. Since people may use the resulting pass-mi/gal figure to compare rail energy efficiency to the auto, a conversion to gasoline-equivalent gallons needs to be made.

But there still remains a very serious error. It is due to fact that the pass-mi per car-mi is only for strictly passenger cars and excludes the car-mi of club, lounge, dining, observation, and baggage cars. Most of the energy used to haul these types or rail cars should be allocated to the transportation of passengers. Fortunately, statistics were kept on the car-mi of such cars (see Appendix 3) except that baggage cars were included in "other cars". Baggage cars were often used for mail and freight in addition to the baggage of passengers. To estimate this I assumed that only 1/2 of a baggage car was used per train to transport the baggage of the passengers. This may be understating the fuel used for passengers but there is still another possible problem.

Does moving a mail or baggage car used for transporting freight use the same energy per car-mile as a passenger car? While such "freight" cars may be heavier and thus use more energy per mile, there are two reasons why they might not use as much fuel as expected.
1. Passenger trains expend a significant portion of their energy for heating and air-conditioning passenger cars.
2. The special passenger trains that carried "freight-only" may have made fewer stops.

Thus based on all the above discussion there is a way to estimate the passenger miles per gallon. Exactly how this is done will be illustrated by the following example.

Example Calculation

Based on the methodology described above the pass-mi/gal is obtained by multiplying together the following three statistics:
1. car-mi/gal
2. pass-mi/car-mi 3. factor F. F is to account for cars in the train which serve passengers but were not counted by pass-mi/car-mi (2 above). Statistics 1, 2, and 3 above come respectively from ICC statements listed in Appendices 1, 2, and 3.

F is about 0.8 but varies from year to year. Its calculated from the car-mi/train-mi statistics (see Appendix-3) for various types of passenger cars. Here's an example of calculating F for 1936: The ICC reports 2.08 car-mi/train-mi for passenger coach cars. This means that the typical train had 2.08 coaches in it. Here "typical" means what observers would observe if stationed along the track so that long distance trains would thus count for more than short distance ones.

For 1936 per the ICC there were also 2.30 sleeping and parlor cars in the "typical train". This gives 4.38 (2.08 + 2.30) cars on which the car-mi (in the pass-mi/car-mi statistic) is based on. But the number of cars/train used by passengers is larger than 4.38 since there were total of 0.62 club, lounge, dining, and observation cars in the "typical train". There is also assumed to be 0.5 baggage cars resulting in a grand total of 5.55 (= 4.38 + 0.62 +0.5) cars which are earmarked for passenger use. Now we would like to convert the pass-mi/car-mi figure to include the car-mi of club, lounge, dining, observation and baggage cars. How do we do this? Well, we multiply the car-mi for 1936 (used in the pass-mi/car-mi statistic) by 5.55/4.38, or what amounts to the same thing, we multiply pass-mi/car-mi by the inverse of this: 4.38/5.55. This is the just the factor F mentioned above. For 1936 it was 0.789.

Thus for 1936 we multiply 0.789 by 13.33 pass-mi/car-mi to get 10.5 pass-mi/car-mi and then divide by 0.19 gal/car-mi to get 55.4 passenger-miles/gallon (diesel).

Results and Discussion

Now for some results. Today (1998) the automobile in intercity use gets about 25 mi/gal and has 2.0 people in it resulting in about 50 pass-mi/gal (gasoline). Amtrak does about the same (See Appendix A). Trains of 1936 thru 1963 did somewhat worse except during the war years of World War II, where they got about 80 pass-mi/gal due to high usage.

Passenger-mile/gallon (gasoline equivalent):

Year	Pass-mile/gall
1936	50
1945	83
1955	40
1963	40
1940	39
1950	41
1960	41

Note that the ICC figures for gal/car-mi were only given to 2 significant figures such as .19 gal/car-mi in 1936. A project for a future version of this document is to obtain these estimates for all the years 1936-1963 and to redo the ICC derivations to get more significant figures.

Why did energy-efficiency (pass-mi/gallon) drop from 50 to 39 from 1936 to 1940? It's not due to fewer passengers per car but due to an increase in gal/car-mi from 0.19 in 1936 to 0.25 in 1940. The reasons seem to include the introduction of air-conditioning and the introduction of diesel service to trains that made more stops. As time went on the gal/car-mi continued to increase, reaching 0.35 by 1963. This was partly due to the discontinuance of long distance trains which made few stops resulting in greater significance of suburban trains which wasted energy making many stops. However this lead to a relative decline in sleeping car travel resulting in more passengers per car. This compensated for the worse fuel economy per car-mile.

During World War II the average number of passengers per car more than doubled from about 14 during the 1930's to over 30 during the war. At the same time, due to longer trains there were fewer dining cars, etc. per passenger car. With gasoline rationing, people flocked to the railroads and many were turned back for lack of space. People are unlikely to tolerate such train crowding in peacetime. The wartime record does show that under conditions of long trains full of passengers, rail transportation can be energy-efficient (provided it doesn't go too fast since aerodynamic drag increases with the square of the velocity).

The train appears to have been somewhat more energy efficient than the automobile of that era, assuming 15 miles/gallon and 2.2 passengers per auto (33 pass-mi/gal). Automobiles today get better mileage and are somewhat more energy efficient that the trains were then. There are no satisfactory estimates of the average automobile occupancy (assumed to be 2.2) for 1936-1963 (for trips similar to rail trips). Data in the "Nationwide Personal Transportation Study" for 1970 was in error due to double counting and thus can't be used.

Another consideration is that the car-mi of sleeping cars was roughly equal to the car-mi of coaches during the 1930s. Thus, one could argue that some of the energy for "hotel services" on the train should not be counted, since if a person were traveling via automobile and stayed in a hotel (or motel), "hotel service" energy would be used for the overnight stop (which is not counted by the pass-mi per gal by auto).

Conclusion

In conclusion, between 1936 to 1963, it seems that overall, railroad transportation in diesel powered trains was about 20% to 50% more energy-efficient than the automobile in peacetime. In wartime with gasoline rationing, it was roughly twice as efficient due to very high load factors (percentage of seats filled). Due to energy-efficiency improvements in automobile since then, the passenger train today seems to have roughly the same energy efficiency as the automobile. (See Appendix A)

Appendices

Note, Appendices 1-3:

These appendices list Interstate Commerce Commission (ICC) "statistics" used. These ICC publications changed names between 1936 and 1963. In 1936 they were issued by the ICC's "Bureau of Statistics". In 1963 it was "Bureau of Transport Economics and Statistics". In all cases, "Switching and Terminal Companies Not Included" appears after the title (in smaller print). Here is given the starting name in 1936 and the ending name in 1963. For 1936 a _36 suffix is used. 1963 uses a _63 suffix.

Appendix 1:

1_36. "Fuel and Power for Locomotives and Rail Motor Cars of Class I Steam Railways in the United States" (Statement M-230)
1_63. "Fuel and Power Statistics of Class I Railroads in the United States" (Statement Q-230)
Statistic Used: "9. Fuel and power consumed per passenger-train car-mile --road passenger service: 9-03. Gallons of diesel fuel (diesel locomotives)"

Appendix 2:

2_36. "Revenue Traffic Statistics of Class I Steam Railways in the United States" (Statement M-220)
2_63. "Revenue Traffic Statistics of Class I Line-haul Railroads in the United States" (Statement Q-220)
Statistic Used: Passenger-miles per car-mile

Appendix 3:

3_36. "Passenger Train Performance of Class I Steam Railways in the United States" (Statement M-213)
3_63. "Passenger Train Performance of Class I Railroads in the United States" (Statement Q-213)
Statistics Used: "10. Car-miles per train-mile in locomotive-propelled trains: 10-01. Passenger

coaches, 10-02. Sleeping and parlor cars, 10-03. Club, lounge, dining, and observation cars, 10-04. Other passenger-train cars"

Appendix A:

For the energy efficiencies see: "Amtrak and Energy Conservation in Intercity Passenger Transportation" by Stephen J. Thompson (Congressional Research Service, Report to Congress) Sept. 3, 1996. (http://www.ncseonline.org/NLE/CRSreports/energy/eng-11.cfm)

See also "Transportation Energy Data Book" Edition 29 Energy Intensities of Passenger Modes, Oak Ridge National Laboratory, 2011. (Transportation Energy Data Book, Chapter 2). This shows the energy of Amtrak to be better than the automobile. But the automobile figure is for both city and intercity driving. To fairly compare it to Amtrak, one must correct the auto figure so it reflects intercity use. For intercity, there are about 2 persons/auto as compared to 1.6 overall and the auto gets more miles/gallon (about 26 as compared to 22 overall). After making this correction, Amtrak appears to be no more energy efficient that the auto.