Transportation for Sustainable Communities: A cost and impact comparison between alternative transportation modes.

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ABSTRACT
In this paper, the authors ask: what is the optimal relationship between sustainable community design and transit? This seemingly straightforward question is very rarely asked in a literature dominated by work that typically focuses on one or the other element of sustainable community design or assumes a technical orientation to transportation questions without regard to community design and community context. What is lacking is a holistic approach. In this modest attempt we ask "what transit system is optimal" against three well accepted sustainability criteria: long term cost, greenhouse gas reduction, and compatibility with complete community objectives. Our results strongly suggest that modern, at-grade tram technology should be the mainstay of any sustainable community design. Tram was found to be one of the most affordable modes in terms of long term environmental and economic cost; it was consistently associated with urban form that boasts the lowest total per capita greenhouse emissions; and it is highly compatible with complete community objectives. Our data is primarily from accepted secondary sources, with the exception of data from the Toronto Transit Authority, which is primary. Our unique contribution to the discourse is in assembling this information in such a way that more broadly sustainable choices begin to emerge.

Figures

Figure 1. Skytrain, a system designed to move people rapidly from the edge of the region to the centre.

Figure 2. Shows the dense development and mixed-use characteristic of “streetcar neighbourhoods.”

Figure 3. The modern Combino tram uses 0.11 kWh of energy per passenger-mile (given typical vehicle occupancy).

Figure 4. A trolleybus in Vancouver, BC is powered by overhead electrical wires therefore eliminating any tailpipe emissions. A trolleybus uses 0.36 kWh of energy per passenger-mile (given typical occupancy).

Figure 5. The skytrain in Vancouver, BC uses 0.30 kWh of energy per passenger-mile (given typical occupancy).

Figure 6. Shows an articulated diesel bus in service in Vancouver, BC that uses 0.56 kWh of energy per passenger-mile (given typical occupancy).

Figure 7. The Toyota Prius is an electric hybrid that provides substantial gains in fuel economy and major reductions in total tailpipe emissions. It uses 0.64 kWh of energy per passenger-mile (given typical vehicle occupancy).

Figure 8. This 2007 Ford Explorer uses 1.42 kWh of energy per passenger-mile (given typical occupancy).

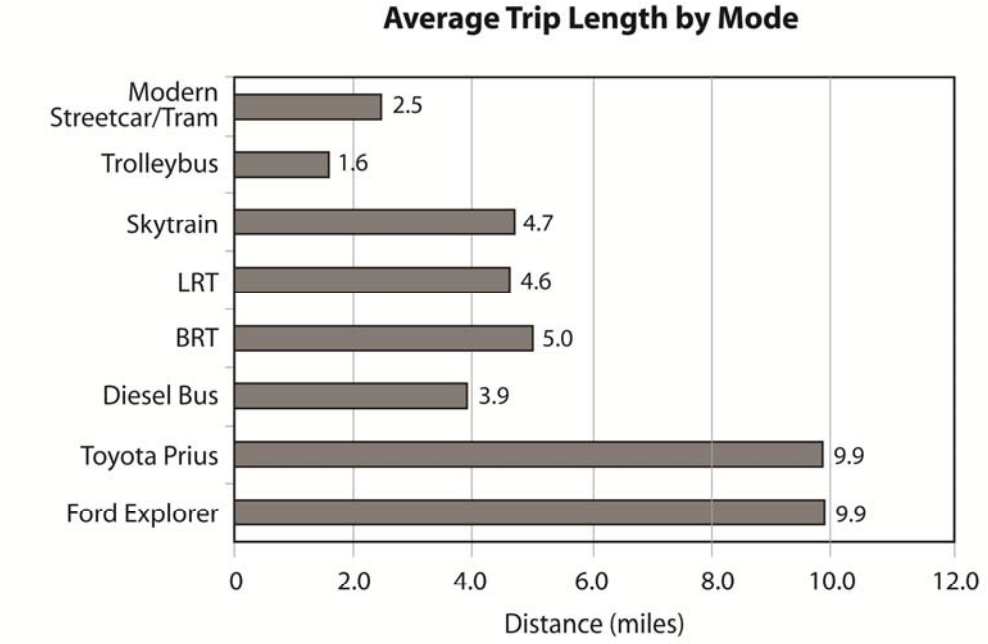

Figure 9. Average trip length by mode (Source: APTA 2009; Buehler, Pucher, Kunert, 2009; IBI Group, 2003)

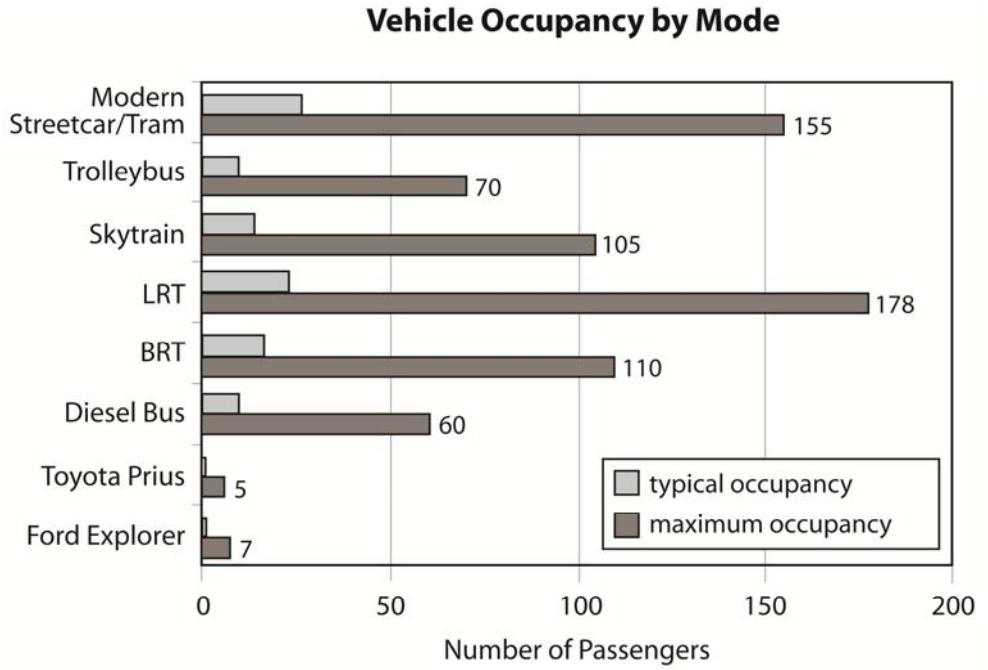

Figure 10. Vehicle Occupancy by Mode (Source: The maximum vehicle capacity for each mode was gathered from manufacturing specifications for the following vehicle models: 2007 Ford Explorer, 2007 Toyota Prius, 1998 Gillig Phantom, 2001 D60LF Articulated Bus, SD-400 and SD-460 90' single articulated LRT, Mark I and Mark II skytrain vehicles, ETI Skoda Trolley Bus and Siemens Combino Plus tram. Typical vehicle occupancies for the transit modes were calculated from operating data reported from existing systems using these vehicles. Transit occupancy data from Translink 2003; FTA 2005; NTD 2007; PUTA 2007; Translink 2008b; Davis 2009; VanElsas 2009; TTC 2009. The typical occupancy for private automobiles is based on the average vehicle occupancy for trips to or from work in the United States (BTS 2001)).

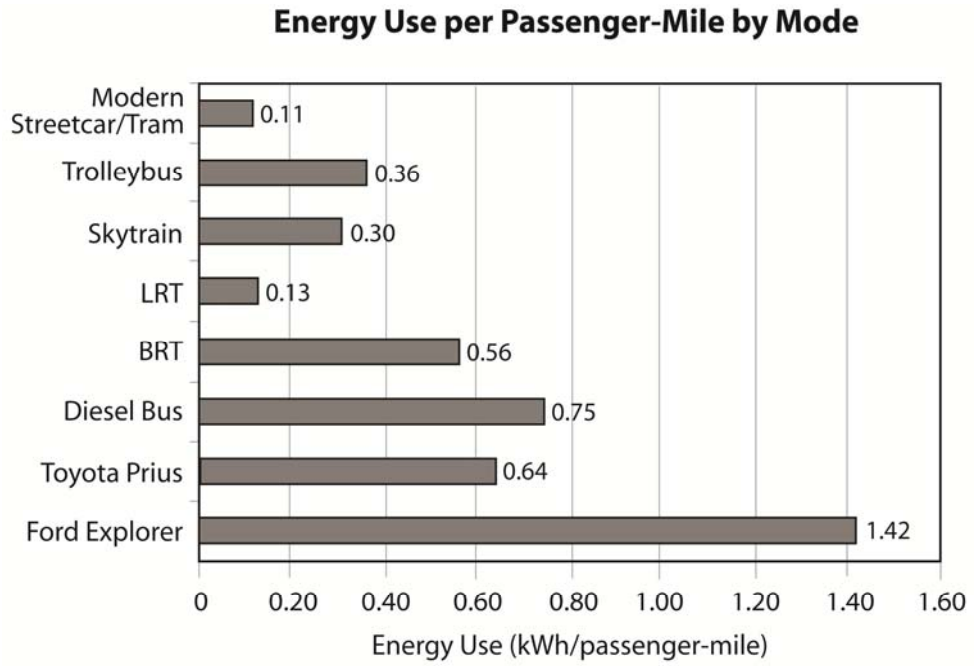

Figure 11. Energy Use per Passenger-Mile by Mode (Source: Vehicle energy use data from Strickland 2008. Typical vehicle occupancy from BTS 2001; Translink 2003; FTA 2005; NTD 2007; PUTA 2007; Translink 2008b; Davis 2009; VanElsas 2009; TTC 2009).

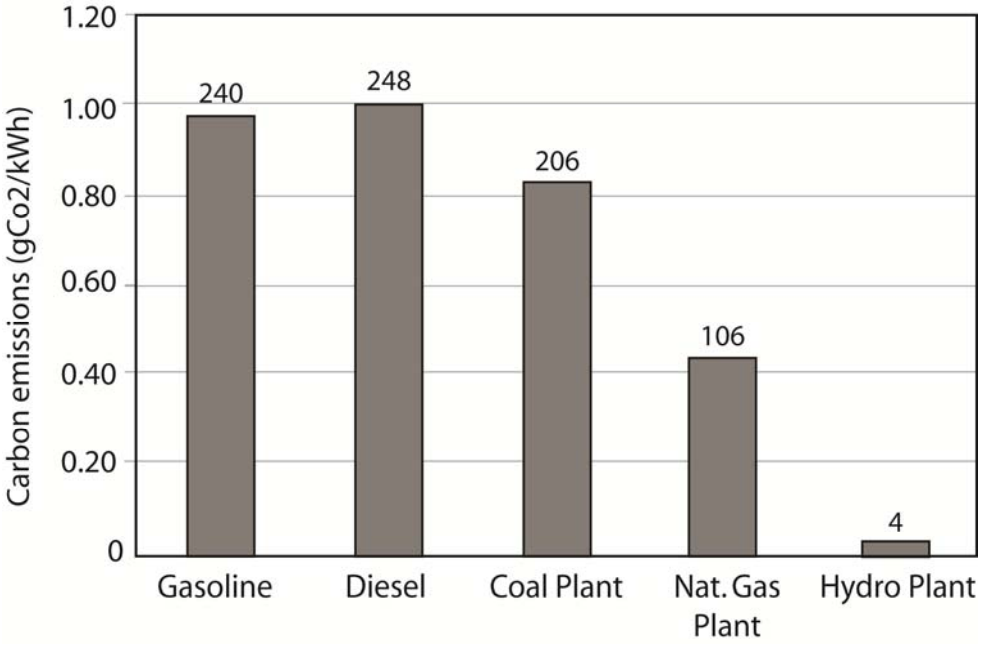

Figure 12. Carbon Emissions by Energy Source (Source: Spadaro, Langlois, Hamilton 2000; EPA, 2005; Strickland 2008)

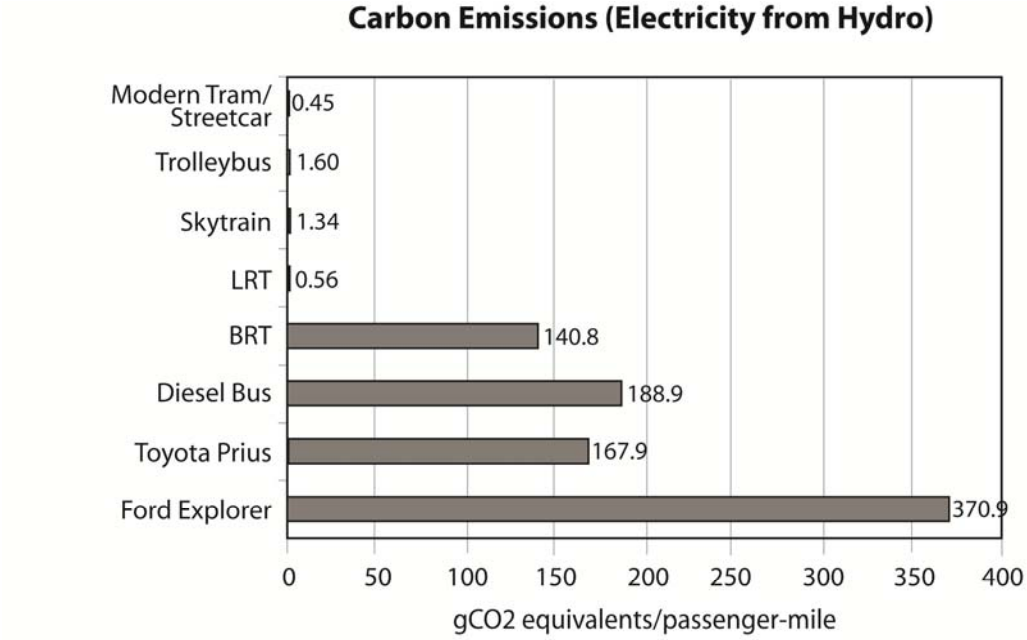

Figure 13. Carbon Emissions (Electricity from Hydro) (Source: Vehicle energy data from Strickland 2008; energy conversions to carbon equivalents from Spadaro et al. 2000. Typical vehicle occupancy data from BTS 2001; Translink 2003; FTA 2005; NTD 2007; PUTA 2007; Translink 2008b; Davis 2009; Van Elsas 2009; TTC 2009.)

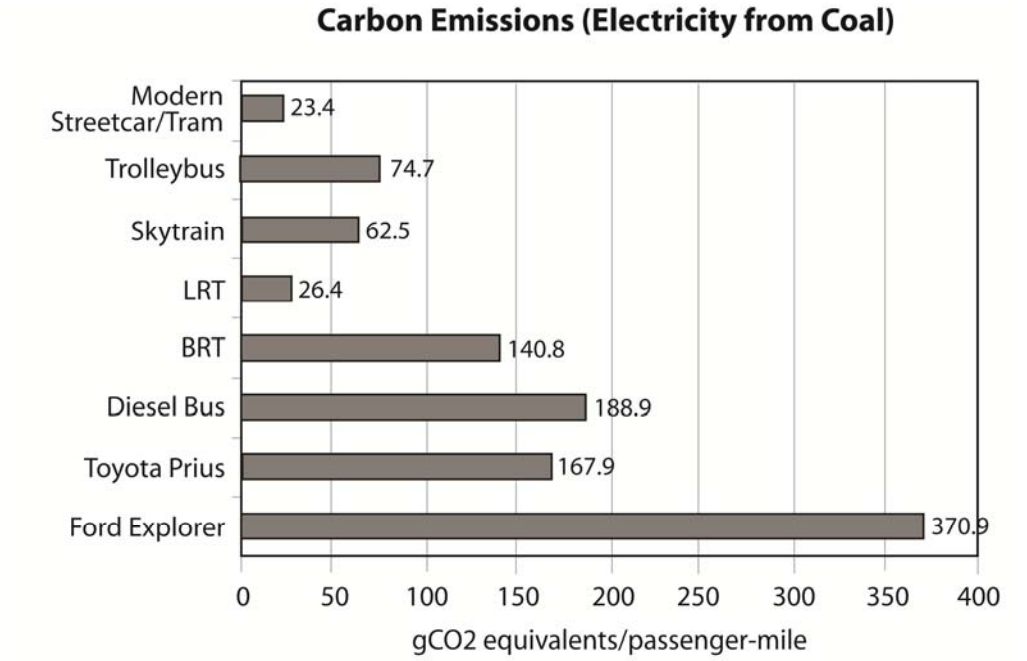

Figure 14. Carbon Emissions (Electricity from Coal). (Source: Vehicle energy data from Strickland 2008, energy conversions to carbon equivalents from Spadaro et al. 2000. Typical vehicle occupancy data from BTS 2001; Translink 2003; FTA 2005; NTD 2007; PUTA 2007; Translink 2008b; Davis 2009; VanElsas 2009; TTC 2009).

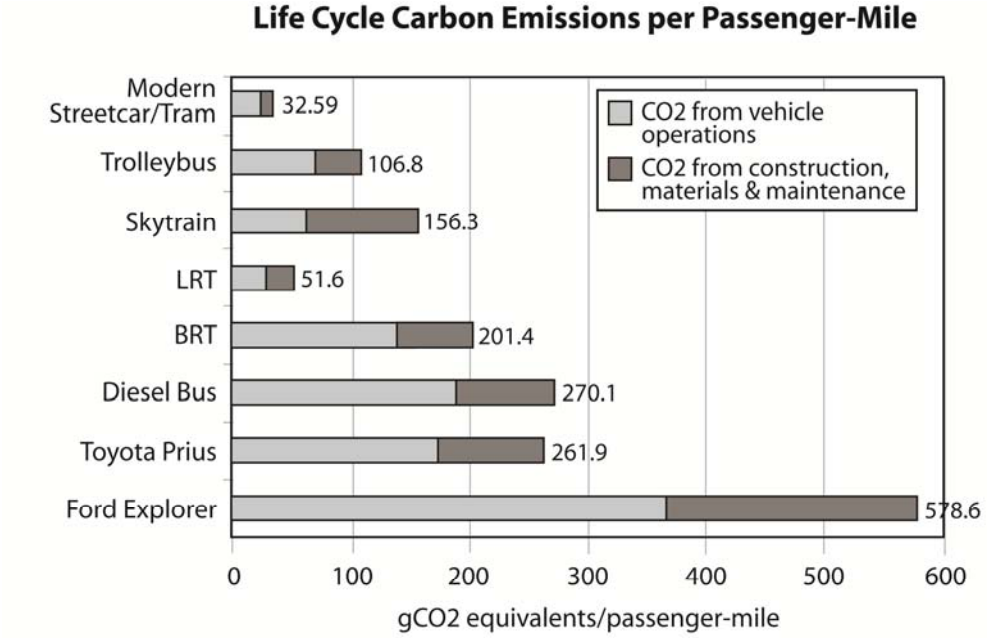

Figure 15. Life cycle carbon emissions per passenger-mile (when electricity is from coal). (Source: Vehicle operation emissions were calculated using typical vehicle occupancy for each mode and energy data from Strickland 2008 and conversion factors from Spadaro et al. 2000. Non-vehicle operation emissions were calculated using results from Chester 2008).

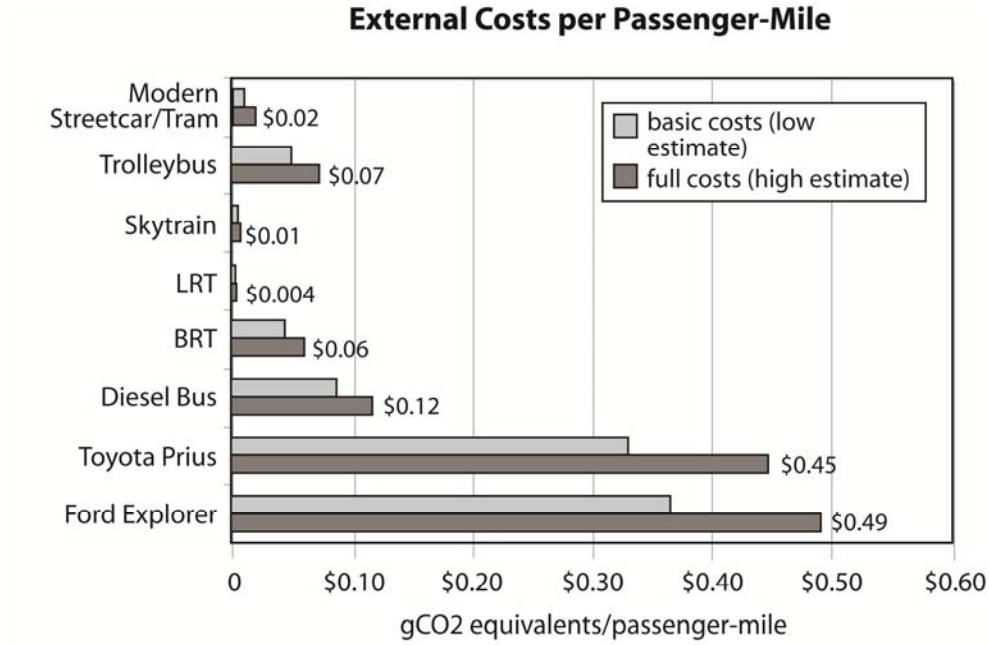

Figure 16. Full external costs include the cost of parking infrastructure, road facilities, land value, land use impacts, resource externalities, congestion, traffic services, transport diversity and barrier effects. They do not include air pollution, GHG, noise, water pollution or waste. Basic external costs include only parking infrastructure, road facilities, land value and resource externalities. Pollution costs are not included in this analysis as estimates vary widely and we itemize the GHG consequences of each mode separately. (Source: Litman 2009).

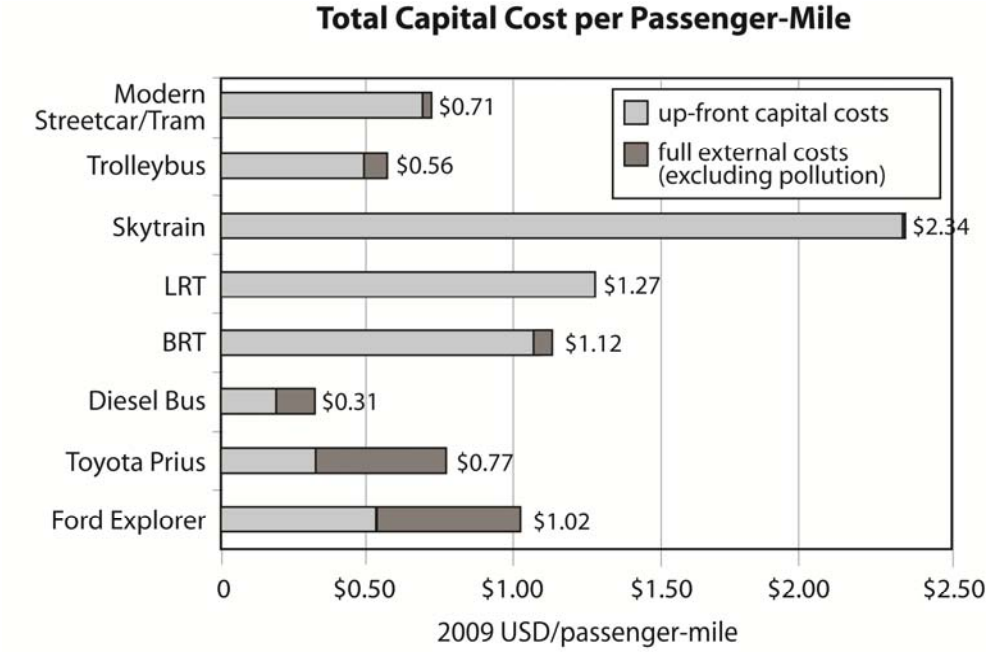

Figure 17. Capital costs were calculated using construction costs and/or vehicle costs ammortised over the expected life of the system and/or vehicles. This annualized cost was then divided by the annual passenger-miles of each mode. (Source: American Automobile Association 2009; Translink 2008b; TTC 2007; Translink 2003; National Transit Database 1998-2007; Portland Bureau of Transportation and Portland Streetcar Inc. 2008; Buchanan 2008).

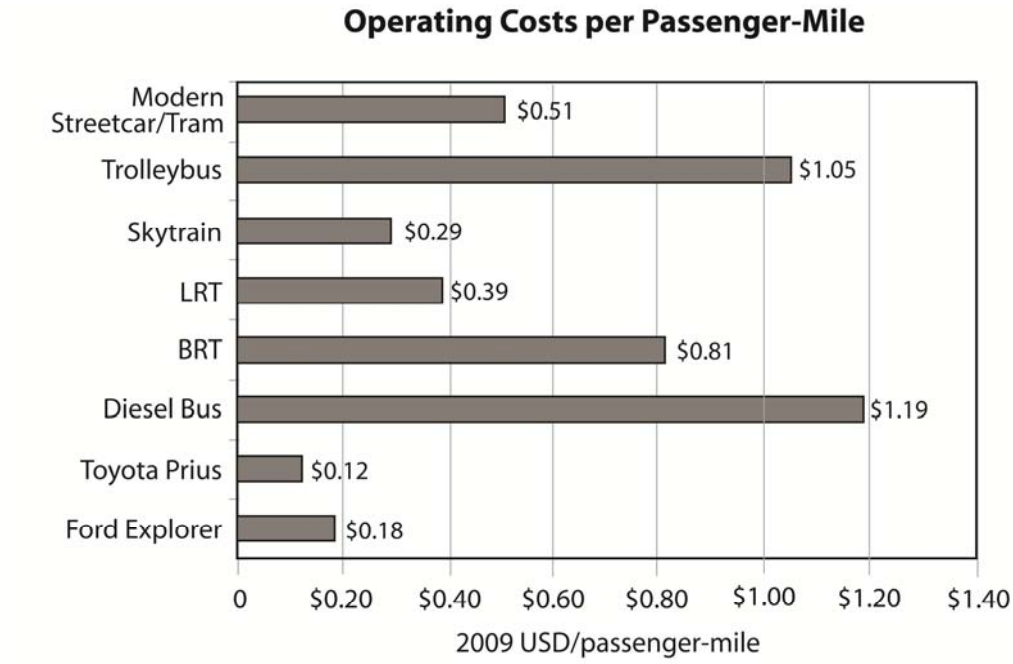

Figure 18. Operating costs for private automobile include parking, insurance, maintenance, and fuel. Operating costs for transit modes also include employee salaries.

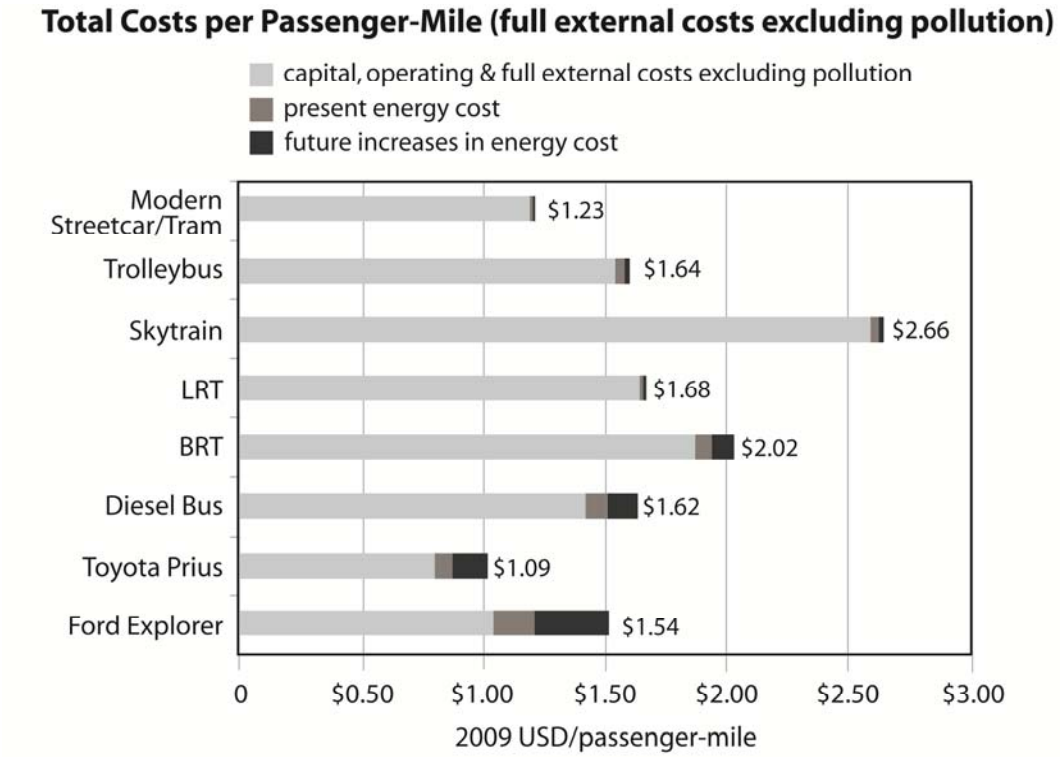

Figure 19. The total cost per passenger-mile was calculated by adding the capital, operating, full external costs (excluding pollution) and present and future energy costs for each mode.

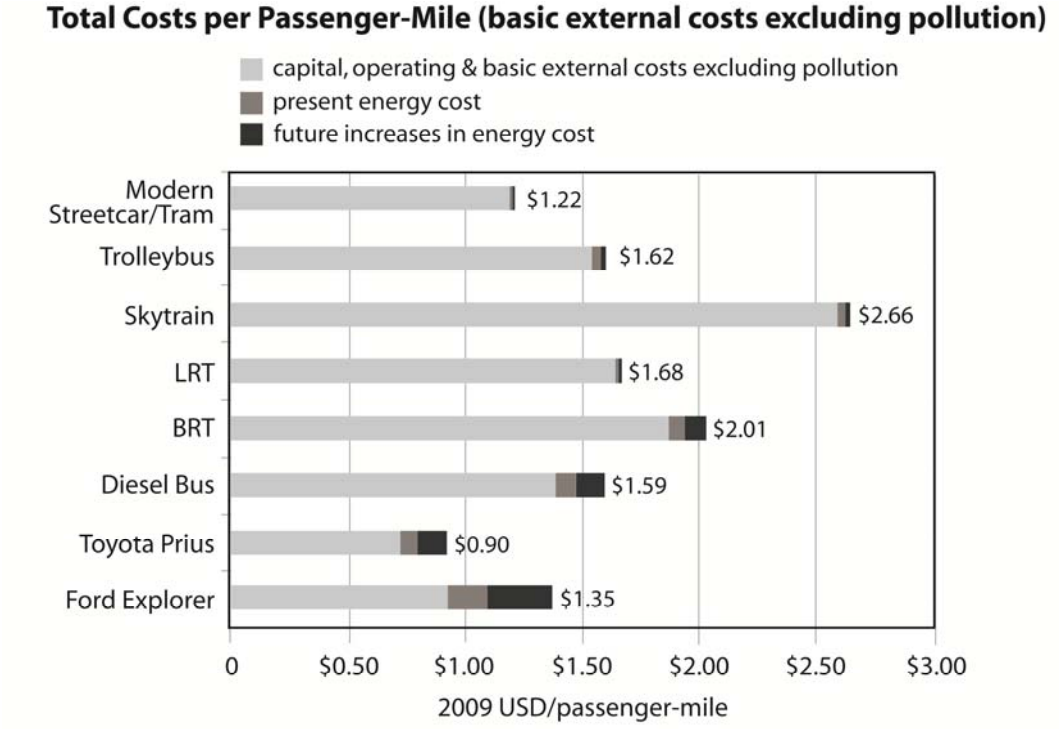

Figure 20.The total cost per passenger-mile was calculated by adding the capital, operating, basic external costs (excluding pollution) and present and future energy costs for each mode.

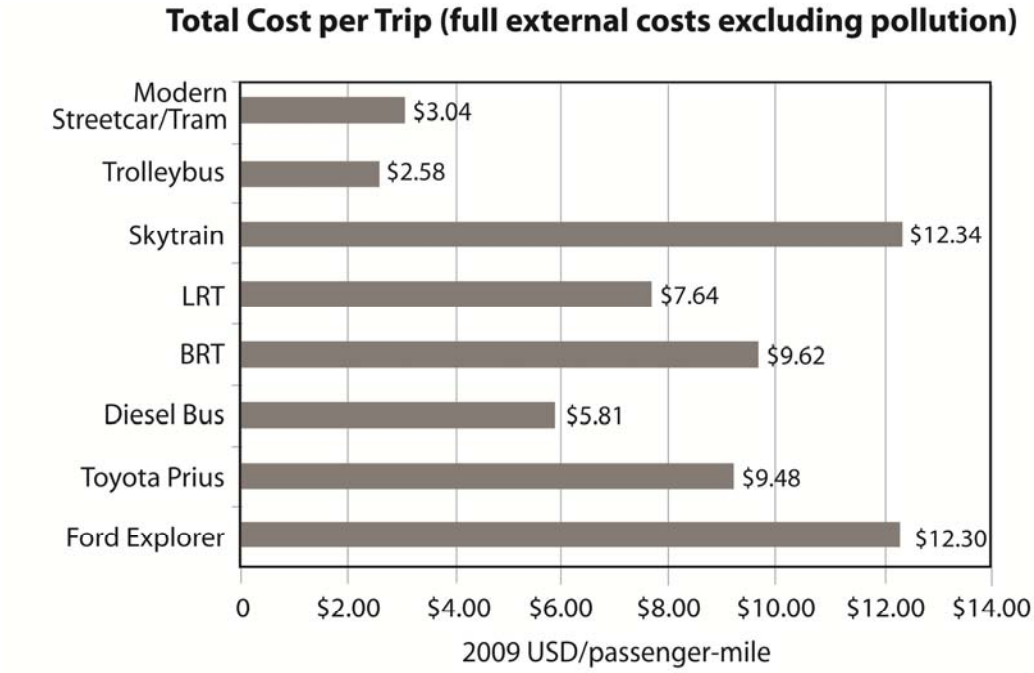

Figure 21. The total cost per trip was calculated using average trip distance and total cost per passenger-mile. This calculation includes the full external costs, excluding the costs associated with air, land and water pollution.