Economics of Electric Trolley Coach Operation

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In 1995, pollution, congestion, urban viability and shrinking transit subsidies raise concerns for planners seeking alternative means of public transportation. Although the electric trolley coach alone cannot solve all or any of these problems, it may have the potential to mitigate some of them. Although the trolley coach emits no odors or particulates, it has not always been considered the most efficient means of public transportation. Over the past 40 years its use has declined by almost 93 percent, but the cost savings and revenue from modernization have never materialized on a per passenger basis. Its decline resulted in higher costs per passenger with less revenue. The use of simplistic cost-per-mile comparisons is partly to blame for the retrogression. A better cost measure is needed. Five North American transit systems still operate trolley coaches. Generally these are well-patronized systems. Their operating statistics are analyzed and compared with same-system diesel bus operations. It often appears that well-managed trolley coaches are moving people at lower costs on suitable routes than diesel buses and earn a higher revenue-to-cost ratio. The potential of increased revenue and ridership make trolley coaches worth reconsidering. Their advantages include traffic relief, stimulated economic activity, and reduced pollution. The up-front investment would be considerable and close management attention would be essential, but the adverse impact observed with its curtailment in the past suggests that a revival is worthy of study by many urban transit systems.

With the Clean Air Act amendments of 1990 mandating significant changes in transit bus propulsion and with cost control, revenue augmentation, and traffic congestion prime considerations, it may be useful to reexamine the trolley coach (trackless trolley) for urban transit application.

HISTORY

From 1934 to 1950 (excluding the war-rationed years of 1942 to 1945) electric trolley coach operation expanded from a fleet of 441 North American vehicles carrying 230,000 weekday passengers to almost 7,000 vehicles carrying six million weekday passengers. Diesel bus operations began about 1936, so it appears that management officials considered the trolley coach more economical than diesel buses for replacement of old, gasoline-powered buses and worn-out street railway lines. In a time when revenue per route was sufficient to earn a return on investment, streetcars continued to be employed as the most economical transit vehicle. About 6,000 new rail cars were ordered during this period (*1*).

Why were trolley coaches so popular during this period, and why have they become so unpopular since? At least four reasons can be given for the widespread use of trolley coaches during that 16-year period:

1. The electric power system required for trolley coaches resulted in a larger "rate base" than a diesel bus system would enjoy, making the electric operation more profitable under rate regulation. (The rate base is the active, used, and useful net investment in assets on which a profit was permitted to be earned. Rates charged by private transit companies were regulated by government authorities.)
2. The trolley coach had a superior power-to-weight ratio, which provided faster acceleration rates, particularly on hills. Brake wear was less with dynamic braking. Eight trolley coaches in rigorous service could do the same work on the same headway as nine diesel buses of equal capacity. A trolley coach might average 21.4 km/hr (13.3 mph) including stops, whereas a bus might average only 19.3 km/hr (12 mph) under the same conditions. On longer, less dense routes with fewer stops, the trolley coach lost some of its advantage.
3. Trolley coaches were usually 12.2 m (40 ft) long and 2.54 m (8.33 ft) wide, whereas internal combustion vehicles (buses) were limited by law to 10.7 m (35 ft) in length and 2.44 m in width, resulting in 10 fewer passengers per coach at the maximum load point, a difference of 18 percent. Labor cost per passenger was much less for trolley coaches.
4. The trolley coach contained nothing to freeze in winter, cost less to service and maintain, and was quiet and fume-free. However, weighed against the savings were added costs for power systems. Trolley coaches did not have to be fueled every day, however.

Around 1949, laws governing motor vehicles were liberalized to permit 12.2-m (40-ft) diesel buses, but the 10.7-m (35-ft) bus bodies were too weak to be lengthened. The 12.2-m bus required a heavier body. More recent law revisions have allowed 2.6 m (8.5 ft) of body width.

Beginning in 1949 on the best transit systems, and before that on bus-only systems worn by war work, ridership declined as gasoline rationing ended and automobile manufacturing resumed, creating a surplus of transit vehicles and a shortage of cash. A few well-managed suburban systems, such as the Philadelphia Suburban Transportation Company and the city of Shaker Heights [Ohio] Department of Transportation, continued to sustain ridership with rail operation.

With the steady decline in transit revenue offset by continuing increases in cost, no new investment in fixed facilities was feasible other than for easily transferred buses on equipment trust certificates (mortgages). The rate base was no longer an issue, as the next week's payroll took top priority. Copper wires could be sold to raise cash, subject to reduced income tax rates. The trolley coach had lost two of its advantages, and private enterprise lost interest in the other two advantages, believing they were unachievable.

From 1950 to 1964, transit management officials had little opportunity to invest in future projects. Efforts were focused on survival, and often meant reduction in service (cost), increased fares, selling assets, and avoiding investment. Investment in trolley coaches was seldom considered, except in Philadelphia in 1954, when the city (not the transit company) purchased 43 Marmon-Herrington trolley

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coaches to replace an aging outlying streetcar line in a growing area. The transit company leased the coaches at cost.

Management's ranks thinned as the industry shrank. Retiring professional engineers were seldom replaced. Trolley coaches were too much trouble to justify the effort involved in operating them, except in a few places, like Dayton, Ohio. Because the electric vehicles were limited to fixed routes (unless costly and complex supplementary power was added), they were not freely rerouted for one-way street plans or suburban expansion. They caused operating problems in emergencies and required more management attention. Trolley poles sometimes left the wire, causing minor (occasionally major) delays. In bad weather, trolley shoes had to be changed to avoid decimation. Overhead line crews were an added expense, and many residents objected to the overhead wires.

CASE FOR THE TROLLEY COACH'S RETURN

In view of this history, why consider trolley coaches again? It appears they have proven costly and obsolete. Conditions, however, have changed. The Urban Mass Transit Act now provides investment capital, if justified. The Clean Air Act amendments of 1990 prohibit the manufacture of diesel buses unless they are equipped with costly and heavy particulate traps or clean-fuel engines. Two-axle diesel and natural gas buses 12.2 m long are too heavy to comply with the weight limits necessitated by pavement destruction, catch basin collapse, and gas and water main damage. To maintain schedules, bus drivers must turn off air-conditioning when accelerating on hills, because it drains power from the engine. A greater problem arises at recovery time (layover) terminals where the engine must be turned off to comply with laws and community demands to mitigate pollution. When this is done, the bus quickly becomes unbearably hot and the windows are opened, rarely to be closed again until the bus is serviced. Today's bus patron expects an inside temperature of 76°F and is not interested in the problems involved in maintaining that temperature. Bus maintenance departments also encounter problems with the air-conditioning machinery.

Trolley coaches do not draw on the motors for their air-conditioning energy. The energy comes directly from the powerhouse and does not have to be turned off when climbing hills or idling. Power failures are also infrequent.

The increasing cost associated with diesel buses (greater weight, particulate traps or natural gas fuel, air conditioning, and the need for more powerful engines) has induced some transit authorities to reconsider trolley coaches. In cities such as San Francisco, Seattle, Washington, and Vancouver, British Columbia, the trolley coach never lost its appeal. These three cities are among the four highest in ridership per capita where rubber-tired vehicles are used (*2*). These systems have found that trolley coaches cost less to operate than diesel buses under similar conditions. The operational savings exceed the added cost of electric power (*3*). In these three cities and in Dayton, Ohio, transit management officials believe trolley coaches are worth the additional effort necessary to keep them running.

There is anecdotal evidence that passengers prefer well-managed trolley coaches, at least in favorable settings. About 40 years ago the Akron [Ohio] Transportation Company phased out its trolley coaches in favor of a revamped all-diesel bus operation. The company realigned its routes without fixed facility investment to improve service and reduce the number of bus-to-bus transfers required. A nationally known transit consulting firm was retained to help conduct origin-to-destination studies to ensure that the most efficient and effective plan was developed and installed.

After implementation of the "improved" service, almost one-fourth (25 percent) of the patronage was lost. The diesel buses had a negative effect. Old rider habits were hard to break and anticipated new riders were not interested. Roughly 16 to 18 percent of the loss was attributed to the frequent labor strife in Akron, fare increases, and the decline in ridership after World War II. However, the elimination of the trolley coach appears to account for the remaining 6 or 7 percent ridership loss (*4*).

The Denver [Colorado] Tramway Corporation had a similar experience about the same time. Its relatively new trolley coaches were replaced by through-routed diesel buses in what was described as a "more efficient" operating pattern. Riders avoided the new diesel buses in sufficient numbers to create an accelerated loss of ridership beyond what would be expected from the post-war trend (*5*).

More recently, Dayton attempted to eliminate trolley coaches against the wishes of some board members and many citizens. As the trolley coach operation shrank, so did patronage, despite an increase in service. Annual boardings dropped from 20.5 million in 1982 to 13.6 million in 1992, a loss of 34 percent. As trolley coach mileage shrank from 27 percent of the system to 10 percent, total kilometers operated increased by 31 percent. In nearby Cincinnati, Ohio, which had less service change, patronage declined by 19 percent with a service reduction of 14 percent (*6*). Public opposition in Dayton resulted in a change of management and a vote to restore the trolley coach system.

The new trolley coaches installed in Philadelphia in 1954 countered the trend of declining patronage. Because ridership required a 90-sec headway on the inner segment of the route, the city had the company install express wires to provide faster and less costly service for more passengers with the same number of coaches.

Even more recently, San Francisco, Seattle, and Vancouver have been expanding their trolley coach operations by replacing diesel buses on strategic routes. Toronto, however, has eliminated its trolley coach service despite public protest and favorable costs per bus hour (*7*). Ridership has fallen since the trolley coach service was terminated. Aging electrical equipment and high costs per vehicle kilometer were the factors cited for the decision. For example, during the phase-down sequence, trolley coach operations became much more costly per unit of service because of the loss of utilization.

COST PER KILOMETER OR COST PER HOUR?

Toronto's experience raises the question of cost per vehicle kilometer or cost per vehicle hour: which is more realistic or does it matter? Previously, most transit managers simplistically measured their economic performance in terms of cost per vehicle kilometer. Streetcars cost more because of track maintenance, and hence were eliminated in favor of smaller buses with lower costs per vehicle kilometer. However, the buses had lower carrying capacity and revenue potential. Although trolley coaches cost less per kilometer than rail cars, they now cost more per kilometer than diesel buses and have been eliminated except in certain transit systems where ridership is strong. Despite the higher cost per vehicle kilometer, trolley coaches often operate with a lower deficit and with a higher revenue-to-cost ratio. It was once thought that lowering the cost per kilometer without lowering revenue would reduce deficits. Unfortunately, this was not the case.

The experience of Youngstown, Ohio, which has 72 trolley coaches and 72 diesel buses, is illustrative. With trackless trolleys, the system was earning a 6 percent return on its investment as required by the franchise. Ridership and revenue were declining as inflation forced fares higher and more commercial activities provided free parking. It was naively thought that substituting 43-cent/km (1956) diesel buses for 50-cent/km trolley coaches would not only preserve the enterprise, but also would result in a capital gain at a lower tax rate from the sale of the copper trolley wires. This was not to be. Since the trolley coaches were eliminated in 1957, ridership has fallen substantially. By 1958, the system fleet was reduced from 144 vehicles to 82 vehicles, all diesel buses. Ridership fell from 67,000 per weekday with trolley coaches to only 44,400 after a full year of diesel operation. A fare increase discouraged an estimated 10 percent of riders despite the efficiency of diesel buses. The secular trend of that time suggests that an additional 12 percent was lost. It appears that the loss of about 9 percent of the ridership was caused by the elimination of trolley coaches (*4*). This was worse than Akron's experience for lack of route improvements.

Because of the considerable investment required for its power system, the trolley coach's operation is limited to the busiest routes, whereas diesel buses can be used on both heavy and light routes. With more stops and traffic signals, the trolley coach averages 16 km/hr, including recovery time at terminals. With less traffic and fewer stops per kilometer, the typical diesel bus averages 19 km/hr (19 percent faster than the trolley coach). The diesel bus is not a faster vehicle in traffic, but enjoys more open road. Stopping for passengers and signals causes a loss of speed but is unavoidable, as passengers are the purpose of the operation. Trolley coaches average three stops per kilometer with 40 sec lost per stop, including the time for deceleration and acceleration, plus 1¼ min/km (48 km/hr). Excluding recovery time, this averages 3.3 min/km or 18 km/hr.

Diesel buses on longer, less dense routes average only 2.2 stops per kilometer at 45 sec each (fewer doors and less acceleration), so only 2.9 min are consumed per kilometer, which is 21 km/hr. Actual speeds will vary with the route, but the difference is the issue.

Despite the frequent use of mileage as a cost analysis tool, most transit operating expenses are not related directly to distance. There are six primary categories of transit costs, none of which is directly related to distance. Almost half the total costs are salaries for the driver and his or her supervisors (including fringe benefits). Almost universally, drivers in urban service are paid by the hour, not by the kilometer. Assuming a $15/hr basic wage for 1995, with 40 percent fringe benefits it costs $1.30/km to pay the driver on a 16-km/hr schedule including recovery time, compared with only $1.09/hr on a 19-km/hr schedule. Whether diesel buses or trolley coaches are used is not important. That is where Youngstown and others erred. By looking only at cost per kilometer, they saw an 8 percent overall savings (16 percent on drivers alone) that was not there when diesel buses were assigned to slower, heavier routes.

OTHER COST FACTORS

Physical plant maintenance is only partially related to vehicle kilometers or hours. Trolley wire and hardware become worn in direct proportion to vehicle passes, or kilometers, but the wages and fringe benefits of overhead line men, and the maintenance costs for substations, span wires, feeder cables, accidents, weather adjustments, and rerouting are more significant and not related to vehicle kilometers. Length of wire is a more common denominator. Trolley wire and substations cost $4,800/year per route kilometer for maintenance, or $3,100/km plus 1.5 cents per vehicle kilometer. Economy is enhanced where travel is dense or more than one route uses the same wires.

Garage costs are determined by fleet size and length of wire in the yard, where applicable. Low utilization, peak-only suburban service requires as much garage space as busy all-day vehicles with high use.

Maintenance of vehicles is more proportional to the number of accelerations and decelerations than the number of kilometers traveled, except for tire rental, which is only 2 percent of the cost. Tire rental can be computed separately.

Air-conditioned, reclining-seat, lavatory-equipped intercity buses cost less per kilometer to maintain, even with three axles, than spartan urban buses. By the bus hour, however, intercity buses cost more.

In the nation's capital, the Washington Metropolitan Area Transit Authority must keep detailed records to bill two adjoining states (Maryland and Virginia) and the District of Columbia separately for specific services rendered. These records confirm that the number of mechanics per thousand vehicle kilometers is much less in the inner city (16 km/hr) than in the suburbs (22-1/2 km/hr). Despite the lower number of mechanics in the city, the distance between failures is seldom up to 3,200 km, compared with more than 6,400 km in Virginia, which has more mechanics per bus. All of the Washington, D.C. buses are maintained at the same central overhaul shop, and many are old (*8*).

Accelerations cause wear on a vehicle's drivetrain, and decelerations wear out the brakes. Cruising on a suburban freeway is much less mechanically costly, despite the rapid accumulation of kilometers. Bus hours are a much more accurate denominator of vehicle maintenance cost, which averages 75 cents/km at 16 km/hr, but only 62 cents/km at 19 km/hr. Youngstown experienced a 17 percent savings on maintenance by replacing trolley coaches with diesel buses, but the savings evaporated when diesel buses were used for busy routes.

Energy consumption offers an excellent example of the error of using kilometers to estimate fuel cost. J. Northcutt reported that for the Cincinnati Transit Company (now known as the Southwestern Ohio Regional Transportation Authority) careful measurement on four routes (two diesel and two trolley coach and two hilly and two level) found energy consumption more proportional to hours than kilometers. Diesel buses continue to consume fuel when stopped, but electric buses do not. Cincinnati found that more than two-thirds of the energy cost was proportional to time and less than one-third to distance. Because trolley coaches accelerate faster, they consume more energy in that phase, but will coast more at speed. The added energy for acceleration is justified by reduced vehicle hours and added ridership, as well as by maintenance savings.

Precise energy consumption measurements on Philadelphia MP-85 commuter cars (Silverliner II and III) determined that these electric vehicles consumed 220 kW·h of power per scheduled vehicle hour at any speed. In local service at a 32 km/hr average with 0.8 km station spacing, power consumption was 7 kW·hr per car kilometer, but at a 97-km/hr average (28 km between stops) it was only 2.3 kW·hr/km, a perfect correlation with hours but none at all with distance (*9*).

Casualty and insurance costs are not related to hours or kilometers. They are incurred by passenger mishaps and traffic conflicts. A bus kilometer on a suburban freeway with 3½ m lane widths will be almost accident-free, but a bus kilometer on congested, narrow, signalized streets with passengers boarding and alighting will be accident-prone. For lack of a better correlation, one-third of casualty costs will be related to passengers, one-third to bus hours, and one-third to kilometers to reflect traffic exposure. Routes selected for trolley coach operation will be a much higher accident risk than outlying diesel bus routes. On the same street there should be no difference. Trucks touching overhead wires may be a nuisance, but circuit breakers immediately shut off power. Diesel buses carry hazardous fuel that causes toxic exhaust.

General and administrative costs are difficult to assign meaningfully. Some properties assign them by revenue to make busy routes help carry poor routes. Youngstown loaded trolley coach costs in this way. Other properties assign general and administrative costs in proportion to other costs, again favoring diesel buses if costs are distance-based. In Youngstown all income taxes were charged to trolley coaches since diesels operated at a loss. Income taxes are no longer a transit problem, but they illustrate the cost allocation problem.

Since there is no obvious common denominator for general and administrative costs, one-third may best be apportioned by revenue as a surrogate for passengers carried; one-third in proportion to vehicle hours for operational relationship; and one-third in proportion to all other costs as a reflection of where effort is being directed. Some analysts omit general and administrative costs from comparisons, but this risks the omission of relevant costs.

ELECTRIFICATION INVESTMENT

The electrification system for trolley coaches is capital intensive, although much less so than for a rail system. One million dollars for 1.61 km (1 mi) is a probable cost in 1995, if excessive design and hardware costs are avoided (see Table 1). Garage costs for trolley coaches can be less. No fueling facilities are required, nor do coaches need to be stored inside or heated all night in cold climates. This may save up to $125,000 per trolley coach on garage facilities. Air pollution controls will also cost less, with substantial savings described in the following sections.

In addition to the operational savings described previously, trolley coaches reduce environmental clean-up costs and have a minor impact on highway costs by increasing transit usage. There are no fuel spills or leaking tanks to clean up, nor is there any increase in local air pollution. If coal or oil is used for power generation, there is effluent comparable with the pollution emanating from oil refineries, but the transit vehicle is more fuel-efficient on busy routes. With natural gas or water power, the trolley coach involves no air pollution, nor does it contribute to noise pollution.

A diesel bus averages 42,580 L of fuel consumption per vehicle per year, resulting in almost 1 Mg of nitrous oxide, particulates, and volatile organic compounds. The practical cost of mitigating air pollution is approximately $2,250/Mg. Much higher costs are possible, but they can be avoided by alternative solutions (*10*).

On a busy downtown street with 120 buses per peak hour in both directions, the pall and odor of diesel bus exhaust is as noticeable as it is offensive and costly to alleviate. Pedestrians, including motorists who have parked, are loath to breathe the offensive air and may take their activity elsewhere. Some are allergic to diesel fumes. With trolley coaches, these problems are avoided. Concerns over electromagnetic effects have been relieved by studies that have proven electric vehicles to be no more dangerous than common household appliances (*11*).

TABLE 1 Trolley Coach Power Supply Investment: 1995 Estimate

ELEMENT	Dollars per Two-way Kilometer
Substations - 60 kw / coach, 1 coach / km.	$ 247,000
Trolley Contact Wire, 2/0 grooved (a)	15,500
Power Feeder Cble - 500 cm (a)	20,200
Span Wires - 44 spans	1,500
Hardware - 360 pieces per km.	18,600
Line Poles - 44 (assume 43 more joint use)	43,000
Feeder Insulators - 93	6,200
Special Work (Trolley frogs, etc)	18,600
Installation Labor - 410 hours, force account	24,800
Engineering at ten percent	39,600
Contingencies at 15 percent	65,000
MINIMUM TOTAL for ONE TANGENT KILOMETER	$ 500,000
Additional investment for heavier traffic density, curves, no shared line poles, and unusual situations	$ 125,000
AVERAGE TOTAL per two-way route kilometer	$ 625,000
AVERAGE TOTAL for One Mile	$ 1,000,000

(a) = Copper and phosphor-bronze metal prices are subject to considerable fluctuation and may vary considerably, year to year.

SOURCE: H.S. Zwilling, and Harrison; Design of Catenary Systems Transportation Research Board, Specialty Conference, Pittsburgh, Penna. 1985. page 21 , adjusted to 1995.

REVENUE

Passenger revenue is also a factor in public transit economics. It is not fixed or inelastic, particularly among choice riders. The quality of transit service will have some impact on revenue. Studies in Philadelphia and St. Louis, Missouri, found that transit patronage increased by 3 percent for each minute of travel time saved (*12*). Because trolley coaches accelerate faster than diesel buses and load more quickly with double-front doors, there is the possibility of saving 11 percent of the running time. Traffic problems restrict free-running operation, so only one-half of the potential is likely. A 3 percent gain in revenue is almost certain. The fixed routes and absence of fumes may also contribute to increased ridership. Overall, trolley coaches should attract at least 5 percent more passengers than diesel buses on the same route and schedule. As noted previously, conversion from trolley coach to diesel operation has usually been accompanied with rider loss. Dayton gained only 22.5 percent in revenue from a fare increase of 84.5 percent, whereas costs increased 102.5 percent from 1982 to 1992 as diesel buses replaced trolley coaches (*13*).

Based on the information in this study, it appears that trolley coaches generate up to $4,000 more revenue per year than diesel buses on the same route and schedule.

REAL-TIME COSTS

The matrix of unit costs shown in Table 2 has been compiled from actual operating results in Dayton, Philadelphia, San Francisco, and Seattle. In Table 3, Vancouver is compared with Toronto when it had more trolley coach operation in 1987. The data is adjusted to reflect $15/hr basic wages to avoid distortion by varying wage rates. Some large systems have higher wages than $15/hr. Fringe benefits are actual values.

San Francisco power costs are excluded from the cost data because the power there is not bought at market rates. Amortization assumes a trolley coach density of one coach per directional kilometer, or two coaches per route kilometer with salvage value deducted. Actual costs will vary inversely, proportional to service density. For routes with electrification in place, amortization will be greatly reduced.

CONCLUSION

Although trolley coaches (trackless trolleys) cannot be economical on most transit routes, they can be economical and effective on relatively busy bus routes less subject to rerouting because they are in mature areas. Light-rail transit may sometimes be more economical and efficient on the busiest routes, but a significant percentage of passengers can be well-served by trolley coach operation. Depending on the route pattern and the length of common or joint route overlap under common wires, trolley coaches can be economical for routes with at least 6,000 weekday passengers (*15*). When travel volume exceeds 20,000 weekday passengers per route, light rail should be considered if its installation is practical. When light rail is impractical, trolley coaches should be considered for up to 25,000 weekday passengers. For more than 25,000 weekday passengers, some form of rail transit should be devised.

Each route requires unique analysis. System standardization should not be more important than operating economy and ridership maximization. Air pollution control, revenue optimization, operational economy, passenger attraction, and traffic relief all must be given serious consideration before capital is invested in transit rolling stock. The Clean Air Act amendments of 1990 and the Intermodal Surface Transportation Efficiency Act have made these considerations a priority in an effort to persuade motorists to switch to public transit.

TABLE 2 Operating and Maintenance Cost Comparison: 1992

	COST per VEHICLE HOUR (14)	
COST or REVENUE ELEMENT - 1992	DIESEL BUSES	TROLLEY COACHES
Maintenance of Physical Plant	$ 3.95	$ 5.06
Maintenance of Vehicles	12.42	9.91
Fuel or Power (excl. San Francisco)	2.43	2.61
Conducting Transportation	32.28	32.28
Casualty and Insurance	2.28	1.96
General and Administrative	10.89	8.18
TOTAL COST per VEHICLE HOUR	$ 64.25	$ 60.00
Passenger Revenue from Operations	23.04	24.40
NET COST per VEHICLE HOUR	41.21	35.60
Revenue to Cost Ratio	36 %	41 %
Estimated Pollution Abatement Cost	$ 0.83	0
Amortization of Investment	13.00	$ 19.00
GROSS COST per VEHICLE HOUR	78.08	79.00
NET COST per VEHICLE HOUR	$ 55.04	$ 54.60

TABLE 3 Dayton and Canadian Trolley Coach Operating Results: 1987

	COST per COACH HOUR					
COST CATEGORY	BUS DAYTON	TROLLEY	BUS TORONTO[c]	TROLLEY	BUS VANCOUVER[c]	TROLLEY
Plant Maintenance	$ 2.09	$ 6.10	$ 1.61	$ 4.80	$ 0.00[d]	$ 0.53
Vehicle Maint'nce	8.45	8.44	9.18	10.14	10.61	10.00
Fuel or Power	2.34	2.62	4.10	2.00	5.00	2.00
Transportation	25.43	20.45[a]	27.46	28.18	29.82	29.82
Casualty Costs	1.18	1.03	1.20	1.24	1.42	1.33
General and Administrative	7.29	5.36	6.73	7.36	7.40	6.32
1987 TOTAL	$ 46.78	$ 44.00	$ 50.28	$ 53.72	$ 54.25	$ 50.00
Annual Fare Revenue	$ 7.38	$ 11.04	$ 27.34	$ 33.91	$ 25.59	$ 28.08
NET COST / BUS HR.	$39.40	$ 32.96	$ 22.94	$ 19.81	$ 28.66	$ 21.92
REVENUE-COST RATIO	16 %	25 %	54 %	63 %	47 %	56 %
POLLUTION COST[b]	$ 0.83	o	$ 0.83	o	$ 0.83	o
PLANT INVESTMENT	$ 13.00	$ 19.00	$ 13.00	$ 19.00	$ 13.00	$ 19.00
GROSS COST / HR.	$ 60.61	$ 63.00	$ 64.11	$ 72.72	$ 68.08	$ 69.00
NET COST Per HOUR	$ 53.23	$ 51.96	$ 36.27	$ 38.84	$ 42.49	$ 40.93

(a) = indicates the reported expenditure was inordinately low - 25 percent has been added.

(b) = indicates the frugal cost of mitigating a megagram (0.9 ton) of air pollution per bus per year. See reference (10).

(c) = Neither Toronto nor Vancouver reported all details available in Section 15 reporting. Interpolation has been utilized to estimate the sub-items. The totals are as reported and not estimated.

(d) = Garage fixed facility costs are included in Vehicle Maintenance.

Both Dayton and Toronto were planning to phase out trolley coaches in 1987.

Successful trolley coach systems require more effort at the management level, but in appropriate cases are well worth the additional time and energy to operate them.

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