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# Economic Synergism in Railroad Electrification

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ABSTRACT

Railroad electrification has been generally accepted as the optimum method of propulsion for trunk lines in most developed nations of the world, except for North America. But in North America repeated studies have shown above-average rates of return on investment, greater efficiency, and faster operation. In this paper the possible reasons for North America's failure to develop railroad electrification, the advantages and disadvantages of electrification, and possible means for obtaining the benefits of electrification in North America are addressed. Because electrification requires a major increase in investment, synergism may be necessary to render electrification economically practical. Low-rated bulk commodities in volume can move more economically with electric power, but not always sufficiently so to induce private capital to make the effort or to take the risk. Other nations provide government funding to gain the substantial benefits of electrification. High-rated competitive movements seldom go by rail today, but they more likely would if the speed and economy made possible by electrification were made available to users. If high-rated goods were moved by rail, the added volume would reduce the unit costs of fixed expense, thereby reversing the downward slide of carloadings, which provokes rate increases, causes lower traffic volumes, results in reduced service, and repeats the downward cycle. In addition to freight, passengers, mail, and express also have profit potential under electric operations and offer the opportunity to make the total railroad operation more cost effective and useful than a single-purpose bulk commodity facility.

Except in North America, most developed nations of the world have progressed railroad electrification to a highly developed and extensive degree. The question must be asked, What is so different about North America that denies conventional wisdom favoring railroad electrification?

Most important is the institutional difference. Only in the United States (and partly in Canada) are railroads funded by tax-paying private investors in search of a profit, yet at the same time competing with government-subsidized highway, waterway, and airway facilities. In most other countries railroads are funded by government in the same manner as the other transport modes.

Many recent domestic studies have found highly positive rates of return on investment for American railroad electrification, ranging between 15 and 20 percent for the most promising routes (1). For an industry straining hard and futilely to earn even 6 percent (2), electrification would seem essential, and indeed it may be. Why then is there little progress and actual disinvestment?

## WHY NOT?

Railroads are not operated solely for their rates of return. They are too essential and important, both economically and politically, to be liquidated because of their inadequate profits. It is difficult to attract all of the necessary capital in this mixed, or double-standard, economic climate of socialized subsidy funding for all other transport modes. Competition is not conducted with economic equity. After taxes and debt interest, too many of the real benefits of electrification are siphoned off, leaving too little net income to fund the necessary effort with adequate margin or safety factors. Why would an investor risk competing with untaxed, free transportation capital from the government? Gresham's law cannot be repealed. Good business practice in this climate may be bad business practice for the investor.

A second drawback to electrification is operational. Why bother? It is a nuisance. Operating officials prefer a single, ubiquitous, simple, standardized pool of motorized power that can go anywhere and pull anything. Engineering officials do not want to bother with catenary and substation maintenance. Financial officers do not want the added debt and watered stock necessary to fund electrification.

A third significant excuse for avoiding electrification is the declining market share of the railroad industry. Carloads go down, level off, then go down again (3). Piggyback growth is often profitless. Highway, waterway, and air carriers are winning a larger share of the nation's transportation fast, overnight and midday electric multiple-unit freight trains in intermodal joint activity with local short-haul trucking firms (not TOFC), railroads can gross $0.20 per ton mile, which is equal to $6 per car mile for this type of high-rated freight ($0.20 x 30 tons = $6).

Currently, railroads average little better than $1.15 per car mile (2). Costs for short multiple-unit trains will be much higher per car mile, but not as high as the revenue. The gross revenue will thus be higher, thereby reducing the share of the revenue dollar consumed by track maintenance, debt service, and electrification investment. There is far more dollar value in LTL activity than there is in carload movement and in the market for bulk commodities (4).

Mail and express were once a mainstay of railroad revenue. They could be again, but not in the labor-intensive manner of old. As with the LTL opportunity, dedicated short trains of multiple-unit mail and express cars or mail and passenger trains can gross high revenues per car mile, with savings for the Post Office and United Parcel Service (UPS) under ideal conditions, which often require electrification for success.

Much attention is now being paid to high-speed ground transportation. For more than 50 years railroads successfully and safely provided 100-mph passenger service in many areas of the nation (6). Several examples, such as National Railroad Passenger Corporation's (Amtrak) San Diegans, the Northeast Corridor, and the Keystone Service, have proved that travelers want and will use convenient or high-speed service at a competitive price, such a $0.15 per mile (the perceived cost of driving an automobile). This is but half the true cost (7). Such rail service can produce $6.30 per car mile in revenue, well in excess of Amtrak's full costs:

84 seats x 50 percent load x $0.15 per mile = $6.30.

The assumed 50 percent load factor is readily attainable with short trains tailored to specific markets. There is a profit potential here also, but electrification often may be necessary to serve it successfully. Frequent service is a most essential element, but such frequency is not often feasible, economically or technically, without electrification. Superior acceleration is required for point-to-point speed, particularly with grades and curves. Locomotives must be avoided on short trains with short turnarounds. Only electrification can provide the essential elements economically. Self-propelled diesel rail cars have seldom proved economical or successful. Maintenance costs are too high, and operating characteristics are too slow.

High-valued freight can also be recovered for rail movement and augmented revenue. Better service at lower cost is the essential ingredient. Even with electrification, rail movement over most distances will not be equal to truck time and convenience, but inventory savings are not usually worth more than $25 per day per carload. The inherent economy of electrification can justify rate differentials sufficiently low to recapture some high-rated LTL freight in longer distance rail market areas.

## HOW?

How can electrification do all this? Why can't proven and accepted diesel-electric powered service do the same?

The difference relates to performance with economy (i.e., higher acceleration with lower maintenance costs). Lower cost of coal-generated electricity will assist. Right-of-way costs will also be reduced per unit of movement, not absolutely, but per ton mile moved and per revenue dollar. The improved array of services will increase revenue faster than it increases cost. The room for growth is apparent when it is realized that transportation consumes 20 percent of the gross national product (GNP), but railroads capture only 2 percent of it (GNP) for doing most of the heavy work.

A typical freight car that can gross $1.15 per total car mile will see nearly 20 percent of it consumed by right-of-way maintenance, but a $6 per mile car will yield less than 10 percent of the gross for track maintenance. Conversely, superior service will increase transportation expenses, although not in direct proportion. A train and engine crew of three may typically cost $3.60 per train mile (including fringe benefits). This is little more than the revenue from the movement of a single loaded car and less than the revenue from just one car of high-rated lading. Crew cost should not severely constrain efforts to earn superior revenue from added traffic won with much improved service.

The advantage of synergism is great. If a rail line is carrying 15 million gross ton miles of traffic per year, which consists primarily of low-rated commodities and TOFCs, it will gross roughly $200,000 to $250,000 per route mile per year:

15 million x 45 percent revenue tons x $0.03
= $209,250.

When less-than-carload freight, mail, and passenger service are added on a carefully selected basis for a known strong market, even on a small scale, it is reasonable to assume that gross revenue will increase 35 percent or more without overtaxing the inherent capacity of a well-maintained, properly equipped single track.

The disastrous past experience with passengers and less-than-carload (LCL) freight will give pause to these thoughts of resurrecting this type of service. However, airlines, buses, and trucks all made healthy rates of return on this type of traffic before the concurrent impacts of recession and deregulation. The national economy will recover. The higher unit costs of the other modes did not restrain their growth or their profitability (4). Management and marketing skills may have as much to do with profitability as does technical superiority.

As mentioned previously, LCL freight will be profitable only if it is handled as if it were full carloads between major terminals on overnight schedules. For example, a train of four electric multiple-unit cars could be spotted on a team track or at a loading dock in the late afternoon to be loaded directly from local pickup and delivery trucks, just as highway tractor-trailers are loaded at motor freight terminals. There would be no added cost for transshipment. The work of loading the rail cars would be performed by the same crew that handled the truckloads, but now with rail supervision. No locomotives and no yards would be involved. These costs would be avoided. The electric trains would simply depart for their destination(s) when ready, with the possible interchange of a couple of cars at a major junction point midway. Before morning the destination would be reached some 200 to 400 miles away without excessive speed. The key to obtaining higher revenue is reliable overnight service.

Profitable passenger service would in many ways be similar, except it would favor daytime service. No extensive switching of sleeping cars would be involved. Such passenger trains will have to be of the multiple-unit type and be fast between short stops, with proven reliable commuter-tested electrical and mechanical equipment, combined with intercity decor inside. These short, frequent trains would need little or no terminal switching. When necessary, cars can be switched under their own power. Consists must be adjustable to fit loading requirements and schedule effeciency. Locomotives would be used only when frequency does not eliminate the need for long trains. The multiple-unit concept is most efficient with consists of four or fewer cars, and with six cars only rarely. Longer trains are more efficient with locomotives.

Profits are possible on intercity service of this type if commuters are also served under contract with public agencies in metropolitan areas. The commuter activity can provide public funding for the terminal infrastructure and for the main line in commuter territory, with operating assistance for expenses not covered by fares. This will relieve the intercity service of sole responsibility for the most difficult financial problems, and will aid freight service greatly as fixed costs are more widely distributed. [The availability of public financing was recently demonstrated in Dallas (August 1983), where the voters approved an increase in the sales tax to fund electric rail transit that uses railroad rights-of-way.]

Rail diesel cars offer a technological alternative to electrification for short passenger train operation, but their acceleration rate is slow and their maintenance cost is too high to compete with electric operation or to meet the market demand in most major markets. Experience with rail diesel cars has not usually proved satisfactory. Many such diesel operations have been sharply curtailed or abandoned, whereas electric multiple-unit operations continue to expand in many areas (Brewster, New York; Northport, Long Island; Warminister, Pennsylvania; Park Forest South, Illinois; Portland, Oregon; and San Diego, California).

Putting these elements of railroad operation together, a synergistic electrified railroad is likely to consist of 6 through heavy freight trains per day as a minimum, 4 LCL multiple-unit electric freight trains, 12 intercity passenger trains, and 8 local commuter trains in appropriate territory (7), plus 2 diesel-electric local or way freights--32 trains per day in all. The capacity of a single track need not be exceeded if it is properly signaled and scheduled. Thus, instead of $250,000 per mile gross annual revenue from typical bulk commodity freight train operations, the added service made possible by electrification could increase gross revenue to $375,000 per mile--up 50 percent. Debt service on electrification can be covered by the more economical movement of the heavy freight, but at $75,000 per mile per year it is too much without double coverage by the incremental net income on the added new services made economically possible by electrification. Such double coverage makes financing much more attractive, but it cannot be determined by fully allocated cost accounting unless the entire railroad is electrified. Fully allocated accounting has no place in incremental decision making.

Can a conjectural analysis of this nature have practical application? It should, and it appears that it does, based on a specific test application. A concrete example will be illustrative.

## T³: THE TEXAS TRIANGLE

The sunbelt area of Texas is growing rapidly and is outstripping highway capacity in some major centers. Several large metropolitan areas are strung out along railroad rights-of-way. The best example may be the Dallas/Fort Worth, San Antonio, and Houston triangle, with Austin, Waco, and other smaller cities in between.

The Forth Worth-Houston corridor has been seriously and favorably considered for electrification by the Missouri-Kansas-Texas (Katy) Railroad. High interest rates and recession traffic levels have made financing questionable, however. With higher levels of revenue, Katy would be better able to pursue its plan. Synergism could produce the higher levels of revenue and net income. Thus synergism may increase railroad electrification in North America. To be synergistic, however, it is necessary to add Dallas and San Antonio to the electrification plan. Katy does not project sufficient bulk commodities to support electrification to those cities now, but with new sources of traffic, and some of it guaranteed, it could. The basic Fort Worth-Houston line is 327 miles long (8). A Dallas connection would add 66 miles, and a San Antonio extension would add 126 miles. The synergism of adding these three additional markets (Dallas, San Antonio, and Austin) is far more than simply the added population and commercial activity. Several more city-pair opportunities are made possible. That is why synergism is so important (see Table 1).

In addition to current and prospective tonnage freight movements, and one Amtrak train part way, additional sources of traffic could be made economically feasible with electrification if operated with properly designed rolling stock (see Table 2).

**TABLE 1 City Pair Traffic Potential: Synergism in Modest Expansion of Basic Electrification**

| | Miles | County Population | Traffic Units[a] |
|---|---|---|---|
| Basic electrification | | | |
| Houston to | | 2,409,544 | |
| Fort Worth | 327 | 860,880 | 2.0 |
| Waco | 238[b] | 170,755 | 0.7 |
| Total | 327 | 3,441,179 | 2.7 |
| System expanded 59 percent | | | |
| Dallas to | | 1,556,549 | |
| Houston | 338 | 2,409,544[b] | 3.3 |
| San Antonio | 293 | 988,800 | 1.8 |
| Austin | 210 | 419,335 | 1.5 |
| San Antonio to | | 988,800[b] | |
| Houston | 283 | 2,409,544[b] | 3.0 |
| Fort Worth | 281 | 860,880[b] | 1.1 |
| Waco | 193 | 171,775[b] | 0.5 |
| Austin to | | 419,335[b] | |
| Houston | 200 | 2,409,544[b] | 2.5 |
| Fort Worth | 198 | 860,880[b] | 0.9 |
| Expanded total[c] | 519[d] | 6,405,863 | 17.3 |

[a]Denotes dimensionless numbers based on the proportional attraction between bodies of population relative to size, and inversely proportional to the square of the distance between them, as in gravity models. (This is for intrastate general traffic only; it does not apply to interstate bulk commodities.) Applicable only to rail movements with superior service over distances in excess of 175 miles; shorter distances cannot justify the pick-up and delivery reloading.
[b]Duplication of population mileage.
[c]Percentage increases for expanded totals are as follows: miles = 59 percent, county population = 86 percent, and traffic units = 541 percent.
[d]Denotes total route mileage, eliminating duplication on common trackage.

## ANALYSIS

On 520 miles of railroad, increasing gross revenue from $75 million to $112 million will go far toward financing electrification. It has already been justified by savings on moving existing traffic (1). Instead of a 4 to 1 ratio of electrification investment to annual gross revenue, the ratio falls to a much more attractive 2.7 to 1 with synergism.

It is essential that cost and value be differentiated. A standard freight car costs $40,000, but

TABLE 2 Additional Sources of Traffic

| | Cars per Day, Each Way | |
|---|---|---|
| Source of Traffic | LCL Freight | Passenger |
| Dallas-Houston | 4 | 0 |
| Dallas-San Antonio | 3 | 12 |
| Dallas-Austin | 2 | 0 |
| Houston-Austin | 1 | 0 |
| Houston-Fort Worth | 3 | 0 |
| Houston-San Antonio | 3 | 0 |
| Houston-Waco | 2 | 0 |
| San Antonio-Fort Worth | 2 | 0 |
| San Antonio-Waco | 1 | 0 |
| Forth Worth-Hillsboro | 0 | 6 |
| Houston-Taylor | 0 | 6 |
| Temple-San Antonio (Amtrak) | 0 | 6 |
| Dallas-Waco | 0 | 12 |
| Houston-Addicks | 0 | 12 |

it travels only 20,000 miles per year, and it earns only $22,000 gross revenue (2). Interest and depreciation consume 25 percent of this meager revenue. With operating ratios more than 90 percent for most railroads (9), new conventional railroad equipment offers a dim financial prospect.

In contrast, an electric self-propelled freight car without passenger amenities but mechanically similar to a commuter car except for length may cost more than $600,000. This first cost might be reduced by constructing such cars from serviceable components of retired commuter cars and diesel-electric locomotives, as was done by the intercity electric traction industry in the past.

Even at $600,000, however, the electric freight car could earn up to $450,000 per year, which is more than 12 times the earning capacity of a well-used standard freight car. Such a dramatic increase in earning power comes about by virtue of the always loaded, high-mileage, overnight loading capability of the self-propelled freight car. Instead of the 60 miles per day that freight cars usually average (2), the electric car will average 300 to 400 miles per day. It will carry higher-rated freight, thus sharply increasing gross revenue per car mile, even though loading is lighter. Less track wear will also be experienced.

Unfortunately, costs will also rise, from $1 per car mile for the typical freight car of 1984 to as much as $4 per car mile, a 300 percent increase. Interest and depreciation will also be heavy at $75,000 per car per year, but even so there may remain a net income of $70,000 per car per year, which is infinitely more than the minuscule profit, if any, earned by low-mileage freight cars or high mileage TOFC cars (piggyback).

Synergism should not be misunderstood. Current bulk commodities now moving by rail are not susceptible to economical movement by means of self-propelled cars in short trains. Electrification will reduce movement time, maintenance costs, and possibly fuel costs, but it will not change the physical method of moving heavy bulk commodities at low rates. It will simply increase the efficiency of moving them. The point of synergism is that it will reopen whole new markets, just as automobile racks won back much of that lost traffic, and just as refrigerated TOFC service is winning back the lost perishable traffic.

Railroads have practiced the technique of retrenchment economy to the point of diminishing return. Now it is time to reduce unit costs still further (in constant dollars) by expanding markets and plant use with improved and more efficient services, so that the high fixed and sunk costs inherent in railroading can be distributed much more widely and thinly among many more dollars of revenue. That will be a true long-run economy. As much of the remainder of the world has proved, electrification can make better service possible at lower unit cost where conditions are favorable.

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