Operating Costs Comparison: Steam, Diesel, And Electric

By: Michael Sol

Little Joe, cost per HP purchase price: $15.15
S-2: $35.56
F-7: $100.00

Based on Economic Service Life:
Little Joe: $15.15
S-2: $35.56
F-7,GP-35,SD-40 (pro-rated): $447.62

Maintenance Cost, per 1000 ton-miles:
Electric fleet: $0.10
Litte Joes (est. from published curves): $.03
Steam fleet (average age > 20 years): $0.44
Diesel fleet (average age < 5 years): $0.36
Age adjusted using standard published maintenance cost curves, the steam fleet adjusted to an average age of five years would be about $0.25 per 1000 ton-miles.

The average maintenance cost over the economic service life skews heavily against the Diesel-electric. At age ten years, the Electric would have maintenance costs just slightly above 10 cents per 1000 miles, the S-2 about 16 cents, and the Diesel-electric about 24 cents.

At age 20 years, the Electric would be costing about 14 cents per 1000 miles, the S-2 about 20 cents, and the Diesel-electric would be past its economic service life and recapitalized either through an overhaul or a new purchase. At the time, if a Diesel-electric were maintained only, to 20 years, the estimated maintenance cost per 1000 miles would be approximately 36 cents.

From these published figures, it can be seen that Milwaukee Road's fleet-averaged maintenance costs tended to be on the high side for both Steam and Diesel. Its Electric fleet maintenance costs, however, were well within the expected range for a fleet of that age that, at the time the numbers were recorded, did not include the Little Joes as a significant portion of the maintenance.

Operating (fuel/power) cost, per 1000-ton miles
Electric fleet: $0.38
Combined Diesel and Steam: $0.38

The figures do not break out for "train fuel purchased". It is likely at the time that the cost of operation for fuel broke slightly in favor of Steam at the time based on the BTU cost differential between coal and diesel fuel.

With the exception of the published maintenance curves, taken from a contemporary publication by Alfred Bruce, "The Steam Locomotive," (1952), these are based on the Annual Report figures published by the Milwaukee Road in 1950 and don't represent any particularized work on my part.

"*Maintenance costs are higer for diesel than steam?*"

Well, maintenance is maintenance and includes labor and parts specifically associated with the individual units serviced in a roundhouse or other facility.

Water isn't maintenance. With Steam, the cost of water, in prodigious amounts, was $646,701 in 1950. However, a Diesel-electric uses considerably more lubricant that a steam locomotive, generally equivalent to about 10% of the cost of diesel fuel itself. By 1950, the cost of lubricants for road motive power had risen to $625,090. In figures I've compared over the period of dieselization, it was generally a wash; whatever was saved in "water" costs was lost to the higher cost of lubricants used. Yes, I used the word "wash."

Over time, water generally cost about the same; lubricants naturally tracked the overall rise in the cost of petroleum products after 1950.

The maintenance costs curves associated with aging profiles of Steam, Diesel-electric, and Electric have been published in about a million different places: there is no disagreement among mechanical engineers as to the historic cost of maintenance of the respective motive power types. On every single published curve, the cost of maintenance of road Diesel-electric motive power ALWAYS exceeds the age-adjusted cost of maintaining an equivalent Steam engine. And both of them ALWAYS exceed the age-adjusted cost of Electric motive power.

These are standard published curves. Let me repeat that: this isn't a figment of anybody's imagination, these are the accepted conclusions of the engineering profession.

Railfans, and often railroaders of that era who weren't actually looking at the cost numbers, mistook the substantial decline in shop forces of that era as having some "special meaning" regarding the maintenance requirements of a modern Steam engine.

The decline in shop forces mirrored three significant post-War influences: 1) automation, 2) the decline in tonnage hauled during the period of Dieselization (a decline which averaged about 42% on US railroads, which just about matched the percentage decline in shop forces), and 3)the wholesale replacement of a motive power type with an average age of 27 years (on the Milwaukee), and near the top end of their service life maintenance curves, with machines that were at the bottom of their service life maintenance cost curves.

Given those three important factors, it is not remarkable that maintenance costs generally increased, inflation adjusted, per unit horsepower on US railroads as those "new" units began to age.

That is why, for instance, the net cost per horsepower for the Diesel-electric alternative is more than an order of magnitude higher than for Steam power -- that's the multiplicative effect of the acknowledged relatively short economic service life of a road Diesel-electric locomotive.

Steam engines could not have the long, 30 year service lives universally attributed to them if their annual maintenance costs were high, especially considering that the per hp capital cost of a steam engine is low, compared to its Diesel-electric counterpart. If, for example, their maintenance costs were equivalent, the Steam engine would have the shorter economic service life.

Based on how ESL is calculated, the 30 year ESL for a Steam locomotive is consistent with a low capital cost and low maintenance costs. The roughly 8 year ESL for a Diesel-electric road unit in mainline road service is consistent with a high capital cost and high maintenance costs (14 years is the statutory depreciation period).

If a Diesel-electric locomotive had lower maintenance costs than an equivalent Steam engine, then because of its substantially higher capital cost, it would have a substantially longer ESL.

It doesn't. Nowhere. The notion that maintenance costs were lower is strictly refuted by the Economic Service Lives assigned by the railroads themselves to the machines for depreciation purposes.

Just by way of supporting what the Milwaukee Road shows in its actual operating results, it is mathematically impossible, based on the ESL estimates made by the railroad companies, for the maintenance cost of a Diesel-electric to be lower than the maintenance cost for an equivalent Steam engine of a similar age.

"*Did the cost of water include the cost of water treatments and the tanks?*"

"Water" included the costs of treatment. The maintenance of "water stations" was a separate operating expense not attributable entirely, however, to Steam engines. In 1950, maintenance cost of such facilities was approximately $24,000 annually; by 1961 -- five years after the end of steam operations -- maintenance of such facilities was still costing nearly $11,000 annually.

The cost of water in 1961 for road locomotives was still $71,000 compared to the cost of lubricants used in 1961 which was nearly $700,000 even though traffic was down considerably compared to 1950 levels, that cost exceeding the 1950 cost of water at $647,000.

From everything I've looked at, "cost of water" was inevitably more than offset by "cost of lubricants" over the transition.

HF Brown, who assisted on some of the Milwaukee Road Electrification study work, made this observation in his much discussed 1961 paper.

Looking at it from the perspective of 1950, the "promise" and the "reality" was quite a bit different.

The promise was:

1) The Diesel-electric had an economic service life of at least 20 years, and GM specifically advertised (in Milwaukee Road Magazine!) that the life span of a road diesel was "forever."

2) Interest rates, 1945-1950 were between 1.5% and 2%.

3) Diesel fuel was about 7 cents a gallon (equivalent of 9.5 lbs of coal, coal $4.86 ton, about 2 cents worth of coal).

4) Low maintenance costs meant low employment needs.

5) Multiple Unit capability meant fewer engine crew needs.

The risks were:

1) Diesel-electric locomotives had performed well below 500,000 miles of service which is about what the early generation saw over WWII and before 1950. But, there was little experience with large fleet numbers over 10 years old. It was a very large gamble made with astonishingly little experience.

2) Interest rates were at a historic low. The economic service life of the machine would be critical to its economic viability: the shorter the life, the greater the impact of interest rates on overall cost.

3) Everyone switching over to diesel fuel made it less likely over the long run that cost would stay low. Even before 1956, oil experts were predicting "Peak Oil" was only 15-18 years out and that costs would invariably increase.

The results were:

1) GM recommended in 1954 that the economic service life of road diesels be reduced from 20 years to 14 years. A 43% reduction in ESL has a huge impact on internal rate of return calculations. If anyone was doing such a thing then, the picture had to have looked considerably less optimistic.

2) The cost of diesel fuel really didn't start to rise until 1973 but by 1960, the price of coal was 50 cents cheaper per ton.

3) The ESL of mainline road Diesel-electrics practically speaking became set at about 8-10 years. This required three replacements of motive power over the ESL of a single Steam engine. The initial cost estimates of $3-$5 per Diesel HP, compared to $1 per Steam HP, became in reality, $9-15 per Diesel HP compared to $1 cost per Steam HP.

4) Engine crew requirements changed little. Indeed, they went up as the early generation of Diesel-electrics required an additional crew member -- a "Maintainer" -- to work the engine compartment. The vision of large trains hauled by huge lashups of Diesel-electrics was impractical because, unless you were the Union Pacific, railroading still consisted primarily of trains aggregating and disaggregating traffic connected by long haul trains that still had to fit into existing sidings and yards, hauling trains equipped with couplers which couldn't put any more stress on them than was already being put on to them by existing large steam.

5) The cost of new facilities to service Diesel-electrics required approximately twice the existing capital investment in Steam support facilities, and the cost of upgrading virtually the entire US Rail system insofar as yard size and siding length, to accommodate even marginally longer trains, cost more than the entire investment made in first generation Diesel-electrics, at a time when railroad revenues were hard pressed to support Dieselization, let alone the (unexpected) capital needs of making the system fit the theory of longer trains. You can read the literature of the era and not realize, amidst the hype and glory of technological gains, that nobody, no one at all, was talking about the fact that, if true, the infrastructure could not support the longer trains envisioned by full Dieselization.

6) The carrying cost of the Steam Fleet had been zero% because of the long service life of Steam engines. The carrying cost of Diesel Electrics, because of their short ESL, rose from 2% in 1950 to 3% in 1955, to 4.5% in 1960, 8% in 1970, 12% in 1975, to 20% in 1980, each increase representing an increasing net burden on the earning power of railways.