Canadian Railway and Marine World

May, 1919

The Economics of Electric Operation of Railways.

By W. G. Gordon, Transportation Engineer, Canadian General Electric Co.

Much has been written descriptive of the different railways now operating electrically, wholly or in part, and of the results as compared with steam operation. I will present some of the latest figures regarding the economies effected by electric operation. At the American Institute of Electrical Engineers convention last year, E. W. Rice said:—"Electric locomotives have been so improved and simplified that they are competent to haul the heaviest train that can be held together with the present train construction; to operate at the highest speed permissible by the alignment of the road and independent of its grades; and the electric locomotives can meet, in the most efficient and adequate manner, the transportation problems confronting the country, and offer better results than are now obtained or seem possible with steam locomotives. It should not be forgotten that steam locomotives burn about 25% of the entire coal mined in the United States, and that 12% of the entire ton mileage movement of freight and passengers carried, is represented in cars and tenders required to haul coal to supply steam for the locomotives." This percentage is shown from the following table (1) of one year's ton mile movement:

	Millions ton miles	Per cent. of total
Revenue coal	204,600	12.56
Railway coal	52,000	4.96
Revenue freight	372,040	35.60
Railway freight	5,600	0.55
Locomotives	148,200	14.20
Locomotive tenders.......	74,630	7.14
Passenger cars	186,890	17.90
	1,043,960	100.00

The comparative percentages for the different classifications are very close to those given above for the operation of our steam railways in Canada.

Where a trunk line is electrically operated from water power stations, it means that the total movement for railway coal and locomotive tenders is eliminated, and even if partially or wholly operated from steam power stations, the movement for locomotive tenders is eliminated, and the movement for railway coal greatly decreased. The benefit is self evident, of being able to apply this ton mileage, at present absorbed by steam operation, in the movement of revenue tonnage.

The cost of maintenance of the electric locomotive is very much less than that of the steam locomotive. Table 2 gives the cost of maintenance in cents per locomotive mile for a number of roads, these costs being for the years they have been operating electrically to 1917, inclusive. The costs are given for an average of 5 years for 3 roads, and average of 4 years for 2 roads and an average of 2 years for the Chicago, Milwaukee & St. Paul Ry. The average locomotive weight in tons is given for each road, and in order to obtain a comparison, I have given the cost also on the basis of the locomotives weighing 100 tons in each case.

Table 2. Cost of Maintenance of Electric Locomotives.

Road.	Average loco. wt. in tons.	Average maint. per loco. mile.	Average maint. on basis of loco. weighing 100 tons.	No. of years.
Baltimore & Ohio Rd.	98	5.13	5.24	5
Butte, Anaconda & Pacific Ry.	80	5.66	7.08	4
Chicago, Milwaukee & St. Paul Ry.	290	8.94	3.09	2
Michigan Central Rd.	108	4.39	4.06	4
New York Central Rd.	118	4.12	3.5	5
Pennsylvania Rd.	156	5.3	3.4	5
General average		5.59	4.39	

The cost of maintenance per locomotive mile for steam locomotives, compared with the above, will be from 10c to 20c or higher, depending on the capacity and service of the locomotive.

A very interesting comparison is given in Table 3, showing comparative results between steam and electric operation on the Butte, Anaconda & Pacific Rd. In 1913 the operation was entirely steam; since then it has been gradually superseded by electric. The figures for electric operation are averaged for 3 years, and as there was still a considerable amount of steam operation during these 3 years, the figures do not show full credit to the benefit of electric operation.

Table 3. Comparative Results, Steam and Electric Operation, B. A. & P. Rd.

	Steam 1913	Electric average for 3 yrs.	Saving in amount	Elec. Operation %
Fuel & power	$294,830	175,165	119,665	40.59
Loco. repairs	97,492	57,881	39,611	40.61
Loco. men, wages	99,611	74,036	25,575	25.67
Loco. house expenses	28,342	16,703	11,639	41.06
Lubricants	9,345	5,444	3,901	41.76
Water	4,491	2,084	2,407	53.59
Other supplies	5,435	4,308	1,127	20.74
Total.	$539,546	$335,621	$203,925	37.80
Revenue ton miles hauled	153,168,648	169,553,405	16,384,757	10.70

Table 3 shows a saving in electric operation of 37.8%, and at the same time an increase in the revenue ton miles hauled of 10.7%. Had this increased ton miles been hauled in 1913, the total cost would have been $597,277, so that the actual saving in electric operation is 44%. On this road 17 electric locomotives were in operation in 1914, 24 in 1916, and at present there are 28.

Where mountain divisions are electrically operated, a further marked economy is effected by regenerative braking. This is obtained by exciting the fields of the motors on the locomotive on down grades, so that the counter electro-motive force builds up higher than the line voltage, and returns power to the line, this action retarding the train to whatever extent desired, without the use of the air brakes, as well as supplying power to other trains running on the level, or up grades. This action, of course, reduces the total demand on the substations, with consequent reduction in the power demand on the primary source of supply.

Table 4 which shows the saving thus obtained on the Chicago, Milwaukee & St. Paul Ry. is the result of careful tests just worked up by General Electric Co.'s engineers.

The above results are of extreme interest. The runs were taken in both directions, over the total electrified distance of 437.6 miles, with trains as high as 2,853 tons trailing load, giving a general average in watt hours per ton mile, without regenerative braking, of 24.06; and with regenerative braking of 19.72; or a reduction in power due to regenerative braking of 18.04%. As a direct result of regenerative braking, a large saving is effected in brake shoe wear, apart from the elimination of wrecks caused by overheating of the brake shoes, brake heads and wheels, where heavy trains are handled on long down grades. The air brakes are only required for emergency, as the braking is all done by the locomotive. It has been estimated that on the Chicago, Milwaukee & St. Paul Ry. the saving per

Table 4. Chicago, Milwaukee & St. Paul Ry. Tests. Watt Hours Per Ton Mile.

Preliminary calculation made from watthour meter reading taken on locomotives. This calculation includes ton mileage of road and helper locomotives.

Run no.		No. of cars	Trailing tonnage	Ton miles trip includ'g locos.	With Reg. Brak. Kw. hrs. for trip	With Reg. Brak. W. hr. ton mi.	Without Reg. Brak. Kw. hrs. for trip	Without Reg. Brak. W. hr. ton mi.
Missoula Division—211.2 miles.								
3	Avery to Deer Lodge...	57-56	2497-2457	596485	15068	25.23	16432	27.55
7	Avery to Deer Lodge...	58	2767	656516	17207	26.20	18374	27.97
10	Avery to Deer Lodge...	61-60	2836-2796	665505	17971	27.00	19622	29.48
6	Deer Lodge to Avery...	62	2383	575436	6943	12.05	8927	15.51
9	Deer Lodge to Avery...	82	2853	674700	9344	13.85	11618	17.24
	Average Values.							
	Avery to Deer Lodge...					26.14		28.35
	Deer Lodge to Avery...					12.95		16.37
	Round trip average Missoula Division					19.54		22.35
Rocky Mountain Division—226.4 miles.								
4	Deer Lodge to Harlowton	58-56	2539-2466	637367	10392	16.30	15141	23.75
11	Deer Lodge to Harlowton	60	2817	712518	12155	17.06	17405	24.42
5	Harlowton to Deer Lodge	67	2264	588640	14654	24.90	16792	28.52
12	Harlowton to Deer Lodge	64	2762	700021	14929	21.32	18498	26.40
	Average Values.							
	Deer Lodge to Harlowton					16.68		24.08
	Harlowton to Deer Lodge					23.11		27.46
	Round trip average Rocky Mt. Div.					19.89		25.77
	General average					19.72		24.06
	Reduction in power due to regeneration.....					18.04%		