IW - Diesel @ fork / van

Depreciation - & Interest -
D @ c.109794
I @ c.080556

Conclusion - Great Increase in train tonnage? & speed?
Practically no limit to motive power?

Comparative - 1% traffic growth - what is basis?
1966 figure 519,000 diff ?
1986 figure 330,000 "

		CHK	FK	
Pg 3 -	diesel	57	37	?
	elec	37	36	-

Class power irrelevant - Don't agree.

Salvage logic ?

Loco Mtce TP1 pg. 10.

Question signal feeder logic - Could use commercial at most points in this day of REA.

Added cost mtce in Elect territory -
"No data but substantial" - What is difference between flat & mountain mtce?

Fire loss - Question whole approach. Well maintained modern power with superchargers don't cause fires. Brake shoes do.

Depreciation? What place does it have in study such as this?

Comment (3) pg 18 - What happens when we quite being tonnage hogs? Same for Comment (2) pg 20.

25 KV - French like it
Belgians & Dutch don't } difficult in tite spots.

Comment (4) pg 20 -- Why ?

Review of Report Prepared by
L. Wylie, Consulting Engineer, on
Economics of Electrification
Harlowton to Tacoma
= October 1969 =

Chicago - October 20, 1969

Mr. B. J. Worley:

As requested, I have reviewed the report by Mr. Laurence Wylie, Consulting Engineer, of the electrification, and the several correspondence files pertaining to it. My report is attached. I have selected and include certain papers which bear on the economics of continuing the electrification versus dieselization, and the data used in support of the alternate plans. I have, of course, not included material contained in the comprehensive Wylie Report, including the historical background for the electrification, except his conclusions and summary of relative costs, identified as Sheet A 40-34.

No attempt has been made to verify the highly technical data contained in Mr. Wylie's study. I am impressed by the professional approach and quality of his investigation. A thorough review of the report is required to appreciate the depth of his investigation.

Mr. G. A. Kellow's economic analysis of the Wylie Report is included in full for ready reference, except for exhibits. It is most thorough, and supported by underlying work papers. The format he uses to present comparisons is appropriate, and I have more or less followed it except that I have not prepared statements based on a "mixed" operation, in view of actual and potential operations to obtain maximum utilization of equipment.

I found it either necessary or desirable to supplement available data with certain additional information or costs of significance, however it is understood there are innumerable items bearing on the subject that are not covered in any of the reports but which in the aggregate are offsetting or may not influence managements' decision in any event. Finances may dictate a course of action rather than economics.

I have taken exception to the application of the salvage from electrification facilities as a credit to the acquisition of diesel power, as in certain of the reports. That may be the source of funds but it is illogical to so apply it in any comparison of the economics of the two types of motive power.

In consideration of changing times, especially the growth of new sources of electric power and of diesel fuel, it seems prudent to restrict immediate considerations to the reasonable life of new diesel and electric locomotives, with consideration also to the remaining life of the existing electrification plant as a whole, and my statements, like those of Mr. Kellow, are based on costs over a 30-year period.

CVL

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INTRODUCTORY STATEMENT

Under date of April 1968 Mr. Laurence Wylie, Consulting Engineer, submitted a comprehensive report on the merits and economics of retaining the existing sections of electrification between Harlowton, Mont. and Tacoma, Wa., and electrifying the territory between Avery and Othello to close the "gap," versus full diesel operation.

Unit costs and other data used by Wylie and by the several departments in commenting on his report are not in agreement, contributing to conflicting conclusions.

The purpose of this review is to discuss such conflicts and to prepare comparative statements of cost based on data selected as the most reasonable, also to offer conclusions therefrom and from other data and information as to the economics of the alternate plans. It is understood there are innumerable items bearing on the subject that are not specifically covered but which in the aggregate are offsetting or may not influence the decision in any event.

Office of Vice President - Chief Engineer
Chicago, Illinois October 1969

THE WYLIE REPORT

This study is presented in two volumes. It is most comprehensive and only the conclusions and the summary of comparative costs of diesel versus electric operation (3400 volt DC system) Harlowton to Tacoma dated November 17, 1967, identified as Sheet A 40-34, is next attached to this review report for convenience in making comparisons to other cost statements.

The study is developed along accepted methods of analysis and determines rail horsepower requirements from considerations of track profile, tonnage and train speed. The horsepower thus determined for motive power, together with the assumed annual traffic, is the statistical basis for estimates of comparative costs.

C O N C L U S I O N S

The Electrification System still represents a valuable asset to the Railroad Company and should be retained. The section between Avery and Othello should be electrified in order to secure the greatest utilization and the greatest economy from the additional investment required for additional electric locomotives.

With the present inflationary trend indicating a marked increase in the cost of labor, and possibly in the cost of diesel fuel, electrical operation would form a substantial hedge in the operating costs between Harlowton and Tacoma, due largely to the fixed cost of electric power and the greatly decreased cost of repairs for electric locomotives as compared to diesel-electric locomotives. The electrification system is capable of superior performance as compared to any other existing system of railroad transportation except perhaps a more modern electrification system and which, with the present traffic and high cost of installation is, at this time, prohibitive for consideration as a replacement for the present direct current system of electrification on the Milwaukee Road.

The 3300 Volt Direct Current electrification proposed for the Avery-Othello section would have silicon dry type rectifiers, with an efficiency of approximately 97 per cent, 20 mile substation spacing as compared to the average of 30 mile spacing between Harlowton and Avery and between Othello and Tacoma, and heavy trolley system feeder cables of aluminum, permitting supply of ample power to the locomotives with greatly decreased losses in the trolley distribution system. Between Avery and Othello trains of any tonnage could be handled at speeds in excess of the track structure.

With the traffic assumed for this study it has been estimated that savings of approximately $11,000,000 could be made in the 20 year period assumed with such traffic as estimated for this period. With a greater increase in traffic than has been assumed, an increase in estimated savings would result.

It should be a matter of serious consideration for any railroad to know that having once made the investment in the electrification system and the necessary electric locomotives, that this one non-repetitive investment would suffice for a period of 20 years, and in all probability, for a much longer period.

Seattle, March 1, 1968

SUMMARY COMPARISON OF DIESEL /S. ELECTRIC OPERATION
FOR FREIGHT SERVICE -- HARLOWTON-TACOMA

YEAR	1966		1986	
METHOD OF OPERATION	DIESEL	ELECTRIC	DIESEL	ELECTRIC
STATISTICS				
M G T M Trailing	5,342,526	5,342,526	6,408,000	6,408,000
Train and Locomotive Miles	1,414,264	1,414,264	1,696,000	1,696,000
Locomotive Units per Train	4	2	4	2
Horsepower per Unit	3,000	5,000	3,000	5,000
Locomotive Unit Miles	5,657,056	2,828,528	6,784,000	3,392,000
Electric Locomotive Repairs-Per Unit Mile	---	$0.34 WA	---	$0.34 WA
Diesel Locomotive Repairs-Per Unit Mile	$0.40 WA	---	$0.40 WA	---
Cost of Fuel per Gal. or Power per KWH@SS	$0.09	$0.00544	$0.09	$0.00544
Gallons of Fuel at Loco. or Power at SS	15,840,000	237,000,000	18,995,000	283,700,000
Total Locomotive Horsepower Required	204,000	204,000	226,000	226,000
Existing Locomotive Horsepower Available	---	60,000	---	---
Net Locomotive Horsepower Capitalized	204,000	144,000	226,000	226,000
INVESTMENT REQUIRED				
Avery-Othello Electrification	---	$10,277,712	---	$10,277,712
Locomotives	$16,320,000	$14,400,000	$18,080,000	$22,600,000
Total Investment	$16,320,000	$24,677,712	$18,080,000	$32,877,712
OPERATING EXPENSES				
Diesel Fuel or Electric Power	$ 1,426,000	$ 1,287,000	$ 1,708,000	$ 1,542,000
Locomotive Repairs	$ 2,265,000	$ 961,000	$ 2,710,000	$ 1,154,000
Maintenance Transmission, Trolley System	---	$ 272,750	---	$ 272,750
Maintenance, Power Substations	---	$ 128,517	---	$ 128,517
Operation, Power Substations	---	$ 321,474	---	$ 321,474
Total Operating Expense Above	$ 3,691,000	$ 2,974,741	$ 4,418,000	$ 3,422,741
DEPRECIATION AND INTEREST				
D & I Factors - 0.109794 and 0.080586				
Depreciation and Interest Charges, Annual	$ 1,791,838	$ 1,989,000	$ 1,985,075	$ 2,650,000
TOTAL OPERATING EXPENSE, Depr. & Int.	$ 5,482,838	$ 4,963,741	$ 6,403,075	$ 6,072,741

Seattle, Washington, November 17, 1967

BRIEF SYNOPSIS OF PRINCIPAL SUBJECT MATTER CONTAINED IN STUDY AND REPORT OF ECONOMIC AND OPERATING COMPARISON *DIESEL VS ELECTRIC OF THE C M ST P & P RAILROAD

1. PREFACE:

The purpose of the study and report was to develop information relative to the suitability and comparative cost of operating diesel locomotives as compared to electric locomotives in the mountainous territory of the C M ST P & P railroad between Harlowton Montana and Tacoma, Washington, a distance of 867 miles, and for the period 1966 to 1986. The principal question " Should the present electrification system be retained and the gap between Avery, Idaho and Othello, Washington electrified to obtain the advantages of continuity, or should all electrical operation be abandoned in favor of diesel operation ? "

2. CONCLUSIONS :

The present electrification system represents a valuable asset to the Railroad Company and should be retained. It is a fallacy to assume that only one type of motive power is suitable for the entire railroad system. The railroad electrification system was originally installed to provide adequate power to handle heavy freight trains over the five mountain ranges between Harlowton and Tacoma, and in which section the great increase in train tonnage and speed has created demand for corresponding increase in the capacity of the motive power used to handle these trains. By retaining the present electrification system and supplementing electric locomotives with diesel locomotives, when and where necessary, there is practically no limit to the amount of motive power which can be supplied to the individual trains.

3. COMPARATIVE COSTS :

Based on traffic growth of one per cent per year for the period 1966 to 1986, the cost of electrical operation would be less than cost of diesel operation as follows ;

For the year 1966	$ 519,097
" " " 1986	$ 330,334
1966 to 1986	$ 11,000,000

It has been determined that the cost of electrical energy for the entire period considered will remain constant. Operating costs would be influenced by the density of traffic, by the cost of diesel fuel oil, and by the cost of locomotive maintenance repairs and an increase in any or all of these three items would operate to increase the savings due to electrical operation.

4. PRINCIPAL ITEMS TO BE CONSIDERED :

Information shown on the two pages under the above title is condensed as much as possible and should be read and studied carefully.

5. HISTIRY AND PURPOSE OF ELECTRIFICATION (See complete report)

6. GEOGRAPHY OF ELECTRIFIED TERRITORY " " "

7. ELECTRIFICATION FACILITIES " " "

8. POWER CONTRACTS " " "

9. PRICE OF DIESEL FUEL OIL :

No reliable information is available to indicate future price of diesel fuel oil. However it is reasonable to assume that with continued inflation the cost of petroleum products will increase.

10. EFFECT ON EMPLOYEES OF ABANDONMENT OF ELECTRICAL OPERATION:

If decision to include Electrification Department employees under Maintenance of Employment Agreement is in favor of these employees, cost to the railroad company is estimated to be as follows ;

Harlowton to Avery	$ 1,000,000
Othello to Tacoma	500,000
TOTAL	$ 1,000,000

The above figures do not include 92 employees in the mechanical department. It has apparently been assumed that these employees could be transferred to other locations without penalty being imposed on the railroad company.

11. TAX CONSEQUENCES OF ABANDONMENT OF ELECTRICAL OPERATION ;

The cash value of salvage recovered from electrification power lines and equipment could have wide variation due to price of copper scrap at the time of retirement and cost of removal from railroad property. On this item Mr. Kratochwill has issued an opinion as follows ;
" We are of the opinion, however, that the price changes (in copper scrap) would not be enough to alter the general conclusions as to the materiality of the tax consequences "

12. ESTIMATED EFFECT ON PRE TAX INCOMA OF ABANDONMENT OF ELECTRIFICATION :
On this item Mr. Kratochwill has ruled as follows;
" To complete the measurement of effect of dieselization on pre tax income I believe it is necessary to make a determination of the costs which would result from the Power Contracts "

The ststement referred to above is taken to mean such costs as might be imposed on the Railroad Company by the Power Companies due to abandonment of electrical operation prior to date of expiration of the present power contracts. As this is a matter which involves legal decisions and authority to bargain on the part of the railroad management, this subject has not been the subject of discussion between Power Company officials and L.Wylie, and such " costs " as referred to have not been determined.

Seattle July 26 1968. L.Wylie.

COMMENTS ON THE WYLIE REPORT BY OTHER DEPARTMENTS

Attached are copies of letters and reports by other departments commenting on the Wylie Report, selected from correspondence files for ready reference.

Mr. F. A. Upton's letter of July 11, 1968 is discussed elsewhere in connection with cost data.

The following comments are submitted with respect to Mr. G. A. Kellow's very thorough study of the Wylie Report:

Kellows' "evaluation" of the report is largely an independent report. It is an analysis of itself, using data contained both in the Wylie Report and furnished by the Mechanical Department or other sources. It is carefully prepared, and documented by available data, and includes the charting of trains operated to determine the number of locomotive units required of a selected type. A few comments on Kellows' selection of data or exceptions to his analysis follow:

(1) Kellows' analysis is based on the acquisition of 20 new electric locomotives in 1969, 5 in 1972 and 12 in 1980 to maintain a fleet of 37 total, either for full electrification or as at present. Mr. T. B. Kirk estimates a total of 36 required. Thus there is good agreement here.

In the case of diesels, Kellow figures 57 units (SD-45) required for full dieselization (at design tonnage), whereas Kirk states only that 37 units of this class would be needed "at present traffic levels."

Inasmuch as it is believed any study should be based on horsepower requirements rather than any particular class of power the apparent discrepancy becomes irrelevant.

(2) In his analysis Kellow includes the entire fleet required for full dieselization and disregards the diesel units already pressed into service in recent years in the electrified territory. This seems logical for the reason stated - diesels are not captive as are electrics, however the acquisition of new electrics is provided for at a later date.

(3) Kellow credits the investment in dieselization with the net salvage from retirement of the electrification transmission and trolley lines. This is not logical in an economic comparison. The salvage should be credited to the net cost of the existing electrification, even though retired by reason of obsolescence or change in methods. It is one of the benefits of electrification.

(4) The analysis includes also costs for operation of the "gap" with diesel locomotives, and full restoration of electric operation in the electrified territories. This plan shows economy as compared to either full electrification or full dieselization.

A return to this arrangement however is not consistent with the Operating Department's desire and current trends toward through operation of motive power in the interests of maximum utilization and most efficient operation. It is not included in the Wylie Study.

P. J. Worley

Tacoma, July 11, 1968

File: General
E-5-44

Mr. C.E. Crippen:

Relative to Mr. L. Wylie's Study on comparative diesel and electric operation, which Mr. McGinn has asked us to evaluate. The substance of the study would seem to be in the summary sheets A, B, and C, which differ only in costs assigned to engine maintenance. We would like to comment as follows:

Locomotives

The ratio of electric to diesel engines would be higher than the 1 to 2 ratio shown. New diesels purchased for mountain service probably would be the 3,600 h.p.,190 Ton,S.D.-45 Class. The only satisfactory electric engine available, without paying a large development charge, is a 4,500 h.p.,190 Ton, 6-axle locomotive. This engine would have the same tonnage capability,on mountain grade, as the S.D-45, but would have nearly 50% more power available for speed.

Engine Maintenance

Costs shown are much higher than costs now being reported.

1986 Costs

These costs are much too low. Predictions are that wage rates in 1985 will be at least double those of 1965.

Diesel costs will increase for new engines, engine maintenance and fuel.

Electric engine maintenance costs will increase.

Line maintenance costs will increase faster than wages due to a heavy pole replacement program which will be required.

Substation operation and maintenance will also increase rapidly, unless the stations are modernized and automated as much as possible.

July 11, 1968

Mr. Wylie's Study contains a large amount of research which can be valuable to the Railroad for reference. In particular, the section on Unit H.P. requirements may be valuable.

T. B. Knight
Electrical Engineer

bk-k

Encl.

Milwaukee, Wisconsin
July 11, 1968
File: 2202-L-1

Mr. C. E. Crippen:

File: S-1217 - Electrified Train Operation Vs. Diesel Train Operation

Mr. Wylie's report regarding Diesel-Electric Vs. Electric Locomotive operation Harlowton to Tacoma which was transmitted to me with your letter of June 24 contains a great deal of valuable information and a complete evaluation of all of the data will require extensive investigation.

Our examination of the data to date indicates the method of evaluating the two systems as stated in the summary tabulation identified as Sheet A 40-34 appears reasonable. However, three items as follows appear to be worthy of comment:

(A) The locomotive repair cost estimate stated is apparently based on a weighted average cost of repairs per unit mile with no specific detail stated except that "R.R. Statistics; Industry Data" was used. In our past discussions with Mr. Wylie, we were advised that due to heavy power demand on units in mountain service he preferred to use a cost per mile weighted for heavier work performed in mountains. We have considered this approach and concluded that the most reasonable way to estimate this type of weighted locomotive repair cost is to base the estimate on fuel or power consumed which is, in our opinion, the most practical measure of work performed. Tabulation No. I attached states our cost of repairs (Account 311) for electric and diesel units on basis of cost per dollar of fuel or electric power consumed. Using the 1966 cost of fuel and power stated in Mr. Wylie's Sheet A 40-34 produces an estimated locomotive repair cost of:

Diesel - $1,426,000 x 1.25*= $1,780,000 per year
Electric - $1,287,000 x 0.82*= $1,055,000 per year
* Repairs Per Dollar of Fuel or Power Year 1966

This is the most valid estimate of locomotive repair cost (weighted on basis of work performed) which we feel we can produce with data we have available. It is our opinion that the data which we state on Tabulation No. I is prime Accounting Department information from I.C.C. Form "A" and should be reliable. Further, we obtained 1967 I.C.C. Form "A" data for Pennsylvania Railroad which operates a substantial diesel and electric locomotive fleet and have stated this information and Milwaukee Road data on Tabulation II attached. Tabulation II indicates that we will not overburden the electrified operation with locomotive maintenance expense by using locomotive repair estimate of $1,780,000 per year for diesels and $1,055,000 for Electrics as stated above.

(B) Diesel fuel oil cost per gallon you will note in Mr. Wylie's graphical presentation dated 10-20-67 is shown as practically constant from 1960 to 1985. The future cost of fuel is difficult to estimate but the reasons and facts for arriving at conclusion stated by Mr. Wylie have substance in our opinion. However, I understand we have definite facts to anticipate a 0.6¢ per gallon fuel oil cost increase now, and this anticipated increase from 9¢ to 9.6¢ per gallon for diesel fuel will increase the estimated fuel expense to handle business volume of year 1966: $1,426,000 x 9.6¢ ÷ 9 = $1,520,000 per year for fuel oil for Harlowton - Tacoma service.

(C) The tabulation sheet A 40-34 for year 1966 in Mr. Wylie's report is based on the 12 EF-4 "Joe" units being available with no investment required. We also have considerable diesel power available with no added investment and if we fully dieselized, investment of sufficient funds for diesels to replace the present 12 "Joe" units and 34 operative GE 1500 h.p. electric units or acquire 111,000 h.p. in new diesel units would be adequate. This is more than sufficient diesel powerto fully dieselize the operation.

An alternate to the analysis described immediately above would be to burden the electric and the diesel operation with all of locomotive units to be used for Harlowton - Tacoma service.

The year 1966 traffic data we assume is pertinent for evaluating our present situation. We have, therefore, revised the basic year 1966 data tabulated in Mr. Wylie's sheet A 40-34 to incorporate the locomotive repair cost estimate stated in paragraph "A" above, the added diesel fuel cost per paragraph "B" and the locomotive investment expense modification per paragraph "C" above. This revised data is stated on Tabulations Nos. III and IV attached for your consideration. Tabulations Nos. III and IV support continued acquisition of diesel units.

However, if you prefer to accept data which Mr. Wylie states on sheet A 40-34 for year 1966, we note it requires a $8,357,000 greater investment to electrify than to dieselize with estimated operating expense savings of $519,097. This added capital expense and savings does not appear to be attractive in terms of what is normally desired.

Please let me know if there is any detail regarding this study which you wish to have us investigate in greater detail. We have accumulated additional detailed information which we can have available if you wish to discuss or further refine this analysis.

cc: F. G. McGinn
B. J. Worley

TABULATION III

Summary Comparison of Diesel vs. Electric Operation for Freight Service Harlowton-Tacoma Based on Investment for New Locomotives Which Would Have To Be Acquired and Utilizing Locomotives Which We Now Have Available and Suitable For Use

YEAR METHOD OF OPERATION	1966 Traffic All Diesel	 All Electric
STATISTICS		
M G T M Trailing	5,342,526	5,342,526
Train and Locomotive Miles	1,414,264	1,414,264
Cost of Fuel per Gal. or Power per KWH @ SS	$0.096	$0.00544
Gallons of Fuel at Loco. or Power at SS	15,840,000	237,000,000
Total Locomotive Horsepower Required	204,000	204,000
Existing Locomotive Horsepower Assumed Available	93,000	60,000
Net Locomotive Horsepower To Be Capitalized	111,000	144,000
INVESTMENT REQUIRED		
Avery-Othello Electrification	-	$10,277,712
Locomotives *	$8,880,000	14,400,000
Total Investment	$8,880,000	$24,677,712
OPERATING EXPENSES		
Diesel Fuel or Electric Power	$1,520,000	$ 1,287,000
Locomotive Repairs	1,780,000	1,055,000
Maintenance Transmission, Trolley System	-	272,750
Maintenance, Power Substations	-	128,517
Operation, Power Substations	-	321,474
Total Operating Expense Above	$3,300,000	$ 3,064,741
DEPRECIATION AND INTEREST		
Depreciation, Annual	$ 421,800	$ 565,169
Interest @ 6.5%, Annual	577,200	1,604,051
Total Operating Expense Per Year Including Depreciation and Interest	$4,299,000	$ 5,233,961

Depreciation Rates From Accounting Department Utilized: Diesel Locomotive 4.75%, Electric Locomotive 2.03%, Trolley Dist. System 2.7%, Sub-Station Bldgs. 1.2%, Substation Equipment 2.6%, Signal Equipment 2.9%.

(*) $100 per Horsepower for Electric Locomotives and $80 per Horsepower for Diesel Locomotives, which is figure used in Mr. Wylie's April 1968 Report.

July 11, 1968

TABULATION IV

Summary Comparison of Diesel vs. Electric Operation for Freight Service Harlowton-Tacoma Based on Burdening Both Systems With Full Investment For Locomotives Required

YEAR METHOD OF OPERATION	1966 Traffic All Diesel	 All Electric
STATISTICS		
M.T.T.M. Trailing	5,342,526	5,342,526
Train and Locomotive Miles	1,414,264	1,414,264
Cost of Fuel per Gal. or Power per KWH @ SS	$0.096	$0.00544
Gallons of Fuel at Loco. or Power at SS	15,840,000	237,000,000
Total Locomotive Horsepower Required	204,000	204,000
Locomotive Horsepower Capitalized	204,000	204,000
INVESTMENT REQUIRED		
Avery-Othello Electrification	-	$10,277,712
Locomotives (*)	$16,320,000	20,400,000
Total Investment	$16,320,000	$30,677,712
OPERATING EXPENSES		
Diesel Fuel or Electric Power	$ 1,520,000	$ 1,287,000
Locomotive Pepairs	1,780,000	1,055,000
Maintenance Transmission, Trolley System	-	272,750
Maintenance, Power Sub-Stations	-	128,517
Operation, Power Substations	-	321,474
Total Operating Expense Above	$ 3,300,000	$ 3,064,741
DEPRECIATION AND INTEREST		
Depreciation, Annual	$ 775,200	$ 686,969
Interest, @ 6.5%, Annual	1,060,800	1,994,051
Total Operating Expense Per Year Including Depreciation and Interest	$ 5,136,000	$ 5,745,761

Depreciation Rates From Accounting Department Utilized: Diesel Locomotive 4.75%, Electric Locomotive $2.03%, Trolley Dist. System 2.7%, Sub-Station Bldgs. 1.2%, Substation Equipment 2.6%, Signal Equipment 2.9%.

(*) $100 Per Horsepower For Electric Locomotives and $80.00 Per Horsepower for Diesel Locomotives, Which Is Used in Mr. Wylie's April 1968 Report.

July 11, 1968

TABULATION II

Diesel and Electric Traction Fuel, Power, and Locomotive Repair Cost
for Milwaukee and Pennsylvania Railroads from ICC Annual Report Form "A"

		Milw. Road 1956 **	Milw. Road 1957 **	Milw. Road 1966	Milw. Road 1967	Penn. R. R. 1967 *
Acct. 311 Repair Expense (Diesel)	$	11,157,264	12,128,958	11,358,687	9,828,818	32,176,095
Diesel Locomotive Fuel Used (Gals.)		96,791,920	92,321,711	95,416,160	95,664,044	250,322,176
Acct. 311 Diesel Repair Expense Per Gallon Diesel Fuel Used	$	.115	.131	.119	.103	.129
Acct. 311 Repair Expense (Electric)	$	1,495,584	1,574,735	700,977	726,005	7,909,550
Kilowatt Hours of Electric Locomotive Power Used		165,508,566	142,377,440	100,506,427	94,052,676	647,167,163
Acct. 311 Electric Locomotive Repair Expense Per KWH of Power Used	$	.0090	.0111	.0070	.0077	.0120

(*) PRR Data obtained by Mr. Edman

(**) Year 1956 and 1957 stated to Present Data for Operation When Old GE 1500 units were Maintained without cannibalization and Electrification was Fully Utilized.

July 11, 1968

TABULATION NO. 1

Diesel and Electric Traction Fuel, Power and Locomotive Repair Costs
for Milwaukee Road - All Data from ICC Annual Report Form "A"

	Year 1956	Year 1957	Year 1964	Year 1965	Year 1966	Year 1967
Diesel Fuel Train (Cost)	$8,433,076	$8,220,598	$7,239,284	$7,553,888	$8,138,318	$8,230,488
Diesel Fuel Yard Sw. (Cost)	940,690	979,339	883,217	894,094	928,334	914,499
Diesel Fuel Total (Cost)	9,373,766	9,199,937	8,122,501	8,447,982	9,066,652	9,144,987
Diesel Repair Train (Cost)	9,276,983	10,174,336	6,940,429	8,119,263	9,634,409	8,139,471
Diesel Repair Yard Sw. (Cost)	1,680,281	1,954,622	2,526,906	2,026,908	1,724,278	1,689,347
Diesel Fuel Total (Cost)	11,157,264	12,128,958	9,467,335	10,146,171	11,358,687	9,828,818
Diesel Locomotive Repair Cost per dollar of fuel oil	1.19	1.32	1.17	1.20	1.25	1.08
Electric Power Train (Cost)	1,457,477	1,264,521	771,192	800,758	849,194	795,187
Electric Power Yard Sw. (Cost)	32,100	16,876	21,087	16,042	6,641	20,389
Electric Power Total (Cost)	1,489,577	1,281,397	792,279	816,800	855,835	815,576
Electric Locomotive Repair Train	1,465,591	1,558,531	571,613	577,591	681,531	707,755
Electric Locomotive Repair Yard Sw.	30,093	16,204	59,351	30,952	19,446	18,250
Electric Locomotive Repair Total	1,495,684	1,574,735	629,964	608,453	700,977	726,005
Electric Locomotive Repair Cost Per dollar of electric power	1.00	1.23	0.76	0.74	0.82	0.89

July 11, 1968

M. 63547

Chicago - July 15, 1968.
S-1217

Mr. C. E. Crippen:-

Your letter June 24th relative to report of Mr. L. Wylie concerning electrified train operation compared with diesel train operation.

As far as closing the gap between Othello and Avery, in view of the Capital investment that is involved, I recommend that we phase out the electrification between Othello and Tacoma and salvage these facilities inasmuch as we are practically operating dieselized service now, with the exception of electric helpers Cedar Falls to Hyak, four or five times a week.

At the most, think we would possibly require two units of diesel power.

With the present electrification personnel of 71 people and approximately 22 of them in field work, it appears they could be used to salvage the facilities for some period of time and take advantage of the high price for copper.

We could retain the necessary pole line for the Communication and Signal department, and as far as the high voltage line, I think we have an obligation to maintain it until the contract runs out.

With the 12 Joes remaining on the Rocky Mountain Division, perhaps in five or six years consideration could be given to discontinuing that operation, if the economics

cont'd

so indicated at that time.

We can phase out the western end of it with practically no added cost or investment.

It is suggested we have a meeting with Messrs. Worley, Kirk and Upton the week of July 22d, and finalize our recommendations.

ORIGINAL SIGNED
J. G. McGinn

cc - Messrs. B. J. Worley
F. A. Upton
T. B. Kirk

M.A. Kellow

Chicago, July 29, 1968

Mr. C. E. Crippen:

I offer this appraisal of the current report by Laurence Wylie on diesel-electric vs. electric operation between Harlowton and Tacoma:

I believe the economic aspect of this matter is highly important. If it is not most important, it is at least an essential starting point or base for consideration of other aspects.

Mr. Wylie's evaluation of economics is summed up in his "Sheet A 40-34". For reasons not explained, he has chosen, in his evaluation to ignore two cost elements which would be involved in the event of a change to all-diesel operation: new signal line, and net salvage from the existing electrification facilities.

Since it seems necessary to consider these elements, I have had Sheet A 40-34 revised to include them. Revised Sheet A 40-34, otherwise substantially the same as Mr. Wylie's, is attached. It shows, on line 16, that all-diesel operation should get the nod on the basis of economics alone, for both the near-term and the long-term.

The margin of superiority of all-diesel in this comparison is not impressive. It must be recognized that the error in these figures could easily exceed that margin, particularly in the case of the long-term situation.

The evaluation is particularly vulnerable with respect to the cost of locomotive repairs, an item of major difference between diesel-electric and electric. If there has been any real measurement of it, there is no evidence in the report. There is not even any discussion of the subject. True repair costs are undeniably difficult to get at, particularly when the current operation is mixed to the point that there can be no all-diesel or all-electric experience data for this particular territory to look at. This very difficulty, I should think, would be an important reason for engaging a consultant to make engineering-type measurements.

Another matter that needs more attention, in my opinion, is the matter of the power contracts. This subject is dismissed by inserting in the report a chapter from the 1958 report plus a brief statement that the power companies would like to see the contracts extended. This seems obvious. The important question is: could we get a release from the contracts and, if so, how much would it cost? Ten years ago this question was overshadowed by economics favoring continuation of electrified operation. Today, it is a question which must be disposed of before anything else can be studied to a useful conclusion.

Operating aspects are not dealt with sufficiently. It may be, for example, that the all-electric operation as proposed can move all the tons that will need to be moved, but will it have the operational flexibility and speed that are demanded by current and prospective competitive conditions? If not, to what extent must it be supplemented by diesel power and what are the cost implications of this both as to locomotive units and keeping mechanical facilities for two kinds of power? I do not presume to judge this aspect one way or the other, but I think it deserves attention.

In summary, I do not think the current Wylie report provides an adequate basis for a management decision on this very important question. I recommend that we engage a top engineering firm to make a study and recommendation.

For R. F. Kratochwill

SUMMARY MPARISON OF D SEL VS. ELECTRI OPERATIO
FOR FREIGHT SERVICE -- HARLOWTON-TAC A

Revised 7/10/68

LINE NO.	ITEM	1966 DIESEL	1966 ELECTRIC	1986 DIESEL	1986 ELECTRIC
	INVESTMENT REQUIRED				
1	Avery-Othello Electrification	---	$10,27 ,000	---	$10,278,000
2	Locomotives	$16,320,000	14,400,000	$18,080,000	22,600,000
3	New signal line	1,856,000	---	1,856,000	---
4	Salvage (Net-of-taxes basis)	(7,141,000)	---	(7,141,000)	---
5	Total Investment	11,035,000	24,67 ,000	12,795,000	32,878,000
	OPERATING EXPENSES				
6	Diesel Fuel or Electric Power (24 x 25)	1,426,000	1,289,000	1,710,000	1,543,000
7	Locomotive Repairs (21 x 22 or 23)	2,263,000	962,000	2,714,000	1,153,000
8	Maintenance Transmission, Trolley System	---	273,000	---	273,000
9	Maintenance, Power Substations	---	129,000	---	129,000
10	Operation, Power Substations	---	321,000	---	321,000
11	Total Operating Expense Above	3,689,000	2,974,000	4,424,000	3,419,000
	DEPRECIATION AND INTEREST				
	D & I Factors - 0.109794 and 0.080586				
12	Depreciation and Interest Charges, Annual	1,792,000	1,989,000	1,985,000	2,650,000
13	Depr.-Inter. on New Signal Line	150,000	---	150,000	---
14	Depr.-Inter. on Salvage	(784,000)	---	(784,000)	---
15	Total Depreciation and Interest	1,158,000	1,989,000	1,351,000	2,650,000
16	Total Expenses, depreciation and interest	$ 4,847,000	$ 4,963,000	$ 5,775,000	$ 6,069,000
	STATISTICS				
17	M G T M Trailing	5,343,000	5,343,000	6,408,000	6,408,000
18	Train and Locomotive Miles	1,414,000	1,414,000	1,696,000	1,696,000
19	Locomotive Units per Train	4	2	4	2
20	Horsepower per Unit	3,000	5,000	3,000	5,000
21	Locomotive Unit Miles	5,656,000	2,828,000	6,784,000	3,392,000
22	Electric Locomotive Repairs-Per Unit Mile	---	$ 0.34WA	---	$ 0.34WA
23	Diesel Locomotive Repairs-Per Unit Mile	$ 0.40WA	---	$ 0.40WA	---
24	Cost of Fuel per Gal. or Power per KWH at SS	$ 0.09	$ 0.00544	$ 0.09	$ 0.00544
25	Gallons of Fuel at Loco. or Power at SS	15,840,000	237,000,000	18,995,000	283,700,000
26	Total Locomotive Horsepower Required	204,000	204,000	226,000	226,000
27	Existing Locomotive Horsepower Available	---	60,000	---	---
28	Net Locomotive Horsepower Capitalized	204,000	144,000	226,000	226,000

( ) Denotes contra items.

Seattle, Washington, November 17, 1967
Revised July 10, 1968

Chicago - August 2, 1968

Mr. C. E. Crippen:

Attached is my evaluation of the Wylie report covering the economics of electric versus diesel operation between Harlowton and Tacoma. The evaluation analyzes all elements of cost - investment, operating, and depreciation and interest - for three alternatives, i.e. full electrification or full dieselization as covered in the Wylie study, and in addition, continuation of present electrified and diesel operating territories.

The evaluation develops total costs under the three alternatives at present levels of traffic for 15 and 30 years - the estimated life cycles of diesel and electric power. A summary of all costs (Exhibit III) shows that:

1. Over both a 15-year and a 30-year span, total costs are less with electric operation in the present electrified territory and diesels in the gap than with full diesel operation.

2. Over a 15-year span, full electrification and full dieselization are just about a stand-off. Over a 30-year span, full electrification is considerably less than full dieselization.

3. Over a 30-year span, the savings in equipment financing costs for electrification (full or partial) is a major part of the savings over dieselization. This is the result of:

   a. Greater life expectancy of electric power, and

   b. Ability to use some of existing electric power, thus deferring expenditures to future years.

The cost data in the exhibits are based on present traffic volumes. If the volume of business increases to the point where additional motive power is needed, the same relationships of diesel and electric costs should continue - both as to added investment and annual operating expenses.

Based on data shown in the exhibits attached, it is my conclusion that full electric operation should be established in the present electrified territories with diesel operation in the Avery - Othello gap.

The economic data supporting the conclusion is considered to be reasonable and conservative. I have the following suggestions to make that could be helpful support for the data in the attached exhibits:

1. For the Operating Department

   a. Make its own evaluation of locomotive power requirements to substantiate data in Exhibit IV.

   b. Document the operating advantages and disadvantages of the two types of motive power in the territory involved, to determine if considerations other than economy will seriously influence the decision to be made.

2. For the Locomotive Department

   a. Determine if 15 and 30 years respectively for diesel and electric power are reasonable life cycles.

   b. Because there are no over-all historical repair costs for the specific types of motive power proposed, try developing a comparative cost by estimating maintenance costs of the individual major components of each type over the life of those components. Components to be considered (and on which there might be historical costs) could include wheels and trucks, traction motors, main generators, engines and major components, compressors, etc.

3. For the Electrification Department

   Verify probable maintenance and operating costs shown in Exhibit II for continuing the transmission lines and substation operations under full dieselization until power contracts expire.

Finally, it has been suggested that outside consultants be engaged to make a study and recommendations. An outside firm would probably ask the railroad to provide them with data on operating and maintenance costs, possibly make an inspection of the properties involved, consider investment costs, make an economic study and report, and collect a fancy fee. I think there is sufficient data to make a decision without outside help.

EVALUATION OF REPORT COVERING ECONOMICS OF DIESEL VS. ELECTRIC OPERATIONS HARLOWTON TO TACOMA

GENERAL:

The report prepared by L. Wylie contains sheet A 40-34 entitled "Summary Comparison of Diesel vs. Electric Operation for Freight Service" which compares investment requirements and annual operating expenses. This statement is intended to support the conclusions he states as follows:

1. The electrification system . . . . should be retained.

2. The section between Avery and Othello should be electrified . . . .

Data shown in sheet A 40-34 is difficult to evaluate because of lack of underlying detail. There is no specific data to show type and number of locomotive units required. It apparently assumes that the present EF 4 electric units on the R M Division would not be replaced until 1986 - a 36-year life. I believe that GP 40 diesel units were projected with full dieselization.

The report considers only two alternatives - full dieselization or full electrification. To me, a third alternative that should be considered is full electric operation in present electrified territories with diesel operation in the gap.

INVESTMENT REQUIREMENTS:

Exhibit I attached was developed to compare investment requirements for the two alternatives in the Wylie study and a third alternative - present electrification and diesels in the gap. The exhibit is designed to compare investment costs considering present value of future expenditures at 7% interest rates. The estimated net salvage from retirement of the electrification is credited to full dieselization.

The results of a preliminary study of locomotive needs for present schedules, with helpers and extras, are shown in Exhibit IV. A total of 37 - 4560 hp electrics and 57 - SD 45 diesels are estimated to be needed for full electrification or full dieselization. The preliminary study also indicated that if the present electrified territories were continued with diesels between Avery and Othello, a total of 37 electric and 13 - SD 45 diesels would be required.

The following assumptions were made in developing the comparison of investment needs:

1. The present diesel units now operating on regular trains between Harlowton and Tacoma can be reassigned to other main line freight service. It is reasonable to assume that their release will eliminate the need for capital investment that would have to be made for diesel replacement on the balance of the railroad. Thus, the full investment cost for diesels should be included in the economic evaluation.

2. The 12 - EF 4 electric units purchased in 1950 and now operating on the Rocky Mountain Division will probably need replacement in about 1980 (assuming a 30-year life) if full electrification is maintained.

3. The present EF 3's and 5's are being used in helper service at Beverly and Cedar Falls and have covered some extra service. By continuing the cannibalizing program, power replacement for at least the Beverly and Cedar Falls helpers can be deferred to 1972.

Exhibit I indicates that total investment is least for full dieselization when the salvage value from retirement of the present electrification is credited against investment. It is interesting to note that if salvage were not considered, present value of all investment for full dieselization is a little higher than maintaining present electric and diesel operations. Investment costs for full electrification are considerably higher than either of the other two alternatives.

ESTIMATED ANNUAL COSTS:

Exhibit II has been prepared to show revised estimated expenses for three alternatives. The exhibit includes the annual operating expenses reported in the Wylie study for comparison. Comments on individual items are as follows:

Electric Power Costs:

The table below compares actual consumption of electric power under complete electric operation in 1943 and 1944 with estimated power consumption at the traffic levels used in the study:

	Harlowton-Avery	Avery-Othello	Othello-Tacoma
Actual Power Consumption			
All Elect. - MGTM*	3,020,000	- -	1,060,000
KWH (000)*	153,600	-	59,540
KWH Per MGTM	50.8	- -	56.2
Est. Power Consumption			
1966 MGTM	3,082,300	1,249,700	1,010,500
Est. KWH (000)	147,900	29,400	59,500
Est. KWH Per MGTM	48	23.5	59

* 1944 data Harlowton-Avery; 1943 data Othello-Tacoma.

The KWH per MGTM used to estimate power costs in the present electrified territory are very close to actual experience at the comparable traffic levels in 1943 and 1944. I can see no reason to question the cost figures in the study.

Diesel Fuel Costs:

The Wylie study estimates 15,840,000 gallons of fuel oil to move 5,342,526 MGTM - an average of 2.97 gallons per MGTM. This appears high compared to an average of 1.73 gallons for System Freight Service shown in the 1967 annual statistical report. Locomotive department service tests in January 1968 developed a consumption of 2.35 gallons per MGTM with SD 45 units on 263 - 264.

In contrast, the 9¢ per gallon cost is low. In 1967, the average cost per gallon was 9.6¢ and present indications are that the price of fuel oil will increase. At a rate of consumption of 2.35 gallons per MGTM and a price of 10¢ per gallon, fuel costs would be $1,256,000, or $170,000 less than included in the Wylie study.

Each cent increase in fuel costs will add $125,000 per year to diesel operating expenses.

Diesel Lube Oil:

There is an element of cost omitted in the Wylie study - the cost of lube oil for diesels. The annual report to the ICC shows the following expense relationship:

Acct. 394 - Train Fuel (Freight Service)	$6,837,359
Acct. 398 - Lubricants for Train Loco. (Frt)	619,729

Lubricant expenses are approximately 9% of fuel costs. Using the cost of $1,256,000 for fuel and the 9% relationship, an additional $113,000 should be added to operating expenses for diesel operation.

Locomotive Repairs:

There is no underlying data in the Wylie report to support the costs shown. In his letter of July 11, 1968, F. A. Upton projected locomotive repair costs (diesel and electric) based on a system ratio of repair costs to fuel costs. The table below compares the locomotive department costs and the Wylie study costs:

	Diesel	Electric
Locomotive Miles	1,414,264	1,414,264
Locomotive Unit Miles	5,657,056	2,828,528
M.O.E. Estimate		
Repair Costs	$1,780,000	$1,055,000
Cost/Unit Mile	0.314	0.373
Wylie Study		
Repair Costs	$2,265,000	$ 961,000
Cost/Unit Mile	0.40	0.34

There is considerable difference of opinion on locomotive repair costs. The real problem is that the railroad doesn't really have any historical cost data available for the types of diesel and electric units considered in this study. It is further complicated by the lack of historical data for diesel power costs in heavy mountain service.

For this analysis, locomotive department repair costs as included in F. A. Upton's letter of July 11, 1968, are used both for diesel and electrics. It can be noted that if the estimated fuel costs of $1,256,000 just developed for diesels were used, locomotive repair costs could be cut to $1,570,000, or a reduction of $210,000.

Electrification Costs:

The Wylie study indicates that the railroad would be obligated to maintain the transmission lines and substation operations until 1975 and 1976 when the power contracts expire. Some costs will be incurred and the figures shown in Exhibit II under full diesel operation, were included for this purpose.

Other Costs:

Added costs of power and signal maintenance are as shown in the Wylie report and correspondence files. For some unknown reason, these costs were not included in the Wylie comparison on sheet A 40-34.

Depreciation:

The following depreciation factors were used to calculate annual depreciation costs:

Electric Locomotives	3.03%	(30-year life - 9% salvage)
Diesel Locomotives	6.00%	(15 year life 10% salvage)
Electrification	2.70%	
Signals	2.90%	

Depreciation on present electrification is as now charged. Likewise the $21,000 depreciation is as now charged for the EF 4 locomotives. All other electric locomotives have been fully depreciated.

SUMMARY OF ANNUAL EXPENSES:

Exhibit III is a comparison by years of annual expenses for three alternatives - full electrification, full dieselization, and maintaining present electric and diesel operations. A brief explanation of the columns is as follows:

Operating Expenses	- As shown in Exhibit II
Depreciation	- As shown in Exhibit II
Interest	- Annual cost of interest at 7% on all new investments except motive power.
Equipment, Principal & Interest	- Annual principal and interest payments on 15-year conditional sales agreements, payments semi-annually at a 7% rate of interest.

Exhibit III is constructed to show annual cost over a 30-year span, to cover two 15-year cycles of diesel costs, and to go to the estimated 30-year life of those electrics acquired in 1969.

There are some interesting facts developed in this exhibit:

1. Over both a 15-year and a 30-year span, total costs are less with electric operation in the present electrified territory and diesels in the gap than with full diesel operation.

2. Over a 15-year span, full electrification and full dieselization are just about a stand-off. Over a 30-year span, full electrification is considerably less than full dieselization.

3. Over a 30-year span, the savings in equipment financing costs for electrification (full or partial) is a major part of the savings over dieselization. This is the result of:

   a. Greater life expectancy of electric power, and

   b. Ability to use some of existing electric power, thus deferring expenditures to future years.

GENERAL SUMMARY AND CONCLUSIONS:

The data included in Exhibit III shows that over a 15-year span, maintaining present electric and diesel operations would cost about $4,466,000 less than full dieselization and $4,860,000 less than full electrification. Over a span of 30 years, maintaining present operations is $18,676,000 less than full dieselization and $9,952,000 less than full electrification.

Based on these figures, my conclusion would be to establish full electric operation in the present electrified territories Harlowton - Avery and Othello-Tacoma with diesel operation in the Avery-Othello gap.

EXHIBIT IV

MOTIVE POWER REQUIREMENTS
ELECTRIC VS. DIESEL OPERATION
HARLOWTON - TACOMA

	No. Loco	No. of Units Electric	No. of Units Diesel
FULL ELECTRIFICATION OR FULL DIESEL			
Regular Trains	7	14	21
Extra Service	2	4	6
Helpers - Harlowton	2	4	6
Avery	3	6	9
Beverly	2	4	6
Cedar Falls	2	2	4
Spare Units		3	5
Total		37	57
PRESENT ELECTRIFICATION			
Harlowton - Avery			
Regular Trains	5	10	--
Extra Service	1	2	--
Helpers - Harlowton	2	4	--
Avery	3	6	-
Spare Units		2	--
Total		24	
Avery - Othello			
Regular Trains	3		9
Extra Service	1		3
Spare Units			1
Total			13
Othello - Tacoma			
Regular Trains	3	6	
Helpers - Beverly	2	4	
Cedar Falls	2	2	
Spare Units		1	
Total		13	
TOTAL ALL TERRITORIES		37	13

8-1-68

DISCUSSION OF SELECTED DATA AND COSTS

SELECTION OF STUDY PERIOD

The economics of alternate plans for providing a service depends in large part on the time for which the service must be provided. In undertaking original electrification, studies were presumably based on comparative costs over an indefinite (permanent) period of years, and electrification was found justified. The question is raised as to the period for which comparative costs should now be projected.

In the current study emphasis appears to have been placed on the service life of locomotives. Among other considerations it seems logical to consider the remaining service life of the electrification facilities as a whole.

Two considerations in particular dictate that some period be selected in projecting studies at this time:

(a) There remains a large usable (but certainly not permanent) investment in the fixed electrification plant.

(b) The rapidly expanding field of nuclear power, as well as new sources of hydro-electric power and of crude oil, suggest it would not be prudent to project cost studies on an indefinite basis.

A study life of 30 years as used by Kellow appears to be well chosen, not only because it is accepted as a reasonable service life for new electric locomotives, but because it also reflects the minimum reasonable remaining service life of much of the overall existing fixed plant as a whole without upgrading, except as to transmission and trolley line poles. A study period of only 15 years serves the purpose of reflecting conditions if abrupt changes in power or fuel costs, or improvements in locomotive design, merit reconsideration before new electric power is worn out.

COST OF ELECTRIFICATION AVERY TO OTHELLO

Wylie's Summary Sheet A 40-34 includes this cost in total amount of $9,599,953. The cost of the trolley distribution system is estimated at $6,744,253 and the cost for nine rectifier substations for converting 13,800 volt 3-phase 60 cycle alternating current to 3000 volt direct current is estimated at $2,855,700.

Under date of May 27, 1969 Kirk prepared an estimate for the trolley distribution for a 3400 volt system in amount of $5,851,724, and which was furnished to the Washington Water Power Co. His estimate is thus $892,529 less for this portion of the project than that used by Wylie. It is understood this is made possible by simplified design. For purposes of this study it appears inadvisable to reduce Wylie's estimate of total cost.

Details of concurrent annual maintenance expense of the added electrification system are not available, however the cost is understood to be included in the appropriate item of Wylie's summary statement.

COST OF NEW LOCOMOTIVES:

Electric Locomotives:

For the purpose of his study Wylie estimated the cost of electric locomotives at $100 per rail horsepower. He based his study on two 5000 h.p. units per train for normal operation, with helper service as required (Sheet A40-34). He calculated that a total of 204,000 hp would be required for full electrification, including the existing twelve EF-4's now on the Rocky Mountain Division (equivalent to 41 units of that capacity).

Under date of June 17, 1968 General Electric had quoted 3000 volt dc six-axle, six-motor 4560 rail hp units including regenerative braking at $460,000 each on an order of 20 units and at $470,000 each on an order of 10 units. The larger order approximates $100 per hp, the figure used by Wylie for 5000 hp units.

Kirk advised that the only 3000 volt locomotive presently available without paying a large development charge was a six-axle 4560 hp unit which would have the same tonnage rating as the SD-45 on mountain grades, but would have nearly 50% more power available for speed. He estimated full electrification would require 24 such units plus the existing EF-4's, total 36. Kellow based his analysis for present schedules on the acquisition of 20 new electric units in 1969 and 5 in 1972 at the prices quoted by G.E. His estimate of the total requirements was made upon a careful analysis of train schedules.

Under date of July 24, 1969 General Electric revised its quotation, upon further study and revision to traction motor design, to $485,000 for a locomotive of 5400 continuous rail horsepower, six-axle, six-motor dc unit, based however on an order of 30 units. This large a unit and order reduces the cost to $90 per hp.

In its review of Wylies' report the Mechanical Department took no exception to the report as respects the capacity or total horsepower of electrics required. The performance of the EF-4's serves also as a guide to the practicality of electrics of relatively large horsepower. It seems prudent therefore to accept the judgment of Wylie as to total horsepower requirements, however it appears a price per hp somewhat less than he used can be negotiated, probably in the amount of $500,000 per unit or approximately $92 per hp. This figure is assumed in revised calculations.

Diesel Locomotives:

Wylie estimated the cost of diesel locomotives at $80 per hp. He based his study on four units of 3000 hp per train in normal operation. Inasmuch as the comparisons are made on the basis of rail horsepower this indicates a unit comparable to the SD-45. As in the case of electrics he used 204,000 hp as being required.

Kellow calculated 57 SD-45's would be required for full dieselization, which produces about 160,000 rail hp or 20% less than Wylie used for his study. He applied the then current price of $276,000 per unit, which amounts to approximately $90 per rail hp.

In its letter of July 24, 1969 General Electric states that the current price for six-axle diesels is $90 per rail hp "before allowance for trade-in locomotives." Wylie apparently allowed for "trade-in" value in his lower unit price, whereas Kellow allows a salvage value of 10% in computing depreciation for diesels.

A figure of $90 is assumed in revised calculations.

NEW SIGNAL LINES AND ALTERATIONS

In the event of full dieselization it becomes necessary to either maintain the existing trolley poles in the electrified territory for support of the 4400 volt signal wires, or to remove the present pole lines in their entirety in connection with salvage operations, replacing them with new signal lines.

New signal lines for both of the territories are estimated to cost $1,856,000, and the annual maintenance costs of the lines $50,000. These figures do not appear in Wylie's summary, but are included in Kellow's analysis.

It is now Kirk's opinion that salvage operations do not necessitate removal of the trolley poles and existing signal lines, hence the above expenditure is not required, but in which case annual maintenance of the pole line shifts from electrification to dieselization. It is assumed this plan would be followed.

In the event of full electrification it also becomes necessary to modify the signalling system Avery to Othello to the extent of replacing the present dc primary between Ethelton and Sorrento Tunnel, and between Marengo and Othello, with a 4400 volt ac system. The Signal Department estimated the cost at $527,539 of which $506,909 is capital investment. Wylie estimated the cost at $677,789 and Kellow uses this figure. The difference in costs figures is not explained, however the larger figure used is accepted as being conservative.

ELECTRIC POWER COSTS

Data used by Wylie on power consumption is stated by Kirk (letter June 2, 1969 to Kellow) to be incorrect. Kirk advises that figures on 1943-44 consumption includes passenger trains then operated, hence would be high. Other information furnished by him further show Wylie's figures for the present electrified territory to be high, and for the Avery-Othello section to be low.

In his compilation of general information furnished under date of February 6, 1967, Kirk quotes consumption of 41.5 KWH per gross MGTM from statistical data. In his letter June 2, 1969 to Kellow, Kirk reports 40 & 41 KWH per trailing MGTM for the Rocky Mountain and Coast Divisions in measured tests. These may appear inconsistent, however the latter includes idling time, not included in test runs.

Kirk's data is supported by metered consumption for several years prior to use of diesels and appears to be most reliable. His data results in the following revisions:

	Harlowton - Avery	Avery - Othello	Othello - Tacoma	TOTALS
Est. Power Consumption:				
1966 MGTM	3,082,300	1,249,700	1,010,500	5,342,500
Est. KWH per MGTM	40	30(est.)	41	--
Est. KWH (000) (Metered at Substations)	123,292	37,491	41,430	202,213
Rate per KWH	.00536	*.00550(est.)	.00587(Av.)	
Est. Cost:	$ 660,845	$ 206,200	$ 243,194	$1,110,239

*Basic rate - does not include annual charge on transmission lines to Substations, estimated at $70,000.

DIESEL FUEL COSTS

Measurements of diesel fuel consumption of Trains 261 and 262 by Winfrey in August 1967 show an average of 1.62 gals. for Train 261 and 2.13 gals. per MGTM for Train 262 for the entire distance Harlowton to Tacoma. Separate readings for Train 261 Harlowton to Deer Lodge produced 1.89 gals per MGTM or only 17% greater consumption than for the full distance. Using this figure as representative of "mountain" territory, which approximates 75% of the entire distance, then the consumption Avery - Othello could be only 0.80 gals. per MGTM - an obviously erroneous figure, hence these measurements should be questioned. (In this connection, it may be observed that the rise and fall Harlowton - Deer Lodge approximates 34 ft. per mile compared to about 29 ft. for the entire distance Harlowton - Avery and 33 ft. for the Coast.)

Tests made by the Electrification Department in April and May of 1968 produced an actual figure of 3.17 gals. per MGTM for Train 262 (76 train average) between Tacoma and Avery. No helpers were used and tonnage was accurately determined.

On the basis of tests made by the Mechanical Department in January 1968 on Trains 263-264 between Harlowton and Tacoma, using 3-unit SD-45 locomotives, Kellow used a figure of 2.35 gal. per MGTM as against Wylie's figure of 2.97 for all service. Wylie's study is thought to be based on the concept of higher train speeds with either kind of locomotive which may account for his higher power and fuel consumption (and repair) costs.

Kirk takes exception to the figure of 2.35 and computes a figure of 2.80 for normal operation in the electrified territory, including idling time, local trains, road switching and helper service, to make proper comparison to the figures used for electric power consumption.

Inasmuch as the figure 2.35 represents running performance only it is not appropriate data for estimating annual operating costs. In the absence of better data greater weight should be accorded Kirk's estimates, and it is suggested his figures of 2.80 be accepted for mountain territory, and his ratio of 75% of that figure for the Avery-Othello section, or 2.10, be accepted. (The system figure of 1.73 for gross-tons, including locomotives, is not applicable to this study). This produces an average for the full dieselization plan of about 2.63.

On this basis total consumption approximates 14,084,300 gals. and the expense $1,352,093 using the figure of 9.6¢ gal. current at the time of the study, and this figure is used in revised calculations.

LOCOMOTIVE REPAIR COSTS

It appears the Mechanical Department can furnish no usable statistics on repair costs per unit mile. The complexity of the many classes of diesel locomotives of different manufacture, varying ages, and utilization, makes presently available statistics impractical for use in establishing costs over the service life of particular classes of equipment on a unit basis. Upton therefore relates System repair costs to fuel (or power) costs to compute annual cost of repairs.

There is no logical relation between the cost of repairs and the cost of fuel. If the cost of fuel oil were doubled, for example, it does not follow that there would be a change in the cost of repairs. There is reasonable basis, however, for relating costs of repairs to fuel (or power) consumed, since both factors reflect work performed by the locomotive. Upton states that "the most reasonable way to estimate . . . repair costs is to base the estimate on fuel or power consumed," however he then proceeds to use data from Tabulation No. 1 attached to his letter July 11, 1968 which is based on fuel and power costs. (Underscoring added.)

Using Upton's estimate of annual costs Kellow applies these figures to Wylie's estimated unit miles, and thus derives a greater repair cost per unit mile for electric units ($0.373) than for diesel units ($0.314). This may appear to be an erroneous result, however it should be understood the electric locomotives assumed in this calculation are new undeveloped 5000 HP units, with only two units per train (Statement 40-34). The calculation is misleading, however, for the reason that unit costs thus derived for diesels is for the System and is not correct for use in mountain territory, being too low. The figure he uses for electrics could be either too low, if it reflects only the very minimum of repair to this kind of power in 1966, or too high with the sharp decrease in use of electric locomotives, and most likely a composite of both.

Diesel locomotives have been in service sufficiently long to provide reasonably usable costs of repair based on the relation of repair costs to gallons of fuel for a fleet that is being economically maintained. On the other hand, the fleet of electric locomotives has not been maintained or repaired with view to their continued use, and utilization has been drastically reduced, such that unit costs shown on Upton's Tabulation No. 2 are questionable as a measure of repair costs. Under these circumstances, and in the absence of other supporting data, it becomes largely a matter of judgment as to the proper unit cost for electric locomotives. Authoritative opinion is expressed that the cost for electrics is about one-half that for diesels. Upton's calculations, which we may assume reflects also the broad experience of his staff, produces a cost for electrics of 59.3% of that for diesels.

Applying this percentage we obtain the following:

Diesel expense - 14,050,800 gal. @ $0.119 = $1,672,045

Electric expense - 59.3% X $1,672,045 = $ 991,523

These annual costs are each only 6% (approx.) less than those proposed by Upton, and are used in revised calculations.

TRANSMISSION AND TROLLEY POLES

There are 9610 poles in the transmission lines and 37,500 poles in trolley lines, total 47,110. Wylie states these "are considered to have an unlimited remaining life, assuming adequate maintenance" by renewals as required, and he figures one percent or 470 poles per year as sufficient. Kirk states an "annual replacement rate of approximately 100 poles should be maintained on each division in the future."

Over the past 16 years for which there is record, replacements have averaged 120 poles per year on the Coast Division, and 92 poles per year on the Rocky Mountain Division. During the period 1960-66, which it is believed reflects the period of Wylie's maintenance costs, replacements averaged 97 and 77 poles respectively.

The Electrification Department estimates that to date only 17% of the poles on the Coast Division have been replaced and only 8% on the Rocky Mountain Division.

It seems apparent that the replacement of transmission and trolley poles now presents a large maintenance expense. The stubbing program of the early 1930's served to extend the life of the poles, by providing a new butt in the ground, however the poles above ground will be failing. All poles not replaced have been stubbed.

It is expected that all stubbed poles on the west slope of the Cascades will need to be replaced within the next 6 - 10 years, and the remainder of all poles within 15 to 20 years at the latest. For the purposes of this study it is assumed that the 83% of all poles not previously replaced will be replaced within the next 15 years, beginning on the west slope of the Cascades. On this basis there would be 840 poles on the Coast that will be replaced annually at an estimated cost of approximately $100 per pole, including incidental hardware and cross-arms, if the electrification were to be properly maintained with view of its continuance.

Likewise on the Rocky Mountain Division it is expected that stubbed poles west of St. Regis will need to be replaced within the next 10 years, and the remainder within 15-20 years. On this basis it will be assumed that the 92% of all poles not replaced will be replaced within the next 20 years, beginning in the Bitter Roots. On this basis there would be an average of 1468 poles to replace annually.

Line maintenance costs used in the study provides only for the replacement of a nominal number of poles. Presuming the averages for the 1960 - 1966 period was included, the excess amounts to 743 poles on the Coast and 1391 poles on the Rocky Mountain. The extraordinary annual maintenance cost therefore approx imates $74,000 and $139,000 respectively for the two divisions until the programs are completed, total $213,000 annually

In event of full dieselization it is proposed to retain the trolley poles for support of the signal feeders. Replacements will utilize a less costly class of pole, at an approximate cost of $60 per pole installed. On this basis extraordinary maintenance will approximate $42,000 and $65,000 respectively for the two divisions.

SUBSTATIONS

There are 8 substations on the Coast Division. The substation at Taunton, Cle Elum and Renton are unmanned, and the substation at Tacoma Junction is no longer used as such, the feeder extending from Renton.

These are all brick masonry buildings on heavy concrete foundations, constructed for the original electrification. The buildings are all in generally good condition, except for the brickwork at Cedar Falls and to lesser extent the brickwork at Hyak, Renton and Tacoma Junction. Maintenance of roofing has been neglected to the extent that leakage has caused damage to the walls at all these locations.

The brickwork at Cedar Falls in particular has been extremely troublesome for many years and numerous efforts have been made to repair the walls. The brick appears to have been of poor quality also the mortar. Repairs may be made to the brickwork at the other locations, however there appears to be no practical repair short of complete reconstruction above foundations at Cedar Falls. As an alternate, study should be given to replacing the building with an insulated sheet metal building, eliminating the overhead crane, and to eliminating the transformer room, providing "outside" type equipment instead. The availability of rubber-tired heavy duty cranes now eliminates the need for providing overhead cranes.

Accordingly, future planning should include an expenditure of $150,000 for extraordinary repair within the next five years to substations on the Coast Division. Some portion of this expense reflects deferred maintenance, resulting from the uncertainty of the electrification.

There are 14 substations on the Rocky Mountain Division, 3 of which are unmanned. These are also brick masonry buildings on heavy concrete foundations, constructed at the time of the electrification. These are all in generally good condition.

Originally three operator's bungalows were provided at each substation. Some of these have been sold through the years as unneeded, others are leased or occupants pay some rental. At present the railroad still maintains 22 bungalows on the Coast and 30 on the Rocky Mountain Division, not all of which are occupied however. As a whole these buildings are in only fair condntion. Presently 33 operators are employed and 10 repair and maintenance men. The net cost is reflected in substation maintenance charges.

ADDITIONAL MOW EXPENSE

It is recognized that track, bridge and tunnel maintenance expense is increased in electrified territory because of the interference of the overhead construction to normal labor and work equipment methods and efficiency. No data is available as to the added expense, however it is substantial. An average annual cost of $7500 is estimated for the Coast Division and $15,000 for the Rocky Mountain. The added cost on the Idaho Division would be somewhat less than for the Coast and $6000 is used.

LOSS FROM RIGHT OF WAY AND OTHER FIRES

Diesel locomotives set many right of way fires, resulting not only in direct loss but in the payment of claims. Fires attributed to the electrification originate from lightning or electrical malfunctions. Statistics of such losses vary to such extent that it is not possible to assign any sound figure to such costs, yet some value must be given to the greater expense of the one service over the other. Messrs. Hass and Centen have supplied the following information for guidance:

Direct loss involving diesel locomotives 1968 (electrified territory)

Rocky Mountain Division	$ 3,420
Coast Division	28,570
Claims	3,655
	35,645
Less losses due to electrification	4,396
Excess	$ 31,249

In addition there is considerable expense in fire "suppression" with no property loss, in patrolling track, etc., for which there is no cost record. It would seem that an annual expense in amount of $60,000 to reflect the excess loss from fire attributable to type of motive power would not be unreasonable, and this amount is included in attached statements.

UPGRADING OF SUBSTATIONS

Rotating electrical machinery in the substations is reported by Wylie to be in good condition and with proper maintenance can be kept in service for many more years. It is, however, 50 or more years old and as is true of any equipment repair parts become increasingly difficult if not impossible to obtain. Skilled personnel to keep the motor-generator equipment in good condition have become difficult to secure for our service.

There is now available much more efficient electrical equipment to transform the high voltage AC power to DC by means of rectifier equipment. The replacement of the rotating machinery with rectifier type is costly, approximating $300,000 per substation on the average, however the overall savings in substation maintenance and operation, and in the cost of power, appears to be quite attractive. A replacement program should be studied if existing electrification is continued.

The comparative cost statements attached to this review make no provision for upgrading of substation apparatus.

SEPARATION OF EMPLOYMENT ALLOWANCES

In event of dieselization the Railroad becomes subject to separation payments. This subject has been reviewed by the office of Vice President Finance and Accounting, on the basis of which an amount of $1,000,000 is included in statements, one-half of which will be assumed to be made in lump sum initial payments and the balance paid out over a five-year period. It is understood these amount are charged to Operating Expenses.

Total personnel of the department has shown a steady decline generally for some years, reflecting increased efficiency and automation, and reduced maintenance budgets. Selected data from information furnished by the Electrification Department follows:

Classification (Both territories)

Year	Substation	Line	Supervision	Elec.Engrs. Office	Total
1950	70	32	5	7	114
1955	69	34	5	6	114
1960	49	36	5	6	96
1965	43	23	5	5	96
1969(Mar.)	35	25	5	4	69

(In August '69 there was a lay-off of five operators on the Coast Division.)

More than half of the employees on the Rocky Mountain Division have ten or more years service, and all but a few on the Coast.

TAX CONSEQUENCES OF ABANDONMENT OF ELECTRIFICATION

This subject was studied by the Vice President Finance and Accounting, with the opinion that an excess of net salvage over adjusted tax basis of $830,000 would result in an IRS tax of $200,000, to be regarded as a "one-time cost of changing to full diesel operation, even though we are not currently paying taxes."

In consideration of its uncertainty this item is omitted from attached statements.

AD VALOREM TAX SAVINGS

Retirement of the electrification facilities will result in a reduction of the valuation of property in the several states, one of the elements used in the determination of taxes. It is the opinion of our Tax Commissioner and Auditor of Capital Expenditures that there would be no reduction of taxes in the states of Idaho and Washington, and that the tax savings in Montana would approximate $50,000 annually.

As information the valuation of fixed properties in 1968 follows:

Harlowton - Avery	Estimated Investment	Depreciation Reserve-Taxes
Transmission & Distribution Systems	$ 5,378,683	$ 2,380,167
Substation Buildings	691,125	492,840*
Operator's Dwellings	60,975	65,963*
Substation Apparatus	2,522,233	1,776,548*
Totals	$ 8,653,016	$ 4,715,518
Othello - Tacoma		
Transmission & Distribution Systems	$ 2,775,779	$ 1,228,285
Substation Buildings	458,337	254,310*
Operator's Dwellings	78,982	25,009*
Substation Apparatus	1,621,246	916,713*
Totals	$ 4,934,344	$ 2,424,317
Totals	$13,587,360	$ 7,139,835

*Items prorated same as Transmission & Distribution Systems.

SALVAGE FROM ELECTRIFICATION

Wylie estimated net salvage from the existing electrification at $7,341,225 based largely on copper and aluminum prices of $0.50 and $0.20 per pound. Kellow reduced these unit prices 20%, resulting in a net salvage of $5,686,00. Kirk recently estimated the net salvage at $5,653,816 assuming sale of the transmission line for $800,000. The investment in the electrification system, excluding dwellings, approximates $13,447,000.

Salvage from electrification is a credit to the investment in electrification, and while the monies may be applied to the purchase of diesel locomotives, or any other investment, it is illogical to apply it as a credit to diesel operation in any comparative economic study of methods, as appears in certain correspondence. High salvage value is one of the benefits of electrification.

Salvage therefore does not appear in attached statements. (It is shown as a credit to electrification in the discussion of tax consequences of abandonment in the 1959 Finance and Accounting Department Study.) For purposes of accounting salvage value is credited to Accrued Depreciation.

Wylie's estimate for electrification of the gap fails to show credit for its ultimate salvage value. Transmission lines would be constructed by others, and feeder lines would be of aluminum, however copper trolley conductors alone would have substantial salvage value, probably approximating $3.84 million, the initial cost, and other salvage would offset all costs of recovery. Inasmuch as full electrification would assume an indefinite life this item does not appear on statements, but is a consideration.

COSTS INCIDENT TO REMOVAL OF ELECTRIFICATION

In event of an abandonment of the electrification, it is understood that for accounting purposes Operating Expenses would be charged with the expense for removal of the facilities, estimated to cost $2.01 million by Wylie and more recently at $1.35 million by Kirk. The latter figure is based on the assumption the transmission line will not be taken down.

For purposes of economic comparisons of methods this expense, like salvage, is omitted from statements.

STATEMENTS OF COMPARATIVE COSTS

The attached statements summarize costs of diesel versus electric operation for the study period. The initial year is shown as 1969 only to reasonably reflect the statistical data used in the Wylie Report.

The statements are based on horsepower requirements as determined by Wylie, without reference to any particular models of locomotives. This is appropriate since models not only change but in the case of diesels various consists may be assigned from time to time.

Statements A - B and C are prepared on the basis of an all-electric operation using the 3400 volt DC trolley system as at present, and continuance of existing electrical machinery and the overhead system except for ordinary replacements.

Statement A summarizes estimated costs of Investment, including charges for electrification of the "gap," (referred to also as the "Idaho Division" in various reports), and for motive power for full dieselization or electrification, including replacement of the EF-4's in 1980.

Statement B summarizes estimated annual Operating Expenses, including certain non-repetitive expenses. Heavy expenditures anticipated for replacement of poles is included, with from only 8% to 17% of poles having been replaced in the electrified territories.

Statement C summarizes both investment and operating expense costs, and is the basis for a comparison of the 3400 volt DC system with dieselization.

Inasmuch as the present electrification requires that diesel locomotives (boosters) be substituted for portion of electric locomotives for comparable operation, due to limitations of the electrification system, Statement C-1 has been prepared to reflect the effects of such modification based on an assumed one-third of the horsepower requirements being supplied by diesels.

It will be noted that no statements show shop and engine-house expenses. Account 235 is a composite of locomotive and car facilities, and stores expenses, and it is not possible to segregate costs of maintaing locomotives only, or for apportioning expenses between diesel and electric locomotives. For the purpose of Wylie's study and this review the differences are disregarded.

Likewise the cost of maintaing fueling facilities for diesel locomotives is not shown, since it is not readily possible to determine the expense assignable to main line operation. The amount is not significant since the charges to Account 233 for the entire system for the study year 1966 amounted to only about $25,000.

Transportation of diesel fuel over our lines is not included. It is an item of cost even though not charged to accounts.

COMMENTS

With respect to comparative statements of cost:

(1) Statement B shows that full diesel operation Harlowton to Tacoma is approximately 9.5% more costly in Operating Expenses than an all-electric operation at the 1966 level of traffic, exclusive of short-term or extraordinary expenses, and 14.5% more expensive at the estimated 1986 level of traffic. The difference in cost is approximately $283,000 and $492,300 annually. Short-term or extraordinary items of cost are offsetting to a large extent.

The cost of fuel and repairs only for diesel locomotives is shown to exceed that for electrics by more than $1.0 million annually at the 1966 level of traffic, and $1.25 million at the 1986 level. The difference is substantially reduced by expenses of maintenance and operation incident to electrification.

The statement shows a cost for substation maintenance and operation amounting to approximately $450,000 annually. Use of rectifier type substations in the electrification of the "gap", which eliminates most of such expense, is reflected in this figure.

(2) Statement C shows an average annual savings of approximately $383,000 for electrified operation over diesel operation over the 30-year study period.

(3) Studies of horsepower requirements prepared by Kirk show that the present 3400 volt DC system lacks capacity to meet the demands of present schedules and tonnage and diesel boosters must be used to implement electric locomotives.

Statement C-1 shows that if diesel boosters must be substituted for an assumed one-third of the required horsepower in electrified territory, the average cost of all-diesel operation becomes less than that for the electric operation, amount to approximately $327,000 annually over the 30-year study period.

Other Considerations:

(4) In view of indicated savings in operating costs of electrification where power costs are favorable, much study has been given to conversion of the existing DC system to an AC system to overcome the deficiencies of the former. Wylie reports an entirely new system would cost approximately $26 million (excluding locomotives) and commented as follows:

"There are no reasons for considering a change from the present 3300 volt direct current electrification system presently in operation . . . . to a 25 KV single phase system at this time. Such latter system is one which might better be considered by some railroad which does not now have any electrification system."

Kirk reports on the other hand that by retaining the existing trolley wires and messenger an AC system can be provided for approximately $12 million. There are problems involved with signals and communications, and with tunnel clearances, and for which he has made certain allowances in his estimate.

With indicated savings of approximately $1.0 million annually in operating expenses, and the likelihood of future increases in the cost of diesel fuel that could very substantially increase the savings, it appears that this approach should not be dismissed because of its complexities, but should be investigated in greater depth, including possible financing by the power companies and leasing of the system up to the trolley to the Railroad.

(5) Fundamentally, the same conditions prevail now that existed at the time the railroad electrified. The original objectives were the better performance of electric power in mountain territory, operating economies by reason of favorable power rates in the growing hydro-electric field, in maintenance of locomotives, and in the virtual elimination of the fire hazard of steam locomotives. Disastrous forest fires of the times motivated some alternative to fuel-burning locomotives.

It follows that if electrification is justified in a certain territory, the benefits and economies are only diluted with the substitution of diesel power in whole or in part.

(6) A 1959 study by the Finance and Accounting Department reached no specific conclusions, however statements showed no savings in full dieselization as compared to the existing operation.

CONCLUSIONS

(1) The cost per rail horsepower of diesel locomotives and of electric locomotives is not much different, and not a decisive item.

(2) The existing electrification system cannot meet the requirements of fast train schedules and heavy tonnage comparable to diesel locomotive consists in use. Neither one can meet the maximum speeds permitted by track conditions throughout the entire electrified territories.

(3) At prevailing power and fuel prices Statement C shows that operation with electric power is less costly than with diesel locomotives Harlowton to Tacoma over the next 30-year period. Statement C-1 shows that if diesel boosters are used this savings is lost, depending on the extent of use.

(4) To realize the full savings of the existing electrification system slower train schedules must be restored.

(5) Kirk reports the existing DC system cannot be economically upgraded through replacement of rotating machinery and of feeder lines, etc., as compared to conversion to an AC system.

(6) If favorable electric power rates can be renegotiated on a long-term basis further study should be made of an AC electrification system, retaining the existing trolley in presently electrified territories. The voltage selected appears to depend in part on problems with inductive interference to signal and communication lines. Construction and maintenance by the electric power industry, excepting the trolley, but including the sale of existing transmission lines, should be further explored. Future increases in the price of diesel fuel seems certain.