Summary

Liviu L. Alston, International Bank for Reconstruction and Development, Washington, D.C., and Chairman of the Committee on Electrification Systems

In 1977, for the first time, TRB's annual meeting included a session on railroad electrification. Its purpose was to identify some of the main issues that affect railroad electrification and to prepare for a more extensive discussion of these issues at the Conference on Railroad Electrification: The Issues. The papers presented the railroad, economic, financial, and government points of view.

One of the most striking features of the annual meeting session was the apparent enthusiasm for electrification from some members of the audience and the reservations the speakers had about it. The enthusiasm is partly traditional because electrification has in the past been associated with a modern, efficient railway operation. Diesel traction has since been developed, and it has many of the advantages of electrification, with two important exceptions.

First, it uses oil, which, as we are finding out, is a very scarce resource. Diesel traction is, however, in excellent company in this respect since almost all transport derives its energy from oil. In fact, electric railways are the only major means of transport that need not use an oil-based fuel, and this has heightened interest in electrification. However, since U.S. railroads account for only about 2 percent of national oil consumption, the impact of railway electrification on national oil consumption cannot be very significant. On the other hand, electrification could have an important impact on railway fuel costs if, as a result of future price movements, electrical energy became significantly cheaper than diesel fuel.

The second exception is that a diesel locomotive has to carry a small power plant. As a result, maintenance costs for electric traction are substantially less than for diesel traction. But this advantage—and any fuel cost advantage—has to be paid for, literally, by high investment costs in fixed installations. Since these investment costs increase much less than fuel and maintenance costs as traffic increases, the viability of electrification depends on the level of traffic, but the critical traffic density for any railway depends on local conditions.

EXTENT OF ELECTRIFICATION

Since the end of World War II, American railroads have considered that the price of electrification is not worth paying, apart from minor exceptions, although electrification is now being planned by the Consolidated Rail Corporation (Conrail); the results of that exercise will be watched with considerable interest. In contrast, overseas railways have electrified extensively. The percentage of electrified track kilometers is less than 1 percent in the United States but 16 percent in Britain, 29 percent in West Germany, 25 percent in France and the Soviet Union, 40 percent in Japan, 47 percent in Italy, 60 percent in Sweden, and 99 percent in Switzerland. I believe that the issues affecting electrification can be illuminated by an analysis of the reasons for the differences in the extent of railway electrification in the United States and other countries.

The main difference is that U.S. railways are privately owned, whereas other railways are state owned. Because they are private commercial organizations, U.S. railways would electrify only if a financial analysis showed that electrification would be profitable for the railroad. While such analysis is also important for a state-owned railroad, it takes second place to an analysis of the benefits of electrification to the country. There is a suspicion that this economic analysis has sometimes been superficial and based on such global considerations as independence from oil imports. This may well have happened in some cases, particularly for the older electrification schemes. However, modern economic analysis is quite as searching as a financial analysis, except that its objective is to ensure the most efficient use of national resources rather than to increase the profitability of the railway. Thus the economic analysis ignores the impact of electrification on taxes paid by the railway and prices such resources as oil and electric power at their value to the national economy, which may differ from the market price.

Another important issue is the availability of investment funds. Foreign railways rely heavily on government funds, so that, once the economic justification of the project is demonstrated, the availability of financing depends on national investment policies. This can be a mixed blessing, but it has nevertheless resulted in the execution of fairly extensive electrification. American railroads rely on their internally generated funds and the capital market. In general, they are short of funds, particularly for fixed installations, and, since their ability to borrow at any time depends partly on their existing debts, they must be very careful about which projects they borrow for. There are thus many projects competing for limited investment funds, and many give a greater—and generally quicker—return than electrification.

Two suggestions were made that could make electrification more attractive to the private investor. One was the creation of tax-exempt bonds, like municipal bonds. Another was the creation of revenue bonds, which would involve the creation of an entity that would own the catenary, substations, and related facilities and would sell power to the railway at the pantograph. An alternative suggestion was that a governmental authority construct and own these installations and lease them to the

railroad. The total investment needed, assuming that about 10 percent of the U.S. railroads' track, which carried about 50 percent of the traffic, were electrified, was estimated by one speaker to be $7 billion.

Cost differences between the United States and other countries arise for several reasons. The United States is pioneering the 50-kV system, which should result in some cost reduction. However, there is very little recent experience with electrification in the United States, and this may well increase the cost of the first few electrification projects. Again, labor rates are different. Probably the most important differences arise in regard to signaling and telecommunications. The electrification of foreign railroads was usually part of a comprehensive modernization program that involved replacement of signaling and telecommunications, including the installation of underground cables. Under these circumstances, the only signaling and telecommunications cost attributed to electrification was the additional cost needed to protect the signaling and telecommunications equipment, including the cable, from interference from the traction current; this typically amounted to 10 to 15 percent of the total cost of fixed installations. In the United States, on the other hand, the railroads already have modern signaling and telecommunications, and these installations now have to be protected. Probably the greatest single factor that would reduce electrification costs would be the development of less expensive techniques for protecting signaling and telecommunications.

The cost of fixed installations, including signaling and telecommunications and clearances for Southern Railway Company's main line, has been estimated at $75 000/track km ($120 000/track mile). This estimate is consistent with a cost breakdown reported by American Railway Engineering Association (AREA) in 1976 (1). It is rather higher than estimates encountered in other countries, but seems reasonable when the above differences are taken into account. Another speaker quoted a price range of $75 000 to $300 000/route km ($120 000 to $500 000/route mile) for the same installations. The route-kilometer cost is greater partly because it may encompass several tracks. This is unlikely to affect the attractiveness of electrification, because the key parameter is the traffic density per track. However, the upper end of the cost range may reflect problems with clearances and other public works; these make electrification less attractive or, to put it another way, require a greater traffic density to justify it. In general, electrification is not thought to be justified in this country for annual traffic densities of less than 36 gross Tg (40 million gross tons), although substantially lower figures appear to be adequate elsewhere; in the Soviet Union, for example, the critical density is 9 to 11 net Tg (10 to 12 million net tons) for a single-track line (2).

Let us now turn to locomotives. Outside North America, the cost per unit of power of an electric locomotive is less than that of a diesel because the electric does not carry a relatively expensive diesel motor. However, the large market available to U.S. diesel locomotive manufacturers has resulted in the production of diesel locomotives at relatively low cost. One would expect that, as the demand for electric locomotives grows, they will ultimately become available at even lower cost; the AREA report mentioned above (1) estimates that an electric would cost $170/kW ($125/hp) compared with $200/kW ($150/hp) for a diesel. However, this necessitates substantial developments in the production of electric locomotives, and meanwhile the railroads are left uncertain as to when electric locomotives will become cheaper than diesels.

BENEFITS OF ELECTRIFICATION

So much for the cost. Let us now turn again to the benefits of electrification, which as we have seen relate primarily to fuel and maintenance costs. The impact of electrification on fuel costs depends on the energy policy and, until its impact on future oil and electricity prices emerges more clearly, there will be considerable uncertainty as to the extent of the energy savings the railroads could achieve by electrification. Of course, these savings could be appreciable if oil prices increase significantly more than electricity prices do.

Maintenance cost savings result because electrification eliminates the maintenance of diesel motors. Furthermore, electric locomotives can be substantially more powerful than the most powerful diesels now available, and they have an overload capacity that diesels lack. For a given level of traffic, there are thus fewer electrics than diesels to maintain. Although additional maintenance costs are incurred on an electrified railway in respect to fixed installations, total traction maintenance costs are substantially less for an electric railway than for one that uses diesel traction. However, a reduction in maintenance costs generally implies a reduction of staff, which may raise labor problems.

A further advantage of electrification is that in certain circumstances it may increase speed, though only to a limited extent. This may result in more efficient use of staff and equipment but, for a freight railway, is unlikely to be very significant unless traffic on the line approaches saturation and electrification postpones major civil engineering works needed to improve capacity.

A common feature of all these benefits is that they accrue slowly, over many years, although the costs have to be paid immediately. There is thus an initial negative impact on the railroads' cash flow, while the railroads have to face the risk that future changes in traffic patterns or energy costs may decrease the benefits.

There are, in sum, several factors that make electrification less attractive in the United States than in other countries. However, the attractiveness of electrification increases with traffic density, and some U.S. railroads carry a very high level of traffic. For example, the average annual traffic density on electrified lines varies in different European countries from 11 to 19 gross Tg (12 to 21 million gross tons), while electrification is being considered in the United States only for lines that carry more than 36 gross Tg. Nevertheless, uncertainties associated with electrification, some of which I have mentioned, coupled with the financing problems, are causing the railroads to hesitate. A demonstration project will be very valuable in resolving some of these uncertainties, and it is to be hoped that Conrail's electrification of the Harrisburg to Pittsburgh line will fulfill this role.

In any event, it is clear that important issues remain to be answered concerning railway electrification in the United States. The objective of this conference is to focus on these issues, define them, and, to the extent possible, assist in resolving them.

REFERENCES

1. Report of Committee 33 on Electrical Energy Utilization. American Railway Engineering Association Bulletin, Jan.-Feb. 1976, pp. 403-413.
2. D. Jacenko. Report on the Visit to the USSR by the U.S. Electrification Delegation, May 26 to June 5, 1975. Office of Passenger Systems, Federal Railroad Administration, 1975, 127 pp.