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A Concise Medium for Industrywide Dissemination of Railroad Fuel Savings Measures

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ABSTRACT

CENTRALLY-ORGANIZED corporate programs to reduce operational consumption of petroleum fuels consistent with service requirements and safe practices are in relative infancy in the rail industry. A day-long coordination meeting held in Chicago in early 1982 involving designated fuel conservation officers of several railroads and representatives of government and the academic community confirmed that no substantial consensus has formed regarding the most cost-effective measures to cut fuel demand. An issue still unresolved for most carriers is the determination of just how much diesel fuel is not being productively used, some meeting participants having estimated that up to 5% of fuel purchased is unaccounted for at some point in the distribution system. Although fuel inventory monitoring and control are improving significantly, it is still very difficult to estimate with assurance how much less fuel need actually be purchased or how much other costs will change if a given conservation strategy is implemented. Nevertheless, efforts to disseminate information throughout the industry on a wide variety of fuel-conserving techniques should continue, according to this group. While the Association of American Railroads, the Federal Railroad Administration and individual carriers have sponsored extensive research on reduction of wastage and potential alternative fuels, data and information generated by these efforts had not been assembled into "ready reference" format covering both operational strategies and capital investment opportunities.

In order to meet the need for a concise compendium of information relating to fuel conservation in railroad freight operations, a "matrix" was developed at Argonne National Laboratory which summarized a wide variety of fuel-saving measures and their associated costs and benefits. Organizational approach and technique were consistent with that applied to the earlier formulation by Argonne of a matrix for use by the maritime shipping industry. Information was derived primarily from technical sources and manufacturers' literature. This matrix was reviewed by a panel of experts from the rail industry and was revised based upon their critique. In its final form, it lists 38 fuel savings measures under seven principal headings. These headings are:

- Education, Understand, Follow-Through;
- Moving Train Operation;
- Stationary Locomotive Procedures;
- Control of Fuel Inventory;
- Capital Investments;
- Developing Technologies;
- Alternative Energy Sources.

Special emphasis is placed on **well-conceived education and training programs, improved fuel inventory control and handling, reduction of empty freight car miles, and elimination of unnecessary idling**, all identified by the coordination meeting participants as crucial to any railroad energy cost reduction program.

The matrix has been distributed free of charge to over 120 domestic rail carriers.

1. BACKGROUND

Central-organized corporate programs to reduce operational consumption of petroleum fuels consistent with service requirements and safe practices are in relative infancy in the rail industry. In spite of recently plummeting fuel prices, these programs in no way appear threatened with an early death. For those carriers that have delegated fuel conservation authority to specific individuals in the management structure—authority that may cut across traditional lines of divisional organization—the vision and active encouragement of Chief Executive Officers have been essential elements in the success of this approach. Noteworthy for sustained accomplishment among carriers that have moved in this direction are the Chessie System (CSX Corporation), the Union Pacific, Illinois Central Gulf, Chi-

**Argonne National Laboratory, Center for Transportation Research.*

cago and North Western, Santa Fe, and Burlington Northern. Fuel conservation officers for these roads, with the support of top management, have helped instill a fuel-saver consciousness among employees in almost every capacity, such that mechanical, operations, and maintenance divisions across the system are coming to recognize that they share many more concerns, interests, and responsibilities than standard practice in the "throwaway fuel" era may have led them to believe. Originally top-down programs, these fuel conservation efforts are now paying off in enthusiastic staff involvement, with many useful recommendations for procedural change being put forward by trainmen, dispatchers, mechanical engineers, and others on lower rungs of the corporate ladder. That these recommendations are frequently adopted is of great credit to rail carriers in this new era of deregulated operation, and indicative of the recognition that, when corporate opportunities expand dramatically, good ideas to capitalize on them may be found at all levels of theorganization.

Fuel inventory control and use constitute a special problem in rail operations relative to other modal carriers because there are so many opportunities for unaccounted "leaks" to develop in the system from acquisition to disposal of the liquid product. The rail freight system cannot count on achievement of near uniform control over the fate of its fuel inventory in normal revenue service. That is, upper and lower limits on expected fuel use for a given type of operation have yet to be defined with useful precision for any circumstance. With their high variability in power requirements, aerodynamic drag, terrain effects, and non-fuel costs, train movements represent much less of a 'closed system' than do the operations of waterborne vessels, pipelines, or even trucks. It is nevertheless critical to the financial health and viability of modern railroad operations to find ways to continue to improve on gallon-per-ton-mile fuel efficiencies which, though far superior to those of the early 1970's (when diesel fuel averaged $0.10/gallon purchased in quantity), could not prevent Class I railroad consumption of a near-record 0.6 quads of petroleum in 1980,[1] when freight was still moving at pre-recession levels. Although railroad revenues were relatively healthy in 1980 (the fuel consumption figure primarily indicates a high volume of traffic), future profitability will rest significantly on each company's ability to control its fuel and other variable costs in a business climate in which oil price changes may be insensitive to the peaks and troughs of economic cycles.

The Association of American Railroads (AAR), the Federal Railroad Administration (FRA), the U.S. Department of Energy (DOE), and individual railroad companies have actively pursued reasonable and effective measures to reduce fuel consumption in the rail system.[2] No one source of guidance on implementing these measures has been accepted as universally appropriate, although acquaintance with and utilization of available published documents and other resources have been increasing. This paper focuses on the development, refinement, and distribution of one such resource: a rail energy efficiency measures matrix prepared at Argonne National Laboratory (ANL) as part of a program begun in 1981 to assess the parameters of fuel use for the chief freight haul modes and codify measures and strategies to reduce fuel demand and cost per unit of haul.

The program was sponsored by the Office of Vehicle and Engine Research and Development, U.S. DOE, whose Program Manager of Heavy Duty Transport, E.W. Gregory II, provided the insight that guided the effort at ANL: namely, that freight operators need brief single-source documents (compiled, as necessary, from widely-scattered sources of information) to promote and systematize fuel cost reduction efforts by their organizations. A key element of each document would be verification or updating of published estimates of potential fuel savings by means of information exchange and, where possible, consensus of a coordination meeting involving experienced industry operators and researchers from government and academia. The first product of this program, a matrix (ready-reference chart, with annotations) of over 60 maritime fuel savings measures directed at waterborne carriers in U.S.-foreign trade, was distributed to fuel officers of over 1050 U.S. and foreign shipping companies. Over 100 requests for additional information were received by ANL from owner/operators in 28 countries.[3] The success of this effort indicated that a similar approach could be adopted for the domestic rail industry. Thus, drawing on the best available sources of quantitative information and checking their reliability with authorities both at large and in the aforementioned coordination meeting, ANL researchers sought to extract succinct yet comprehensive descriptions of the most successful short-term and most promising intermediate- and long-term measures for fuel-related operation and capital investment.

They then endeavored to compile these in a concise ready-reference chart useful to railway management.

2. PROCEDURE

2.1 Literature Review and Matrix Preparation

The literature review conducted prior to preparation of the draft reference chart, or measures matrix, encompassed U.S. Government agency contract technical reports, trade journals, AAR publications, and literature of railway equipment suppliers and manufacturers. No one segment of these source categories uniformly provided transferable quantitative estimates of fuel savings for given measures or strategies. Estimates of percent or gallons of fuel saved under given conditions appeared most often in manufacturers' literature. While the reliability of manufacturers' claims could not be directly ascertained, similar difficulties were encountered in the interpretation of results of research performed under contract, because the degree of control on or changes in conditions during tests were not always documented. In the end, it was decided to cite for the matrix all sources in which at least some attempt was made to quantify fuel savings (perhaps 25% of total sources consulted) and to provide appropriate cautions on those estimates in a remarks column.

The draft 10-page matrix identified sets of fuel savings measures under two primary improvement area categories: operations (near-term and/or quick-response measures) and capital investment (middle- to long-term measures). For each measure, the matrix identified the type of equipment or personnel targeted, nonfuel cost considerations (investment, labor and maintenance), payback period on investment (were applicable), and fuel cost savings based on a price of $1.20/gallon for diesel #2 oil and a hypothetical linehaul of 7 million ton-miles. Parameters with these values would place this haul about halfway between the extremes of unit coal train movements (western coal to utilities) and premium trailer-on-flatcar express service. In many cases, due to the wide variability in operational circumstances under which a particular measure could be implemented, fuel savings were characterized as 'operation specific,' and not assigned a numerical value. Based on a principal finding of the work leading to development of the earlier maritime matrix, **motivational development programs for personnel** were assigned first position among near-term priority measures.

2.2 Industry Coordination Meeting

In order to refine the matrix through guidance and revision recommended by persons directly or indirectly involved in rail fuel conservation programs, ANL convened an Industry Coordination Meeting on Rail Energy Efficiency Measures at the headquarters building of the Atchison, Topeka and Santa Fe Railway Company in Chicago on January 29, 1982. The roll of attendees is included as Appendix A to this report. Fuel conservation officers for several railroads and representatives of the AAR, the academic community, and relevant federal agencies were invited. Because of constraints on travel time and budgets, ANL contacted only railroads headquartered in Chicago and nearby midwestern cities. All but one of the invited railroads were represented at the meeting and three lines each sent two representatives. Attendees from a connecting (belt) service operator as well as from large intercity trunk carriers contributed a broad and lively mix of viewpoints to the working group's discussions of specific matrix measures.

Among items for which there was general agreement was that the published estimates of fuel savings cited in the draft matrix were highly questionable when generalized, and their reliability was restricted in most cases to the particular conditions under which the tests that produced them were conducted. No one in attendance could report an experience on his own carrier in which results of the magnitude claimed by most of matrix references was achieved; and for those few percentage estimates deemed reasonable by meeting participants, there was a brief that synergistic effects were probably present. Regarding the method chosen to report the magnitude of expected fuel savings in the matrix, participants agred that it would be more useful to decision-makers if different performance yardsticks were applied to different types of operation. For example, strategies related to smooothing out 'sawtooth' speed profiles for a line haul (such as adding a fourth phase to block signaling, reducing reliance on power braking, and cutting maximum speeds) are closely related to crew runs in a specific topographical regime and thus should be assessed according to **gallons saved per crew run** (disaggregated, where possible, by terrain/average grade conditions). Elimination of unnecessary idling by yard duty engines should result in fuel savings measurable **per hour of service of** these engines. As anticipated, participants concurred that, whatever yardstick is used, little real fuel saving will result without education, motivation and training programs designed to secure the active and understanding participation of enginemen, dispatchers and other personnel in a systematic conservation effort.

The participants could not agree on usefulness of locomotive add-on control and monitoring devices touted by their manufacturers and promoters as significant fuel savers. Some participants allowed that at least the presence of such devices could make enginemen more aware of the need to save fuel, but all concurred that the engineer was the key ingredient in any fuel-efficient train movement, and many cited practices now in force on their respective railroads that essentially obviated the add-ons. However, the belief was widespread that development of a reliable fuel-flow or ampere-hour meter for the locomotive cab would be useful and very welcome.

A more general issue of fuel use and control came to light when inventory security procedures were mentioned. Simple padlocking of fuel storage tanks was cited as a measure with considerable immediate benefits in eliminating substantial pilferage losses. Nevertheless, some carrier representatives estimated that as much as 5 to 10% of purchased fuel is still unaccounted for at some point in the distribution system.

Non-industry attendees were again reminded that TOFC, COFC and other inter-modal operations do not save fuel for the railroads, though they may reduce petroleum consumption in the nation at large. Inter-modal transportation is a premium service offered by trunk haulers in order to compete for higher-value traffic with other railroads and the trucking industry: horsepower-per-ton ratio and thus fuel consumption per revenue mile is the highest of any regular line-haul operation. If the railroads could move this traffic by conventional means and remain competitive, they would do so.

The issue of increased non-fuel costs of fuel-savings measures was raised with respect to regularizing maintenance practices (to keep locomotives "in tune"), reduced operating speeds, power/tonnage matching programs, and aerodynamically efficient consist grouping. With labor agreements involving crew change frequency and sorting and blocking procedures in transition, most of the added cost factors of the latter measures could prove to be less troublesome in the future. Because of the relatively high non-fuel costs, however, the representatives doubted that the experimentation by some roads with uniform inspection schedules for locomotives would be universally adopted. That is, many carriers would continue to shop motive power only when it was bad-ordered.

There was a surprising degree of optimism about emerging capital investment opportunities, although individual viewpoints were again tempered by an understanding of the dimensions of procedural obstacles in capital budgeting that would have to be overcome before substantial energy-related cost savings could be realized from such investments. Installation of wheel slippage control systems for improved rail adhesion received favorable reaction as an effective and relatively inexpensive near-term means to increase trailing gross tonnage without increasing horsepower requirement. Both hybrid truck/train equipment and lightweight TOFC/COFC multiple units such as the Santa Fe "Fuel Foiler" and TTX "4-Runner" won a positive response for their success at reducing tare weights and increasing fuel efficiency of intermodal hauls (though some manufacturers' claims were termed exaggerated). Santa Fe has identified a fuel saving of up to 6000 gallons with Fuel-Foiler® on its Chicago-Barstow round trip runs (about 4000 miles). Potential alternative fuels to diesel oil #2 were viewed with some skepticism, since the modifications required of existing engines to burn these fuels without increased damage and wear are still unspecified.

With respect to electrification, an assertion that "if we had the catenary up, we'd go electric today" was generally accepted; but only one of the railroads represented was actively moving toward overhead electrification on one of its lines at that time, since outlays required for substations, new communications and signalling, and civil reconstruction in addition to catenary would boost total electrification cost to over $1 million per mile in many cases. Given that there is a capital shortfall of $13 to $16 billion for needed improvements in the industry overall, and a backlog exceeding $6 billion of deferred capital maintenance and construction,[4] the perception by meeting attendees appears accurate that significant new electrification is unlikely in the near future. Moreover, despite the substantial saving in propulsion fuel cost per ton-mile of movement represented by electrified vis-a-vis all-diesel operation, overall savings including net of capital investment was not believed by the participants to exceed 20%. When discussion of a return to direct coal-firing of locomotives as an alternative arose, carrier representatives acknowledged the substantial progress in steam propulsion technology and efficiency since the twilight of the steam era. However, they were reluctant to endorse a return, even for specialized purposes, to direct coal firing, due to increased ash disposal costs, water requirements, and the attendant (but unspecified) cost of new infrastructure required.

Due to time limitations and a general reluctance to plunge into the turbid waters of policy recommendations, the working group at this meeting, although asked to do so, did not develop a ranking package of 'most promising measures' to be featured above all others in the matrix. This again may be charged to the recognition that there is danger in generalizing any strategy over all types and conditions of rail operations. The working group was satisfied to agree that **well-conceived education and training programs, improved fuel inventory control and handling, reduction of empty freight car miles and elimination of unnecessary idling** would comprise at least a part of whatever energy cost reduction program evolved and successfully gained momentum on any given railroad.

2.3 Revision of Matrix

Based on the Industry Coordination Meeting Results, the draft rail matrix underwent substantial revision. The divergence between the position on fuel savings estimates taken by the meeting attendees and the numbers reported in the sources used for the draft matrix led to a decision to adopt a two-column reporting format for fuel-savings estimates in the revised matrix: one column for published results and manufacturers' and/or researchers' claims, and the other for the working group consensus. In most cases, the entries for a given measure were not incompatible between columns; however, where substantial disagreement was present, ANL sought to avoid implying greater credence of one source over another. Thus both columns were retained whenever information was available.

The headings under 'Additional Cost' (Investment, Maintenance, Other) were replaced by **Fixed Cost** and **Variable Costs**, in order to separate the notion of capital acquisition requirements and regular (joint) operating expenses from that of avoidable costs. For some measures virtually all non-fuel costs would be one-time fixed investments; for others, costs would accrue on a regular basis and might be divisible from other operating accounts. Railroads need to know how long they might expect to continue paying for a fuel efficiency improvement, and whether the costs will likely rise or fall over time.

Where it was impossible to do so, fuel savings for linehaul-related measures were not expressed in gallons per movement increment. This did not completely comply with the coordination meeting consensus, but was at least a step closer to what was desired. It was noted with some disappointment that the proportion of measures for which only the "operation specific" descriptor can be applied increased considerably from the draft version of the matrix. On reflection, it was realized that this development generally supported the perception gained in undertaking this investigation that the results of experimental/controlled research conducted on test tracks and benches fail to provide the kinds of answers needed by railroad fuel conservation officers, particularly in trying to sell a program to their Chief Operating Officers. For this reason, and because of the continued disparity in fuel utilization procedures across operations and among carriers, no consensus has yet formed regarding the most effective (and cost-saving) measures to cut fuel demand in all applications.

As a final modification to the matrix format, categories of measures were expanded according to the time horizon of expected implementation. At the very near-term end, "Modification of Existing Operations" includes major subheads of **Education / Motivation / Follow-Through, Moving Train Operation, Stationary Locomotive Procedures,** and **Control of Fuel Inventory.** The 'Capital Investments' category was disaggregated to separate likely near-term measures from 'Developing Technologies' and 'Alternative Energy Sources.' Under these revised headings, several specific measures for the draft matrix were consolidated under generic headings (e.g., electrification was broadened to include wayside energy storage) while others (e.g., reducing the tare weight of intermodal hauls) have been expanded into multiple measures. A few measures not reviewed at the meeting—largely involving friction-reducing equipment—have been added. ANL believes that the current 9-page version of the matrix represents an appropriate consolidation of the results of the literature review and the Industry Coordination Meeting in reporting the maximum useful data obtained from each within the constraints of the desired compact format.

The list of references containing specific fuel-savings estimates that were used in preparation of the matrix is included in Appendix B to this report.

3. DISTRIBUTION

In August, the matrix in its present form was mailed to Industry Coordination Meeting participants and to a selected list of qualified rail industry personnel and academicians for a final review. The recommendations arising from this review were incorporated into the matrix and the final version prepared in October. The matrix has now been mailed to over 120 domestic rail carriers, and the AAR has requested (and received) permission for further reproduction. Copies are available on request from the Center for Transportation Research of Argonne National Laboratory.

Termination of this project at the close of fiscal 1982 has precluded additional follow-up to assess the industry's reaction to and utilization of fuel-saving information in this matrix format. Moreover, the concern arose at Argonne and in the media as 1982 drew to a close that the continuing decline in diesel fuel price would deflate much of the industry interest in information on fuel-saving techniques that was so enthusiastically

APPENDIX A

Attendees:

ANL Rail Energy Efficiency Industry Coordination Meeting—January 29, 1982

Name and Position	Organization
Michael Arakelian Director, Locomotive Operations	Chicago & North Western Railway
Mike Bronzini Associate Director	Transportation Center University of Tennessee
G. Richard Cataldi Energy Engineer, Research & Testing Department	Association of American Railroads
Tom Dorsey Manager, Energy Systems	Illinois Central Gulf RR
Jerry Fazekas Assistant Superintendent, Equipment and Locomotives	Indiana Harbor Belt RR
Conan R. Furber Manager, Energy Studies and Director, Research & Testing Department	Association of American Railroads
Bert Larzelere General Road Foreman	Indiana Harbor Belt RR
Hank M. Lees, Jr. Director, Energy Conservation	Burlington Northern, Inc.
Dale Long Mechanical Assistant	Atchison, Topeka and Santa Fe Railway
Cole Oehler Executive Representative	Missouri Pacific RR
Bill Sadler Manager, Energy Conservation	Illinois Central Gulf RR
Mike Volkmar System Fuel Officer	Chicago & North Western Railway
Ken Bertram Center for Transportation Research	Argonne National Laboratory
Chris Saricks Center for Transportation Research	Argonne National Laboratory

expressed at the coordination meeting. This belief was refuted, to our great satisfaction, by the agenda of a conference on railroad energy technology held in Memphis in December. The variety of topics and carriers represented at this symposium[5] confirmed that energy efficiency is still and will continue to be near the top of the list of rail industry objectives for the 1980's.

APPENDIX B

MATRIX REFERENCES

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12. *Railway Age,* Vol. 183 (March 29, 1982).
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16. Whitford, R. K., *Railroad Electrification: An Option for Petroleum Savings.* Automotive Transportation Center, Purdue University (August 1980).
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FOOTNOTES

1 Yearbook of Railroad Facts, Association of American Railroads, 1981.

2 Examples of the products of internal and contracted research by these organizations are liberally scattered throughout the reference list in Appendix B. The most notable recent findings are documented in: Fuel Conservation in Train Operation, Association of American Railroads Report No. R-506 (December 1981).

3 Bertram, K. M. and Saricks, C. L., Summary of International Maritime Fuel Conservation Measures, Report No. ANL/CNSV-TM-88, prepared for U.S. Department of Energy (November 1981).

4 Advanced Rail Technology, Report prepared by the Subcommittee on Transportation, Aviation and Materials, Committee on Science and Technology, U.S. House of Representatives (September 1982).

5 Progressive Railroading 26:2 (February 1983), pp. 42-48.