

Response of Freight Transportation to Fuel Supply Shortages

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This paper describes near-term and long-range responses by freight carriers, shippers, and manufacturers to fuel price increases and availability questions since the 1973-1974 oil embargo. Near-term refers to those events that are nonrecurring, whereas long-term refers to the anticipated responses of freight movers in the next 10 years. A telephone survey that was used to collect responses from carriers suggests that near-term responses were primarily cost-cutting operational strategies and long-term planning emphasized vehicle changes to such an extent that modal attributes are effectively changed over time.

The consumer is just beginning to feel the full extent of effects from fuel price and availability questions for the freight sector. During the shortage crises, publicity was primarily oriented to passenger travel because consumer hardships were felt immediately. Recent data collection and analyses, however, have contributed to an understanding of the freight sector's energy-use problem, and they are especially insightful about changes in the truck and rail modes. The 1977 Census of Transportation shows some interesting new trends in truck use (1) and variations in modal shifts among manufactured commodities (2). There are also modeling efforts that have contributed to an understanding of fuel price increases and their impacts on freight transportation; these include the CACI modal simulations (3), the Association of American Railroads (AAR) truck cost model (4), and two cost studies of truck and rail by the Transportation Systems Center (5, 6). These sources were effective in quantifying recent and projected impacts, although they were not as helpful as the telephone survey method in perceiving individual carrier strategy options and future responses.

THE SURVEY

Throughout November 1979, informal telephone conversations with carriers and manufacturers provided the primary data for this analysis. Shipper responses were originally solicited, but, after uninformative responses by the groups contacted, secondary sources were considered to be more desirable. Information was obtained from two rail and truck associations. (This study is responsive only to these two modes because the competitive parameters and the type of shipments distinctive of other modes are often so far removed from characteristics of truck and rail.)

The sample survey for this paper in no way represents a statistically sound cross section of actors for freight carriage and vehicle manufacturers, but all of the persons contacted were well versed in the current trends in their business; thus, current industry thinking is represented. Additional carrier, manufacturer, and shipper responses were obtained through a review of transportation periodicals.

The lack of shipper responsiveness to fuel pricing and availability questions in this analysis is a real setback. Commodity-sector sensitivity to price, time, and service parameters over time is the only real means to effectively determine shipper responses and, therefore, future modal shifts. The literature hints that shippers are becoming more cognizant of transportation costs in total goods pricing and are willing to deemphasize rail shipment-time inconsistencies (7). But this exploration effort is by no means indicative of a mass movement, as many in the field intuitively feel.

THE ACTORS

The carrier respondents to the telephone survey are for-hire common carriers. But the trucking industry also consists of

a number of carrier types that were included in the secondary source analysis. There are for-hire and private carriers. The for-hire segment consists of both common carriers and contract carriers plus others that are exempt from economic regulation. Each of these carriers can be distinguished from others based on the size of the firm, size of shipments, lengths of haul, and commodity characteristics. The diversity of operating attributes among the for-hire carriers is extreme. The private carriers also have operating variations, but these are primarily based on the type of commodity (or business) with which the carriers are affiliated. The shipper owns or leases the vehicle in private carrier operations. Thus, service, time, and cost variables are substantially different from any type of for-hire operation. In this paper, a carrier is defined as a regulated for-hire carrier, unless otherwise stated. Secondary source information was helpful in supplying information on for-hire, owner-operators, and unregulated truckers.

Survey data from rail carriers only included reactions of class 1 railroads. There is no shipper that has ownership of a major rail line. The ownership characteristics between truck and rail modes are substantially different because of the operating authority given to different types of carriers.

Each carrier type has responded to the energy shortage problems in different ways. The responses are described in the following sections of the paper in terms of near- and long-term consumer responses. The consumer in this case is any actor involved in the movement of goods (i.e., carriers, shippers, and vehicle manufacturers). Following the discussion of near- and long-term response measures, conclusions are made as to the overall impacts of fuel price and supply instability on truck and rail freight movement in the future.

SHORT-TERM RESPONSE

This section describes events that have occurred since the 1973-1974 embargo, as well as current issues facing freight carriers, shippers, and manufacturers. The discussion includes a timeline of events as described through telephone interviews and a literature search. The discussion of shipper reaction is based entirely on secondary source information.

Carriers

Truck

The response of truckers was by far the most vocal of any freight carrier after the embargo. Owner-operators were in the national spotlight in January 1974 when they requested assurances of guaranteed fuel allocations and higher shipping rates to recover fuel costs. The incidences of violence that occurred during the owner-operator struggle did not reflect the industry as a whole, however. Most carriers responded with reasonable short-term operating strategies.

The telephone survey revealed that, from 1974 to 1980, the trucking industry has concerned itself with three major issues: (a) energy price and efficiency, (b) inflation and cost control, and (c) deregulation. These were ranked by the respondents in order of importance. It is likely that energy pricing would take a lower priority in this list of issues if the Interstate Commerce Commission (ICC) instituted fuel surcharges at a more rapid pace than was the case in 1973.

Owner-operators felt the immediate effects of fuel price increases. Because they exist on such a narrow operating budget, there is little flexibility for price increases. On the

other hand, trucking companies are in a position to bear the crunch of short-term cost increases, such as the 1973-1974 fuel price increases, because their return on investment is so high. In fact, relative to other transportation modes, for-hire common carriers have historically received the highest revenues, according to Michael Pacquin of Thermo-Electron, Inc. For example, in 1975, the airline industry averaged a 6 percent return on investment; railroads, 4 percent; and common-carrier truckers, 17 percent.

As applications were made for increasing fuel surcharges, carriers also worked on the problem of decreasing fuel reserves. Fuel-order procedures were on a daily basis rather than monthly distributions. The Nixon Administration developed the Voluntary Fuel Allotment Plan (May 1973) that called for an assurance of 10 percent of supplies for eight priority groups (including freight carriers), but the carriers were actively developing other plans to ensure adequate fuel supplies. Richard A. Staley of the American Trucking Associations (ATA) noted that, by December 1973, some trucking firms had initiated their own fuel-trading plans to ensure adequate supply allocations to participating fleets. The Ryder System was even more direct; it ordered import diesel fuel directly to supplement its own domestically ensured supplies (8). These painstaking actions of the carriers in organizing their own fuel reserves were soon recognized by the Federal Energy Administration (FEA) as hoarding rather than as appropriate fuel supply planning, so a ruling that monthly fuel inventories be submitted from all major carriers was soon released. The carrier response to absolute bottoming out of fuel supplies was an impressive display of internal organization to ensure that at least daily supply crunches could be met. Other operational strategies were developed within the fleets to conserve fuel supplies; these are discussed here.

Ironically, the most controversial strategy for fuel saving became the 55-mph speed limit, passed in 1973. This restriction produced much more of a protest from truckers than any other issue since the 1973-1974 oil embargo. Clearly, the 55-mph speed limit had to be standard for all highway vehicles for safety reasons, but truckers had focused more on the operational problems they were likely to face at the lower speed. Initially, they refused to comply. Trucking associations asserted that the limit would create serious operational problems, cause unnecessary delays, and actually create increased vehicle fuel consumption. In rebuttal to these accusations, the Federal Highway Administration (FHWA) conducted exhaustive testing to determine the most fuel-efficient speed for truckers. The tests satisfied no one. The Teamsters Union then required a pay adjustment for over-the-road drivers adversely affected by lower highway speed limits. FHWA continued its tests via a new program—the Voluntary Truck and Bus Fuel Economy Program in 1975 (9)—that was committed to reducing energy consumption by commercial carriers through a number of options. However, it appeared that, by October 1977, the issue was moot because a DOT study then determined that no state even approached the 85 percent compliance standard for meeting the 55-mph speed limit on divided highways.

Despite the earlier inconsistencies and controversy over the 55-mph limit, the trucking companies surveyed were committed to it as an operational improvement. In fact, Kenneth J. Gentl of Overnight Transportation commented that "getting the drivers to slow down—and stay slowed down is the (operational) key". Other companies have enforced the limit more stringently by requiring metering devices on all vehicles so that maximum speed levels, lengths of haul, braking distances, and downtime can be recorded throughout each trip. The records of metered trips are filed with the driver's personnel data. Driver wage increases may then be based on the accumulated trip-proficiency records. Insurance companies will often base fleet rates on driver records; thus, there is a real incentive for carriers to keep such data on their drivers.

Finally, this method of data collection has real merit in terms of coming to grips with fleet operating statistics so that the carrier has a better handle on total fixed and variable business costs. The data provide information to support investment decisions for vehicle depreciation and to determine the economic life of vehicles.

Another method of reducing the impact of energy-related constraints on the carrier has been an emphasis on increased per-vehicle loads. The issue of truck size and weight is gaining widespread attention because fuel is beginning to represent a larger share of total operating costs for intercity movements. The significance of increased size and weight on different carriers varies by the type of operation and its associated trip charges. Truck load (TL) operations, for example, involve three types of carrier movements: regular-route common carrier, irregular-route common carrier, and private carrier. Each TL move represents different line-haul shipping charges as a percentage of total costs: regular-route common carrier, 52 percent; irregular-route common carrier, 100 percent; and private carrier, 80 percent. The advantage of movement by an irregular-route common carrier to increased size and weight vehicles is immediately visible because all of the charges are attributable to over-the-road movement. The other two types of carriers can benefit by making the distribution among charges weigh more heavily toward pickup and delivery and terminal movements, similar to the way in which rail trailer on flatcar (TOFC) and rail boxcar charge allocations represent trip costs (6).

The primary emphasis of increased size and weight for carriers centers on the ability to capture increased revenue per power unit on the front haul. Aside from the energy saving on a fleetwide basis, there is added incentive through decreased labor costs. As noted above, different carrier types will be affected by increased sizes and weights to varying degrees. In the case of less-than-truckload (LTL) and private operators, increased trailer size restrictions are more favorable than increased weight because they generally cube out before they weight out. (Cubing out is an industry expression for maximizing trailer capacity; weighting out refers to maximizing trailer gross vehicle weight.) TL operators generally weight out first.

The reasons that passage of increased size and weights for all states has yet to occur is predominantly due to safety and road maintenance problems. The double trailer operations will cause visual barriers for other highway vehicles. The increased weight may cause additional road maintenance problems in already rapidly declining highway surface conditions. Bridge load-bearing weight constraints are also a problem. In the newer highway systems, the road maintenance questions are not as critical as on the older, predominantly eastern, roads.

It is no surprise that western states were the first to ratify increases in truck sizes in 1974. In fact, twin-trailer combinations are still referred to as western doubles. Eastern states have been more reluctant to ratify increased truck sizes. This issue went as far as the U.S. Supreme Court in March 1977. Wisconsin had banned twin trailers and trucks more than 55 ft in length based on the assumption that the increased capacities placed a discriminatory burden on interstate commerce. The Supreme Court ruled unanimously that cost savings and no measurable increases of safety hazards suggested that larger trucks (up to 65 ft) would not be discriminatory; therefore, the court approved the increased size. Although this set a precedent, it in no way cleared the issue on a nationwide basis. Some 14 states have yet to ratify increased size and weight restrictions. (Further details on the increased size and weight problem are included in the long-term strategy section of this paper.)

Increasing the vehicle size is one way to improve the average load factor; thus, carriers have focused on the problem by increasing capacities for each vehicle trip. (For truck hauls, a trip includes fronthaul and backhaul loads.) According to Richard A. Staley of ATA, the empty backhaul and deadheading problems that many of its member carriers

were concerned with were researched by the association. Then ATA developed a computerized system to match loads between carriers on a 24-h basis. The system was called the Computerized Interchange Substituted Service (CISS). CISS solicits loaded trailers for unhitched tractors. The carrier advertising the load delivers a trailer to the matched carrier's terminal for hauling to a destination terminal at a fixed fee of \$0.70/mile. ATA's goal was to reduce deadhead mileage by 25 percent and to reduce operating costs. Ryder truck lines had established a similar matching service four years earlier. The loads were offered to any participating subscriber to the matching service. Although both load-matchup programs did not represent the number of carriers that the system had planned, the concept caught on and, for some fixed-route services of carriers, inbound and outbound traffic has been paired on a regular basis. In May 1975, the ICC attempted to formalize such pooling efforts through the promotion of legislation that also called for joint rates between modes on matchups, route-deviation allowances, and motor carrier substitution of service to further reduce empty backhaul movements. It is unclear why the legislation failed (8).

Empty backhaul issues are inherent to any freight transportation mode. It is unlikely that carriers will ever eliminate nonrevenue vehicle miles, but some advocates suggest that deregulation may put the deadheading issue to rest forever. The evidence suggests that increasing backhaul loads will only serve to increase time and service impediments on the revenue haul. Empty truck movements will continue to exist regardless of the emergence of deregulation or free-market entry (10).

ICC empty backhaul data support the statement that few improvements on backhaul loads are likely to occur. The survey showed that 20 percent of all truck movements is empty, and 14 percent more is LTL. Private carriers showed 27 percent empty loads, while exempt commodity carriers and regulated carriers showed 21 percent and 16 percent, respectively (11).

Private carriers are shippers that transport goods via their own transportation system. Trucks operating under a private carrier are nonregulated and are the fastest-growing fleet. If ownership characteristics continue similar to past trends, the less-efficient goods movers will haul a larger percentage of freight with disproportionately higher energy consumption because of the low-load capacity attributes.

There has been at least one effort to improve private carrier average loads. In June 1974, the ICC proposed permitting private carriers to lease trucks and drivers in their fleet to regulated motor carriers as a means of saving fuel. Unfortunately, the blatant institutional constraints obvious from the beginning caused a lot of antagonism between the carrier groups, and the plan died.

From 1973 until today, truck carriers were forced to make immediate changes to respond to the supply-side constraints. Legislative issues developed, daily fuel shortage problems persisted, and operational constraints dominated each carrier, but the situation clearly caused immediate actions that responded to the near- and long-term needs of the industry.

Rail

Rail carriers did not have to be as responsive to the near-term energy supply constraints as the competitive trucking mode. Shipping constraints that arose for rail carriers largely centered on terminal movements by trucks to a final destination. At the time of the most severe shortages, truckers responded first to line-haul TL deliveries. Rail interchange loads took a lesser priority. Terminal operators were often forced to call numerous carriers to move the load out of the operations area, explained Vern McCullough of the Green Bay and Western Railway (Wisconsin).

Increased movements by rail created some of the worst constraints. If freight forwarders were incapable of routing loads through truckers, they would look to rail as the only

alternative. Boxcar shortages developed because no trucks were available at the receiving end; cars were left to wait in the terminal area, said Bob Howard and M. Dittler of the Sante Fe Railway (Chicago).

No immediate strategies could be cited by the rail carriers surveyed; but, as a result of the lack of responsiveness during the crunch periods, new measures have been put into effect that are likely to have more of an impact on long-term developments. These include increased emphasis on (a) intermodalism so that terminal area costs to the shippers (in terms of service and time) are not as excessive, (b) better shipment inventories to match destination of goods, and (c) new rates that give greater cost savings to full-car shipments in order to improve load factors.

Shippers

The telephone survey did not include shipper-group detail, but secondary sources have illustrated some of the changes prompted by energy constraints. Some of the larger shippers are looking at trade-offs in cost, time, and quality-of-service attributes in determining which shipments, currently moved by truck carriers, are flexible enough to go by rail (7). Shippers sensitive to costs are likely to be transporting low-value goods, which implies that they may be willing to give up time and service quality attributes in favor of cost savings and, therefore, commit some movements to rail. Any analysis of this trend would have to be on a commodity-specific basis in order to determine the likelihood of modal-choice changes by given shipper groups over time. In some cases where shippers use rail as the primary mover, a private truck fleet is used to supplement critical (i.e., time-sensitive) movements. The private truck is likely to be characteristic of low annual vehicle miles of travel (VMT), reflecting that the irregular supplement of shipper-owned truck fleets has an adverse effect on total truck energy consumption because of their traditionally low productivity.

Some new operational strategies that shippers use to reduce transportation costs generally have had positive effects on reducing energy. A strategy that one shipper used to reduce pickup and delivery charges and decrease dockside congestion has decreased shipper costs. A traffic manager discovered that the same type of shipment came to the shipper's dock several times a week. By merely specifying a larger shipment one time a week, the pickup and delivery charges were reduced, there were no dock-queuing problems, and less dockside labor was required. Although the load factors of each delivery vehicle still did not substantiate TL rates, the shipper was able to benefit through the indirect decreases in operating costs (12).

Manufacturers of Truck and Rail Equipment

Vehicle manufacturers have responded to truck conservation through purchase of new equipment in the past five years. The Voluntary Truck and Bus Fuel Economy Program contributed to quick market penetration of both new engine designs and vehicle accessories. Table 1 (1) and the information below (13) show that the per-vehicle saving and the stock penetration for fuel conservation devices are noteworthy:

Equipment	Fuel Con- served (gal 000 000s)	Savings per Vehicle (%)
Aerodynamic devices	49	6
Medium-duty diesel	32	4
Fuel-efficient diesel	288	33
Class 7 and 8 dieselization	78	9
Variable fan devices	206	24
Radial tires	204	24

Table 1. Number of vehicles (in thousands) that use fuel-conservation equipment, 1977.

Equipment	Type of Vehicle				Total
	Light	Medium	Heavy	Heavy-Heavy	
Radial tires	3 850.7	117.8	45.1	310.4	42 967.9
Drag-reduction devices	96.8	6.1	3.6	50.2	157.0
Variable-speed fans	2 603.6	123.2	36.3	164.0	2 927.5
Fuel-efficient engine	13 311.6	88.5	43.6	197.4	1 641.5
Axle or drive ratio change	827.0	335.2	327.6	407.3	1 897.5

Some of these measures are additive. For example, if a gasoline heavy-heavy truck without conservation devices was replaced by a diesel heavy-heavy truck with an airfoil, a diesel bottoming cycle engine, and radial tires, according to the Voluntary Truck and Bus Fuel Economy Program, the new vehicle would realize a saving of as much as 72 percent on an intercity trip. (This calculation suggests that some of the program's assumptions are misguided.)

The manufacturers reacted rapidly to the increased fuel-efficiency needs of the truck carriers, and the preliminary data suggest that commercialization efforts were minimal because of immediate market response to the new devices. Rail equipment did not go through the same easy transformation to fuel conservation accessories. (Rail developments are discussed in the next section of this paper.)

LONG-TERM RESPONSE

A long-term response implies a reaction to the energy supply and price situation by a given carrier during the past five years, but with effects that are not likely to be realized until perhaps 10 years from the initiation. Long-term responses tend to have technological rather than operational orientations.

Carriers

Trucks

Just as truck carriers had immediate short-term reactions to the energy picture, they are also cognizant of the importance of continued efficiency improvements within the mode. Truck energy intensities are likely to decline at a more rapid rate than any other freight transportation mode because of the more extreme sensitivities of that mode to changing energy futures.

The composition of truck fleets is likely to change in the future. Projections of the truck stock show increased dieselization and declining intercity vehicle miles per truck for the heaviest size classes (14). The vehicle mile projections are based on a preliminary analysis of the 1977 Truck Inventory and Use Survey Data (1). These data are somewhat alarming because they indicate that, for the first time since the survey began, vehicle stocks, vehicle miles of travel, and energy consumption are on a declining growth rate. There is evidence of increased portions of the stock in fleets of 10 or less, suggesting that private fleets operating in urban areas represent the largest growth sector.

Consolidation terminals are in the planning stages for larger common carriers. The terminals allow long-haul vehicles to maintain intercity fuel efficiencies, with supplemental small delivery vehicles to make short-run, LTL deliveries to the final destination in an urbanized area. The heavier, high-capacity trucks are on the line-haul portion of the trip to the consolidation terminal, where smaller, less-full consumptive vehicles complete the delivery to final destinations in an urban area, according to Staley and Gentl.

Rail

Rail carriers should have more noticeable efficiency and operations improvements over the long term. Excessive federal financing of rail research and development, as well as terminal and switching improvements, should provide for a healthier system in the future. Interestingly enough, many of the rail improvement strategies are intermodal in nature and center on heavy emphasis of trailer-on-flatcar and container-on-flatcar (COFC) operations.

The Santa Fe Railroad has taken center stage in the TOFC state of the art. Santa Fe has large TOFC yards that can facilitate regular traffic at a greater rate than any other road in the business. In May 1977, the Six Pack was introduced to carry six trailers per flat car. The car cuts the regular tare weight by 35 percent and, therefore, reduces per-car energy consumption. The Santa Fe went a step further in April 1978, when it introduced the Ten-Packer, which has a 10-trailer capacity per flat car. The Chicago-Barstow run tests show that the Ten-Packer is 15 percent more fuel-efficient than the traditional two-trailer flat cars.

Coincidental to the development of the Ten-Packer was work by the Southern Pacific to create a two-container flatcar that is capable of stacking the containers, but with a tare weight 45 percent lower than a traditional flat car.

Rail electrification has also been studied as a long-term efficiency improvement. In May 1973, the Southern Railroad initiated electrification of the Cincinnati-Chattanooga freight route, a distance of 338 miles. Longer-haul unit train routes are the most likely beneficiary of electrification improvements. A pilot demonstration program on the Black Mesa and Lake Power Railway is scheduled, which will primarily cater to unit coal train traffic.

Truck-rail intermodalism is stressed in this research largely due to the emphasis on only truck and rail improvement strategies. There are cases in which rail could be more cost competitive by using waterways for certain hauls. Low-value bulk goods that are sensitive to shipping costs more so than time factors such as coal, taconite, and iron ore and with destinations that require only one intermodal transfer are likely to find rail-water movements cost effective. If shipping requires a second transfer, cost advantages disappear because of prohibitive transshipment costs. Lower shipping costs can be realized for bulk commodities through rail-water shipments so that modes are capable of increased revenues in addition to an energy saving for the entire movement. The concept of lowered, delivered western coal costs to eastern markets was explored in work completed in the past year at the Argonne National Laboratory (Illinois). In a case study, several western-coal-user demands were aggregated in order to capture lower unit train rates to a midwest transshipment site. The coal was to be ferried to Michigan utilities located on the lake shore. Lower per-ton coal transport costs were calculated for the move (15).

Some rail carriers have a special interest in developing similar intermodal projects because of the potential prospects for increased traffic to the rail line. The Burlington Northern has especially benefited recently in the development of western coal fields. This line is currently working on a project with American Commercial Barge Lines to develop a rail-to-barge transfer terminal that will serve to decrease rail transport costs. In yet another instance, the rail carrier has become a short-haul waterway carrier in order to capture line-haul rail traffic. The same is true for the Southern Railway. The Southern Railway owns and operates its own barge line on the Ohio and Tennessee Rivers, which contributes to the reduction of its total transport costs to contracted carriers.

Manufacturers

New vehicle technologies are apparent in both modes, but developments related to trucks appear to be occurring at a

Table 2. Calculations used in determining projected heavy-heavy diesel truck bottoming cycle penetration and energy consumption and savings, 1985-2000.

Factor	1985	1990	1995	2000
Number of heavy-heavy diesel intercity trucks (000 000s)	0.98	1.18	1.43	1.43
Bottoming cycle penetration (000 000s)	0.01	0.3	0.47	0.40
VMT per heavy-heavy truck (000s)	61.38	60.91	60.45	60.45
Heavy-heavy truck VMT with bottoming cycle (000 000 000s)	0.31	17.24	28.53	24.18
Net vehicle fuel efficiency				
Heavy-heavy standard	4.76	4.76	4.76	4.76
With bottoming cycle	5.47	5.47	5.47	5.47
Diesel fuel saved (gal 000 000 000s)	0.08	0.47	0.79	0.67

more rapid rate than those for rail. A greater sensitivity to efficiency improvements over the next 15 years is the predominant driving force of manufacturer improvements (16). Energy-efficiency improvements (e.g., accessory options such as fan clutches, radial tires, and aerodynamic devices that were discussed as elements of the Voluntary Truck and Bus Fuel Economy Program) are likely to penetrate the market without significant manufacturer incentives. This type of equipment change, which reduces fuel consumption, is, in a sense, proven technology with an already assured market.

New technologies that will have more significant impacts on the power-unit fuel consumption, such as engine design alternations, are now in research and development. Few of the new technologies are likely to penetrate the heavy-heavy intercity truck fleet as soon as they come on board, but gradual penetration should occur through the mid-1990s. The interesting aspect of these new technologies is that they all seem to compete for the same market; thus, estimates of fuel conservation by each new technology cannot be considered as an additive function. Because much of the research is in its initial testing phase, competition among new technologies for a relatively small vehicle stock may never become a problem. Some of the concepts may drop out due to high production-line start-up costs, environmental constraints, or specific engine problems that prove the engine design to be less efficient than was originally thought.

One concept that appears to be a good prospect for commercialization by 1985 is the heavy-duty diesel truck bottoming cycle program. The program involves increasing diesel energy efficiency by recycling exhaust heat. When class 7 and 8 trucks are traveling intercity routes (i.e., line-haul portion of the trip), the bottoming cycle is most effective. The new engine designed for this purpose should realize a 15 percent fuel saving over the line-haul trip. Table 2 (16) shows the calculations that were made for an analysis of the bottoming cycle program. Other energy-saving truck technologies that are likely to penetrate the heavy-heavy truck stock in the future include the turbocompound diesel (8 percent saving), advanced heavy-duty gas turbine (30 percent saving), and the adiabatic diesel (33 percent saving). All of the new technologies are projected to come onboard during the mid-1980s.

Hardware programs for rail are less developed, but projections show that, during the early 1990s, the medium-speed diesel alternative fuels program and the Rankine bottoming cycle should provide substantial improvements. The alternative fuels program is scheduled to derive fuels from coal or oil shale, thus giving a 100 percent petroleum saving at the time of substitution into the locomotive fleet. This is based on work in progress at Argonne under the direction of Marianne Millar.

Other programs that have developed new technologies are biomodal in nature. The Strick Corporation is attempting to commercialize a 26-ft, two-axle vehicle that is capable of increasing payload capacity some 20 percent by carrying one trailer on its back and towing the other. The two-trailer

concept is called cab-under, referring to the power unit that is much lower than the conventional semi. The Bi-Modal Corporation and North American Car have introduced a combined highway-railway trailer with interchangeable road and rail wheels at its rear. The trailer may realize an operating cost saving of 75 percent over all-highway operations. This estimate assumes that the trailer does all line-haul on the rail.

SUMMARY

Conversations with carriers and manufacturers, as well as secondary source information, indicate that motor carriers are very responsive to energy supply constraints and are seeking operational and new technology strategies that will improve fleet fuel efficiency. The most obvious concern for freight transportation carriers is centered on increased payload capacities of the vehicles. This trend to upsize freight vehicles is occurring at the same time that personal passenger-vehicle manufacturers are involved in efforts to downsize. Growing pressure on states to ratify increased size and weight for trucks is likely to show near-term energy-intensity improvements. Increased load factors and vehicle carrying capacity will hedge increased fuel costs for truckers. Other ways that carriers are responding to decrease near-term fleet consumption is through enforcement of the 55-mph speed limit, accessory energy conservation equipment, driver-efficiency measures, and aggregating shipments to increase loads of the backhaul.

Rail carriers were hurt during the 1973-1974 gasoline shortages because the trucking portion (pickup and delivery) of their operations faced serious delays. TOFC and COFC developments will reduce the terminal-area pickup and delivery problems through immediate unloadings, with significant shipment time saving.

Long-term improvements in truck and rail are technology specific. The new engines and alternative fuels programs are scheduled for commercialization in the mid-1980s. Based on the experience of market development of fuel conservation equipment for freight vehicles, any cost-effective technological changes that will reduce energy consumption are likely to develop a market independently and require little marketing effort for fleet penetration.

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Consumer Reactions to the 1979 Gasoline Shortage

Jill L. Habermann (in conjunction with a presentation by Lois Jacobini)

The gasoline crisis of 1979 started on the West Coast of the United States nearly four months after the Iranian revolution in December 1978. The revolution precipitated the cutoff of approximately 500 000 bbl/day of crude oil normally destined for U. S. markets (500 000 bbl of crude oil represents approximately 10 million gal of gasoline). Reactions from every sector of the economy set in as the gasoline shortages spread.

To understand the underlying motivations for the reactions from consumers, industry, and government during the gasoline shortage, it is necessary to understand the relation of the average U.S. citizen to the automobile in psychological terms. Paul W. McCracken, who received the National Automobile Dealers Association's Freedom of Mobility Award in 1979, remarked that "a strategy for a national energy policy, which assumes automobiles must be abolished...will fail because it will fail to perceive the extent to which an automobile is for the common man not only the symbol, but an important source, of freedom." Right or wrong, decision makers in the United States tend to perpetuate this concept of the automobile as a symbol of freedom. Consequently, many decisions concerning gasoline were shortsighted and sought only to increase supplies. Short-term plans that perpetuate the use of the private automobile as the primary travel mode—for example, automobiles that are more fuel-efficient and gasohol to stretch fuel supplies—are more popular and pose fewer political and economic risks. The alternative, which is long-term planning, involves changes in life-styles, such as carpooling and using mass transit.

The issue at hand is not to evaluate the U.S. love affair with the automobile; rather, it is to evaluate the reactions to the 1979 shortage in relation to reactions to the 1973-1974 shortage and to speculate on future implications.

Richard J. Barnet, who wrote *The Lean Years: Politics in the Age of Scarcity*, calls for the development of a high degree of public participation, understanding, and decision making, which would lead to the development of a sense of stewardship. Stewardship is the concept that each one of us has the responsibility to inform ourselves and evaluate our past and current actions in order to plan for the future. This paper develops the thesis that the kind of information available to the U.S. public and the manner in which it was presented was a major factor in the types of consumer responses that occurred during the first six months of 1979. These reactions, in turn, motivated many government and industry decisions that did not necessarily accurately reflect needs.

Extrapolating Barnet's stewardship theory, I submit that the development of a national energy-awareness program is important to ensure rational, nondisruptive, long-term planning for energy conservation in the transportation sector. Some 50 percent of the petroleum imported by the United States is used to fuel personal motor vehicles. The

average citizen used 11.7 bbl of gasoline in 1979, compared to 2.8 in France, 1.8 in Italy, 2.8 in the United Kingdom, 3.2 in West Germany, and 1.9 in Japan. Faced with an inexorably diminishing world petroleum supply, the United States must divide up available sources among transportation, agriculture, residential, and industrial sectors. With cooperation, communication, and accountability at every level of society, the United States can conserve and reduce foreign oil imports. The transportation sector is potentially the flagship sector for assessing the U.S. commitment to energy-conservation awareness.

REGIONAL DIFFERENCES

Quality of Information Flow

In any situation, one's reactions are usually based on two types of information: actual first-hand experience and information culled from a variety of second-hand sources. Most people consciously evaluate the information received from second-hand sources (i.e., television, newspapers, annual reports, and government documents) before taking action. When the gasoline lines started in California, most citizens were already aware of the correlation between the Iranian oil shutoff and scattered predictions of spot shortages nationwide. Nevertheless, there was little continuity in the information made public at first. The White House balked at giving the nation a realistic report, i.e., that gasoline was going to be expensive and in short supply. The White House was concerned that too much publicity would trigger the same panic buying, hoarding, and topping off that exacerbated gasoline shortages during the 1973-1974 oil embargo. Also, it was unwilling to take responsibility for the inevitable negative reactions to mandatory rationing and conservation plans.

The quality and consistency of the information flow represent the first step in establishing a sense of awareness in the consumer that leads to rational action, an evaluation of consequences, and a new awareness. The then DOE Secretary James Schlesinger announced on February 10, 1979, that the halt of Iranian oil exports was "prospectively more serious" than the oil embargo of 1973-1974. Then, four days later, the vice chairman of the Ford Motor Company, Phillip Caldwell, said that this gasoline crisis would not be as severe as the crisis caused by the 1973 cutoff because there were more gasoline stocks available and more fuel-efficient cars being manufactured. (The average automobile in 1979 got 16.4 miles/gal compared to the 1974 figure of 13.7 miles/gal.) U.S. Deputy Secretary of Energy John O'Leary warned on that same day that the current fuel pinch was but a foretaste of permanent shortages that could appear by 1981. The chairman of Exxon Corporation, C. C. Garvin, shortly thereafter