Oak Ridge National Laboratory. Several Union College students contributed to this study; Frank Fu, John Cook, Karen Gottheim, and Mike Wayand deserve special appreciation. I would like to thank the numerous transportation manufacturers and associations around the world for providing the information that I used.

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One Approach to Local Transportation Planning for National Energy Contingencies

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Because of the uncertainties associated with the nation's petroleum supply and the possible effects of federally imposed fuel contingency measures on transportation, the steering committee of the Metropolitan Planning Organization in the north central Texas region directed the development of a plan to minimize the impact of federal fuel contingencies on transportation in the Dallas-Fort Worth metropolitan area. This paper summarizes the planning effort that resulted. The major objective of the plan was to minimize the impact of fuel allocation and rationing on local mobility, especially work trips, and thereby to reduce the adverse effects of a near-term energy shortage on the local economy. Through an examination of these federal regulations, the impact of the 1973-1974 Arab oil embargo, and projections of future petroleum supply and demand characteristics, alternate fuel shortage scenarios were developed and transportation-related problems identified. Potential solutions of these problems were analyzed as to their effectiveness and applicability. A set of recommendations for actions by local governments, public transit systems, and the private sector was developed from the results of these analyses.

Past experience has shown that the imposition of federal contingency policies regarding energy use can have a profound impact on local transportation systems. Federally imposed fuel austerity measures during World War II and the more recent federal fuel allocation program of the 1973-1974 Arab oil embargo produced significant modifications in public travel habits. The more recent of these experiences demonstrated that local problems resulting from these contingencies will vary in each area and will require resolution at the local level.

With these concerns in mind, the steering committee of the Metropolitan Planning Organization (MPO) of the Dallas-Fort Worth area requested the North Central Texas Council of Governments' (NCTCOG) Transportation Department to develop short-range plans that would minimize the effects of national energy contingencies on local ground transportation systems. This paper highlights portions of the resulting short-range plan, A Metropolitan Transportation Plan for National Energy Contingencies (1).

STUDY DESCRIPTION

The initial assumption of the energy contingency study was that the threat of a future oil interruption is a distinct possibility. If and when such an emergency were to occur, it was further assumed that the federal government would impose fuel allocations, rationing programs, or both, that would affect the local transportation system. These federal actions would spread the oil shortages equally across the nation, and the Dallas-Fort Worth area would experience fuel reductions similar to those in other urban areas.

It was decided at the outset that, since the federal regulations provided the mechanism for the necessary fuel reductions, local energy conservation should not be the intended goal of the study. It became apparent, however, that energy conservation would indeed be a by-product of many of the recommended actions.

Because the purpose of the study was to assure the continued economic vitality of the Dallas-Fort Worth area, a major concern was the maintenance of local mobility, especially of work trips. Therefore, a major objective was to ensure some means of transportation by which every worker in the area could reach his or her place of employment. Since most work trips (about 90 percent) are made by automobile, the study paid special attention to the expected problems of these automobile users. The development and use of alternate transportation modes (e.g., transit, carpools, and taxis) in areas where they are not now available also became a major study objective.

At the same time, the study team wanted to ensure that the existing transit and paratransit systems would be utilized to their maximum and that these systems would be allowed to continue operations as efficiently as possible. Resolving the anticipated problems of fuel shortages, passenger overloading, and unmet transit and paratransit demands were major concerns. Planning

in the area of goods movement was not incorporated in this study since it was anticipated that actions in this regard would be the result of private decisions.

Finally, it was determined that the actions suggested by the plan should adhere to a number of specified guidelines:

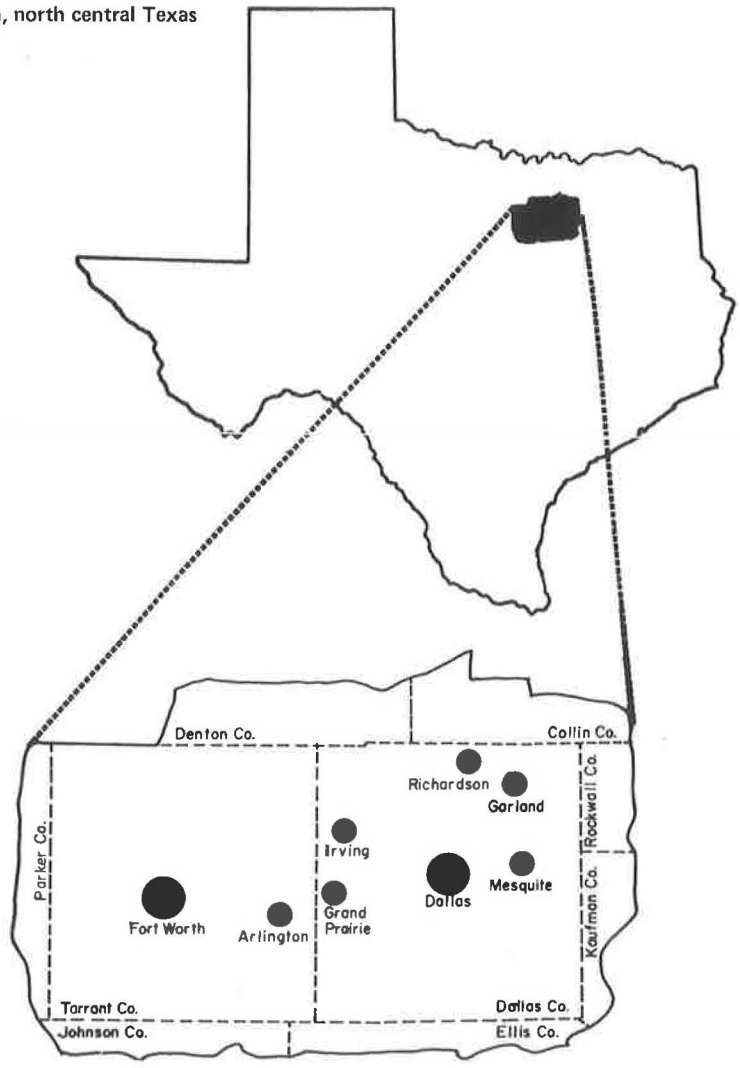
1. The recommended measures should encourage voluntary rather than mandatory energy actions.
2. Because the plan only considers problems that may occur in the near term, it is applicable for a period of approximately 5 years. The study used 1980 as a target year.
3. The contingency actions should be of a quick-response nature. They must be implementable within 3 months of the initiation of a supply interruption.
4. The strategies must be locally effective. They must be applicable to the needs and characteristics of a large metropolitan area, in this case, the Intensive Study Area.

The basic approach of the NCTCOG study was to develop alternative energy shortage scenarios, identify anticipated local problems, and then suggest actions that would ameliorate these difficulties. The study followed these general steps:

1. Current trends in national energy supply and existing statements of federal energy policy were examined to determine the possible extent of a future oil supply interruption.
2. Under the basic assumption that a future oil crisis will affect the area in ways similar to, although possibly more severe than, the 1973-1974 embargo, the study closely examined the local as well as national reactions to this previous shortage, especially with regard to transportation.
3. Next, the implications of the preceding analyses were synthesized to produce possible short-term local fuel shortage scenarios.
4. Community transportation problems were identified and analyzed.
5. To meet these community needs, alternate actions and strategies were proposed and evaluated.
6. Finally, a set of recommendations, closely adhering to the predetermined objectives, was developed for present and future community action.

The recommendations of the NCTCOG study dealt with a geographic area termed the Intensive Study Area. This area includes Dallas and Tarrant Counties as well as portions of eight surrounding north central Texas counties. The major cities are Dallas (population 870 000) and Fort Worth (386 000). These cities are surrounded by numerous suburban communities, the largest of which are Arlington (139 000), Garland

Figure 1. Location of the Intensive Study Area, north central Texas planning region.



(128 000), Grand Prairie (65 000), Irving (118 000), Mesquite (68 000), and Richardson (68 000). As of January 1, 1977, the population of the Intensive Study Area was approximately 2 450 000 (see Figure 1).

Like many other urban areas that experienced the bulk of their population growth after World War II, the Dallas-Fort Worth area has a strong automobile orientation. According to the 1970 census, both the Dallas and Fort Worth urbanized areas had a relatively high 1.5 automobiles/household, with 88.5 percent of Dallas workers and 92.2 percent of Forth Worth workers using automobiles to get to work. Related to this highway orientation is a relatively low population density of 726 persons/km^2 (1 880 persons/mile^2) for the combined Dallas-Fort Worth urbanized area in 1970.

Public transportation systems in the area include the Dallas Transit System (DTS) with a total fleet of 407 buses operating over 758.6 km (471.5 miles) for a total of 20 113 000 vehicle kilometers (12 500 000 vehicle miles) annually. CITRAN, the mass transit system of Fort Worth, operates 121 buses over 4 304 000 km (2 675 000 miles) annually. The total number of revenue passengers in 1976 for CITRAN was 4 361 000. A number of major private bus companies provide intercity service within the north central Texas region.

IMPACT OF THE 1973-1974 OIL EMBARGO

The study examined the impact of the 1973-1974 energy crisis on national and local transportation. Because the impact of the oil embargo was not as severe in the Dallas-Fort Worth area as in some other areas of the nation, it was determined that the experiences of other more severely affected areas should also be studied to provide some idea of the effect of a more severe oil shortage on the study area. While economic changes such as unemployment, industrial production, gasoline pump prices, and automobile sales were examined to provide a more complete understanding of the embargo's effects, special attention was paid to changes in transportation indicators. The table below shows some of the major transportation-related changes experienced in the Dallas-Fort Worth area during 1973-1974.

Indicator	Change From Previous Year (%)
Daily vehicle kilometers traveled	-2
Automobile occupancy rate	+4
City transit ridership	+5 to +20
Intercity transit ridership	+10 to +200
Taxi passengers	-5
Regular gasoline pump price	+38
Consumer transportation price index	+14

To provide information on local travel behavior changes and public opinion and expectations, an ongoing urban panel survey (2) of local residents conducted by the North Central Texas Council of Governments was used. Survey respondents were asked about their reactions to the energy crisis, current views on energy issues, and ideas on how local governments should react to a future oil shortage. Figure 2 lists these questions and the local responses.

An analysis of automobile travel changes was made by examining such indicators as traffic volume changes and differences in automobile occupancy rates. Findings here, reinforced by the urban panel survey, indicated that a substantial reduction in automobile travel did occur locally and that a small but significant increase in the number of carpools resulted in higher automobile occupancy rates.

Because the effect of the oil shortage on local gasoline station operations was not known in quantitative detail, a survey was conducted by the NCTCOG Transportation Department to determine this impact. Nearly 100 cooperating station operators answered questions concerning such issues as the problems experienced in obtaining gasoline supplies, long customer lines, and

Figure 2. Urban panel survey questions and responses.

1. How important a problem do you feel the energy shortage is for this country?
   - Most Important 26%
   - Very Important 52%
   - Fairly Important 14%
   - No Problem 7%
2. How did the last energy crisis affect your driving habits?*
   - Carpooled 10%
   - Used Bus More 4%
   - Bought Smaller Car 10%
   - Took Fewer Trips 41%
   - Drove Slower 38%
   - Nothing 25%
   - Other 14%
3. A number of options are open to the federal government in the event of another oil embargo. I am going to name three options. Which of the following options would you accept most readily?*
   - Gas Rationing 40%
   - Higher Gasoline Taxes 12%
   - Let Gasoline Price Rise Without Increase Tax 33%
   - None Acceptable 13%
   - Option Not Mentioned 2%
4. Suppose the price of gasoline were to rise to one dollar or more. I am going to name five options you might consider if this situation occurred. Would one or more of these options be attractive to you?
   - Carpool More 32%
   - Use Public Transportation More 28%
   - Buy a Smaller Car 30%
   - Change Jobs 2%
   - Move Closer to Work 9%
   - None Acceptable 17%
   - Option Not Mentioned 8%
5. Gasoline rationing should be enacted if an energy crisis occurs.
   - Agree 60%
   - Disagree 33%
   - Uncertain 7%
6. Gasoline prices will not rise much further in the next 12 months.
   - Agree 39%
   - Disagree 40%
   - Uncertain 21%
7. I tried to use less gasoline during the last energy crisis.
   - Agree 86%
   - Disagree 11%
   - Uncertain 3%
8. One thing a city should do in the event of another energy crisis is to provide Park and Ride service.
   - Agree 86%
   - Disagree 7%
   - Uncertain 7%
9. A city should encourage carpool operations in the event of another energy crisis.
   - Agree 90%
   - Disagree 6%
   - Uncertain 4%
10. In the event of another energy crisis, a city should increase the cost of parking to reduce automobile travel into the downtown area.
    - Agree 36%
    - Disagree 55%
    - Uncertain 9%

*More than one response allowed.

Table 1. Percentage of service station operators in Dallas and Tarrant counties answering yes to NCTCOG survey questions.

Item	Total (n = 93)	Dallas County (n = 60)	Tarrant County (n = 33)	Major Oil Companies (n = 63)	Independents (n = 30)
Limited customer fuel sales	61	60	62	66	50
Reduced hours of operation	72	70	75	83	46
Closed on Sundays	71	68	75	78	53
Longer than usual lines	77	80	72	86	63
Gas sales decreased	61	61	60	68	44
Ran out of gasoline	70	66	78	82	50
Curtailed complimentary customer service	29	35	14	22	61
Started self-service pumps	9	11	5	7	23

changes in operations. Table 1 gives the results of this poll.

Another major concern of the study was the impact of increased demand fuel restraint on transit systems. The effects of the crisis on local as well as transit systems in other areas of the nation were examined through a review of historical ridership and operation records as well as existing studies (3) on the subject. The findings here indicated that, in most cases, transit ridership increased significantly during the embargo period, but the degree of change varied considerably from one system to another and from line to line. Ridership on DTS increased by up to 20 percent from a similar period the previous year, while CITRAN patronage was about 5 percent higher. Some suburban-to-CBD lines, however, nearly doubled their ridership volumes. Intercity transit usage, moreover, experienced even larger gains. For example, it was found that a private bus line between Irving and Dallas increased ridership by as much as 200 percent during the embargo period.

Another concern of transit operations was the availability of an adequate fuel supply. DTS and CITRAN, however, reported that obtaining fuel was no problem for them during the embargo, although the increased cost of fuel produced a considerable increase in operating expenses. Inquiries to other transit systems, however, indicated that some operations (e.g., HOUTRAN in Houston) did not receive sufficient fuel allocations and were forced to apply for additional fuel.

To summarize the overall effects of the 1973-1974 embargo, the major findings included the following:

1, There was a high degree of public awareness of the energy situation and support for energy conservation measures.
2. An increased interest in carpooling, either through private arrangements or area carpool programs run by the cities of Dallas and Fort Worth, resulted in a greater utilization of this travel mode.
3. Retail gasoline stations received insufficient allotments to meet customer demands. This resulted in consumer inconveniences in obtaining fuel supplies.
4. Transit ridership increased noticeably, especially during peak commuter hours in middle- and upper-income areas and along intercity routes. As buses became overcrowded, additional service was provided in some areas.
5. Reduced fuel supplies for municipal operations resulted in significant service cutbacks. Although local transit systems did not experience difficulty obtaining fuel, they undoubtedly would have been affected had the embargo continued much longer.
6. Increased petroleum product costs affected not only public transit systems but also led to taxicab fare increases. These fare increases may explain the reduction in taxi ridership noted during this time.

PROBLEM ANALYSIS

A major study task involved a review of the federal contingency regulations that would have an adverse effect on local transportation. To do this, the existing fuel allocation regulations resulting from the Energy Policy and Conservation Act of 1975 and the Federal Energy Administration's fuel rationing plan of 1976 were examined. This analysis was useful in obtaining a working knowledge of contingency characteristics, advantages, disadvantages, possible problem areas, and previous experience in the use of these policies.

An examination of current supply trends reinforced the contention that the nation's petroleum shortage will become increasingly critical in the near future. From this analysis, it was determined that a near-term oil interruption (assumably from Arab oil-exporting nations) would likely result in a 10 to 25 percent national oil shortfall. This became a major assumption in the development of energy crisis scenarios.

From the review of local and national experiences during the 1973-1974 oil embargo, an examination of federal allocation regulations, and the study of the oil shortfall assumptions, it was possible to develop a future fuel allocation scenario with regard to fuel availability and consumer response. However, due to the limited national experience with fuel rationing and the uncertainties of specific guidelines (e.g., the number of liters of gasoline allowed per ration period, the length of each ration period, and the cost of additional coupons are only estimates subject to considerable change), the fuel rationing scenario became largely a subject of conjecture based on given assumptions. To allow for this uncertainty, the study examined two different rationing cases. One was described as a mild oil shortage [a 10 percent oil shortfall with a ration of 34.8 L (9.2 gal) of gasoline per licensed driver per week] and the second represented a severe shortage [a 25 percent shortfall with 27.3 L (7.2 gal) of gasoline per licensed driver per week].

An analysis of these allocation and rationing scenarios resulted in the identification of four basic problems. They were

1. Managing fuel supplies to continue public transportation operations,
2. Contending with mass transit ridership increases,
3. Providing transportation alternatives in suburban areas, and
4. Reducing inequities and uncertainties associated with the contingencies.

Possible solutions to each of these problems were evaluated with regard to feasibility, cost, and anticipated success in meeting the major study objectives.

Managing Fuel Supplies for Public Transportation

Three alternative solutions to the problem of maintaining sufficient fuel supplies for public transportation were examined:

1. Modify existing federal fuel regulations to ensure public transportation providers will receive 100 percent of their needs during any contingencies,
2. Establish or expand in-house fuel supplies to be used if required supplies are cut, and
3. Reduce fuel consumption through conservation measures or service cutbacks.

It was found, however, that each of these possible solutions presented serious implementation problems that had to be considered. The modification of the existing federal regulations appears to be a lengthy process with an uncertain outcome. Establishing in-house fuel supplies appeared to be an attractive solution to small fuel users (CITRAN, for example, already has nearly a 1-month reserve supply of fuel); however, the problems of fuel storage safety and the expense of establishing large reserves could be major obstacles for major users. DTS currently has only a 5-d reserve diesel fuel supply and would have to store an additional 1 135 000 L (300 000 gal) to establish a 1-month reserve. Determination of the most appropriate amount of fuel to be stored, however, was not possible due to the uncertainties involved. A 1-month supply was arbitrarily adopted as an objective.

Many of the examined alternatives of reducing fuel consumption would result in considerable service cutbacks. Although service cutbacks could obtain any desired level of fuel reduction, they are also the least desirable options. It was found that other strategies such as the establishment of exclusive bus lanes or

Table 2. Transit strategies to reduce fuel consumption.

Strategy	Fuel Savings (%)		Impact on Ridership (%)		Annual Operating Cost Savings ($)	
	DTS	CITRAN	DTS	CITRAN	DTS	CITRAN
Eliminate night service	8 to 12	3 to 6	-12.5	-3.0	1 640 000	149 000
Eliminate weekend service	16 to 20	8 to 10	-10.0	-9.0	2 952 000	298 000
Eliminate midday service	20 to 25	20 to 24	-21.0	-27.0	3 690 000	729 000
Increase bus headways (10 to 25%)	10 to 25	10 to 25	-4 to -10	-4 to -10	2 870 000	580 000
Reduce number of bus stops (20 to 50%)	10 to 25	10 to 25	-20 to -50	-20 to -50	196 000	49 000
Shift local service to express (10% of local)	8 to 10	8 to 10	Uncertain	Uncertain	100 000	25 000
Increase bus flow						
Exclusive bus lanes	1 to 5	1 to 5	+2.5	+2.5	28 000	8 400
Other preferential traffic treatment	1 to 2	2 to 4	+0.5	+0.5	17 000	8 400
Decrease "deadhead" bus kilometers	1 to 2	2 to 4	No effect	No effect	17 000	8 400

preferential traffic treatment were more desirable; they could reduce fuel consumption and increase the level of service. Table 2 shows the fuel-reducing strategies that were examined.

Contending With Increased Ridership

Estimates of ridership increases were developed from a study prepared by the U.S. Congress, Office of Technology Assessment (OTA). The study (3) predicted a 10 to 40 percent transit ridership increase during a future period of energy constraints (Figure 3) (3). These findings were applied to local ridership levels under the assumption that a future oil shortage will be spread equally across the nation and that ridership response in Dallas-Fort Worth would be similar to that in other areas. Solutions to contend with large ridership increases were proposed for each level of ridership gain. Figure 4 shows the implementation stages in these proposed strategies.

Due to differences in current transit ridership levels and fleet size, it was found that the two local intracity transit systems, CITRAN and DTS, would require different emergency measures. CITRAN could probably contend with even a 40 percent ridership increase by maximizing the use of existing equipment and spreading peak-period ridership through a program of flexible work hours. In contrast, DTS apparently would not be able to meet all of its passenger demand during a severe oil shortage unless up to 40 additional buses were obtained. Figure 5 shows this expected ridership gain and the extent to which certain measures could be used to accommodate this possible increase in patronage.

In addition to proposals designed to accommodate more riders on the transit systems, suggestions were offered that could alleviate transit ridership increases by providing paratransit alternatives. One suggestion was to use the taxi fleet to establish a route taxi service. Under this proposal, taxis would provide service along specified transit routes, especially along lines where passenger overloading is likely to occur. Analysis of this alternative (Figure 6) found that, depending on the speed of the service and the length of the taxi route, 1800 to 2600 passengers could be carried during a peak period. This represents approximately half of the transit demand that could not be accommodated by the existing bus service during the peak periods. Such a service attempted in Houston during a recent transit strike met with limited success. However, it is felt fuel shortage conditions would encourage commuters to seek such alternatives to the automobile.

The study also examined the impact of another paratransit alternative—an intensive carpool program—on transit ridership changes. Although reliable estimates on the number of new carpools formed from such a program could not be established, a preliminary travel demand assessment in Dallas utilizing a disaggregate demand approach (4) estimated that the expected 40 percent transit passenger increase could possibly be reduced to a more manageable 25 percent gain through an intensive carpool effort.

Providing Transportation Alternatives in Suburbs

An analysis of suburban automobile commuters found that at least 25 percent of local workers would experience difficulty in reaching their place of employment during rationing. The use of park-and-ride transit and of paratransit services was examined in an attempt to find solutions to the problems.

Since it is expected that DTS or CITRAN will have few, if any, surplus vehicles to supply new transit service in suburban areas, these communities should look for alternate sources of buses. Possible solutions could be to rent buses from the private sector (e.g., churches and organizations) or use local school buses.

The school bus concept was further examined under the assumption that such an action, now prohibited by state law, would be legalized. Using a case study of the suburban community of Arlington, an existing school bus sytem was examined to determine a method by which students as well as city residents could best be served. Through a process of aggregating school bus stops to form neighborhood transportation centers and combining bus routes so that a maximum student walk distance of 1 km (0.6 mile) to the school or bus stop was required, it was found that a high level of service (headways as short as 6 min) could be provided for general public commuter purposes as well as school students (Table 3).

The potential of commuter carpooling as a possible solution to gasoline shortages in suburban areas was also examined. Urban panel findings suggested that suburban respondents, as well as those in Dallas and Fort Worth, overwhelmingly (about 90 percent) urged that local cities encourage carpool operations (2). Initial estimates (4) were made suggesting that an existing carpool program at the time of a future severe energy emergency could reduce the number of single-occupant automobile commuters by as much as 17 percent.

Reducing Inequities and Uncertainties

The final section of the problem analysis examined other transportation-related difficulties that may occur from each federal contingency. The study pointed out that special problems during an allocation scenario could occur from inequities in local service station gasoline supply and demand. Long lines of customers, public uncertainty, and confusion in purchasing gasoline are likely to result. During a rationing contingency, problems could arise regarding the redistribution and sale of coupons on the open market. It was found that in most cases out-of-pocket costs of additional coupons to maintain normal trip patterns were minimal, averaging about 40 cents/month/licensed driver [assuming a coupon price of 30 cents/L ($1.20/gal)] (5). Although the number of coupons available to the area appears to be

Figure 3. National transit ridership changes due to oil embargo or similar interruption.

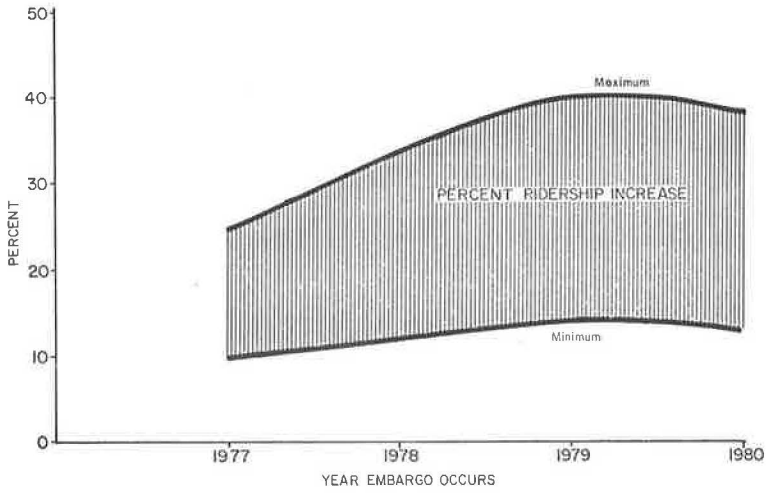


Figure 4. Implementation of short-term transit strategies to contend with ridership increases.

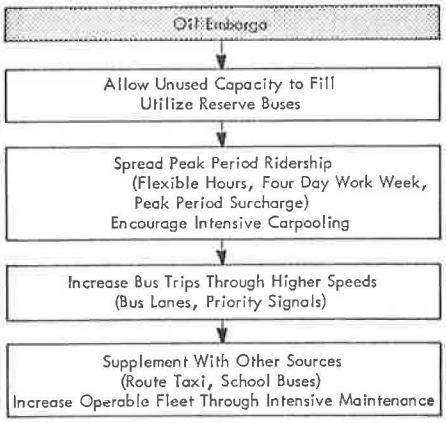
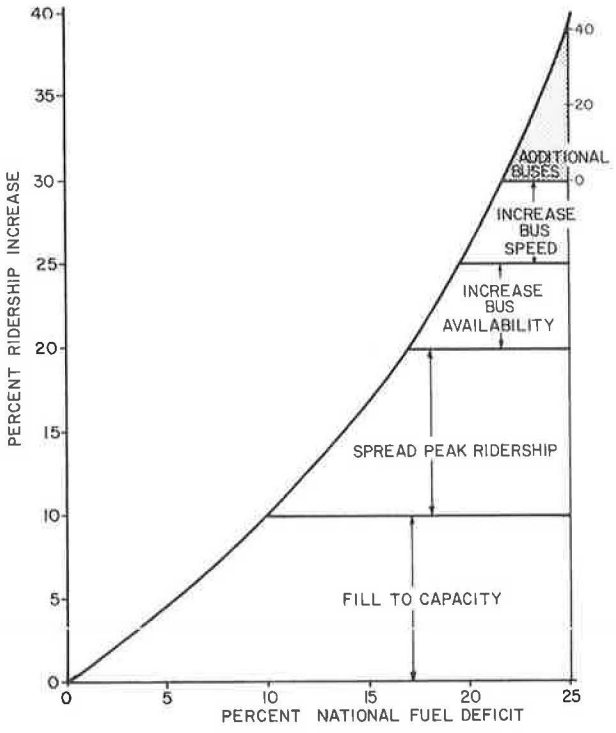


Figure 5. Effect of ridership increases on bus use, Dallas Transit System.



adequate, total coupon sales for the Intensive Study Area, however, were estimated to be over $750 000 each month due to the sale of coupons from central city residents to suburbanites.

To contend with these localized problems, the report suggested that a local energy coordinator (LEC) be designated on a county or city basis. The suggested functions of an LEC would include the following:

1. Respond to public inquiries regarding local problems of fuel allocation and coupon distribution or redistribution;
2. Publish local coupon prices to equalize price differences;
3. Coordinate information and policies with other LECs;
4. Identify local problems, report them to the respective governing bodies, and suggest local solutions; and
5. Coordinate a local public information program.

RECOMMENDATIONS

The report made a set of recommendations which, it was felt, would meet the required objectives at minimal administrative and financial expense. These recommendations were to

1. Modify state and federal fuel contingency regulations to provide priority fuel allocations to public transportation providers;
2. Maintain the present metropolitan carpool programs;
3. Expand or develop fuel storage reserves;
4. Designate an LEC in counties and major cities;
5. Encourage flexible-work-hour programs;
6. Increase transit system bus availability;
7. Modify the Texas state law to permit the use of school buses for the general public under emergency conditions;
8. Investigate the impact of an energy shortage on taxis and their possible role in local mobility during an emergency;
9. Develop regional park-and-ride and an exclusive bus lane plan;
10. Draft contingency agreements to be used between local governments, transit operators, and taxi operators for mutual assistance; and
11. Begin intergovernmental dialogue regarding possible energy contingencies and local solutions.

Figure 6. Potential route taxi passengers and fares for inbound service, Dallas.

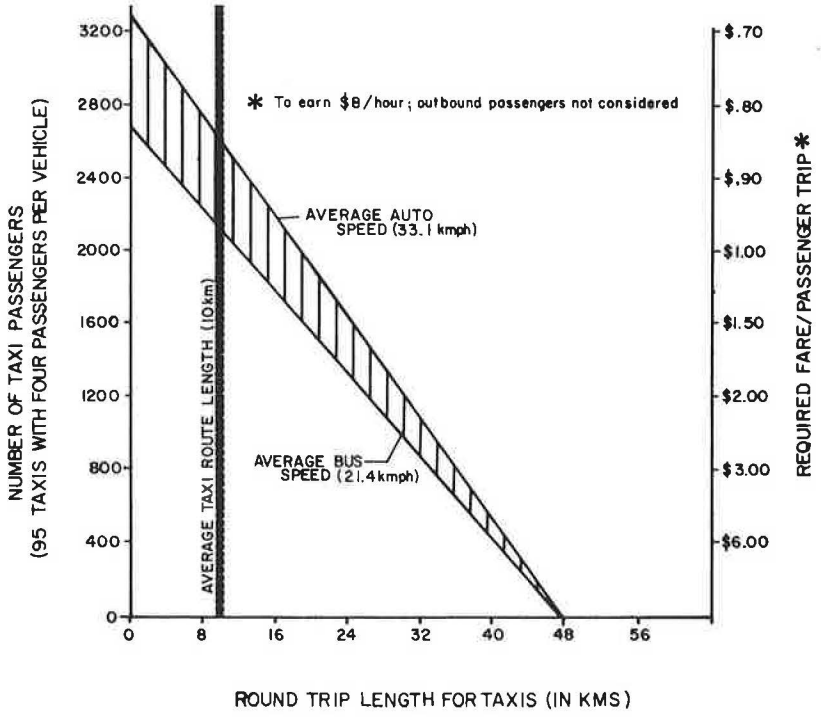


Table 3. Comparison of an existing school bus route system with a proposed modified transportation center system (Arlington, Texas, case study).

Item	Current System	Modified System
Number of buses	50	42
Number of bus routes	50	6
Total route kilometers	956	119
Trips per route per peak period	2	14
Total vehicle kilometers traveled per day	2974.4	3332.9
Seat trip capacity per peak period	7160	6104
Maximum walk distance	3.2 km to school only	1.6 km to school or neighborhood transportation center
Passengers served	Students only	Students and general public; seat trip capacity for 1400 public riders

Note: 1 km = 0.6 mile.

CONCLUSIONS

The contingency study achieved its stated objectives and helped officials to better understand the capacity of the existing transportation resources of the area as well as to identify problem areas and areas for improvement. For example, it became clear that taxis may encounter difficulties accommodating increased fuel costs through fare increases. It was also found that exclusive bus lanes appear to be an attractive immediate improvement to the area transit systems. Local elected officials were, of course, provided with information about the extent of the impact of a future fuel shortage, but they were also given some assurance as to the ability of the region to respond in such an emergency. In short, the study was viewed as an important and useful planning effort.

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