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Estimating Ridesharing Levels for Reductions in VMT

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ABSTRACT

The research described is a set of supply models for estimating the number of commuters needed to participate in ridesharing programs to achieve a desired level of travel reduction. Supply models have been developed that estimate the number of commuters needed to participate in carpooling and vanpooling to achieve given levels of reduction in vehicle-miles of travel and energy consumption. Determining participation levels identifies the degree of effort necessary to reach desired reduction levels and provides a means of assessing whether to continue with these reduction levels or adjust target reduction values to coincide with acceptable intensity and funding levels. Estimating the number of necessary commuters early in the planning process makes possible a realistic assessment of the feasibility of achieving reduction goals given the magnitude of participation levels. For even small reduction levels the number of new ridesharing commuters quickly approaches levels that are realistically difficult to attain.

Transportation activities have changed significantly in recent years with emphasis shifting from major highway construction and long-range master planning to a more diverse set of issues and concern for achieving a set of short-term objectives. A fundamental strategy of short-term objectives is to encourage more efficient use of existing highway facilities through increased vehicle occupancies. Ridesharing offers the chance to extend the use of existing transportation systems in ways that increase their efficiency and reduce the need for additional vehicles and roadway capacity.

Given this renewed interest in ridesharing, transportation planners are increasingly interested in determining the number of commuters needed to participate in ridesharing to achieve a desired level of travel reduction. The ability to estimate the necessary magnitude of ridesharing participation is beneficial in the early planning stages to identify whether desired reduction levels in vehicle-miles of travel (VMT) and energy usage are feasible. Matching these supply estimates with demand estimates provides an assessment of the ability to reach desired reduction levels and the resulting level of program intensity. This in turn provides a means of assessing whether to continue with these reduction levels or adjust target reduction values to coincide with acceptable intensity and funding levels. To accommodate this need, a set of supply models has been developed that estimate the number of commuters needed to participate in ridesharing to achieve given levels of reduction in VMT and energy consumption. Separate figures have been developed for each of these reductions for both carpools and vanpools. These modal breakdowns enable planners to develop an optimum balance in ridesharing modes given the travel characteristics of their community. The use of these models also makes possible an assessment of the practicality of reduction levels in light of the number of commuters needed to participate and the resulting level of program intensity.

MODEL CONSIDERATIONS

In developing the supply models, consideration must be given to vehicle load factors and travel distances in order to make even rough estimates of the potential for ridesharing. Factors that have been considered in the models include prior mode of new carpoolers, vehicle occupancy of new carpools, home-to-work trip length, frequency of carpooling, trip circuity of new carpools, use of vehicles left at home during the work day, and miles of travel generated by persons meeting at pickup points. Failure to account for these various factors could result in estimates that would underestimate participation levels by 50 to 70 percent. A discussion of these considerations and their impact in estimating participation levels follows.

Prior Mode

It cannot be assumed that all new ridesharers are diverted from single-occupant vehicles; many may come from existing carpools and transit. Accounting for these other diversions significantly decreases the expected reduction in VMT because prior mode determines the number of vehicles that are no longer driven to work. For example, if 25 commuters switch to ridesharing and all 25 formerly drove alone, previous vehicle occupancy would be 1.0 and 25 vehicles would no longer be driven to work. On the other hand, if five of these 25 commuters formerly carpooled in five different carpools of two persons each, the previous occupancy would be 1.2 and only 20 vehicles would be removed, a 16 percent decrease from the initial case. In a recent evaluation of FHWA carpool demonstration projects it was reported that 20 percent of new carpoolers were diverted from other than single-occupant vehicles with a vehicle occupancy of 1.2 (1). In the case of vanpooling, a greater percentage of new riders is diverted from carpools than from single-occupant vehicles because of the longer trip distances associated with vanpooling and a greater previous incentive for commuters to form carpools. An examination of previous mode of van riders for various vanpool programs reveals that 57 percent were former carpool riders with an average previous vehicle occupancy of 1.79 (2).

In the case of vanpools, the percentage of riders diverted from carpools can be misleading in determining reductions because the nucleus of riders usually comes from one or more entire carpools. Thus, unlike most situations in carpool formation, commuting vehicles are no longer driven to work. To reflect this situation previous mode data for van riders were examined and the percentage of riders who formerly carpooled was reduced to 45 percent for calculation purposes in the supply models.

Vehicle Occupancy of New Pools

The formation of new pools results in a number of vehicles still being used for commuting to work. In most instances single-occupant vehicles have added riders and are now being used as pool vehicles. In determining energy reductions, the number of vehicles that are still being driven to work, especially those used for commuting, must be accounted for to obtain accurate reduction values. This is accomplished by dividing the total number of new poolers by the vehicle occupancy of new pools. This number in turn is subtracted from the earlier estimate of the number of vehicles no longer driven to work and yields the actual number of vehicles removed. The FHWA carpool evaluation found new carpool occupancy to average 2.85 persons per car (1). Vanpool occupancy averaged approximately 11 riders per van for 12-passenger vans.

Frequency of Ridesharing

The number of days per week each pooler participates in a pool is an important consideration because additional mileage is generated when riders drive to work by themselves. This situation happens frequently when riders need their vehicle during or after work. At some companies where employees must be away from the office during the week a lower frequency of pooling can be anticipated because employees may drive alone on days they will be out of the office or do not make the trip if business takes them out of town. If commuters rideshare only 3 or 4 days per week, a decrease in the expected energy reduction resulting from pooling may occur; this means that additional commuters must participate in pooling to achieve the desired reductions. From carpool evaluation programs throughout the country, it appears reasonable to estimate that, on the average, 84 percent of carpoolers participate in a carpool 5 days a week. The frequency of vanpooling has not been reported in rider evaluations, but it appears reasonable to assume that the rate is higher than that for carpooling because riders purchase a seat on a subscription basis instead of paying for the number of days they actually ride. On the basis of this information and conversations with Knoxville vanpoolers, and considering vacations and sickness, it is assumed that 92 percent of vanpoolers participate 5 days per week.

Trip Circuity of Pools

In most instances carpool trips tend to be longer than single-occupant trips because of the trip circuity of picking riders up at their homes or designated meeting points. Estimates of the added distance are not well documented because they have not been included in program evaluations and, like most distance values, are difficult for riders to estimate. Cambridge Systematics, Inc., analyzed several data sources and estimated trip circuity at 0.5 mile (0.8 km) per person per trip for those carpooling

(3). Trip circuity for vanpooling is not reported in evaluations but is assumed to be longer at 0.75 mile (1.2 km) per rider per trip because of the greater dispersion of vanpoolers.

Vehicle Left at Home

Another distance factor that has received considerable attention is the amount of travel that takes place by vehicles that are left at home by carpoolers. Travel that takes place during the day by these vehicles can be of two types, either additional new travel generated by other family members or existing travel for shopping and so forth that has been diverted to the midday because a vehicle is now available. The ability to distinguish between new and diverted travel and the difficulty in its estimation by poolers has led many evaluators to question its reliability. For this reason and because even if this additional mileage were accounted for it would be slight compared to the many other uncertainties in vehicle occupancy estimates, adjustments have not been made in the supply models to compensate for this additional mileage.

Travel to Pickup Points

A distance factor also to be considered is the amount of travel generated by commuters who arrange to meet their pool at designated pickup points. In these instances a portion of the trip is being made by one or more single-occupant vehicles, not the pooling vehicle, and consequently this practice generates additional mileage that is not considered in the trip distance of the pooling vehicle. In the case of carpools this additional trip distance has not been reported in evaluation studies and consequently is not considered in the supply models. Vanpool evaluations on the other hand have investigated this area because a greater proportion of riders meet at designated points because of the increase in travel time that would result if each rider were picked up at home. Reported results of various vanpool programs indicate that an average of 43.5 percent of the riders meet at a pickup point 3.23 miles (5.2 km) from their homes (2).

MODEL FORMULATION

Formulation of the supply models is relatively straightforward and similar for both carpools and vanpools. To illustrate the general procedure of the models a numerical example is first presented, followed by the algebraic formulation.

Numerical Example

Consider a situation in which a reduction in daily VMT of 500 miles (805 km) is desired and the average round-trip commute distance is 20 miles (32.2 km). The first step is to account for trip circuity of carpoolers, 1 mile (1.6 km), and subtract this distance from the round-trip distance. Dividing the desired VMT reduction of 500 miles (805 km) by the corrected 19-mile (30.6-km) trip distance equals 26.3, which is the number of single-occupant vehicle trips that must be discontinued. Because not all new carpoolers were previously drive-alone commuters, this value must be multiplied by the percentage of new carpoolers who previously drove alone, 80 percent, to yield the number of single-occupant vehicles, 21.0, that are no longer driven to work. The next step is to subtract the number of vehicles that will be used as pooling vehicles from the number of vehicles removed. The number of pooling vehicles is determined by multiplying the number of needed poolers, 26.3, by the percentage who form new carpools, 95, and dividing by the vehicle occupancy of carpools, 2.85. This equals 8.8 vehicles and subtracting from 21.0 results in 12.2 vehicles being removed. This value is then adjusted for the frequency of carpooling by multiplying by 85 percent to yield 10.4 vehicles. Thus, after correcting for vehicle occupancies and additional travel distances, only 198 miles (319 km) or 39.6 percent of the original 500-mile (805-km) reduction has been attained. To attain the 500-mile (805-km) reduction the original estimate of 26.3 single-occupant vehicles is divided by the 39.6 percent reduction to yield 66.4 as the number of total necessary commuters. Energy reductions are calculated in a similar manner except that VMT reduction is replaced with the desired reduction in gallons of gasoline and the appropriate fuel usage rate.

Algebraic Notation

Before developing the algebraic notation of the supply models it is necessary to define the following variables:

- NC_m = number of commuters needed to participate in ridesharing for mode m: m = carpool (c) or vanpool (v);
- VMT = desired or target level of reduction in vehicle-miles of travel (number of miles);
- GR = desired or target level of reduction in fuel (gallons of fuel);
- DIST = round-trip commute distance (number of miles per commuter or vehicle trip);
- MPG = fuel mileage, 17.0 miles per gallon;
- PO_m = percentage of new poolers who previously drove alone in mode m: 80 percent carpools, 43 percent vanpools;
- CO_m = current vehicle occupancy of newly formed pools of mode m (number of passengers per vehicle): 2.85 carpools, 11 vanpools;
- PE_m = percentage of poolers who form new pools for mode m: 95 for carpools, 100 for vanpools;
- FQ_m = percentage of poolers who will be pooling any given day for mode m: 85.0 carpools, 92 vanpools;
- TC_m = trip circuity of poolers in mode m (miles per commuter or vehicle trip): 1.0 miles (1.6 km) carpools, 1.5 miles (2.4 km) vanpools;
- PD_m = distance from home to meeting point for those pooling in mode m (miles per commuter or vehicle trip): zero carpools, 6.46 miles (10.4 km) vanpools; and
- PP_m = percentage of poolers in mode m who meet their pool at a designated meeting place: zero carpools, 43.5 vanpools.

The first step in formulating the supply model is to determine the number of commuters or single-occupant vehicle trips that must be removed. For a specified VMT reduction and round-trip distance, the number of initially removed commuters or vehicle trips for ridesharing mode m is

$$IVR_m = VMT/[DIST - TC_m - (PD_m\ PP_m)] \quad (1)$$

where IVR_m is the number of commuters or single-occupant vehicle trips initially removed for ridesharing mode m.

Correcting for the fact that not all new poolers are former drive-alone commuters, the number of single-occupant vehicles actually removed for mode m is

$$AVR_m = IVR_m \; PO_m \qquad (2)$$

and the number of vehicles that new poolers will be using as pooling vehicles for mode m is

$$PV_m = (IVR_m \; PE_m)/CO_m \qquad (3)$$

where PV_m is the number of vehicles new poolers will occupy for mode m.

Because the initial estimate of removed vehicles included those that will be used as new pooling vehicles, Equation 3 is subtracted from Equation 2 to define the number of vehicles removed as

$$VR_m = AVR_m - PV_m \qquad (4)$$

where VR_m is the number of vehicles removed for mode m.

The percentage of target or desired vehicle-miles actually reduced by ridesharing mode m, out of the desired number and corrected for frequency of pooling for mode m, is

$$PR_m = \{VR_m \; FQ_m \; [DIST - TC_m - (PD_m \; PP_m)]\}/VMT \qquad (5)$$

where PR_m is the percentage of desired vehicle-miles actually reduced by mode m. Therefore, the total number of commuters (both single occupants and former carpoolers) needed to participate in ride-sharing mode m to achieve a desired VMT reduction is

$$NC_m = IVR_m/PR_m \qquad (6)$$

Estimated participation levels for energy reductions are determined in a similar manner except that the fuel usage rate is incorporated in the model. In this case the number of single-occupant vehicle trips or commuters that must be removed with ride-sharing mode m is

$$IVR_m = GR \; MPG/[DIST - TC_m - (PD_m \; PP_m)] \qquad (7)$$

Correcting for the percentage of poolers not diverted from single-occupant vehicles, the number of single-occupant vehicles actually removed for mode m is

$$AVR_m = IVR_m \; PO_m \qquad (8)$$

and the number of vehicles that new poolers will be using as pooling vehicles for mode m is

$$PV_m = (IVR_m \; PE_m)/CO_m \qquad (9)$$

The number of vehicles removed for mode m is

$$VR_m = AVR_m - PV_m \qquad (10)$$

and the percentage of gallons actually reduced with ridesharing mode m, out of the desired number when corrected for frequency of pooling for mode m, is

$$PR_m = \{VR_m \; FQ_m \; [DIST - TC_m - (PD_m \; PP_m)]\}/GR \; MPG \qquad (11)$$

Therefore, the total number of commuters needed to participate in ridesharing mode m to achieve a desired energy reduction is

$$NC_m = IVR_m/PR_m \qquad (12)$$

To facilitate quick use of the supply models a set of figures has been developed to estimate participation numbers for each ridesharing mode. Figures 1-4 show calculations for various round-trip commute distances. Use of the supply model figures

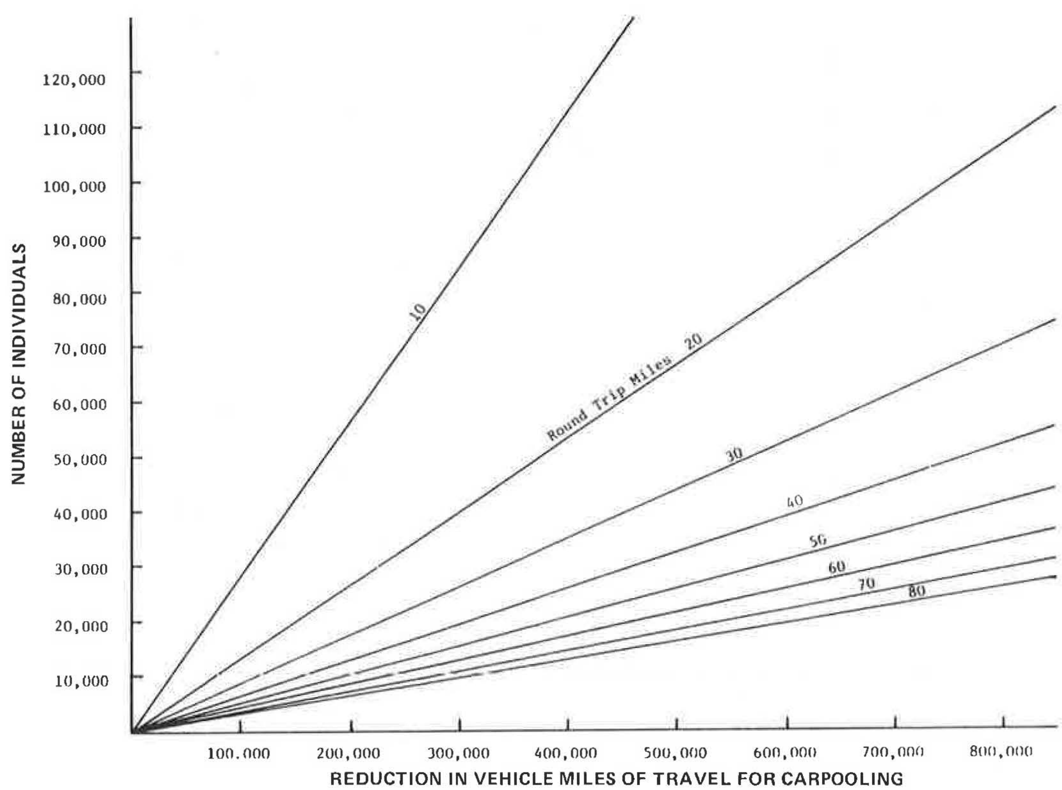

FIGURE 1 Number of individuals needed to carpool for reduction in VMT.

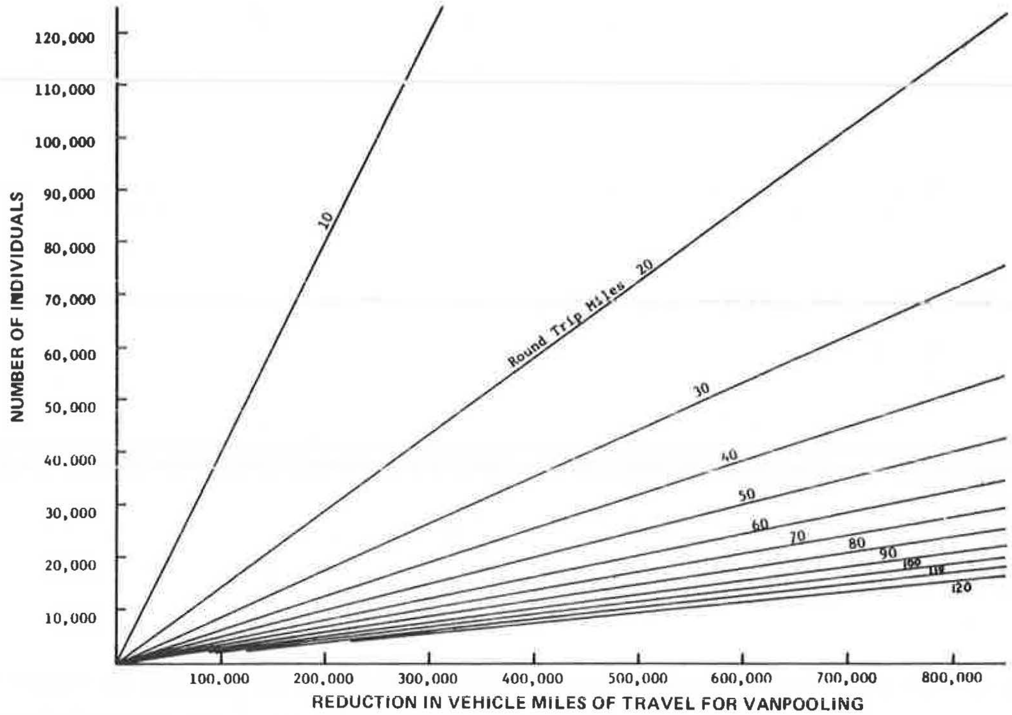

FIGURE 2 Number of individuals needed to vanpool for reduction in VMT.

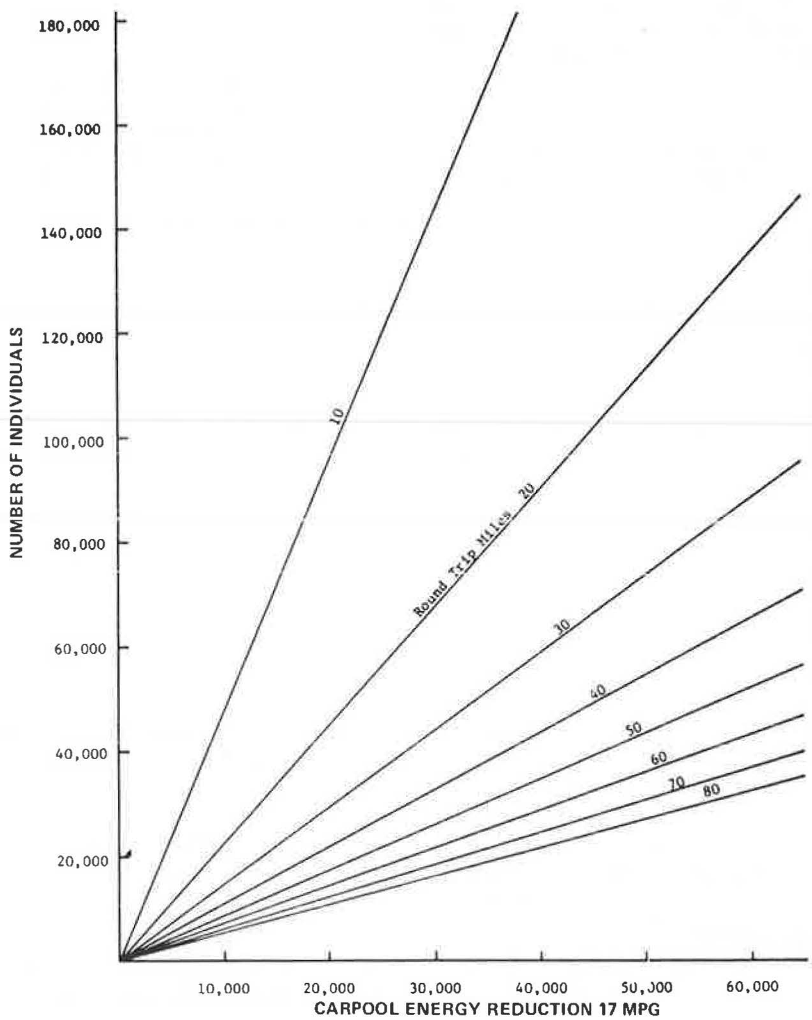

FIGURE 3 Number of individuals needed to carpool for reduction in energy usage.

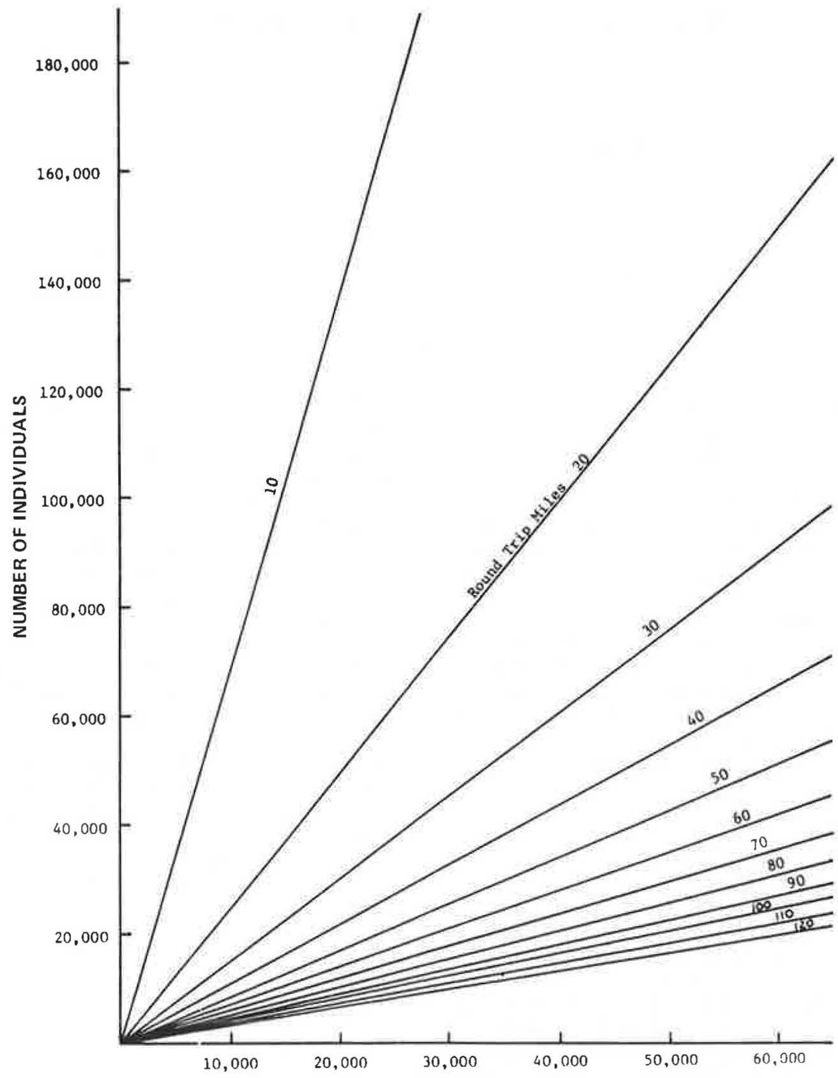

FIGURE 4 Number of individuals needed to vanpool for reduction in energy usage.

is straightforward and requires the following information about commuter characteristics:

1. The percentage distribution of two-way commuter trip lengths. This information may be obtained from origin-destination (O-D) studies, journey-to-work census tabulations, or other planning data or studies that collected information on home-to-work trip lengths. In cases in which these data are not available, it is recommended that the average round-trip commute distance for the entire area be used or the national average of 19 miles (30.6 km) (4).

2. In a comprehensive reduction program ridesharing may be one of many strategies being implemented, and knowing the portion of the reduction that ridesharing is responsible for greatly affects participation levels. For example, ridesharing may be expected to account for 70 percent of the desired reduction of VMT with transit and other programs encompassing the remainder. Thus the percentage of the reduction that ridesharing is expected to account for should be specified if it is part of a total program. Also to be specified is the percentage participation in each ridesharing mode by new poolers. If both car- and vanpooling are being promoted it can be expected that a certain portion of new poolers will carpool while the others vanpool. Because the two modes require different participation levels to achieve the same reduction, it is important to develop a balance between the modes given the potential of each in the area. In most areas it would be unrealistic to expect vanpooling to capture more than 5 to 10 percent of the total trips unless extensive employer-based vanpool programs and financial incentives are undertaken. In these situations vanpooling may capture between 15 and 25 percent of the total trips depending on the intensity of the program.

Example Application

Use of the figures is most easily explained through the following example. Consider the case of Knoxville, Tennessee, where it is desired to reduce daily VMT by 10 percent and current daily VMT is 2.5 million miles (4.6 million kilometers). The distribution of two-way commute trip lengths in the Knoxville area is as follows: 10 miles (16 km), 55 percent; 20 miles (32 km), 25 percent; 30 miles (48.2 km), 11 percent; 40 miles (64.3 km), 3.5 percent; and 50 miles (80.5 km), 3.5 percent. Ridesharing is expected to account for 80 percent of the reduction

TABLE 1 Participation Levels for Car- and Vanpooling in Knoxville, Tennessee

Trip Distance (miles)	No. of Commuters: Carpool (col. 1)	No. of Commuters: Vanpool (col. 2)	Percentage of Trips for Each Distance (col. 3)	Normalized Vanpool Porportions (col. 4)	No. of Commuters Adjusted for Trip Distribution: Column 1 x Column 3 (col. 5)	No. of Commuters Adjusted for Trip Distribution: Column 2 x Column 5 (col. 6)
10	56,022	80,594	55.0	0.0	30,812	0
20	26,537	29,227	25.0	0.0	6,634	0
30	17,386	17,850	13.0	65.0	2,260	11,603
40	12,928	12,849	3.5	17.5	452	2,249
50	10,290	10,037	3.5	17.5	360	1,756
Total			100	100	40,518	15,608

and the split between ridesharing modes is 92 percent carpool, 8 percent vanpool.

The first step is to adjust the 250,000 VMT (402 336 km) to reflect the 80 percent rideshare contribution that yields 200,000 VMT and determine the number of commuters needed to carpool and vanpool for each of the commute distances. These values are obtained from Figures 1 and 2 for the 200,000-VMT (320 000-km) reduction and are tabulated in Columns 1 and 2 of Table 1. The next step is to correct these participation levels to reflect the percentage of trips for each commute distance by multiplying the number of commuters by the corresponding percentage. Because vanpooling is applicable for commute distances greater than 15 miles (24 km) one way, the corresponding percentages for the proportion of trips greater than 30 miles (48.3 km) have been normalized to 100 percent (Column 4) and multiplied by the corresponding participation levels. These values are tabulated in Columns 5 and 6 of Table 1. Summing these columns yields 40,518 and 15,608, which are the numbers of commuters needed to carpool or vanpool to achieve the 10 percent reduction level. If vanpooling was not being considered in the area the number of commuters needed to carpool (40,518) would be the necessary participation level. In the present case vanpooling is included and requires that participation levels be adjusted to reflect the percentage of participation in each mode. The number of commuters needed to participate is determined by multiplying the participation levels for car- and vanpooling by 92 and 8 percent, respectively, and summing. This results in a total participation of 38,526 commuters.

Estimates of participation levels for energy reductions are determined in a similar manner.

SUMMARY

Through use of the supply model figures, it is quickly recognized that, for even small percentage reductions in VMT and energy usage, participation levels are large and can quickly approach the size of the work force. In the Knoxville application an additional 38,526 commuters would need to rideshare to achieve the 10 percent reduction. Currently the work force is approximately 130,000 individuals, and 40 percent (52,000) of these individuals already rideshare. Thus, expecting an additional 38,526 commuters (30 percent of the work force) to rideshare would be questionable unless an extensive change in commuting conditions such as a decrease in the supply of gasoline were to occur.

The supply models have been developed such that they incorporate numerous considerations affecting load factors and travel distances that in turn provide a fairly good estimate of participation levels for decision-making purposes. Proceeding through the process and assessing needed participation levels against the size of the work force, demand estimates, and the resulting level of program intensity and cost enables an in-depth analysis to be undertaken. Through this assessment, changes can be made to reduction levels if resulting participation values are too high, which readjusts the scope of the ridesharing program to acceptable intensity and funding levels. Even with increases in carpool and vanpool occupancies, ridesharing may have a more limited potential than first expected. These implications can quickly be identified through use of the supply models.

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