Contingency Transportation Plans for Urban Areas and Their Potential Impacts

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This paper provides a broad overview of the energy-conserving actions available in urban areas to meet future transportation energy shortages. Based on transportation energy contingency plans prepared in several states and regions, as well as related literature, an inventory of both complementary and competing conservation actions is provided. The need for effective packaging of sets of reinforcing conservation actions is stressed. Illustrative estimates of both individual and cumulative impacts in reducing transportation energy consumption are also given based on the examples reviewed and the literature. The development of alternative energy contingency plans, staged to match anticipated energy shortfalls, and several key implementation-related issues are discussed.

Urban-oriented transportation energy contingency planning is interpreted largely from a short-range, quick-response point of view. Most of the energy-conserving actions considered are consequently near term in nature and can be implemented relatively quickly and at relatively low cost. These actions are to be contrasted with longer-range energy conservation planning, where more permanent and fundamental shifts in urban activity patterns--both directly and indirectly related to transportation needs—should be considered. The view has been expressed by some that significant transportation energy saving can only be achieved by pursuing such long-range solutions and that emphasis on short-range actions may represent a cosmetic, superficial reaction by the transportation planning community (1).

With this caution in mind, there nevertheless is a strongly felt need at state and local political decision-making levels for multiple-action energy contingency plans capable of addressing short-term transportation energy shortages (2-5). Recent experience has shown that such multiple-action strategies can be effective in dealing with temporary shortfalls in the 10-15 percent (and possibly higher) range.

PACKAGING OF ENERGY-CONSERVING ACTIONS

One of the critical steps in developing urban-oriented transportation energy contingency plans involves the grouping, or packaging, of related measures. Though the potential exists for such coordinated packages to provide a cumulatively greater degree of impact in reducing transportation energy consumption, these reinforcing aspects are not clearly understood. Furthermore, when it is realized that different degrees of implementation can be associated with many transportation actions, the number of alternative mix-and-match packages can become very large. Developing such alternative packages, which is another important dimension of contingency readiness, is discussed later in this paper.

In some instances, coordination between packages of measures themselves may be necessary because of associated shifts in travel demand and transportation supply among different packages. An example is the need to match increases in public transportation capability (supply) offered by one package (against the increases in transit use that may be stimulated by another package (such as automobile-use disincentives). Mixing shorter-range, immediate-action contingency actions with longer-range permanent conservation actions can also be an important aspect of developing coordinated packages. As noted above, however, this paper addresses only the shorter-range inventory of transportation-related conservation actions.

A broad approach to identifying packages of transportation-related energy conservation options is perhaps best tied to various components within the urban transportation planning process (6). Under such an approach, both short-range and long-range planning components can be addressed, as well as both publicly and privately oriented energy conservation actions. Both passenger and freight travel patterns should be covered, as well as the various structural elements of transportation supply (e.g., highways and transit). In addition to covering other travel behavior characteristics influencing transportation fuel use, such a broad approach to the inventory and packaging of conservation actions should also include nontransportation considerations. This particularly involves urban economic and institutional infrastructures that directly affect transportation demand and supply.

Table 1 (6) summarizes such a planning process-oriented classification and packaging of 75 different energy-conserving methods. Many are shorter-range in nature (indicated generally by an operations designation under the level-of-planning heading), while many others are longer-range in nature (generally indicated by a policy, systems, or regional designation). Also shown in Table 1 are energy-related influencing factors that are likely to affect each potential conservation method. These include, for example, fuel cost and availability, vehicle costs, and federal, state, and local government policy. The table suggests that, in general, shorter-range contingency-oriented packages of actions can be classed into several groups: travel of persons (including voluntary behavior on the part of individual travelers), freight transportation, transportation infrastructure (availability or price of street-parking supply), and transit infrastructure (wide variety of capacity-increasing, service-improving options).

Other classification efforts aimed particularly at short-range energy contingency planning have concentrated on the packaging of transportation supply elements (7, 8). As indicated in Table 2 (7), under this approach, as many as 10 different packaging categories for more than 50 suggested conservation methods can be identified. Although nearly all of the potential actions listed could be implemented within the space of a few months or less, several could require two to five years before significant impact is achieved. This timing-of-impact dimension in relation to the projected duration of future energy shortfalls represents a critical factor in energy contingency planning. Primary responsibility for nearly all of the actions listed in Table 2 would fall to state or local levels of government, including regional transit operators. In general, within any packaging category, where more than one level of government is indicated, coordination needs are increased.

The different packaging categories in Table 2 generally vary by mode, trip purpose, or type of modification in existing transportation supply. For example, improving traffic operations, ridesharing, and urban transit- and taxi-packaging categories all relate to actions that could be taken within specific modes and for associated transportation supply configurations. A different set of strategies relates to potential reductions in either or both work and nonwork travel.

Other packaging strategies related specifically to restrictions on urban travel supply (price or availability) or on gasoline sales practices (to stretch available supplies over a full month). The comment column in the table indicates some of the coordination and impact elements associated with the packaging of individual actions under each category. For example, reduced work-travel actions may negate transit and carpooling strategies and must also

Table 1. Potential energy conservation methods and related levels of government planning.

Group	Potential Methods for Conserving Energy	Level of Planning[a]	Influencing Factor
Travel of persons	Increase duration but decrease frequency of vacation trips	Policy	Fuel cost and availability
	Increase vehicle loading (car occupancy) by (a) building HOV lanes and (b) building carpool parking lots	(a) Systems and (b) project	Fuel cost, social factors, HOV lanes
	Increase trip chaining	Policy, regional	Fuel cost and availability
	Decrease trip production	Policy, regional	Fuel cost and availability
	Decrease trip length	Policy, regional	Distribution of opportunities
	Increase number of walking trips	Operations	Density, proximity of opportunities
	Increase use of bicycles and mopeds	Operations	Type of work, communications
	Work at home	Policy	Social factors; insurance costs
	Increase carpools and vanpools for work trips	Operations	Vehicle cost; fuel cost
	Speed purchase of fuel-efficient vehicles	Policy	Fuel cost and availability
	Increase use of transit	Policy, systems, and operations	Fuel cost; transit availability
Freight transportation	Increase or reduce truck size (for efficiency)	Policy	Fuel cost, vehicle cost
	Increase truck loading (for efficiency)	Private operations	Fuel cost, vehicle cost
	Reduce empty backhauling	Private operations	Fuel cost, regulations
	Increase efficiency of truck routing	Private operations	Fuel cost
	Consolidate urban deliveries	Private operations	Fuel cost, institutional factors
Urban infrastructure (built environment)	Increase density of residential settlement, particularly on transit routes	Policy, regional	HUD, FHA, state policies
	Increase density of nonresidential settlement; decrease scatter	Policy, regional	Economics of the firm
	Establish multiuse urban centers and subcenters	Policy, regional	State, local policies
	Provide telecommunications substitutes for travel	Policy	Economics
	Establish automobile-restricted zones	Corridor, project	Environmental, urban planning policies
Economic and institutional infrastructure	Establish four-day work week	Policy, individual	State, MPO
	Initiate Sunday store closings	Policy, individual	State, MPO
	Restrict store hours	Policy, individual	State, MPO
	Operate more, but smaller, store units	Individual	Economics; trends in transportation costs
Transportation infrastructure (streets, parking)	Install TOPICS, other signal improvements	Operations	State, federal government
	Install computerized traffic control systems	Operations	State, federal government
	Install access ramp metering	Operations	State, federal government
	Convert to one-way street systems	Operations	State, federal government
	Convert lanes to HOV lanes	Systems, operations	State, federal government
	Provide preferential HOV lanes at toll gates	Operations	State, federal government
	Build preferential access ramps	Systems, operations	State, federal government
	Provide traffic engineering improvements for buses	Operations	State, federal government
	Provide better service to pedestrians	Operations	State, federal government
	Provide bikeways and bike lanes	Operations	State, federal government
	Reduce or increase number of parking spaces	Operations	State, federal government
	Increase parking rates	Operations	State, federal government
	Provide differential parking rates	Operations	State, federal government
	Limit parking (percentage system)	Operations	State, federal government
	Provide parking for carpools and vanpools	Project, operations	State, federal government
	Provide parking for bus passengers	Project, operations	State, federal government
	Differential peak-hour tolls	Operations	State, federal government
	Create automobile-restricted zones	Project, operations	State, federal government
	Restrict trucks on routes and in certain areas	Operations	State, federal government
	Improve road surfaces	Operations, maintenance	State, federal government
	Enforce 55-mph speed limit	Operations	State, federal government
	Provide adequate arterial and expressway capacity	Systems	State, federal government
Transportation infrastructure (transit)	Improve routing and scheduling of buses	Operations	State, local government
	Provide express bus service	Systems, corridor	State, local government
	Park-and-ride service	Operations	State, local government
	Provide shuttle bus to central business districts (CBD's) with peripheral parking	Systems, operation	State, local government
	Improve passenger amenities	Operations	State, local government
	Improve fare-collection systems	Operations	State, local government
	Improve passenger information	Operations	State, local government
	Provide demand-responsive system	Systems, operations	State, local government
	Improve vehicle maintenance	Operations	State, local government
	Improve radio communications to buses	Operations	State, local government
	Install bus bays	Operations	State, local government
	Provide high-speed bus service between cities	Systems, operations	State, federal government
	Increase distances for students walking to school	Operations	Energy costs, safety, parents
	Prohibit taxi cruising	Operations	State, local government
Transportation infrastructure (rail and truck)	Implement trailer on flatcar trains between urban areas	Systems	Federal Railroad Administration
	Consolidate urban deliveries of small freight shipments	Systems, operations	State government
	Increase waterborne transportation	Private operations	State, federal government
	Require adequate urban truck-loading facilities	Private operations	MPO
	Ban truck idling	Operations	MPO, state
Vehicle fleet	Reduce automobile size and weight	Policy, individual	Cost, fuel price
	Selectively remove pollution control devices	Policy	Cost, fuel price
	Increase engine energy efficiency	Policy	Cost, fuel price
	Reduce truck sizes	Policy, individual	Cost, fuel price
	Reduce number of panel trucks and pickups	Individual	Cost, fuel price
	Use electric vehicles	Individual	Economics
Energy and economic factors	Increase fuel price	Policy	World supply, price, and cartels
	Make fuel unavailable	Policy	World supply, price, and cartels
	Ration gasoline	Policy	World supply, price, and cartels

[a]Where the decision maker is the individual or the firm, the "level of planning" indicated refers to that planning that bears on the supporting action, not the actual decision.

Table 2. Summary of potential actions that address transportation energy emergencies.

Action Area	Primary Responsibility	Time Horizon	Comment
Improve car internal operating efficiency			
Radial tires, power train, etc.	F	3 years	Most effective long-run action
Encourage small-car purchases	S	3 years	Low short-term payoff
Improve traffic operations			
Computerized traffic control	L, S	5 years	Most potential areas now in planning stage
TOPICS	L	2 years	Maximum potential not large; does not help rural areas
Access ramp metering	L	5 months	Also encourages carpooling and transit use
One-way streets	L	3 months	Requires major enforcement effort; rural areas primarily benefit
HOV lanes and ramps	L	3 years	
Enforce 55-mph limit	L, S	6 months	Requires major enforcement effort; rural areas primarily benefit
Enforce 50-mph limit	L, S	6 months	
Ridesharing			
Computer-match ridesharing	L	6 months	Very impersonal; actual carpool formation is low
Carpool coordinator program	S, L	1 year	Maximum potential in large companies; locally implemented; integrate with transit; stagger work hours
Vanpooling	F, S, L	1 year	Administrative difficulty; a second step beyond carpooling
Shared-ride taxi	L	2 months	Potential may be high
Reduce nonwork travel			
Encourage reduced discretionary travel	S (information); L (implementation)	1 year	Does not help low-income people; popular; potential is greatest over short term
Local trip-planning assistance	S, L	1 year	Helps public cut discretionary travel in palatable ways
Transportation audit program	S, L	1 year	Provides basic information to families to cope better
Bicycle and pedestrian promotion	L, T	1 year	Promote as alternative to out-of-town travel
Reduce work travel			
Work-hour policies	L, S, F	3 months	May negate transit and carpooling
Four-day work week	L, S, F	3 months	Must be coordinated with reduced weekend travel
Communications in lieu of travel	S, F	2-4 years	Potential is unclear
Urban transit and taxi			
Reduced off-peak fares	L	3 months	May encourage discretionary travel; may divert few riders from peak hour
Routing improvements and transit	L	6 months	Gains counter extra service
Express bus and park-and-ride	L	2 years	Park-and-ride has more potential
Downtown shuttles	L	3 months	Costly; low impact
Amenities	L	3 years	Attracts passengers
Passenger information	T	1 year	Essential step
Demand-responsive service	T	2 years	Uses more energy than is saved
Integrate client-agency services	L, T	1 year	Ensures service to clients of social service agencies; reduces hardship cases; no impact on general public
Fare collection	T		
Maintenance of buses	T	2 years	Marketing combined with information has the most potential
Transit and intercity links to CBD	T	1 year	Can enhance intercity promotion
School bus and charter taxi use	S, L	2 months	Need is unclear; potential unknown
Taxi-idling restrictions		3 months	Difficult to enforce
Diesel taxis	L	5 years	Diesel cab operation is up to 50 percent more efficient than gasoline operation
Urban travel restrictions			
Reduce parking spaces, increase time of day rates	L	2 years	Major negative impact is on commerce
Automobile congestion tolls	L	?	Politically unpopular
Automobile free zones	L	?	Politically unpopular
Urban truck restrictions	L	?	Major benefit is congestion reduction
Intercity travel			
Promote intercity air, rail, and bus	S	4 months	Weekend omitted travel may be reduced substantially
Electrify all trains	S	5 years	Business traffic; encourages increased load factors; short-term potential is low
State, parks, transit services	S	6 months	Could have major impact if tied to incentives (e.g., campsite reservations)
Freight			
Empty backhaul eliminations	S	1 year	Promotes freight competition
Air service rationalization	F, S	2 years	Promotes freight competition
Joint freight and passenger train operations	F, S	?	Generally improves railroad efficiency
Ban truck idling	S	2 months	
Gasoline sales restrictions			
Odd-even, one-half tank	S	2 months	An extreme step; does not conserve per se but reduces travel and prevents panic
Weekend closing of stations	S	2 months	Negative impact on recreation and businesses causes fillup problems during the week
Reduced station hours	S	2 months	May create panic buying and long lines
Rationing plans	F	6 months	Requires congressional approval; plans not available yet
No-drive day	S	2 months	Should be combined with ridesharing or transit actions to increase results

Note: F = federal government; S = state government; L = local government; T = transit.

be coordinated with reduced weekend-travel actions.

Another approach to the delineation of packages of energy-conserving actions focuses more specifically on constraints or restrictions that could be placed on existing transportation supply and demand (9). Such an approach is given in Table 3 (9), which lists seven different policy packages. The time dimension (short range versus long range) of these policy options is not specifically addressed but can be inferred from the data in Tables 1 and 2. In general, the policy emphasis of this approach is designed to indicate how government leadership in energy contingency planning might be structured. Policies are classified according to whether they restrict the cost of automobile travel, the availability of automobile travel and parking capacity, the capabilities of the automobile fleet, the capabilities of the nonautomobile transportation system (i.e., expansion rather than restriction), or in other ways. Table 3 also suggests the type of traveler-behavior response to be expected (e.g., reduction in travel, change in mix of trip purposes, and shift in mode).

Still another approach to the packaging of conservation actions is also organized around constraints on

Table 3. Classification of potential transportation energy policies.

Potential Energy Policy	Potential Travel-Behavior Response: Reduced Travel	Trip Purpose Change	Modal Shift	More Efficient Cars	Trip-End Relocation	Peak-Hour Shift
Increase the cost of automobile travel relative to travel by other modes	Yes	Yes	If available	For gasoline tax only	?	X
Increase fuel cost, either by tax or market rises in price						
Increase in automobile storage (parking) costs via parking fees						
Increase in automobile purchase price by tax or market price increases						
Increase in the time cost of automobile travel by enforced lower speed limits						
Reduce costs of other modes by changes in production technology or direct fare subsidy						
Limit the supply of automobile fuel (gasoline) available to travelers	Yes	Yes	If available	Yes	X	
Government-imposed fuel-rationing systems						
Market shortages (probably caused by external events or price controls)						
Restrictive queuing processes for gasoline purchase (i.e., odd and even days)						
Physically limit the use of automobiles	?	X	If available	X	Possibly	X
Enforced automobile-free zones at major trip destination zones						
Highway lanes reserved for buses only						
Drastically reduced parking capacity at major trip destination zones						
More restrictive driver-licensing regulations						
Change the characteristics of automobiles	X	X	X	Yes	X	X
Excise tax-rebate system based on fuel efficiency						
Enforced fuel-efficiency regulations on new vehicles						
Annual registration fees based on fuel efficiency						
Encouragement of new technology						
Change characteristics of nonautomobile transportation systems	Possible increase	X	Slight	X	X	X
Subsidies for expanded, improved existing transit systems						
Encouragement of vanpooling by subsidy, graduated tolls, or graduated parking fees						
Encouragement of new systems such as demand-activated minibus systems and people-movers						
Influence the geographic distribution of trip ends	Yes	X	If available	X	Yes	X
Encourage industrial parks						
Encourage large commercial centers						
Encourage higher-density residential development in close proximity to work and shopping centers						
Attempt to directly change travel patterns	?	Yes	Possibly	X	X	Yes
Modified work week (e.g., four-day week)						
Staggered work shifts						

transportation supply and demand, which are further distinguished by mode and component of travel behavior, and also by stressing two different impact time horizons (2). These time horizons involve expected time to implement—30 days or less and 6-24 months; see Table 4 (2). To reflect the fact that time required to implement could lead to different degrees of implementation, several specific conservation actions exist under both time horizons (particularly strategies that relate to ridesharing where impact can be expected to vary according to the level of government financial and promotional support and the market response of consumers over time).

Among the six action packages indicated in Table 4, an important distinction is made as to whether they related directly or indirectly to transportation fuel conservation. Direct conservation strategies generally involve ways to make the existing use of private automobiles (primarily) more efficient, while indirect strategies generally deal with improvement in nonautomobile modes designed to induce a modal shift. Direct conservation strategies might be regarded as achieving increased vehicle miles per gallon, while indirect strategies involve achieving increased person miles per gallon (and also include actual reductions in travel demand itself).

Confidence building is also singled out as a distinctly different kind of contingency "package" or action. Note also that, under direct conservation, a variety of voluntary conservation actions by individual motorists, all designed to increase fuel efficiency, is included. One of the more striking results of the 1979 fuel shortages in Illinois, for example, was the realization that a 5-10 percent transportation fuel shortfall can be accommodated relatively easily via such voluntary adjustments in personal travel behavior. Voluntary conservation measures were encouraged by Illinois' governor and by other state and local agencies, and, though data on specific travel behavior responses were not collected, it would appear that the cumulative effect of a variety of actions by individual motorists was sufficient to reduce consumption to a level consistent with reduced supplies. An important related role for confidence-building public information offices, either on the state or local levels, is consequently evident in order to encourage voluntary conservation.

Clearly, these different approaches to packaging and classifying potential energy conservation actions indicate the widely varying scale at which such actions might be taken. This scale is, in turn, reflected in anticipated time horizons of impact, time necessary to implement, and therefore potential use in short-range energy contingency planning.

Within specific urban areas, limited experience to date suggests that local and regional agencies tend to address mode-specific conservation actions whose implementation responsibilities are clear. For example, a series of five program packages was identified in Denver, with the first four of these addressing actions that could be taken (9, 10) within specific modes—ridesharing (carpool or vanpool), transit, parking, and preferential treatment (street or highway mode). Three different incremental-program package alternatives are indicated in Table 5 (11). These vary by (a) number of specific actions included and (b) degree of emphasis or investment with regard to specific actions. The sequential or incremental nature of these alternative packages, each increasing the degree of government effort over the previous package, is a particularly important feature of responsive energy contingency planning. Ideally, with an effective weekly or monthly monitoring program, public agencies could move from one set of conservation packages (i.e., one program) to another in response to monthly shifts in the degree of energy shortfall.

Table 4. Implementation time horizons for selected energy conservation measures.

Conservation Measure	Implementation: 30 Days	Implementation: 6-24 Months
Confidence building		
Public information office	X	
Direct conservation		
Voluntary conservation	X	
Carpooling to work		
Neighborhood ridesharing (nonwork)		
Use 3 gal less per week per vehicle		
Multipurpose trips		
Reduced automobile air-conditioning		
Vehicle maintenance		
Increased transit		
Use fuel-efficient vehicle		
Public carrier for recreation travel		
Phone communication		
Nonmotorized travel		
Reduced public vehicle use	X	
Enforcement of 55-mph limit	X	
Enforcement of 50-mph limit	X	
Reduced use of transit air-conditioning	X	
Voluntary sales management	X	
Mandatory sales management	X	
Restrict weekend use of recreational vehicles	X	
Indirect conservation		
Ridesharing		
Employer-sponsored carpools	X	X
Employer-sponsored vanpools	X	X
Preferential parking for multiple-occupancy vehicles	X	X
One carless day per week	X	X
Preferential lanes for multiple-occupancy vehicles	X	X
Park-and-ride lots	X	X
Transit and land use relations		
Transit service for discretionary travel	X	
Expand transit service	X	X
School bus use	X	
Staggered work hours	X	X
Differential transit fare	X	
Four-day work week		X
Telecommunications		X
Street improvements		
TOPICS		X
On-street parking		X
Bikeways		X
Automobile-free zones		X
Economic disincentives		
Parking tax		X
Gasoline-guzzler tax		X
Registration fee (multiple automobiles)		X
Additional gasoline tax		X
Driving age		X

ESTIMATING INDIVIDUAL AND CUMULATIVE IMPACTS

The complex array of potential energy-conserving actions and the many different ways in which different levels of implementation of such actions can be combined into complementary packages present major problems in the analysis of potential impacts. In general, analysis of direct impacts (i.e., fuel savings) has followed a sequence of analyzing potential reductions in vehicle miles of travel (VMT), which may or may not reflect a preceding analysis of modal shift potentials for person travel, with further variations by trip purpose or peak- and off-peak travel periods possible. Estimated VMT reductions have typically been converted to transportation fuel-use reductions and overall petroleum-based energy consumption reductions for an urban area or state.

As a part of the shift toward transportation system management (TSM) as a major strategy for short-range transportation system improvement in urban areas, a number of federally sponsored analyses of modal shift or VMT reduction potential have already been completed (12-23). Results of these analyses are equally applicable in the analysis of energy conservation potentials for such TSM strategies. Although the general conclusion drawn from these earlier studies is that no single TSM or energy-conserving action is likely to have major impact (beyond a reduction of 1 percent or less in VMT), the literature on travel-behavior response to TSM (and related actions) indicates a limited capability to carefully analyze such responses (24-27). Few real data exist on the actual travel impact of individual TSM strategies.

The Illinois Energy Contingency Plan provides further insights into the uncertainties associated with estimating both the individual and the cumulative impacts of energy-conserving actions (2). In that project, uncertainty was reflected by the use of fairly broad ranges of potential impact for individual conservation actions only. Because our knowledge about overlapping, competing, and cumulative impacts is sparse, it is left to the reader to judge the extent to which individual actions constituting a package would reinforce one another and, particularly, to estimate net total impact. Due to the short time frame of the study itself, major reliance was placed on the TSM travel-behavior impact literature, as well as on limited sensitivity analyses of a logit modal-split model previously calibrated for the Chicago region (2).

Table 6 (2) summarizes the estimated reduction in VMT and annual fuel saving associated with 20 quick-response transportation energy conservation measures studied in Illinois (all potentially implementable within 30 days). As discussed earlier, the table distinguishes between direct conservation measures, which address the manner in which transportation fuels are used by vehicles of different types, and indirect measures, which address more fundamental changes in travel behavior that can either (a) induce

Table 5. Summary of alternative program packages developed in Denver.

Measure	Program 1	Program 2	Program 3
Ridesharing	Employer promotion and matching in all firms with 50 or more employees	Employer promotion and matching in all firms with 50 or more employees; vanpooling available in all firms with 250 or more employees; transit fare subsidy of 50 percent available to all workers; preferential carpool parking	Employer promotion and matching in all firms with 50 or more employees; vanpooling available to all firms with 250 or more employees; transit fare subsidy of 50 percent available to all workers; preferential carpool parking
Transit	Improved frequency on CBD routes	Improved frequency on CBD routes; 20 percent reduction in in-vehicle travel time for CBD routes	25 percent areawide improvement in frequency; 20 percent reduction in in-vehicle travel time for CBD routes
Parking	Increased commuter parking costs in CBD by $1/day	Increased commuter costs in CBD by $1/day; reduced parking availability so that round-trip walk times are increased by 10 min	Increased commuter costs areawide by $1/day; reduced areawide parking availability so that round-trip walk times are increased by 10 min
Preferential treatment	–	Improved areawide level-of-service for all vehicles by 5 percent	Improved areawide level of service for all vehicles by 5 percent
Pricing	–	–	Triple the price of fuel in terms of 1965 dollars

Table 6. Estimated direct impacts of 30-day transportation energy conservation measures in terms of annual fuel saving and reduced VMT.

Measure	Estimated Annual Fuel Saving: Gallons per Year (000 000s)	Estimated Annual Fuel Saving: Btu per Year (000 000 000 000s)	Estimated Annual Fuel Saving: Reduction in Total Energy Use[a] (%)	Estimated Annual Fuel Saving: Reduction in Transportation Fuel Use (%)	Estimated Reduction in Annual VMT: Amount (000 000s)	Estimated Reduction in Annual VMT: Percent[b] Statewide	Estimated Reduction in Annual VMT: Percent[b] Chicago Region	Estimated Reduction in Annual VMT: Percent[b] Peoria Region
Direct conservation								
Voluntary conservation								
Carpooling to work	15.5-116.30	1.94-14.50	0.05-0.40	0.2-1.8	216-1620	0.4-0.7	0.5-0.8	0.2-0.4
Neighborhood ridesharing (nonwork)	38.80	4.85	0.10	0.6	540	1.0-2.5	1.2-3.2	1.0-2.4
Use 3 gal less per week per vehicle	194.0-775.00	24.20-96.90	1.00-2.00	3.0-2.0	2700-9180	5.0-17.0	8.0-24.0	5.6-16.9
Multipurpose trips	19.4-38.80	2.42-4.85	0.06-0.10	0.3-0.6	270-540	0.5-1.0	0.6-1.6	0.5-1.2
Reduced automobile air-conditioning	15.5-23.30	1.94-2.91	0.05-0.07	0.2-0.4	0	0	0	0
Vehicle maintenance	15.5-31.00	1.94-3.88	0.05-0.10	0.2-0.5	0	0	0	0
Increased transit	19.4-38.80	2.42-4.85	0.06-0.10	0.3-0.6	270-540	0.5-1.0	1.1	0.2
Use fuel-efficient vehicle	15.5-27.10	1.94-3.39	0.05-0.08	0.2-0.4	0	0	0	0
Public carrier for recreation travel	11.6-58.10	1.45-7.26	0.04-0.20	0.2-0.9	162-810	0.3-1.5	0.3-1.5[c]	0.3-1.5[c]
Phone communication	11.60	1.45	0.04	0.2	162	0.3	0.0-1.0[c]	0.0-1.0[c]
Nonmotorized travel	19.4-31.00	2.42-3.88	0.06-0.10	0.3-0.5	270-432	0.0-0.4	0.0-0.4	0.0-0.4
Reduced public vehicle use	7.57	0.95	0.02	0.1	105	0.2		
Enforcement of 55-mph limit	19.4-34.90	2.42-4.36	0.06-0.10	0.3-0.5	0	0	0.8[d]	0.9[d]
Enforcement of 50-mph limit	38.8-50.40	4.85-6.30	0.10-0.20	0.6-0.2	0	0	1.5[d]	1.2[d]
Reduced use of transit air-conditioning	0.04-0.07	0.0005-0.01	Negligible	0.001-0.002				
Restrict weekend use of recreational vehicles	27.10	3.39	0.08	0.400	162	0.30		
Indirect conservation								
Transit service for discretionary travel	3.90	0.48	0.01	0.060	54	0.10	0.10	NE[e]
Employer-sponsored carpools	38.80	4.85	0.10	0.60	540	1.00	1.40	1.10
Employer-sponsored vanpools	38.80	4.85	0.10	0.60	540	1.00	1.40	1.10
Preferential parking for multiple-occupancy vehicles	1.9-3.90	0.24-0.48	0.006-0.01	0.03-0.060	27-54	0.05-0.50	0.65	0.05-0.10
One carless day per week	387.60	48.50	1.20	6	5400	5.0-10.0	5.0-10.0	10.0
Preferential lanes for multiple-occupancy vehicles	38.8-116.30	4.85-14.50	0.1-0.40	0.6-1.800	540-1620	1.0-3.0	1.0-3.0	NE[e]
Temporary park-and-ride lots	1.9-3.90	0.24-0.48	0.006-0.01	0.03-0.060	27-54	0.7-0.6	0.5-1.0	NE[e]
Expand transit service	19.4-38.80	2.4-4.80	0.06-0.10	0.3-0.600	270-540	0.5-2.0	0.5-1.0	1.0-3.0
Differential transit fare	1.9-3.90	0.24-0.48	0.006-0.01	0.03-0.060	27-54	0.5-1.0	0.6-1.1	0.4-1.0

[a] For both transportation and nontransportation purposes.
[b] Percentage of automoble VMT, unless otherwise indicated.
[c] Statewide average percentage.
[d] Percentage of fuel saved.
[e] No effect.

increases in shared-vehicle transportation or (b) reduce the amount of or demand for passenger miles of travel. Both voluntary and mandatory energy conservation options are included. In some cases, the same measure may have both a voluntary and a mandatory version.

Table 7 (2) summarizes another set of energy conservation measures that, in general, have implementation time frames ranging from 2 or 3 months to 24 months. All of these measures can be classed as indirect, and most are designed to induce a modal shift to more energy-efficient means of personal travel. Many of the measures are characterized as being more permanent, involving facilities and services that are more extensive and capital-intensive than the 30-day measures. The first six measures in Table 7, all associated with some aspect of ridesharing, represent more sustained and intensive efforts of counterpart 30-day versions. The next two measures also represent more intensive versions of corresponding quick-response actions.

These tables illustrate not only the kinds of energy conservation measures that might be considered in statewide and metropolitan energy contingency plans but also the range of actual fuel-use reductions that might be associated with any individual measure.

In Table 6, a number of essentially voluntary (direct or indirect) measures show the potential for (a) significant cumulative impact on VMT, (b) immediate-action response capabilities, and (c) likelihood of general public acceptance. Nearly all such measures show a potential reduction in transportation fuel use of less than 1 percent on an individual basis, but the aggregate effect of several measures in combination can be more pronounced. Among the different voluntary conservation measures suggested, note that several involve no reduction in actual VMT but, instead, emphasize more fuel-efficient operation of the private vehicle fleet (for example, in multiple-car households, the emphasis is on the use of the most fuel-efficient vehicle). Other voluntary measures emphasize actual reduction in passenger miles and vehicle miles of discretionary travel (e.g., shopping, personal business, social, and recreational) that might be achieved, for example, by multiple-purpose trips (e.g., trip chaining).

Most of the indirect conservation measures listed in Tables 6 and 7 involve different approaches to stimulate or induce a shift from private vehicular travel to ridesharing (carpool or vanpool) or to public transit options. An overriding issue associated with desired or targeted shifts to more fuel-efficient modes consequently centers simply on the probability that such shifts can actually be achieved in the unrestrained consumer marketplace.

For all of the indirect conservation measures listed in Tables 6 and 7, the answer to this question is generally that only rather limited, purely voluntary, shifts to group travel modes should be expected. Results of most urban area travel-demand analyses indicate that, particularly within a 30-day implementation time frame, the kinds of transit or group travel service improvements and promotional campaigns that are possible should not be expected to induce modal shifts of more than a few percentage points. Perhaps the most challenging of the factors affecting implementation difficulty are associated with the modal shift issue.

Tables 8 and 9 (2) summarize judgmental estimates of indirect impact in the Illinois study for the same energy conservation measures listed in Tables 6 and 7. Such indirect impacts of energy conservation on transportation use, performance, and concomitant impacts are likely to have a limited effect on implementation decision making.

Table 7. Estimated direct impacts of transportation energy conservation measures implementable in 6-24 months in terms of annual fuel saving and reduced VMT.

Measure	Estimated Annual Fuel Saving				Estimated Annual Reduction in VMT			
						Percent[b]		
	Gallons per Year (000 000s)	Btu per year (000 000 000 000s)	Reduction in Total Energy Use[a] (%)	Reduction in Transportation Fuel Use (%)	Amount (000 000s)	Statewide	Chicago Region	Peoria Region
Ridesharing								
Carpool and vanpool	36.5	4.57	0.12	0.6	509.2	0.94	1.4	1.1
Preferential parking	13.95	1.733	0.05	0.2	193.7	0.36	0.65	0.1
Carless day	286.4-387.6	35.8-48.46	0.92-1.25	4.4-6.0	3990.0-5400.0	7.39-10.00	5.0-10.0	10.0
Preferential treatment	20.2-60.7	2.53-7.59	0.07-0.20	0.3-0.9	282.0-846.0	0.52-1.57	1.0-3.0	
Park-and-ride	1.01-2.02	0.127-0.253	0.003-0.007	0.02-0.03	14.1-28.2	0.03-0.05	0.05-0.10	
Transit and land use relations								
Transit service improvements	17.57-42.60	2.20-5.33	0.06-0.14	0.3-0.7	245.0-594.0	0.45-1.1	0.5-1.0	1.0-3.0
Staggered work hours	Up to 23.93	Up to 2.997	Up to 0.08	Up to 0.4				
Four-day work week	27.67-166.3	3.46-20.8	0.09-0.54	0.4-2.6	386-2316	0.7-4.3	1.0-6.0	1.0-6.0
Telecommunications	Up to 27.7	Up to 3.46	Up to 0.09	Up to 0.43	Up to 386.0	Up to 0.71	Up to 1.0	Up to 1.0
Street improvements								
TOPICS	Up to 23.93	Up to 2.997	Up to 0.08	Up to 0.4	Up to 334.0	Up to 0.6	Up to 1.0	Up to 0.5
On-street parking	Up to 23.93	Up to 2.997	Up to 0.08	Up to 0.4	Up to 334.0	Up to 0.6	Up to 1.0	Up to 0.5
Bikeways	Up to 13.83	Up to 1.737	Up to 0.05	Up to 0.2	Up to 193.0	Up to 0.4	Up to 0.5	Up to 0.5
Automobile-free zones	11.53-53.59	1.46-6.703	0.04-0.17	0.2-2.8	161.8-746.6	0.3-1.4	0.5-2.5	0.2-0.4
Economic disincentives								
Parking tax	87.3-125.4	10.91-15.69	0.28-0.40	1.4-1.9	1215.8-1747.4	2.3-3.2	3.5-4.5	2.2-4.6
Gasoline guzzler tax	19.3-38.8	2.42-4.85	0.11	5.4				
Registration fee (multiple automobiles)	34.9	4.36	0.06-0.12	0.3-0.6	486.0	0.9	0.9	0.9
Additional gasoline tax	68.3-145.8	8.53-18.22	0.22-0.47	1.1-2.3	951.0-2031.0	1.8-3.8	2.0-4.0	1.5-3.5
Driving age	38.7	2.32	0.12	0.6	540.0	1.0	1.0	1.0

[a]For both transportation and nontransportation purposes. [b]Percentage of automobile VMT, unless otherwise noted.

Table 8. Estimated indirect impacts of 30-day transportation energy conservation measures given certain criteria.

Measure	Criterion						Comment
	Shift to Group Travel[a]	Change in Travel Behavior[b]	Reduction in Peak-Hour Congestion[c]	Improvement in Air Quality	Improvement in Traffic Safety	Undesirable Economic Impact[d]	
Direct conservation							
Voluntary conservation							
Carpooling to work	3	1	3	2	2	1	
Neighborhood ridesharing (nonwork)	1	2	1	1	1	–	
Use 3 gal less per week per vehicle	2	3	1	3	3	2	High level of voluntary change in travel behavior required
Multipurpose trips	1	3	1	2	–	–	
Reduced automobile air-conditioning	–	–	–	2	–	–	
Vehicle maintenance	–	–	–	2	1	–	
Increased transit	2	1	1	1	1	–	
Use fuel-efficient vehicle	–	–	–	2	–	–	
Public carrier for recreation travel	2	2	–	1	1	1	
Phone communication	–	–	–	–	–	–	
Nonmotorized travel	–	1	–	1	–	–	
Reduced public vehicle use	–	–	–	–	–	–	
Enforcement of 55-mph limit	–	–	–	1	2	–	
Enforcement of 50-mph limit	–	–	–	1	3	1	Likely to be unpopular, especially with trucking industry
Restrict weekend use of recreational vehicles	–	2	–	–	–	2	Difficult to enforce; adverse effect on tourist industry
Indirect conservation							
Transit service for discretionary travel	1	1	–	–	–	–	
Employer-sponsored carpools	2	–	1	1	1	–	
Employer-sponsored vanpools	2	–	1	1	1	–	
Preferential parking for multiple-occupancy vehicles	1	–	1	1	–	–	
One carless day per week	3	3	3	3	3	2	Likely to be unpopular with motoring public
Preferential lanes for multiple-occupancy vehicles	3	1	2	1	1	–	
Temporary park-and-ride lots	1	–	–	–	–	–	
Expand transit service	2	1	1	1	1	–	
Limited staggered work hours	–	–	3	1	–	–	

Note: 1 = minor effect; 2 = moderate effect; 3 = major effect.

[a]Transit, carpool, or vanpool.
[b]Reduced frequency or length of nonwork-related (discretionary) travel.
[c]Transit or highway.
[d]Increased unemployment or disruption to economic activity patterns.

Table 9. Estimated indirect impacts of transportation energy conservation measures implementable in 6-24 months given certain criteria.

Measure	Criterion						Comment
	Shift to Group Travel[a]	Change in Travel Behavior[b]	Reduction in Peak-Hour Congestion[c]	Improvement in Air Quality	Improvement in Traffic Safety	Undesirable Economic Impact[d]	
Ridesharing							
Carpool	3	1	3	2	2	1	
Vanpool	2	–	1	1	1	–	
Preferential parking	1	–	1	1	–	–	
Carless day	3	3	3	3	3	2	
Preferential treatment	3	1	2	1	1	–	
Park-and-ride	1	–	–	1	–	–	Suburban station area impacts; more automobile congestion
Transit and land use relations							
Transit service improvements	2	1	1	1	1	–	
Staggered work hours	1	3	3	1	–	2	Change pattern of business
Four-day work week	3	3	2	–	–	3	Major shifts in business activity patterns
Telecommunications	–	3	2	2	1	–	Stimulates some business growth
Street improvements							
TOPICS	–	–	3	1	3	–	
On-street parking	–	–	1	–	1	1	Curb parking important to certain businesses
Bikeways	–	2	2	3	–	–	
Automobile-free zones	1	–	1	3	–	1	Could be major benefit as part of redevelopment
Economic disincentives							
Parking tax	2	2	–	1	–	2	Uneven distribution effects are problems
Gasoline-guzzler tax	1	1	–	2	–	2	Reduced sales of larger vehicles and recreational vehicle business
Registration fee (multiple automobiles)	1	2	–	–	–	1	Reduced automobiles sales and services
Additional gasoline tax	2	2	1	1	–	3	Regressive tax; impact on low-income groups
Driving age	2	3	2	–	2	3	Retards employment; negative impact on drive-ins and other automobile-oriented businesses

Note: 1 = minor effect; 2 = moderate effect; 3 = major effect.

[a] Transit, carpool, or vanpool
[b] Reduced frequency or length on nonwork travel.
[c] Transit or highway.
[d] Increased unemployment or disruption to economic activity patterns.

For one thing, two areas of indirect impact—improvements in air quality and traffic safety—are likely to be beneficial. The reductions in VMT that can help achieve energy conservation are the same VMT reductions associated with reduced air pollutant emissions and lower accident statistics. Although related changes in travel behavior—for example, shift to group travel and reduced frequency or length of nonwork travel—may be viewed as undesired travel hardships by some participants, such feelings of dissatisfaction are not likely to be strong.

Two other kinds of indirect impacts listed in these tables are, however, significant in nature. These impacts—undesirable economic disruption and reduction in peak-hour congestion—should perhaps receive more attention as decision-making criteria for assessing energy conservation options. Undesirable economic impacts that could affect lower-income families, and automobile-oriented commercial enterprises particularly, are generally associated with economic disincentives aimed at the automobile traveler. In addition to these kinds of distributional impact questions within urban areas, some of the stronger energy conservation options aimed at private automobile travel could also impact automobile-purchasing patterns, thus reinforcing the general trend toward smaller and more fuel-efficient vehicles.

In the longer term, reductions in peak-hour automobile congestion are likely to offer continuing and strong incentives for a return to automobile travel. This kind of return-to-normal risk in sustained energy contingency programs should not be underestimated.

STAGING OF ALTERNATIVE CONTINGENCY PLANS

In the Illinois contingency plan, the delineation of packages of energy conservation measures was accompanied by the definition of four alternative scenarios of energy emergency. These scenarios were defined quite simply in terms of the percentage reduction in transportation fuels (primarily gasoline) expected on a month-to-month basis. The four levels ranged from 10 percent to 25 percent shortfall, in five-percentage-point increments.

Figure 1 summarizes an initial attempt to match several quick-response energy conservation packages against the level of energy shortfall for which they seem most appropriate. While such a match was found to be of value at a conceptual or organizational level, participants in the study were not able to reach agreement on the extent to which some individual conservation measures were more or less appropriate for different shortfall levels. In fact, because the level of effort associated with a particular conservation strategy might itself vary with the degree of shortfall, one-step definitions of energy conservation measures tend to be overly simplistic.

Different energy shortfall scenarios should consequently not be expected to have only a single set of applicable energy conservation options. Rather, not only are different individual conservation measures likely to be applicable (at varying levels of effort or public and private commitment), but such individual measures could be combined in different ways to reinforce one another and to reinforce other packages. Full exploration of this kind of multiple matching of conservation measures against shortage scenarios was not possible within the time frame established for the Illinois study. Nevertheless, it should form an important part of more detailed energy contingency planning. As indicated above, the number of alternative actions that have a bearing on energy conservation appears to be quite numerous.

Preliminary analysis of alternate energy shortfall scenarios has also been an important part of transportation energy contingency planning in New York State (7, 8). Four

Figure 1. Illustration of the staging required for 30-day program packages directed toward energy conservation.

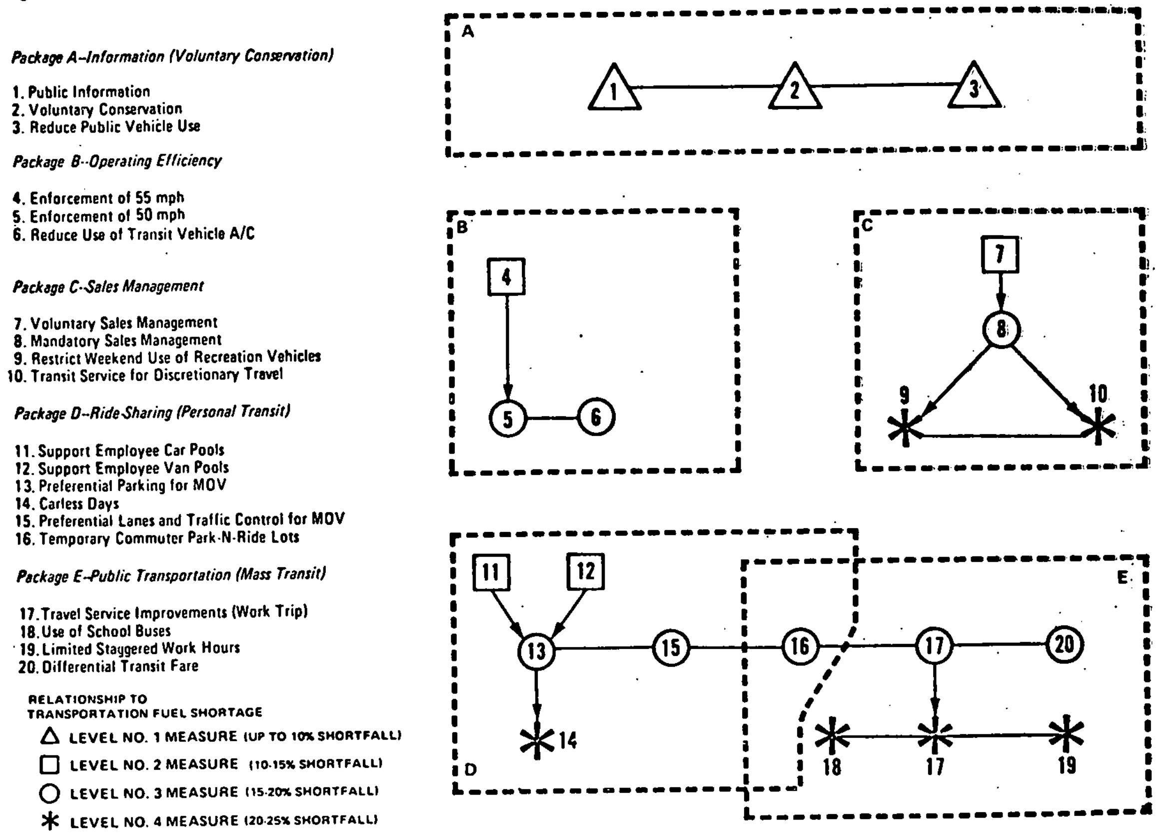

Table 10. Transportation energy contingency scenarios developed for New York State.

Scenario	Gasoline Price ($/gal)	Gasoline Shortfall (%)	Time Horizon	Probability of Occurrence	Immediate Characteristic
Level 1 (relax)	0.95-1.05	1-3	1 year	0.3	Some reduction of nonwork travel, slight shift to transit and ridesharing, trip chaining (multipurpose trips), continued surge in small-car purchasing
Level 2 (muddle)	1.00-1.05	5-10	15-18 months	0.5	Level 1 responses plus increase in commuter transit travel, reduction in weekend travel, further reductions in discretionary travel
Level 3					
Crisis A	0.92-0.98	8-14	Unknown	0.2	Level 2 responses plus long lines at service stations, odd-even rationing, shorter station hours
Crisis B	1.05-1.10	10-20	Unknown	0.2 (after Crisis A)	Level 3-A responses plus transit ridership up another 15-30 percent, summer vacations curtailed, rapidly rising gasoline prices

different scenarios on three levels were identified and are summarized in Table 10 (8). Although clearly speculative in nature, the relative differences among the scenarios are indicative of some of the important indicators that bear monitoring. These include price increases (although price increases since May 1979 have already outstripped each of the scenarios), degree of supply shortfall compared to previous years, time horizon, changes in hours and practices of service stations, observable changes in travel behavior, and modal shifts to transit and shared ride. Though probabilities of occurrence in Table 10 are largely judgmental, such scenarios as "muddle" (probability of occurrence = 0.5) may help put other more optimistic or pessimistic scenarios in perspective. This kind of multiple contingency response to varying energy shortfall scenarios has also been explored at the regional level (5, 28).

UNCERTAINTY REGARDING EFFECTIVENESS

As discussed earlier, the comparison of recent energy contingency plans indicates high levels of uncertainty associated with forecasted travel impacts. Not only is uncertainty associated with the individual and cumulative impacts of different energy-conserving actions, but compounding uncertainties are associated with the timing and duration of transportation fuel shortfalls, as well as with the timing and extent of the implementation of any individual conservation action.

One useful way to summarize these uncertainties is to focus specifically on the types of travel most likely to be affected by different actions. Returning to the broader long-range and short-range inventory of potential energy conservation methods discussed earlier (6), it is possible to identify seven different types of urban-oriented trip making that represent high-priority targets for energy conservation. Table 11 (6) matches these different targets against the various potential energy conservation methods, thus indicating which type of travel is most likely to be affected by a given strategy. The lack of specific quantitative estimates of impact in Table 11 is a corresponding reflection of the uncertainty associated with degree of impact, not only for any given conservation action but also with regard to the differential impact on different types of trip making.

Table 11. Impact of potential methods for conserving energy on urban travel components.

Group	Potential Method for Conserving Energy	Impact of Energy-Conserving Method: Long Trips (All Purposes)	Work Trips	Shopping	Social, Recreational	Trips Within One Mile	Transit Trips	Freight Transportation
Travel of persons	Increase duration but decrease frequency of vacation trips	X						
	Increase vehicle loading (car occupancy) by (a) building HOV lanes and (b) building carpool parking lots		X	X	X			
	Increase trip chaining			X	X			
	Decrease trip production			X	X			
	Decrease trip length	X						
	Increase number of walking trips					X		
	Increase use of bicycles and mopeds					X		
	Work at home		X					
	Increase carpools and vanpools for work trips		X					
	Speed purchase of fuel-efficient vehicles	X	X	X	X	X		
	Increase use of transit		X				X	
Freight transportation	Increase or reduce truck size (for efficiency)							X
	Increase truck loading (for efficiency)							X
	Reduce empty backhauling							X
	Increase efficiency of truck routing							X
	Consolidate urban deliveries							X
Urban infrastructure (built environment)	Increase density of residential settlement, particularly on transit routes	X	X	X	X	X	X	
	Increase density of nonresidential settlement, decrease scatter	X	X	X	X		X	X
	Establish multiuse urban centers and subcenters	X	X	X	X		X	X
	Provide telecommunications substitutes for travel	X	X				X	
	Establish automobile-restricted zones							
Economic and institutional infrastructure	Establish four-day work week		X				X	
	Initiate Sunday store closings			X	X			
	Restrict store hours			X	X			
	Operate more, but smaller, store units		X	X				
Transportation infrastructure (streets, parking)	Install TOPICS, other signal improvements							
	Install computerized traffic control systems		X	X				
	Install access ramp metering	X						
	Convert to one-way street systems	X						
	Convert lanes to HOV lanes	X						
	Provide preferential HOV lanes at toll gates	X						
	Build preferential access ramps	X						
	Provide traffic engineering improvements for buses		X					
	Provide better service to pedestrians					X		
	Provide bikeways and bike lanes					X		
	Reduce or increase number of parking spaces							
	Increase parking rates		X	X				
	Provide differential parking rates		X	X				
	Limit parking (percentage system)		X				X	
	Provide parking for carpools and vanpools		X					
	Provide parking for bus passengers		X				X	
	Differential peak-hour tolls		X					
	Create automobile-restricted zones						X	
	Restrict trucks on routes and in certain areas							X
	Improve road surfaces							
	Enforce 55-mph limit	X						
	Provide adequate arterial and expressway capacity	X						
Transportation infrastructure (transit)	Improve routing and scheduling of buses		X	X			X	
	Provide express bus service		X				X	
	Park-and-ride service		X				X	
	Provide shuttle bus to CBDs with peripheral parking		X	X			X	
	Improve passenger amenities		X	X			X	
	Improve fare-collection systems		X	X			X	
	Improve passenger information		X	X			X	
	Provide demand-responsive system			X			X	
	Improve vehicle maintenance						X	
	Improve radio communications to buses						X	
	Install bus bays						X	
	Provide high-speed bus service between cities	X					X	
	Increase distances for students walking to school					X		
	Prohibit taxi cruising							
Transportation infrastructure (rail and truck)	Implement TOFC trains between urban areas							X
	Consolidate urban deliveries of small freight shipments							X
	Increase waterborne transportation							X
	Require adequate urban truck-loading facilities							X
	Ban truck idling							X
Vehicle fleet	Reduce automobile size and weight	X	X	X	X	X		
	Selectively remove pollution control devices							
	Increase engine energy efficiency	X	X	X	X	X		
	Reduce truck sizes							
	Reduce number of panel trucks and pickups							
	Use electric vehicles							
Energy and economic factors	Increase fuel price	X	X	X	X	X	X	X
	Make fuel unavailable	X	X	X	X	X	X	X
	Ration gasoline	X	X	X	X	X	X	X

Note: X indicates positive impact of energy-conserving action on urban travel component.

Table 12. Energy policy testing based on key UTPS variables.

Policy	Key UTPS Variable	Other Essential Element	Short-Term Forecast: S	E	Difficulty[a]	Overall Capabilities to Test Now
Speed reductions	Distribution (nonwork) modal split		H	L	1	Good
Increased fuel efficiency	Assignment, evaluation	Base (mile/gal)	H	–	1	Good
Transit fare reductions	Distribution modal split		H	M	2	Good
Carpooling	Automobile occupancy		H	L	2	Medium
Increased parking charges	Distribution modal split		H	L	2	Medium
Tax on gasoline	Generation, distribution, and modal split	Gasoline price elasticity	M	L	2	Medium
Staggered work hours, four-day week	Generation and modal split		M	L	3	Medium
Transit use increase due to gasoline price increase	Modal split	Gasoline price forecast; elasticity	M	L	2	Medium
Automobile-restricted zones	Distribution modal split	Redistribution activities	M	M	2	Fair
Gasoline price increase (general)	Generation, distribution, and modal split	Gasoline elasticity by trip purpose; disposable income reallocation	M	–	3	Poor
Gasoline at higher price if car gets low mileage per gallon (gas guzzler)	Generation, distribution, and modal split	Selective trip priorities, frequencies	M	L	3	Poor
Fixed-ration ceiling	Generation, distribution, and modal split (location)	Trip priorities	M	L	3	Poor
Sunday driving ban		Weekend travel patterns, behavior	L	L	4	Poor
Urban activity redistribution	Land use activity	Long-term elasticity; redistribution of activities	L	L	5	Poor

Note: S = sensitivity; E = estimate; H = test can be done; M = some elements possible; L = weak test possible.
[a]Ranked in ascending order of difficulty from 1 (easy) to 5 (very difficult).

The high-priority targets include the following (6):

1. Long trips—all trips more than 6 miles in length and particularly those more than 12 miles in length, without regard to purpose;
2. Work trips—longer-than-average trips that generate approximately 38 percent of daily automobile VMT, or 43 percent of business trips related to work;
3. Social or recreational trips—trips that generate approximately 15 percent of daily automobile VMT;
4. Shopping trips—trips that generate approximately 15 percent of daily automobile VMT;
5. Travel and trip making in exurban and rural areas—especially long trips and to the extent that they are made in panel or pickup trucks and consume extra amounts of gasoline;
6. Trips of less than 1 mile in length—trips that create only a small percentage of total VMT (approximately 3 percent), but walking and bicycles or mopeds can substitute for them if proper facilities are available; and
7. Truck transportation—trips that make up 12-14 percent of VMT daily and probably consume 19-23 percent of available daily gasoline or diesel fuel supply because of trucking's higher energy requirements.

Lack of hard empirical data documenting observed travel-behavior changes for most energy conservation actions and a dearth of knowledge regarding complementary impacts of conservation action packages provide for most of the forecasting uncertainty that should be recognized. Though this uncertainty is consequently significant, existing transportation-demand-modeling capabilities do provide methods for estimating likely modal shifts. As summarized in Table 12 (7), demand-forecasting models within the urban transportation planning system (UTPS), which covers trip generation, distribution, modal split, and assignment, provide a reasonable capability for testing those kinds of conservation policies listed at the top of Table 12 (i.e., service levels) but relatively poor capability for testing those policies listed at the bottom (i.e., broader policies).

Continuing research with sketch-planning level-of-detail demand-forecasting models has further improved our capability to conduct sensitivity analyses of energy conservation actions (1, 11, 29-31). Though the capabilities and limitations listed in Table 12 for UTPS-based models are still applicable, such analytical capabilities as the Short-Range Generalized Policy (SRGP) analysis modeling package provide a strengthened capability to test a wider range of area-specific conservation actions with relatively quick turnaround time and limited staff and data requirements.

When accommodating the stratification of households by geographic location and socioeconomic level, such sketch-planning models provide an improved ability to estimate the relative incidence of conservation action impacts. Interrelated model linkages between steps in travel-behavior decision making (e.g., automobile ownership, work-trip modal choice, non-work-trip generation, and non-work-trip distribution and modal choice) are an important feature of the SRGP package (11, 29). This package has also been used to examine the synergistic (and competing) interactions of energy conservation actions. Further application of such sensitivity-analysis tools consequently represents a major area for continued work in impact analysis for a wide range of energy-conserving actions.

IMPLEMENTATION ISSUES

One of the confusions created by the multiplicity of potential energy conservation measures is the tendency to overlook the aggregate effect of any significant success for those measures—especially those oriented toward encouraging modal shift—on existing transit capacities.

As an example, for medium-sized regions, a shift of only 7 percent of former automobile users to public transit during peak hours of travel could mean as much as a doubling of transit ridership volumes (given a typical peak-hour regional modal split to transit of 5 percent today). Tables 6 and 7 indicate that such a 7 percent modal shift is not unreasonable under a number of different combinations of energy conservation options. Major operational, cost, and funding problems will obviously be created for already hard-pressed bus transit systems in nearly every medium-sized urban area across the country (though relative impacts on the six larger U.S. regions with rail transit systems would be somewhat less).

Some additional capacity expansion might be possible by accelerating maintenance practices and by maximizing the number of spares and reserve bus vehicles actually in revenue service (including reclamation of older buses). In some cases, new vehicle purchases on order might be delivered early, but, on an industrywide basis, limited vehicle production schedules for transit rolling stock are already being observed. Temporary mobilization of often large school bus fleets in private ownership offers good potential (school buses may represent as much as 30 percent of the public transit bus fleet), but scheduling (during the school year), statutory, and financing problems are significant.

Establishing the clarity of public and private responsibility will be one of the most troublesome factors affecting the implementation of energy-conserving actions in multiple-agency settings. Distinguishing between overall coordination responsibility and project component responsibility will be part of the problem here; it will be further compounded by multiple funding sources and associated procedural restrictions and requirements. In general, administrative and procedural difficulties also seem to increase geometrically as the number of agencies involved in a particular action area is increased.

The six different energy conservation measures aimed at ridesharing, listed both in Tables 6 and 7, provide a good example of these kinds of interagency coordination problems. A variety of state, regional, and local public agencies, as well as major employers and private carriers, can all be involved in these measures—carpooling, vanpooling, preferential parking for multiple-occupancy vehicles (MOVs), preferential lane treatment for MOVs, and park-and-ride facilities. In Illinois, for example, the Institute of Natural Resources has been involved in the statewide promotion of and assistance to employer-sponsored vanpools. The Regional Transit Authority in Chicago is currently undertaking a major program in the promotion and encouragement of carpooling activities and is emphasizing employer sponsorship. Regional and local planning agencies have also been involved in recent ridesharing planning activities. The responsibilities of the private sector, in terms of major employers who participate (administratively or financially) in the inauguration of ridesharing activities, as well as private carriers who may undertake related vanpool or demand-responsive paratransit services, can also be significant.

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The 1979 Energy Crisis: Who Conserved How Much?

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During the 1973-1974 oil embargo and again in 1979, U.S. foreign supplies of petroleum were greatly reduced. Transportation, almost totally dependent on petroleum (1), and New York State, whose dependence on foreign oil is much greater than that of the United States (2), were particularly hard hit. During both periods, prices rose about 35 percent and shortfalls of 11-13 percent were experienced (3). People encountered unpleasant experiences of Sunday station closings, long queues at stations, concern about availability, and odd-even and minimum-purchase restrictions. However, during these two shortfall periods, partial relaxation of supplies, coupled with certain government actions and strong positive consumer response, alleviated the crisis in three or four months. But the U.S. embassy takeover in Iran and the Russian invasion of Afghanistan have once again spurred price increases and raised the specter of shortages.

A large number of analyses have been prepared on energy impacts of transportation actions, but until recently most have focused on conservation actions (4-7). More recent attention has turned to the analysis of actions from a contingency viewpoint—that is, studies of transit system capacity (8-12) and ridesharing (10). County, city, and state-level analyses have only recently been prepared (13-16). These efforts are generally intended to address the issues raised by state or federal legislatures, satisfy DOT requests for energy contingency planning, or provide information and overview to planners (17-18). The Emergency Energy Conservation Act of 1979 provides further impetus for the preparation of such plans. Through the Standby Federal Emergency Energy Conservation Plan (proposed interim final rules, February 1980), the federal government, after setting targets for conservation, can impose plans on states whose own plans or efforts to conserve are not satisfactory. A number of states, notably California (19), have begun such work, and some draft guidelines have been prepared by the Massachusetts Institute of Technology (20).

We are particularly concerned, however, that few, if any, of these studies integrate the role of the consumer into the planning and energy contingency efforts. All the studies we have reviewed are prescriptive in nature, purporting to show what actions, if taken by government, can induce the requisite conservation response from the public. Yet numerous reviews of consumer response during the 1973-1974 and 1979 crises (21-23) show that, in spite of government efforts, consumers did the saving on their own by cutting discretionary travel where possible and by taking numerous personal actions to conserve. Although rationing at shortfalls of more than 20 percent (24) may force conservation, state and federal plans developed for less severe shortfalls (8-20 percent) must consider voluntary as well as coerced public response. The purpose of this paper is to determine in actual savings what the nature of public response has been so far and is likely to be in the future.

THE 1979 CRISIS

Both the 1973-1974 and the 1979 crises were precipitated by major international events. In 1979, the Iranian revolution of December 1978 subsequently led to the cutoff of Iranian oil production. When production did resume, it was at significantly lower levels. Government directives concerning the buildup of heating fuel supplies for the 1980 season exacerbated a precarious balance, resulting in a severe (7-10 percent) shortfall in California in May 1979. Pressure subsequently mounted in New York during that same month, resulting in the imposition of an odd-even gasoline purchase plan in New York City in June 1979 and the tapping of future set-asides. In the meantime, the crisis eased in California. These actions, coupled with significant conservation by the public, gradually loosened the squeeze; odd-even was removed in New York City in September 1979 with prices in the $0.97/gal range, an increase of $0.27 in 10 months. The takeover of the U.S. embassy in Iran on November 4, 1979, and the Russian invasion of Afghanistan have spurred prices again; the February 1980 U.S. average price of regular gasoline was $1.15/gal for unleaded, with premium at $0.05-$0.15 higher (prices in New York were about $0.05-$0.15 above the U.S. average). Many analysts predict that gasoline will cost $1.50/gal by the end of 1980.

As a result of these events, traffic and gasoline consumption in New York State since then declined. Traffic was down 4.5 percent in New York, while gasoline consumption dipped 5.3 percent. Total gasoline saving in New York was 280 million gal for the first three quarters, 328 million gal for the year.

CONSUMER SAVINGS

To determine precisely how these savings were achieved, the New York State Department of Transportation (NYSDOT) engaged in a two-part analysis of energy actions. The first part—determining what actions the public took—was obtained from responses to a public opinion poll conducted by Crossley Surveys on behalf of NYSDOT (22). The second part—quantifying the savings from each action—was accomplished by applying reported trip length, trip rate, and energy use data to the Crossley responses. Each of these efforts is discussed below in light of three scenarios: (a) actions between January and October 1979, (b) actions at $1.50/gal for gasoline, and (c) actions at a 20 percent shortfall.

Actions Taken by the Public

Consumer actions taken in 1979 were generally similar to those taken during the 1973-1974 crisis, but several important differences were noted. Table 1 indicates results of the Crossley poll, which was based on a representative sample of 1520 New York households and conducted in October 1979. The poll responses thus cover the period of January through mid-October 1979. Respondents were