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Estimation of the Transportation Energy Conservation Potential of Compressed Work Weeks

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ABSTRACT

THIS PAPER presents the results of an analysis to determine the potential reduction on nationwide gasoline consumption resulting from the implementation of compressed work weeks based on currently available data. The analysis considered only the reduction in automobile travel between home and work using (1) population and employment data from the Bureau of the Census and the Bureau of Labor Statistics, and (2) travel characteristics data from the Nationwide Personal Transportation Study and the Bureau of the Census. To the greatest extent possible, the analysis dealt with travel in specific Standard Metropolitan Statistical Areas (SMSAs) and was sensitive to the following factors:

- modal split;
- average auto trip length;
- auto occupancy;
- average speed in peak and off-peak periods;
- average fuel consumption as a function of speed; and
- percentage of employment likely to comply with four-day work week.

Two scenarios were considered. In the first, all employees in non-essential sectors complied with the compress work week plan. This arrangement resulted in a 6.5 percent reduction in total gasoline consumption. In the second scenario, 100 percent of government employees and 50 percent of private sector employees (in non-essential industries) complied. This resulted in a 5.2 percent gasoline saving. While the findings are limited due to the broad assumptions on travel behavior, there does appear to be a small but significant energy benefit to implementing compressed work weeks.

INTRODUCTION

Purpose of Paper

This paper presents the results of an analysis to determine the potential reduction in nationwide gasoline consumption resulting from the implementation of compressed work weeks. This is one of many forms of alternative work scheduling (AWS) currently being considered by the U.S. Department of Energy as a result of the Energy Policy and Conservation Act of 1975 which requires the President to submit to the Congress for approval one or more national energy conservation contingency plans. Among the forms of AWS possible are [1]:

- compressed work weeks;
- variable work hours, including
  - staggered work hours;
  - flexible work hours ("flexitime"); and
- permanent part-time employment.

AWS is anticipated to have many impacts including the following:

- economic (due to changes in productivity);
- sociological (due to changes in life style);
- legal (due to changes in labor union agreements); and
- ecological (including air pollution and energy impacts, due to changes in the amount of travel).

This paper has a narrow perspective: the change in nationwide petroleum consumption due to the implementation of a particular form of one AWS concept, the compressed work week.

Other researchers [2] have explored the impact of compressed work weeks and variable work hours in terms of changes in vehicle-miles of travel from a macroscopic, nationwide perspective. The findings indicate that neither approach will yield significant overall reductions in travel although variable work hours would tend to improve highway level of service in congested central business districts and radial corridors whereas compressed work weeks would tend to have a more uniform effect throughout an urban area.

Another study [3] examined in more detail the highway network impacts of conversion to compressed work weeks at the state government campus in Albany, New York. By applying traffic assigment models typically used in urban transportation planning it was deter-

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mined that changes in overall network operating speeds, individual link loadings, and the temporal distribution of traffic were relatively small. The network effects were most pronounced in the immediate vicinity of the office campus and decreased with distance from it.

The indication that highway travel characteristics in particular urban areas may be important to the effectiveness of compressed work weeks plus the availability of limited travel demand and supply data at this level of aggregation provided the impetus for this analysis. By applying the most detailed available data in a model sensitive to the impacts of compressed work weeks on travel demand and supply characteristics it was anticipated that more meaningful findings could be obtained that could provide some guidance in policy making.

Compressed Work Week Plan Examined

The compressed work week scheme considered in the analysis is discussed in this section. The general term "Compressed work week" is used rather than the more common "four-day work week" in order to emphasize that a shortened work week could be established in some sectors and activities normally operating six or seven days a week. From the standpoint of the employee, a compressed work week program would indeed involve compressing five work days into four, since most workers normally work five days a week. However, when identifying industries and activities in terms of which may be capable of adjusting to a work week with one less day, the "normal" work week must be considered. Therefore, the term compressed work week indicates that, regardless of the number of days normally worked, one day is to be eliminated.

The specific plan considered would have the following characteristics:

- mandatory for all industries and activities not specifically excluded;
- nationwide in scope;
- leave unchanged the total number of hours worked in a week;
- where the normal work week involves a Monday-to-Friday schedule, it would specify four specific days covered industries would operate. These days would be the same for all workers in these industries;
- initiated by the Federal Government only in the event of a serious energy emergency, and only after a national emergency had been declared by the President;
- day-to-day implementation would be handled by employers, both public and private; and
- enforced by all levels of government, each level assuming responsibility for those aspects of the program it can most closely monitor.

An important input to the analysis is the number of employees likely to comply with the proposed plan. Even during a severe energy emergency, certain industries and activities would have to operate according to existing work schedules. The contingency plan considered here therefore had to establish exemptions, or exemption criteria, to determine which activities could be included in a compressed work week program without seriously affecting national security or overall economic output, or causing severe hardship for a significant segment of the population. The following criteria were established for essential sectors:

- Output (of goods or services) in the sector or activity would be significantly reduced by the compressed work week program;
- Reductions in the sector's output would endanger national security or public health (as essential military activities or the availability to the public of pharmaceutical products);
- Output provided must be available on a 24-hour a day, seven-day a week basis (as hospital care and public safety services);
- Production and/or distribution of energy products would be negatively affected. (The supplies of all energy products must be maintained, or even increased, to help mitigate the impact of a severe shortage in any one fuel. This would be especially true for supplies of fuels potentially substitutable for the curtailed fuel);
- Continuous processes are employed in the industry; and
- Work patterns must be responsive to either continuous or irregular production requirements (as in agriculture).

The industries or activities considered to be exempt from the plan are:

- all of the agricultural sector;
- part of the mining sector (energy-producing industries);
- part of the manufacturing sector, exempt because continuous industrial process involved;
- electric utilities;
- all of the transportation, communications; and utility services sector;
- part of the retail trade sector (restaurants and pharmacies);
- part of the services sector (hotels, etc.; health services; funeral serv-

ices; news syndicates; auto rentals and parking facilities); and

- part of the government sector (50 percent of Federal military activities, 100 percent of the Postal Service, and 50 percent of non-education state and local government activities).

The industries considered to be covered by this plan include the following:

- Remainder of the mining sector;
- All of the construction sector;
- Remainder of the manufacturing sector;
- All of the wholesale trade sector;
- Remainder of the retail trade sector;
- All of the finance, inurance and real estate sector;
- Remainder of the services sector; and
- Remainder of the government sector.

The total employment affected by plan, based on 1975 data and 1980 projection (the assumed year of implementation) supplied by the U.S. Bureau of Labor Statistics, is shown in Table 1.

Organization of Paper

The remainder of this paper is broken into four sections. The first presents a discussion of the initial assumptions used in the analysis. The second section presents the development of the model used to estimate nationwide gasoline savings. The third section presents the analysis findings. The final section interprets these results and presents conclusions.

INITIAL ASSUMPTIONS

The basic approach of this analysis was to make the best use of available data regarding travel demand and supply characteristics in order to compute nationwide gasoline savings due to the implementation of compressed work weeks. It was recognized that it would be desirable to perform the computations at as microscopic a level as possible in order to be as sensitive as possible to the proposed policy and the likely impacts on the transportation system. The limited availability of the needed information required that many assumptions and simplifications be built into the analysis. It is not uncommon for such an approach to be part of an urban transportation analysis. Such analyses deal with very large systems with many parameters which cannot be easily measured, if at all. Accepted relationships and representative values are frequently used to replace missing data.

It is important that the assumptions used in this analysis be explicitly outlined so that the implications of the findings can be understood and applied properly in policy evaluation. The remainder of this section develops the framework for the development of the energy savings model through a point-by-point description of the basic assumptions and data sources.

The fundamental assumption in the model is that the most significant energy savings resulting from compressed work weeks will be due to reductions in automobile travel for the journey to work. This trip purpose currently accounts for 34 percent of total automobile travel on a nationwide basis and it would

TABLE 1

EMPLOYMENT POTENTIALLY AFFECTED BY COMPRESSED WORK WEEK PROGRAM

(Thousands of Employees)

		1975	1980
Total U.S. Employment Potentially Affected		82,001	95,365
Scenario 1:			
	With exemptions as outlined and 100% compliance in all covered industries	57,278 69.9%	66,850 70.1%
Scenario 2:			
	As above, but with 100% compliance in covered government activities and 50% compliance in all other covered industries	34,702 42.3%	39,795 41.7%

seem intuitively obvious that the reduction of 20 percent of this travel by a large segment of workers (changing from a five-day to a four-day work week) would result in the largest energy savings. While there are strong arguments for assuming some increase in leisure travel may occur when a four-day work week is imposed, possibly equal to the savings from reduced work travel, there is no basis in theory or in previous observation for determining what the magnitude of this change might be. The computation of work trip travel in this analysis is limited to travel between home and work and is not concerned with so-called work related or non-home-based work trips. These represent a relatively small fraction of total travel and occur mostly in off-peak period. In addition, there is relatively little data available regarding these trips.

By focusing on the energy consumption between home and work, several advantages emerge. The first and most important is that the journey to work is well-documented on a nationwide basis. The most important current data source in this regard is a special study conducted in 1975 and 1976 by the U.S. Bureau of the Census [4, 5] which describes work travel characteristics in 41 Standard Metropolitan Statistical Areas (SMSAs) representative of the following types of urban areas:

- the largest metropolitan areas having major public transportation systems;
- very large metropolitan areas with less developed public transportation systems;
- other large and medium-sized metropolitan areas with well-established public transportation systems; and
- medium-sized and smaller SMSAs primarily oriented to automobile transportation.

By extending this data to represent all urban areas over 50,000 population, it was possible to develop a model that accurately represented urban areas containing 69 of the 1970 population and employment. Further, by assuming that certain gross descriptors of travel in the SMSAs were representative of the remainder of the country it was possible to base the nationwide estimates of energy savings on these data.

A second basic assumption is that only urban passenger travel will be considered and that the energy required to haul goods will be ignored. Again, while there are strong arguments for assuming a decrease in goods movement energy in urban areas (due to fewer days of work in many sectors), truck drivers will probably operate longer hours on the days they do work. The lack of data or prior observation makes it impossible to determine the change in this aspect of energy consumption.

A final basic assumption is that no change in transit energy consumption will occur when compressed work weeks are implemented. As discussed below, no shifts in modal choice are anticipated. Further, since the magnitude of transit energy consumption is small compared to automobile energy, any anticipated change could be ignored and not significantly affect policy decisions.

THE MODEL

The general formulation used in the analysis was of the form:

$$E = \text{TRIPS} \times \Sigma_i \, (\text{VMT}_i \times \text{RATE}_i) \qquad (1)$$

where

E = total annual nationwide automobile gasoline consumption for all work trips, in gallons.

TRIPS = number of one-way trips between home and work made each year by each employee. It is assumed that each employee makes two identical trips each day he works. Further, it is assumed that all employees currently work a five-day work week and travel to work 230 days per year (260 weekdays less 9 holidays and an average 21 vacation and sick days). Thus, TRIPS currently has the following value:

= 230 workdays × 2 trips/day

= 460.

VMT_i = total daily one-way vehicle-miles travelled between home and work in urban area_i.

RATE_i = average rate of gasoline consumption in urban area_i for work trips, in gallons per mile.

The total daily VMT for automobiles in urban area_i is computed as:

$$\text{VMT}_i = \left(\frac{\text{FRAC}_i \times \text{LEN}_i}{\text{OCC}_i} \right) \times \text{employment} \qquad (2)$$

where

$FRAC_i$ = fraction of work trips by automobile in urban $area_i$ [6]. There is no evidence nor any reasonable expectation for the overall percentage to change when compressed work weeks are implemented [7]. Relative travel times for highway and transit will remain approximately the same for employees in the complying sectors and for non-complying sectors during the days that four-day employees work in larger cities. It would not be reasonable to assume that on the fifth day, non-complying employees in larger cities would change modes. Non-complying employees in smaller urban areas would experience faster travel times, but it is assumed that any shift toward transit among these employees would be negligible on a nation-wide basis.

LEN_i = average distance between home and work for automobile trips in urban $area_i$, in miles. It is assumed that the average automobile trip length will remain constant in the short-run time frame of this analysis. It would be unreasonable to expect large shifts in residential or employment location to result immediately following the implementation of compressed work weeks. More long-term shifts might be expected in order to shorten travel times to counter the longer time spent at work.

OCC_i = average number of passengers per automobile for work trips in urban $area_i$. This is assumed to remain constant since the plan would probably allow employees who currently travel together to continue to do so.

The rate of gasoline consumption was expressed as a formulation sensitive to speed, since speed is an important determinant of fuel efficiency. Recent research [8] has developed the following relationship for gasoline consumption in 10 representative automobiles:

$$R = K_1 + \frac{K_2}{V}, \text{ V less than 35 miles per hour} \qquad (3)$$

where

R is the fuel economy, in miles per gallon

K_1 can be identified with fuel consumed per mile in overcoming the rolling resistance of the vehicle and is thus approximately proportional to the weight of the vehicle.

K_2 is approximately proportional to the idle fuel flow rate, in gallons per hour.

V is the average trip speed, in miles per hour. In some cases, the average speed used in the analysis for some urban areas is slightly greater than 35 mph. It is assumed that the formulation for R still applies in these cases.

By expanding the 10 data points to represent the entire automobile fleet it was possible to crudely approximate fleet average K_1 and K_2 coefficient values. This was accomplished by applying automobile sales data over the past ten years (the assumed vehicle life) distributed by weight class and model year [9] to data on the fraction of vehicle-miles travelled by each model year during the previous 10 years [10]. Combining the data from the previous three references yielded the following weighted average fuel consumption function for the average automobile in the 1978 fleet:

$$R = 0.0368 + \frac{0.781}{V}$$

It is assumed that the characteristics of the average vehicle in the 1980 fleet will be identical. In reality, fuel consumption characteristics are likely to be slightly improved.

By replacing Equations 2, 3, and 4 in Equation 1 the following general form of the model is developed to estimate gasoline consumption E_i for the journey to work in $area_i$:

$$E_i = 460 \times \text{employment} \times \left(\frac{FRAC_i \times LEN_i}{OCC_i}\right) \times \left(0.0368 + \frac{0.781}{V}\right) \qquad (5)$$

Since the value of employment is governed by the definition of the compressed work week plan and $FRAC_i$, LEN_i, and OCC_i are assumed fixed, the value of V becomes a crucial determinant of fuel consumption. As discussed below, the highway network in a particular urban area is assumed to operate in one of two regimes:

- peak flow regime: representing travel during peak periods and reported most accurately by survey data on trip travel times and distances [11, 12].
- average flow regime: the daily average speed on the highway network, computed as the weighted average of the ratio of vehicle-miles traveled to vehicle-hours traveled on the interstate highways and major and minor arterials [13].

It is assumed this measure (based on observed traffic volumes and speeds) must be greater than or equal to the peak flow speed, since the average daily level of congestion is less than that experienced during the peak periods. In those few cases where the average network speed would be less than the peak network speed, it is adjusted to be equal to the peak flow speed.

The final model used in the analysis is based on the above discussion and the assumptions presented in the previous section. Three versions of the model were developed. The first estimated gasoline consumption in the 1975 and the 1980 base cases. The 1975 estimate was used to develop a calibration factor (discussed in the next section). The 1980 base case was used as the basis for comparison in the analysis. The formulation is as follows:

$$E = 460 \times \sum_i \left[\frac{TEMP_i \times FRAC_i \times LEN_i \times \left(0.0368 + \frac{0.781}{PEAK_i}\right)}{OCC_i} \right] \quad (6)$$

where

$TEMP_i$ = total employment in $SMSA_i$

$PEAK_i$ = average current speed for automobiles for the journey to work during peak flow conditions, in miles per hour

Two other equations were developed to estimate gasoline consumption for the two scenarios tested. The first is used to estimate gasoline consumption in SMSAs under 1,000,000 population (1970 estimate) and that portion of the population not located in SMSAs. The guiding assumption here is that congested highway travel times would be experienced only by employees in complying industries. It is assumed that these smaller urban areas experience peak period travel characteristics only when all employees travel. Thus, only participating employees experience congestion when they travel. It is assumed implicity that on those days, the peak period would occur one hour earlier in the morning and one hour later in the afternoon. The nonparticipating employees are assumed to travel in the average flow regime. The formulation is as follows:

$$E = 368 \times \sum_i \left[\frac{EPART_i \times FRAC_i \times LEN_i \times \left(0.0368 + \frac{0.781}{PEAK_i}\right)}{OCC_i} \right] + 460 \times \sum_i \left[\frac{ENON_i \times FRAC_i \times LEN_i \times \left(0.0368 + \frac{0.781}{AVG_i}\right)}{OCC_i} \right] \quad (7)$$

where

368 = average number of one-way trips between home and work per year by employees participating in the compressed work week plan

= 460 × 0.80

$EPART_i$ = number of participating employees in urban $area_i$

$ENON_i$ = number of non-participating employees in urban $area_i$

AVG_i = average highway network speed in urban $area_i$

The final equation was used for SMSAs of 1,000,000 or more population (1970 estimate). The guiding assumption in this case was that congestion is so prevalent in these urban areas that only on the day that participating employees do not work do the non-complying employees experience no congestion.

The formulation is as follows:

$$E = 368 \times \sum_i \left[\frac{TEMP_i \times FRAC_i \times LEN_i \times \left(0.0368 + \frac{0.781}{PEAK_i}\right)}{OCC_i} \right] + 92 \times \sum_i \left[\frac{ENON_i \times FRAC_i \times LEN_i \times \left(0.0368 + \frac{0.781}{AVG_i}\right)}{OCC_i} \right]$$

where

92 = average number of one-way trips per year between home and work by employees who work the fifth day without four-day per week workers

= 460 × 0.20

ESTIMATION OF TRANSPORTATION ENERGY IMPACTS

Equations 6, 7, and 8 were applied to estimate work trip gasoline consumption for the following four scenarios:

- 1975 Base Case: to calibrate Equations 6, 7, and 8 for the remaining scenarios.
- 1980 Base Case: to serve as the basis of comparison for the two compressed work week scenarios.
- 1980 100 Percent Compliance Scenario: in which all employees of covered sectors participate.
- 1980 Partial Compliance Scenario: in which 100 percent of government and 50 percent of private sector employees in covered sectors participate.

The equations were applied to the following urban areas:

- 41 representative SMSAs selected for study by the U.S. Bureau of the Census.
- All remaining SMSAs grouped into the following categories:
  - greater than 1,000,000 population (in 1970)
  - 500,000 to 1,000,000
  - 250,000 to 500,000
  - 100.000 to 250,000
  - 50,000 to 100,000
  - Remainder of the population

The results of the analysis are shown in Table 2. Before these results can be interpreted, it is necessary to apply a calibration factor to adjust the results to more accurately represent the real world. It was acknowledged that the many assumptions and simplifications in the model would result in an estimated value of work trip gasoline consumption different from the actual value, if it could be measured. Of course, there is no direct data available on gasoline consumed exclusively for work trips. It is possible, however, to make a simple nationwide estimate based on total gasoline consumption for auto travel and the fraction of automobile travel for work trips. Total gasoline consumption by automobiles in 1975 was 76010×10^6 gallons [14]. The fraction of total automobile vehicle-miles travelled for work trips based on the following annual household data from the 1972 National Personal Transportation Survey [15]:

Work trip fraction of travel = 4183 miles for the journey to work ÷ 12423 miles total travel = 0.337.

It is assumed this value is valid in the 1975 and 1980 computations since no other data is available. Further, it is assumed that the ratio of work trip to total VMT is equal to the ratio of work trip to total fuel consumption. Since this implies that the relationship holds equal-

TABLE 2

DATA DEVELOPED FOR CALCULATION OF ANNUAL GASOLINE CONSUMPTION

SMSA's	1970 Popul.	1975 Employment: Total Employ	1975: 100% Compliance Employ Exempt	1975: 100% Compliance Employ Covered	1975: 100% Govt./50% Private Employ Unaff.	1975: 100% Govt./50% Private Employ Aff.	Projected 1980 Employment: Total Employ	1980: 100% Compliance Employ Exempt	1980: 100% Compliance Employ Covered	1980: 100% Govt./50% Private Employ Unaff.	1980: 100% Govt./50% Private Employ Aff.	Travel Characteristics: Fraction of Work Trips by Auto	Avg. Work Trip Auto Occupancy	Avg. Distance from Home to Work (miles)	Avg. Peak Period Hwy. Speed (mph)	Avg. Hwy Network Speed (mph)	Estimated Gasoline Consumption for the Journey to Work: 1975 Base Case (gallons x 10^6)	1980 Base Case (gallons x 10^6)	1980 100% Compliance Scenario (gallons x 10^6)	1980 Partial Compliance Scenario (gallons x 10^6)
Atlanta	1,390	558	168	389	321	236	648	194	455	378	271	.90	1.4	10.1	27.3	29	109.008	126.590	108.656	119.038
Chicago	6,979	2,813	848	1,965	1,622	1,190	3,271	978	2,293	1,906	1,365	.79	1.3	7.9	22.0	25	449.134	522.260	447.199	475.086
Cincinnati	1,385	558	168	389	321	236	648	194	455	378	271	.93	1.4	8.8	25.1	27	101.906	118.342	101.531	108.035
Colorado Springs	236	90	27	63	52	38	105	31	74	61	44	.99	1.4	7.1	22.9	32	14.738	17.194	14.076	14.387
Columbus, Ohio	916	369	111	258	213	156	429	128	301	250	179	.94	1.4	8.2	24.5	31	64.181	74.617	61.980	64.159
Hartford	664	271	82	189	156	115	315	94	221	183	131	.93	1.4	7.7	24.6	29	43.709	50.806	42.611	44.344
Kansas City	1,254	508	153	355	293	215	591	177	414	345	247	.96	1.4	8.3	24.2	37	91.865	106.874	90.866	95.960
Madison	290	115	35	80	66	49	134	40	94	78	56	.92	1.4	6.0	21.4	30	15.288	17.814	14.555	14.845
Miami	1,268	508	153	355	293	215	591	177	414	345	247	.92	1.4	8.8	24.2	24.2	93.341	108.591	93.377	99.557
Milwaukee	1,404	566	171	395	326	239	658	197	461	383	275	.91	1.4	7.0	22.1	25	85.459	99.350	85.091	90.388
New Orleans	1,046	418	126	292	241	177	486	145	341	283	203	.86	1.4	6.3	18.4	36	58.969	68.562	57.869	60.743
Newport News/Hampton	292	115	35	80	66	49	134	40	94	78	56	.95	1.4	7.5	23.2	30	18.970	22.104	18.289	18.864
Patterson-Clifton-. Passaic	1,359	549	166	384	317	233	639	191	448	372	267	.89	.4	6.9	22.0	22	80.090	93.220	80.149	85.430
Philadelphia	4,818	1,943	586	1,357	1,121	823	2,260	676	1,584	1,317	943	.83	1.3	8.0	22.9	24	323.691	376.501	323.228	344.115
Portland, Oregon/Wash.	1,009	410	124	286	236	173	477	143	334	278	199	.92	1.4	8.1	25.7	33	67.451	78.473	67.013	71.010
Rochester, New York	883	353	106	246	203	149	410	123	287	239	171	.94	1.4	7.7	24.4	26	57.764	67.091	57.123	60.376
San Antonio	864	353	106	246	203	149	410	123	287	239	171	.95	1.4	8.0	24.7	29	60.311	70.050	58.803	61.408
San Bernadino/Riv/Out	1,143	582	176	407	336	246	677	203	475	395	283	.99	1.4	6.8	25.3	33	87.114	101.334	86.498	91.634
San Diego	1,358	549	166	384	317	233	639	191	448	372	267	.95	1.4	9.9	30.3	36	106.161	123.564	105.757	112.300
San Francisco/Oakland																				
Springfield-Chicopec/	3,110	1,255	378	876	724	531	1,459	436	1,023	850	607	.82	1.3	8.3	25.2	29	204.893	238.198	203.943	216.651
Holyoke	530	213	64	149	123	90	248	74	174	144	103	.96	1.4	5.6	20.1	34	28.465	33.142	26.415	26.215

NOTE: Population and employment values are in thousands

TABLE 2 (Continued)

	1970 Popul.	1975 Employment: Total Employ	1975 Employment: 100% Compliance Employ Exempt	1975 Employment: 100% Compliance Employ Covered	1975 Employment: 100% Govt./50% Private Employ Unaff.	1975 Employment: 100% Govt./50% Private Employ Aff.	Projected 1980 Employment: Total Employ	Projected 1980 Employment: 100% Compliance Employ Exempt	Projected 1980 Employment: 100% Compliance Employ Covered	Projected 1980 Employment: 100% Govt./50% Private Employ Unaff.	Projected 1980 Employment: 100% Govt./50% Private Employ Aff.	Travel Characteristics: Fraction of Work Trips by Auto	Travel Characteristics: Avg. Work Trip Auto Occupancy	Travel Characteristics: Avg. Distance from Home to Work (miles)	Travel Characteristics: Avg. Peak Period Hwy. Speed (mph)	Travel Characteristics: Avg. Hwy Network Speed (mph)	Estimated Gasoline Consumption for the Journey to Work: 1975 Base Case (gallons x 10⁶)	1980 Base Case (gallons x 10⁶)	1980 100% Compliance Scenario (gallons x 10⁶)	1980 Partial Compliance Scenario (gallons x 10⁶)
SMSA's																				
Allentown, Beth, Easton.	544	221	67	155	128	94	257	77	180	150	107	.98	1.4	5.4	19.5	27	29.532	34.342	28.042	28.581
Baltimore	2,071	836	252	584	482	354	973	291	682	567	406	.88	1.4	10.0	26.0	26.0	161.464	188.040	161.680	172.348
Birmingham	739	295	89	206	170	125	343	103	241	200	143	.97	1.4	8.7	25.2	28	55.453	64.476	54.718	57.381
Buffalo	1,349	541	163	378	312	229	629	188	441	367	263	.94	1.4	6.4	21.5	27	78.200	90.920	75.421	78.093
Cleveland	2,064	836	252	584	482	354	973	291	682	567	406	.89	1.4	8.2	23.2	28	141.256	164.404	140.552	149.115
Denver	1,228	492	148	344	283	208	572	171	401	33!	239	.94	1.4	8.2	25.2	31	84.473	98.208	83.936	89.023
Grand Rapids	539	221	67	155	128	94	257	77	180	150	107	.99	1.4	6.7	25.1	36	32.711	38.039	31.131	31.793
Honolulu	629	254	77	178	147	108	296	88	207	172	123	.88	1.4	7.4	20.7	20.7	40.505	47.203	40.441	43.120
Houston	1,985	804	243	561	464	340	935	279	655	545	390	.96	1.4	9.6	26.5	31	161.345	187.634	160.582	170.569
Indianapolis	1,110	451	136	315	260	191	525	157	368	306	219	.97	1.4	7.7	22.2	35	79.668	92.740	78.747	83.070
Las Vegas	273	107	32	74	61	45	124	37	87	72	52	.98	1.4	6.1	22.0	34	15.195	17.609	14.228	14.361
Louisville	827	328	99	229	189	139	381	114	267	222	159	.95	1.4	8.1	23.8	28	57.732	67.061	56.243	58.701
NY, NY	11,572	4,666	1,407	3,259	2,691	1,975	5,426	1,622	3,804	3,162	2,264	.52	1.3	8.6	23.6	23.6	516.055	600.110	515.967	550.031
Oklahoma City	641	262	79	183	151	111	305	91	214	178	127	.99	1.4	7.3	23.7	25	43.397	50.519	43.594	45.588
Omaha	540	221	67	155	127	94	257	77	180	150	107	.95	1.4	5.9	20.8	28	39.260	35.189	28.891	29.592
Providence-Pawtucket/W.	911	369	111	258	213	156	429	128	301	250	179	.96	1.4	6.1	21.4	[illegible]	52.040	60.502	48.852	49.281
Raleigh	228	90	27	63	52	38	105	31	74	61	44	.99	1.4	7.2	24.5	37	14.476	16.889	13.726	13.935
Sacramento	801	319	96	223	184	135	372	111	261	217	155	.98	1.4	7.8	26.0	39	53.551	62.448	50.894	51.787
St. Louis	2,363	951	287	664	549	403	1,106	331	775	644	462	.92	1.4	9.0	26.2	32	177.955	206.959	176.950	187.714
Seattle-Everet	1,422	574	173	401	331	243	668	200	468	388	279			9.5	28.4	28.4	105.990	123.347	106.064	113.007
Subtotal (41 SMSA's)	64,034	25,934	7,821	18,114	14,954	10,978	30,162	9,019	21,145	17,575	12,587						4,093.866	4,761.314	4,055.688	4,291.635
(SMSA's <u>less</u> 41 above)																				
1,000,000 + over	27,973	11,292	3,404	7,887	6,513	4,779	13,132	3,927	9,205	7,652	5,480	.880	1.35	9.8	25.5	33	2,237.383	2,601.958	2,221.120	2,353.495
500,000 - 1,000,000	11,911	4,805	1,449	3,356	2,772	2,034	5,588	1,671	3,917	3,256	2,332	.922	1.4	8.1	24.3	30	812.849	945.307	787.742	817.618
250,000 - 500,000	18,905	7,626	2,299	5,327	4,399	3,228	8,869	2,652	6,217	5,168	3,701	.949	1.4	8.0	25.3	30	1,287.289	1,497.111	125.523	130.982
100,000 - 250,000	14,502	5,855	1,765	4,090	3,377	2,478	6,809	2,036	4,773	3,968	2,841	.964	1.4	8.0	26.7	30	979.947	1,139.617	963.247	1,012.166
50,000 - 100,000	2,092	845	255	590	487	357	982	294	689	572	410	.964	1.4	7.4	24.7	29	135.511	157.481	132.312	138.046
TOTAL-ALL SMSA's	139,417	56,357	16,993	39,364	32,502	23,854	65,542	19,599	45,946	38,191	27,351						9,547.300	11,102.788	8,285.345	8,743.932
Non SMSA	63,795	25,644	7,730	17,914	14,794	10,851	29,823	8,916	20,904	17,378	12,445	.97	1.4	7.75	22.47	30	4,547.185	5,271.199	4,493.713	4,756.374
TOTAL	203,212	82,001	24,723	57,278	47,296	34,705	95,364	28,515	66,850	55,569	39,796						14,094.485	16,373.987	12,779.345	13,500.306

NOTE: Population and employment values are in thousands ly at all travel speeds, it probably underestimates fuel consumption since work trip travel speeds are less fuel efficient than overall travel speeds.

Based on these data, the assumed actual value of work trip gasoline consumption in 1975 is:

E Actual = (76010 × 10^6 gallons) × 0.337 = 25615 × 10^6 gallons.

The value of the calibration factor ADJ is therefore:

ADJ = assumed actual 1975 gasoline consumption ÷ estimated 1975 gasoline consumption = 25615 × 10^6 gallons ÷ 9547.3 × 10^6 gallons = 1.817.

The final annual nationwide gasoline consumption values are shown in Table 3.

CONCLUSIONS AND IMPLICATIONS OF FINDINGS

The results of this analysis indicate a clear potential for the implementation of the four-day work week to reduce automobile gasoline consumption for the journey to work. This finding must be considered in light of several important considerations, however. The first important consideration is that this analysis dealt only with automobile gasoline consumption for the journey to work. Changes in gasoline consumption for other trip purposes were not computed due to the lack of data. It is quite possible that in the absence of other controls, social-recreational travel could at least partially compensate for the decrease. Thus, a more meaningful way to interpret work travel gasoline savings presented in the previous section would be in the context of total gasoline consumption [16], as follows:

- 100 percent Compliance Scenario: 6531.46 × 10^6 gallons saved ÷ 99784.44 × 10^6 total gallons consumed = 6.5 percent savings.
- Partial Compliance Scenario: 5221.47 × 10^6 gallons saved ÷ 99784.44 × 10^6 total gallons consumed = 5.2 percent savings.

Even viewed in this context the savings are still large enough to indicate that implementing a four-day work week may indeed be a worthwhile action to take to reduce gasoline consumption. The only limitation in this finding is that the saving from reduced work travel may be partially or completely compensated by increased leisure travel. Viewed from another perspective though, the findings do indicate that in the event of a gasoline shortage of between 5 and 7 percent, no change in leisure (or other discretionary) travel would be required if a four-day work week was implemented.

The second important consideration regarding the analysis and the applicability of the findings is that the formulation and data used are based on many assumptions regarding urban transportation supply and demand characteristics. The analysis deals with microscopic individual travel decisions on a very macroscopic basis. Many gross descriptors of travel are used that characterize only the average traveler. The result of these assumptions is, at best, a loss of sensitivity, and potentially erroneous conclusions. The only compensating factor in this regard is the likelihood that the errors are systematic and apply equally to all the scenarios examined.

A very worthwhile next step in this line of research would be to conduct a sensitivity analysis on some of the variables in the formulations of gasoline consumption in order to determine the influence of some of the basic assumptions on the findings. This would include varying the percentage changes in mode split and auto occupancy. The result of such an analysis would be greater confidence in the results and more general applicability of the findings.

TABLE 3

TOTAL AUTOMOBILE GASOLINE CONSUMPTION FOR THE JOURNEY TO WORK FOR ALTERNATIVE COMPRESSED WORK WEEK SCENARIOS

Scenario	Gasoline Consumption (Gallons x 10^6) Unadjusted	Gasoline Consumption (Gallons x 10^6) Adjusted	Gasoline Savings (Gallons 10^6)	Percent Change From 1980 Base
1975 Base Case	14094.49	25615.34	N/A	N/A
1980 Base Case	16373.99	29751.53	—	—
1980 100% Compliance	12779.35	23220.07	6531.46	—21.95
1980 Partial Compliance	13500.31	24530.06	5221.47	—17.55

A second important improvement in the analysis would be the application of new data bases. The results of the 1977 National Transportation Survey will provide additional and more up-to-date travel demand data. A survey of travel changes by Federal employees to be conducted by the Civil Service Commission [17] can be used to confirm some of the assumptions in this analysis and provide additional travel demand data.

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