FUEL ECONOMY
AND
EMISSION CONTROL

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR AND WATER PROGRAMS
MOBILE SOURCE POLLUTION CONTROL PROGRAM
November 1972

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I. INTRODUCTION

This paper analyzes the effect on fuel economy of emission controls on automobiles. The analysis examines the various vehicle design factors, including emission control devices, which affect motor vehicle fuel economy and discusses the impact of the individual variables. Fuel penalties which may be associated with emission control systems are placed into the perspective of other fuel penalties which are currently, or may in the future, be experienced by the motoring public.

No attempt is made here to deal with the question of national petroleum consumption. However, this analysis provides a part of the necessary input for such a study.

II. DEFINITION OF "FUEL ECONOMY" [1]

There are many ways to report the fuel economy of automobiles. Miles per gallon (MPG) is the most commonly used and will be used in this analysis. All figures reported in this analysis are in terms of miles per gallon over the Federal Driving Cycle (see Section III. C.) While the single parameter, miles per gallon, is easily understood and a good measure of fuel economy, it must be qualified. Many factors influence fuel economy, and a knowledge of these factors is needed if valid comparisons of fuel economy figures are to be made.

III. FACTORS AFFECTING FUEL ECONOMY

The fuel economy of in-use light duty vehicles can range between 50 and 5 mpg. The major factors that influence fuel economy and account for this wide spread are discussed below.

A. The Design of the Automobile

The most important parameters associated with automobile design include vehicle weight, rolling resistance (including tire, driveline and aerodynamic drag) and axle ratio. Higher weight usually means poorer fuel economy because more work is required to move the vehicle. Higher rolling resistance usually means poorer fuel economy because more work is done deforming the tires and pushing the vehicle through the air. A higher (numerically) axle ratio usually means poorer fuel economy because the engine revolutions per mile are greater. For modern vehicle design, however, weight is the single most important parameter.

B. The Manner In Which The Vehicle Is Driven

This factor is both important and difficult, if not impossible, to quantify. In general, given identical vehicles, the driver who drives "harder" will get poorer fuel economy than the driver who drives less hard. Examples of "hard" driving are accelerating at or near the maximum capability of the vehicle, high cruise speeds, not driving smoothly, and racing the engine at idle. The magnitude of the effect due to the driver can be great, but there is no data on which to quantify this factor.

C. The Type Of Route Traveled

The best fuel economy achievable with automobiles is at constant speed cruise between 20 and 50 miles per hour in high gear. The exact optimum speed depends on the vehicle and engine type. However, no realistic driving is done at such a constant speed. Driving in heavy intracity traffic with many stops per mile, long idling periods, and low average speeds generally results in the poorest fuel economy. Driving on the highway at a constant speed usually results in better fuel economy. For this reason, many references to vehicle fuel economy also refer to the type of route traveled. Usually the distinction is made between city or "around town" type of route; and "highway" type routes.

All fuel economy figures reported in this analysis were measured using the Federal Driving Cycle - an urban driving route. This was done in part because it is the only cycle on which there is consistent data. However, the cycle is useful for this analysis because it is representative of a significant portion of vehicle operation, in particular the driving done in urban areas.

D. The Engine

The design of the engine, its calibration, state of tune and overall mechanical condition affect fuel economy. Important design factors include compression ratio, intake and exhaust system configuration, internal friction and carburetor design. The calibration of the engine, its spark advance curve, the flow curve for the carburetor and the operation of the choke can all affect fuel economy. The state of tune of the engine as well as the condition of the parts that are usually involved in a tune up are important. Finally, the mechanical condition of the engine, especially valves and piston rings, can also hurt fuel economy if it is poor.

Emission controls have affected both the design and calibration of engines. The design of the combustion chamber, the compression ratio, the spark advance curve and the carburetor calibrations have all been changed. In addition, other devices like air pumps and exhaust gas recirculation have been added as emission control devices. All of these changes can have an effect on engine efficiency and, in turn, fuel economy.

E. Power and Convenience Accessories

Many power and convenience accessories are used on modern automobiles, including air conditioning, automatic transmissions, power steering, power brakes, power seats and heated windows. Although all of the devices use energy which eventually results in fuel usage, the effect on fuel economy of all but two are negligible. The two important ones are air conditioning and automatic transmissions.

The use of air conditioning lowers fuel economy. The extent to which it degrades fuel economy depends on how often the device is used, and how much cooling load is required of it.

An automatic transmission is not as efficient as a manual transmission. However, whether a vehicle equipped with an automatic transmission shows better or worse fuel economy than a comparable manual transmission vehicle depends on the way in which each vehicle is driven. All other things being equal, the manual transmission equipped vehicle will generally show better fuel economy.

F. Ambient Conditions

The ambient temperature, humidity, pressure (altitude), and wind speed and direction all affect fuel economy. However, except in the case of large variations from standard conditions (e.g. cruising into a strong headwind or operating at a very high altitude,) the fuel economy effects of ambient conditions are minor.

IV. EMISSION CONTROL EFFECTS ON FUEL ECONOMY

There are, theoretically, two different ways to assess the effects of emission control devices on fuel economy. One way is to determine the effect of any one modification (e.g. retarded spark) on fuel economy. This could be expressed as a percentage loss or gain, and the total effect on a vehicle employing many modifications might be derived from adding up all the individual device effects. This approach is not correct because the effects are not, in general, additive. When one control approach or device is used in combination with other devices as part of a total system, there are various synergistic effects which can either lessen or worsen the impact on fuel economy of any one device.

The other approach, which is employed in this analysis, is to use actual vehicle test data and from this data determine the effect of the complete emission control system on fuel economy. While this approach does not provide data on the effect of individual emission control components, it does yield valid data on the complete system's performance, which is the ultimate concern to the automobile user.

The choice of the test technique and of the type of data used in making this kind of analysis are important. To validly compare fuel economy figures so as to determine the effect of some change in vehicle design or construction (emission controls in this case) the test must hold constant all (or as many as possible) of the factors that influence fuel economy other than the factor under study.

A. Use of the Federal Test Procedure

As indicated in Section III. C, the test used in this analysis to derive the fuel economy figures is the Federal Emission Test Procedure, involving an urban driving route run on a chassis dynamometer under controlled temperature conditions. The advantages and disadvantages of using this procedure are summarized below.

1. Advantages

a. Ambient conditions are closely controlled, thus eliminating variability associated with this factor.

b. Exactly the same route is used every time. The vehicle must be driven over the same speed-time trace each time for the emission test to be valid. This eliminates variability in two factors: the route, and the driver.

c. The weight of the vehicle is known. Since the test procedure involves testing vehicles at a discrete inertia weight, the weight is known for every test and can be isolated as a factor.

2. Disadvantages

a. Since the driving cycle is an urban one, it is not possible to compute a "highway" fuel economy figure.

b. The rolling resistance of the dynamometer used in the test differs slightly from actual on-the-road rolling resistance.

These drawbacks do not, however, prevent valid comparisons regarding urban fuel economy or the overall fuel economy potential of various engine systems or engine/vehicle modifications. In addition, the measurement of CO and CO_2 and miles traveled during the test provides an accurate and repeatable method 2/ of calculating fuel economy.

B. Data Sources

The data used as input for this study came from three major sources: EPA surveillance data, EPA certification data, and EPA inhouse data from various test and evaluation programs.

Use of the surveillance data of older cars can be challenged due to the fact that the older in-use vehicles may not be directly comparable to the 1973 certification prototypes, or to the advanced catalyst equipped prototypes, due to the possible effects of maintenance and mileage on fuel economy. It is, however, the only consistent data which exist for the earlier model years and until such time as data on the effects of accumulated mileage on MPG indicate otherwise, the aggregaton of all the data from the three sources is considered to be a valid assumption.

C. Use of "C" Factor and Display of Data

When the data are plotted as fuel economy (in MPG) versus inertia weight (IW) most of the data lies near the line represented by the equation MPG x IW = C, where "C" is a constant value for any given model year. In order to facilitate using a one parameter curve for each model year the value "C" was calculated in such a way to minimize the squared error. In this way the effect of inertia weight can be eliminated and the value "C" becomes an indicator of the average fuel economy for that model year. The percent loss or gain in average fuel economy for each model year (all vehicle weights) can then be determined by comparing the "C" values.

The average MPG figures for the various model years/inertia weights are shown in Table I. Appendix I contains tables which give the detailed data on average MPG and the range of MPG for the different inertia weights in model years 1957-1973. Figure 1 is a plot of the curves for pre-68 cars and 1973 cars as well as 75/76 prototypes and alternative engines.

TABLE I

MPG vs INERTIA WEIGHT AND MODEL YEAR*

Model Year	INERTIA WEIGHT											# of vehicles in sample
	1750	2000	2250	2500	2750	3000	3500	4000	4500	5000	5500	
57	N.D.	26.5	N.D.	N.D.	N.D.	N.D.	14.8	13.9	N.D.	N.D.	12.9	24
58	N.D.	26.2	19.5	N.D.	13.4	N.D.	14.2	14.4	12.8	10.1	N.D.	23
59	N.D.	29.4	N.D.	N.D.	N.D.	15.7	15.2	14.1	13.4	13.9	N.D.	25
60	N.D.	20.3	N.D.	22.8	24.4	N.D.	16.0	13.4	11.0	11.1	N.D.	19
61	N.D.	30.3	N.D.	21.1	17.6	18.2	13.1	13.5	10.6	N.D.	N.D.	26
62	N.D.	29.9	N.D.	N.D.	18.9	17.2	15.7	15.0	12.4	11.2	N.D.	51
63	N.D.	25.0	20.1	19.2	16.7	15.9	13.7	12.8	11.5	10.7	N.D.	76
64	N.D.	24.1	N.D.	N.D.	17.6	17.0	14.6	14.0	11.5	11.0	N.D.	94
65	N.D.	23.5	N.D.	N.D.	19.0	16.7	14.5	13.4	13.2	10.6	N.D.	137
66	N.D.	24.6	N.D.	N.D.	15.2	14.7	14.3	13.3	12.4	13.0	9.3	102
67	N.D.	24.7	30.6	N.D.	18.8	15.4	13.8	12.5	12.3	11.7	10.3	92
68	N.D.	21.5	20.8	19.3	19.5	15.4	13.3	12.1	11.6	8.8	N.D.	106
69	N.D.	23.1	20.4	19.7	N.D.	15.8	13.4	11.8	11.5	9.8	11.6	163
70	N.D.	24.5	21.1	17.8	18.9	15.6	13.5	12.1	10.9	10.2	9.7	287
71	27.4	21.9	21.2	19.6	18.5	15.2	13.0	11.3	10.6	9.3	8.1	148
72	N.D.	25.7	21.3	18.0	21.7	15.6	14.0	11.2	10.1	9.3	8.7	84
73	N.D.	25.5	20.7	19.9	17.9	16.2	14.0	11.2	10.1	9.4	8.8	630

*MPG figures for early model years (57-62) are based on limited data. This is partly responsible for the wide scatter in this early data.

N.D. - No Data

D. Effect of Emission Control on Fuel Economy

Many things can be inferred from the mass of data. What has been done here is to compare "C" values for each model year. The fuel economy penalties in terms of the constant "C" for model years 68 thru 73 are listed below.

TABLE II - Effect of Emission Control on Fuel Economy

Model Year	"C" Value	Fuel Economy Loss (% of Uncontrolled)
57-67 (Uncontrolled)	52129	None (baseline)
68	47108	9.6
69	47891	7.9
70	48320	7.3
71	47009	9.8
72	49362	5.3
73	48667	6.6

Average loss 68-73, 7.75%

The penalty due to emission controls as expressed above is far from the only cause of the increase in national automotive fuel consumption and can not be compared with total fuel consumption on a one for one basis. Factors such as increasing car population, the relative number of miles driven by controlled and pre-controlled cars, and the varying distribution of vehicle weight in each model year also have to be taken into account. These factors were not analyzed in this study and thus no conclusions concerning total nationwide impact on fuel consumption are drawn.

E. Effect of Compression Ratio Changes

General Motors vehicles went to lower compression ratios across the board in 1971, and others have since done the same. To isolate the effect of compression ratio, data from one-hundred and seventeen 1970 and fifty-five 1971 GM cars of varying weight were examined.

TABLE III - Effect of Lower Compression Ratio, in MPG

Model Year	3500 lb	4000 lb	4500 lb	5000 lb	5500 lb
70	13.7	11.4	10.4	9.9	8.5
71	13.6	11.5	10.7	9.6	8.1

The fuel economy was worse in three weight classes, and better in two. These data do not demonstrate that lowering compression ratio had any effect on vehicle fuel economy.

V. IMPACT OF OTHER AUTOMOTIVE DESIGN FEATURES ON FUEL ECONOMY

To provide an appropriate perspective the data presented above need to be related to other fuel economy penalties being experienced in today's cars.

A. Air Conditioning

EPA laboratory tests of air conditioned full sized cars with and without the air conditioner operating show a 9% loss in fuel economy over the Federal driving cycle in a 70 degree F ambient temperature. This penalty can go as high as 20% (based on compressor hp calculations) for continuous use on a hot day in urban traffic. The penalty can obviously, also, be very low or zero when air conditioning is used little or not at all. The 9% loss measured in the EPA tests is approximately midway between these limits and is considered representative.

B. Automatic Transmissions

The fuel economy penalty associated with the use of automatic transmissions (AT's) is difficult to quantify. There are many types of AT's (different numbers of speeds, and different operating principles). The same engine will be tuned differently for use with an AT than for use with a manual transmission, and different rear axle ratios are used with AT's to optimize their performance. All of this compounds the problem of identifying the impact of AT's on fuel economy. Periodicals on the subject of vehicle performance have reported fuel penalties of 10% for AT's. On the other hand, as indicated earlier, an AT may in certain circumstances improve fuel economy. EPA does not have independent data on this question. In view of all the available data, EPA concludes that the fuel economy penalty of 5% to 6% reported by General Motors in public hearings in April 1972 is representative.

By comparing the fuel economy penalties of an automatic transmission or air conditioning with the penalty attributable to emission controls, it can be seen that the loss due to emission controls through the 1973 model year is about the same size as the penalty incurred due to use of convenience devices such as air conditioning or automatic transmissions.

C. Vehicle Weight

The fuel economy loss associated with emission controls is significantly less than that many vehicle operators claim they are experiencing. One major reason for this is that much of the decreased fuel economy observed is in fact attributable to the phenomenon of nameplate weight growth. When a nameplate, (Chevorlet Impala, for example) is first introduced, it identifies a vehicle weighing a certain amount. Over the years however, vehicles with the same nameplates have typically become heavier, a trend often unnoticed by the vehicle operator. The data in Table I and in Appendix I indicates the dramatic influence of weight on fuel economy. If one only compares the fuel economy of vehicles with the same nameplate (but different weights,) a conclusion regarding the impact of a non-weight parameter (such as emission control) on fuel economy will be wrong. The following example shows this effect:

TABLE IV - Effect of Vehicle Weight Growth on Fuel Economy

YEAR	CAR WEIGHT	NAMEPLATE	MPG
1958	4000 lb	Chevorlet Impala	12.1
1973	5500 lb	Chevorlet Impala	8.5

In this case, the additional 1500 lbs is predominatly responsible for the loss in fuel economy, not the emission controls.

VI. FUTURE TRENDS IN FUEL ECONOMY

A. The 1975/1976 Emission Control System

Very little valid or consistent data exists on fuel economy of 75/76 prototypes. Although some loss may be expected with the use of certain emission control techniques, the small amount of data available to EPA does not yet demonstrate any trends. This lack of trends is further supported by recent (Nov. 1972) reports from several large auto manufacturers who report no difference in the fuel economy of their 1975 prototypes and 1973 vehicles of the same weight.

TABLE V - Comparison of Fuel Economy of 1975/76 Prototypes with 1973 Vehicles

Vehicle Type	Inertia Weight	# of Tests	Prototype Fuel Economy	1973 Vehicles Average	1973 Vehicles Range
75 Prototype	4000	1	10.0	11.2	7.7-14.6
75 Prototype	4500	3	10.7	10.1	7.4-13.6
75 Prototype	5000	1	9.3	9.4	7.6-11.8
75 Prototype	5500	1	6.9	8.8	7.1-10.0
76 Prototype	5000	1	8.6	9.4	7.6-11.8
76 Prototype	5000	1	9.5	9.4	7.6-11.8
76 Prototype	5000	1	6.6	9.4	7.6-11.8

See also Figure 1.

Based on the limited data available from 75/76 systems, the only thing that can be said is that a trend toward better or worse fuel economy has not been demonstrated at this time.

B. Future Weight Trends

Vehicles have historically been getting heavier. Any influences which causes the weight to go up will reduce fuel economy. A major factor is the potential increase in vehicle weight due to future safety standards. The target weight for the Department of Transportation Experimental Safety Vehicle (ESV) was 4200 pounds. Automotive Engineering, September 1972 P.32, reports that the prototype vehicles had weights of 4900, 5300, 5400, and 5800 pounds.

If future vehicles in the standard size class increase as much as these prototypes (700 to 1600 lb) - fuel economy will suffer. As a hypothetical example, increasing the weight of the average 1973 4000 lb vehicle to 5000 lb could mean a drop in fuel economy from 11.2 to 9.4 MPG, a 16% fuel economy penalty.

C. Future New Engines

1. Rotary Engine

While many engines are being investigated as replacements for the conventional spark-ignition, reciprocating engine, the one with the highest potential for near term use is the rotary, or Wankel, engine. Despite the recent increase in publicity, the Wankel is not a newly developed engine. It has been under development for over 20 years and in production for over 5 years by certain foreign manufacturers.

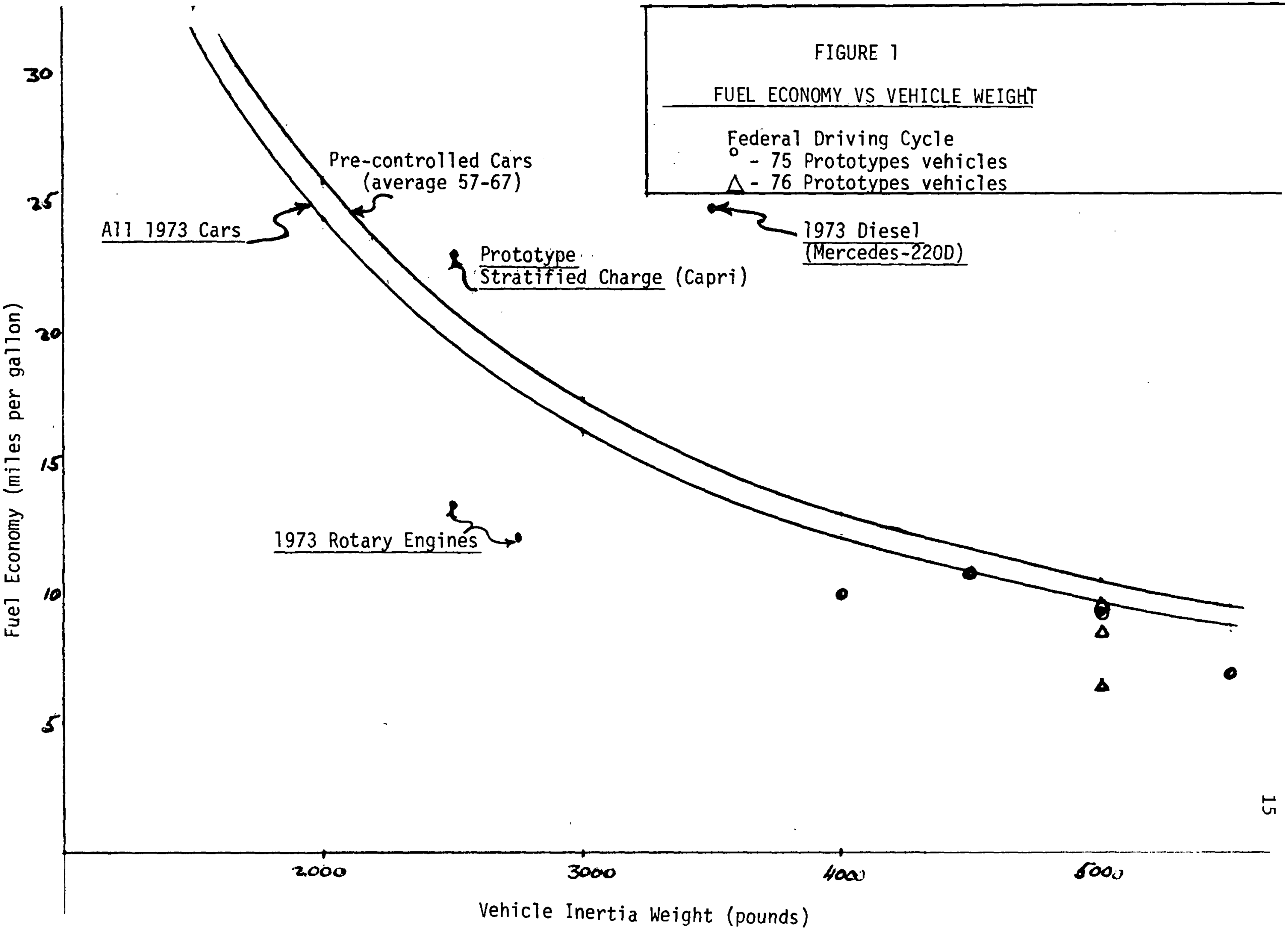

FIGURE 1

FUEL ECONOMY VS VEHICLE WEIGHT

The data available to EPA on fuel economy of rotary engine vehicles is presented below and compared to data on 1973 vehicles of the same weights but equipped with conventional reciprocating engines. See also Figure 1.

TABLE VII - Comparison of Rotary Engine Fuel Economy With 1973 Vehicles

Inertia Weight	Rotary Engine Vehicle	1973 Vehicles Average	1973 Vehicles Range
2250	14.6*	20.7	18.9 to 21.9
2500	13.3	19.9	13.3 to 23.7
2750	12.1	17.9	11.9 to 23.7
2750	12.3	17.9	11.9 to 23.7
2750	11.9	17.9	11.9 to 23.7
3000	14.9*	16.2	13.6 to 19.7

*Not 1973 vehicles.

The rotary engine fuel economy results are consistently at or near the bottom of the range in each weight class and are significantly below the average. The fuel economy data on the 1973 rotary engine vehicles represents a 35% loss in fuel economy when compared to the average for the same weight vehicles equipped with conventional engines. Historically, engines have improved in performance as their development continues and their use increases. Whether this will be the case with the fuel economy of the rotary engine is not known.

2. Diesel Engine

The Diesel engine is the only engine other than the gasoline, spark-ignition, rotary and reciprocating engines that is being used commercially in significant numbers in passenger cars in this country (approximately 6000 are imported each year). The Diesel, however, is not a new engine. It has been used in trucks for over 30 years and is widely used in passenger cars in Europe. The data available to EPA on the fuel economy of a diesel engine vehicle are shown below, and compared to that on 1973 vehicles of the same weight equipped with conventional engines.

TABLE VIII - Comparison of Diesel Engine Fuel Economy With 1973 Data

Inertia Weight	Diesel	All 1973 Vehicles	
		Average	Range
3500	24.7	14.0	9.8 to 17.8

The Diesel (which in this case met the emission levels required by the 1975 standards) achieved 75% better fuel economy than the average 1973 vehicle of the same weight equipped with a conventional engine. See also Figure 1.

3. Other Engines

In addition to the Wankel and Diesel, several other engines are being considered as replacements for the gasoline, spark-ignition, reciprocating engine. These include stratified charge, Stirling, Rankine cycle and gas turbine engines.

For these engines, valid data exists for only the stratified charge engine. At an inertia weight of 2,500 pounds, a vehicle equipped with a stratified charge engine (which in this case met the emission levels, at low mileage, required by the 1976 standards) demonstrated fuel economy of about 23 miles per gallon or 12% better than the average 1973 vehicle of that weight. See Figure 1. Valid data on the fuel economy of the other possible engines is not available at this time.

VII. SUMMARY

The EPA has analyzed fuel economy data from more than 2000 cars (of which over 1400 were equipped with emissions controls) tested on the Federal Driving Cycle.

The data were derived from certification, surveillance and inhouse evaluation testing. This is the most extensive data analysis known to have been performed on this subject to date. It is also considered to be the most accurate for the purpose of comparing vehicle design parameters because of the use of a single consistent driving cycle and controlled ambient conditions.

The study indicates that vehicle weight is the single most important vehicle design parameter affecting fuel economy. Past and future increases in vehicle weight have had, and will continue to have, a significant adverse effect on fuel usage. Weight is a parameter over which the car buyer has direct discretionary control.

The average fuel economy loss due to emission control for 1968-1973 vehicles is less than 8%. This penalty is approximately equal to the penalty associated with the use of convenience devices such as air conditioning or automatic transmissions. Despite the many statements regarding the loss in fuel economy due to meeting the 1975/1976 standards, no significant trend has yet developed in the data available to EPA. EPA will continue to gather data on 75/76 prototype with the aim of making a more definitive statement in the future.

The use of engines other than the present spark-ignition, reciprocating engine could have a significant impact on vehicle fuel economy. Use of the spark-ignition, rotary engines presently results in significant losses in fuel economy, while the Diesel engine offers a significant increase in fuel economy.

VIII. CONCLUSIONS

1. Vehicle weight is the single most important parameter affecting urban fuel economy; a 5000 pound vehicle demonstrates 50% lower fuel economy than a 2500 pound vehicle.

2. The fuel economy loss for 1973 vehicles, compared to uncontrolled (pre 68) vehicles, is less than 7%. The average fuel economy loss due to emission control for all controlled (68-73) vehicles is 7.7%.
3. The fuel economy penalty due to the use of convenience devices such as air conditioning or automatic transmission is roughly equal to the penalty due to emission controls.
4. No trend is shown for fuel economy for 1975 and 1976 vehicles at this point in time. More data are needed.
5. Data on 172 1970 and 1971 GM cars did not demonstrate any effect on fuel economy of reduced compression ratio.
6. Future trends, including increased vehicle weight and possible use of the rotary engine, may result in a significant (20%-35%) fuel economy penalties.
7. The Diesel and stratified charge engines show better fuel economy then the conventional engine with the Diesel showing a fuel economy improvement of more than 70%.
8. Today's car buyer has available a choice of vehicles in terms of the size and weight, engine type, and convenience devices. These choices can influence a vehicle's fuel economy over a range of 4 to 1 (See Range of Data in Appendix I).

FOOTNOTES:

1/ Fuel economy should not be confused with fuel consumption which is expressed in terms of gallons of fuel consumed per mile. One is the inverse of the other. A certain percentage increase or decrease in fuel economy <u>does not equal</u> the same percentage decrease or increase in fuel consumption. For example, one car getting 20 MPG has 33% better fuel economy than one with 15 MPG. However its fuel consumption is 25% less. The two terms cannot be used interchangeably.

2/ <u>Calculation of Fuel Economy</u>

Since both CO and CO_2 are measured for the test, an approximate carbon balance fuel economy figure can be generated from the CO and CO_2 data. The formulae used are:

$$72 \text{ FTP MPG} = \frac{2360}{.429\ (CO) + .272\ (CO_2)}$$

Where the dimensions of CO and CO_2 are grams per mile for the complete test.

$$75 \text{ FTP MPG} = \frac{17800}{.429\ (CO) + .272\ (CO_2)}$$

Where the CO and the CO_2 are the total number of grams of CO and CO_2 in Bags 1 and 2.

Both of these formulae neglect the hydrocarbon contribution to the carbon balance. This however is not serious if the data are used for comparative purposes as is the case in this analysis. In addition, to the accuracy to which the data are reported, the neglect of the hydrocarbons influence is not important.

The accuracy of any single data point is believed to be within ± 5% of the true value. This is the maximum inaccuracy in the CO_2 measurement. The accuracy of the mean or average values is believed to be much higher since the experimental errors are random and tend to cancel out in the sample. No statistical analysis has been performed on this data. The data and conclusions presented on the preceding pages are based only on the <u>observed means</u> of the samples.

APPENDIX I

Inertia Weight	Average MPG	Range	# of Data Points
Model Year 1973	C = 48667		
2000	25.5	23.7 to 28.5	6
2250	20.7	18.9 to 21.9	8
2500	19.9	13.3 to 23.7	74
2750	17.9	11.9 to 23.7	62
3000	16.2	13.6 to 19.7	37
3500	14.0	9.8 to 17.8	64
4000	11.2	7.7 to 14.6	69
4500	10.1	7.4 to 13.6	157
5000	9.4	7.6 to 11.8	96
5500	8.8	7.1 to 10.0	57
Model Year 1972	C = 49362		
2000	25.7	21.4 to 37.8	5
2250	21.3	18.5 to 27.8	5
2500	18.0	17.0 to 19.0	2
2750	21.7	13.0 to 41.7	10
3000	15.6	10.1 to 20.6	7
3500	14.0	10.7 to 19.2	5
4000	11.2	6.3 to 15.3	28
4500	10.1	8.5 to 11.3	8
5000	9.3	7.8 to 10.6	11
5500	8.7	7.8 to 9.2	3
Model Year 1971	C = 47009		
1750	27.4	-	1
2000	21.9	19.3 to 23.9	6
2250	21.2	18.7 to 27.0	11
2500	19.6	14.7 to 25.0	16
2750	18.5	16.8 to 21.9	6
3000	15.2	7.8 to 20.7	10
3500	13.0	8.9 to 20.2	15
4000	11.3	8.8 to 13.6	42
4500	10.6	7.8 to 12.7	30
5000	9.3	5.4 to 15.4	10
5500	8.1	-	1
Model Year 1970	C = 48320		
2000	24.5	20.2 to 32.0	8
2250	21.1	13.1 to 40.1	7
2500	17.8	10.9 to 22.1	11
2750	18.9	15.8 to 20.2	9
3000	15.6	11.5 to 22.4	21
3500	13.5	9.4 to 17.7	65
4000	12.1	8.5 to 15.6	78
4500	10.9	7.3 to 13.3	51
5000	10.2	6.6 to 13.4	30
5500	9.7	8.3 to 12.2	7

Inertia Weight	Average MPG	Range	# of Data Points
Model Year 1969	C = 47891		
2000	23.1	15.3 to 26.0	14
2250	20.4	17.8 to 24.4	4
2500	19.7	18.1 to 26.8	13
3000	15.8	10.5 to 19.8	13
3500	13.4	9.8 to 17.4	37
4000	11.8	9.0 to 15.4	43
4500	11.5	9.1 to 21.2	31
5000	9.8	8.7 to 11.7	6
5500	11.6	10.2 to 12.9	2
Model Year 1968	C = 47108		
2000	21.5	19.9 to 23.6	8
2250	20.8	-	1
2500	19.3	-	1
2750	19.5	-	1
3000	15.4	11.9 to 19.8	15
3500	13.3	9.5 to 25.0	29
4000	12.1	8.8 to 14.8	31
4500	11.6	9.1 to 14.2	18
5000	8.8	8.7 to 8.9	2
Model Year 1967	C = 54170		
2000	24.7	20.0 to 33.0	8
2250	30.6	-	1
2750	18.8	17.9 to 19.7	2
3000	15.4	13.0 to 17.1	5
3500	13.8	11.5 to 18.6	21
4000	12.5	8.4 to 19.7	36
4500	12.3	9.7 to 13.4	16
5000	11.7	10.7 to 12.1	2
5500	10.3	-	1
Model Year 1966	C = 48934		
2000	24.6	20.5 to 31.2	6
2750	15.2	-	1
3000	14.7	12.0 to 16.9	16
3500	14.3	10.0 to 20.7	25
4000	13.3	8.6 to 28.8	34
4500	12.4	9.8 to 15.5	16
5000	13.0	10.9 to 16.9	3
5500	9.3	-	1

Inertia Weight	Average MPG	Range	# of Data Points
Model Year 1965	C = 50581		
2000	23.5	19.0 to 27.5	4
2750	19.0	16.4 to 21.2	8
3000	16.7	10.9 to 21.9	18
3500	14.5	8.4 to 21.8	42
4000	13.4	9.5 to 19.7	46
4500	13.2	7.4 to 27.8	15
5000	10.6	10.1 to 11.0	4
Model Year 1964	C = 50259		
2000	24.1	22.1 to 26.6	3
2750	17.6	16.3 to 20.5	8
3000	17.0	14.3 to 20.9	21
3500	14.6	10.2 to 29.8	28
4000	14.0	9.6 to 30.4	19
4500	11.5	8.6 to 15.5	12
5000	11.0	10.2 to 11.6	3
Model Year 1963	C = 48209		
2000	25.0	22.3 to 27.2	3
2250	20.1	-	1
2500	19.2	-	1
2750	16.7	14.4 to 21.2	8
3000	15.9	10.5 to 20.1	15
3500	13.7	6.0 to 19.0	19
4000	12.8	9.2 to 18.3	18
4500	11.5	9.3 to 13.5	10
5000	10.7	-	1
Model Year 1962	C = 56105		
2000	29.9	25.8 to 38.0	4
2750	18.9	17.1 to 20.6	2
3000	17.2	13.3 to 20.1	9
3500	15.7	13.2 to 18.6	10
4000	15.0	9.4 to 18.6	19
4500	12.4	10.5 to 14.3	5
5000	11.2	10.2 to 12.1	2

Inertia Weight	Average MPG	Range	# of Data Points
Model Year 1961	C = 53672		
2000	30.3	-	1
2500	21.1	19.9 to 22.2	5
2750	17.6	12.0 to 21.3	4
3000	18.2	17.5 to 18.9	2
3500	13.1	8.7 to 17.5	2
4000	13.5	10.5 to 17.1	9
4500	10.5	9.6 to 12.3	3
Model Year 1960	C = 52474		
2000	20.3	-	1
2500	22.8	-	1
2750	24.4	-	1
3500	16.0	15.1 to 16.8	2
4000	13.4	9.9 to 17.9	11
4500	11.0	10.6 to 11.4	2
5000	11.1	-	1
Model Year 1959	C = 56386		
2000	29.4	18.7 to 44.2	3
3000	15.7	15.3 to 16.1	2
3500	15.2	14.4 to 16.1	3
4000	14.1	10.6 to 17.7	13
4500	13.4	10.6 to 17.5	3
5000	13.9	-	1
Model Year 1958	C = 48095		
2000	26.2	-	1
2250	19.5	-	1
2750	13.4	-	1
3500	14.2	11.9 to 17.0	8
4000	14.4	10.8 to 20.2	9
4500	12.8	11.2 to 15.1	3
5000	10.1	-	1
Model Year 1957	C = 54537		
2000	26.5	23.0 to 31.9	3
3500	14.8	11.5 to 18.3	13
4000	13.9	9.4 to 21.6	7
5500	12.9	-	1