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ABSTRACT

This module is intended to increase the students' comprehension of costs, in terms of money and in energy, involved in various modes of transportation. Four main inquiries are covered in the module: (1) money saved by car pooling to school; (2) reductions in fuel consumption possible without car pooling; (3) comparisons of inter-city and urban transportation modes; and (4) vehicle maintenance to reduce fuel consumption. Two to three class periods are required to complete the module. (Author/RE)

TRANSPORTATION

By David F. Treagust

Unit Title: Net Energy

Module Title: Transportation

Description of Module: The purpose of this module is to increase the students' comprehension of costs in terms of both dollars and energy involved in various modes of transportation.

Part I: Dollars saved car pooling to school.

Part II: How students and their families can reduce gasoline consumption without car pooling.

Part III: A comparison of inter-city and urban transportation using different modes of transportation.

Part IV: The maintenance of a vehicle to obtain maximum possible mileage.

The prime objective of this transportation module is to increase the students' comprehension of the concept of net energy. Parts I and II introduce the students to the module at an everyday level which leads into the more complex issue of net energy.

Unit Objectives Met: 2d, 2e, 3a, 3b

Materials Needed: Student pages, pencil, paper. Films: "Featherfoot" (30 min.), or "Running on Empty" (28 min.).

Module Type: Alternative

Context: Science, Social Studies and Mathematics.

Time Required: 2-3 class periods

Mode: Critical reading, pencil and paper activity, mathematical calculations, home activities, discussion.

Sample Evaluation Items

The Youth Energy Project is funded by the Michigan Department of Commerce and the Michigan Energy Extension Service on a pilot basis. Michigan State University's Cooperative Extension Service (4-H - Youth Programs) and the Science and Mathematics Teaching Center are the project contractors. This material was prepared with the support of the U.S. Department of Energy (DOE) Grant No. EC-77-6-01-5092.

SAMPLE EVALUATION ITEMS

1. Calculate the dollar savings you would make in 9 months by carpooling to school with 3 other people if you had to travel 15 miles round trip and your standard sized car cost 17¢ per mile.

<u>*Answer:*</u> *Total daily cost = (.17)¢ x 15 = $2.55 per day.*
Cost over 8 months done = $2.55 x 21 x 9 = $481.95

(cost per day) (days per month) (months)

Cost over 9 months in 4 person carpool = $481.95 / 4 = $120.49

Dollars saved = $481.95 - $120.49 = $361.46

2. A family owns three cars and each year the <u>total</u> expenses for these cars are computed. The total expenses are as follows: Car 1 - $949.00; Car 2 - $1,222.00; Car 3 - $1,525.00. Calculate the dollars saved with 15%, 20% and 25% reduction in use (making the assumption that use is directly proportional to dollars).

<u>*Answer:*</u>

Dollars Saved

	15%	20%	25%
Car 1	142.35	189.80	237.25
Car 2	183.30	244.40	305.50
Car 3	228.75	305.00	381.25
Total Savings	554.40	739.20	924.00

3. a) Examine the data in Table 3 showing that inter-city bus transportation results in an energy cost of 2700 BTU per passenger mile (ppm) when operating with a load factor of 47%. Calculate the BTU ppm if the load factor were increased to 55%, 65%, 70%.

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3. b) With these load factors what other modes of transportation are comparable with the urban bus. (See Table 3 again).

c) What do you suspect will be the BTU ppm for the urban bus during rush hours? (Maximum capacity of bus is 45.)

Answer: a) BTU ppm at 55% load factor $= \frac{47}{55} \times 2700$

$= 2307$ BTU ppm

BTU ppm at 65% load factor $= \frac{47}{65} \times 2700$

$= 1952$ BTU ppm

BTU ppm at 70% load factor $= \frac{47}{70} \times 2700$

$= 1813$ BTU ppm

b) None as presented, the inter-city bus becomes increasingly efficient. However, if the inter-city train had twice the load factor (74%) it would be competitive.

BTU ppm for train at 74% load factor $= \frac{37}{74} \times 4000 = 2000$ BTU ppm

c) BTU ppm for urban bus 100% full $= \frac{12}{45} \times 5300 = 1413$ BTU ppm

90% full $= \frac{12}{.90445} \times 5300 = 1570$ BTU ppm

Note that this is the next lowest BTU ppm to walking! The relative energy cost comparing 100% full urban bus with walking is 1570:710 = 2:2:1.

4. Using Table 3 calculate the increase or decrease in BTU per passenger mile when a person shifts from a) car to urban bus, b) motorcycle to (urban) car and c) urban bus to motorcycle.

Answer: a) BTU increase or decrease = BTU ppm for car - BTU ppm for bus

BTU decrease $= 8900 - 5300$

$= 3600$ BTU ppm

4\. b) BTU increase or decrease = BTU ppm for motorcycle - BTU ppm for car

= 4200 - 8900

BTU increase = -4700 BTU ppm

c) BTU increase or decrease = BTU ppm for urban bus - BTU ppm for motorcycle

= 5300 - 4200

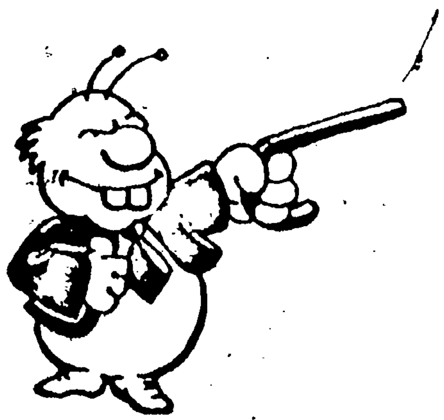
BTU decrease = 1100 BTU ppm

5\. Describe four driving habits that can help you save gas as you drive.

Answer: 1) accelerate smoothly and drive at a steady pace.
2) no need to let car warm up by idling, just drive slowly for the first mile.
3) don't carry unnecessary weight in your car.
4) don't let the engine idle too fast.

6\. Describe four maintenance measures that you can perform to increase the efficiency, i.e. mpg for your car.

Answer: 1) Change spark plugs frequently.
2) Clean air filter.
3) ensure tires are adequately inflated.
4) frequentky have the carbaretor tuned.



For Part I, it is sufficient to introduce car pooling as a means of saving dollars. Ask the students how much they think they will save (in dollars) by car pooling. You may need to provide an exploration of the breakdown of the costs per mile for each size of car, with discussion of relative costs if necessary. In the table below, this data is presented.

Car Size	Vehicle Cost Depreciated	Maintenance Accessories, Parts and Tires	Gas and Oil (Excluding Taxes)	Insurance	State and Federal Taxes	Total Cost (per mile)
Standard	4.5¢	3.7¢	5.5¢	1.7¢	1.6¢	= 17¢
Intermediate	4.2¢	3.4¢	5.3¢	1.6¢	1.5¢	= 16¢
Compact	2.9¢	2.7¢	4.7¢	1.5¢	1.2¢	= 13¢
Subcompact	2.3¢	2.5¢	3.8¢	1.5¢	0.9¢	= 11¢

Adapted from U.S. Dept. of Transportation-Federal Highway Administration Statistics

Table I

You may need to group students together who live in similar vicinities so that they could car pool if they individually drove to school, even if they ordinarily ride the school bus.

Module Title: Transportation

In this module the costs involved in various modes of transportation in terms of both dollars and energy are presented.

Part I (See Reference #1)

Let's look at the dollars saved if you car-pooled to school. Carry out the calculations for your own travel alone and by car-pooling as described in this activity. Also compare passenger miles per gallon for varying the number of occupants.

Car Size	Total Cost Per Mile
Standard	17¢
Intermediate	16¢
Compact	13¢
Subcompact	11¢

Table 1

EXAMPLE: How to figure your present commuting cost (Standard car-Ford LTD) traveling 30 miles round trip.

1. MULTIPLY (.17) x (30) = $ 5.10
   (.17) = Cost per mile; (30) = Miles per day
2. ADD - Daily parking cost + 0
3. TOTAL DAILY COST + $ 5.10
4. MULTIPLY DAILY COST by number of school days per month X 21
5. COST PER MONTH TO DRIVE ALONE = $107.10
6. DIVIDE BY NUMBER OF PEOPLE IN CARPOOL ÷ 4
7. NEW INDIVIDUAL COST BY CAR-POOLING = $ 26.77
8. MONTHLY CARPOOL SAVINGS ($107.10 - $26.77) = $ 80.33

Your Calculation:

1. MULTIPLY ________ X ________ = $ ________
   (first blank) = Cost per Mile; (second blank) = Miles per day
2. ADD - Daily parking cost = $ ________
3. TOTAL DAILY COST = $ ________
4. MULTIPLY DAILY COST by number of school days per month X $ ________
5. COST PER MONTH TO DRIVE ALONE = $ ________
6. DIVIDE BY NUMBER OF PEOPLE IN CARPOOL ÷ $ ________
7. NEW INDIVIDUAL COST BY CARPOOLING = $ ________
8. MONTHLY CARPOOL SAVING (#5-#7) = $ ________

a) What do you suspect is the rationale for calling the largest cars standard?

b) How is the total costs per mile of each car size determined; in other words what factors do you think comprise the total cost for each mile the car is driven?

c) The financial advantages of carpooling are obvious; what are some disadvantages?

**Part II is a week-long assignment, or could be extended until the end of the net energy project. An introduction may be needed regarding how the diary should be kept and that the overall purpose of this assignment is to reduce gasoline consumption by 15%. (Some students may need help with the math involved here.) At the outset you can solicit ideas from the students regarding how they think it will be possible to cut personal gas consumption by 15%.*

Part II

How could you reduce your own gasoline consumption by 15% even without car pooling? Keep a careful record of each driver in your family and keep a record of every trip for a week. Be sure to include yourself if you drive. Record the purpose and mileage of each trip from and back to home. The charts you keep might look something like this.

Table 2

DRIVER A		CAR 1
DATE	PURPOSE	MILES
Monday	Work	14
Tuesday	Work	14
Wednesday	Work	14
Thursday	Work	14
Friday	Work	14
Saturday	Lumber Yard	20
Sunday	Church	8

DRIVER B		CAR 2
DATE	PURPOSE	MILES
Monday	Grocery Store	4
Tuesday	Little League Practice	3
Wednesday	Gas Station	4
Thursday	Piano Practice	6
Friday	(Not used)	0
Saturday	Grocery Store	4
Sunday	Visit Aunt Jane	35

DRIVER C		CAR 2
DATE	PURPOSE	MILES
Monday	School	6
Tuesday	School, Basketball Practice	12
Wednesday	School,	6
Thursday	School, Grocery Store	10
Friday	School, Work	14
Saturday	Work, Movies	10
Sunday	Country Drive	54

a) When the week is over, study the number of trips, their purpose and the total miles driven.

b) Develop a plan with your family that will reduce the number of trips and the miles driven. Get each driver to agree to the plan.

c) How much gasoline has been used in the week?

Determine the mileage rating (miles per gallon) of your family's cars and calculate the dollars spent.

d) How much money is saved with a 15% reduction in miles driven per week.

e) How could you reduce miles driven per week by 20%, 25% and not greatly inconvenience members of your household?

f) Did you know that over 50% of all automobile trips in the United States are less than 5 miles in length. In time trials comparing bikes and cars for urban trips averaging 5 miles, bicycles won 21 out of 25 races. Do you think that bike paths or reserve lanes on major streets and highways should be required and supported by federal funding from the Highway Trust Fund?

**Part III is the first mention of energy cost which is measured as BTU per passenger mile, and serves as an introduction to net energy in this transportation module.*

Some questions you can ask relate to the following issues. Load factor is the percentage of the maximum capacity of a mode of transportation; it is made very obvious by referring to the load factor for a bicycle. Draw the students' attention to data which (1) compares energy cost between different modes of transportation for inter-city traffic, (2) compares energy costs between different modes of transportation for urban traffic, and (3) compares a particular mode of transportation, for example, bus between inter city and urban traffic. Ask the student to determine factors that affect these relative energy costs.

<u>Part 3</u> (See Reference #2)

Consider the data on inter-city and urban transportation presented in Table 3 and compare the energy cost of each mode of transportation.

Selected results on the energy impacts of consumer options in transportation during 1971. Data are expressed in terms of BTU per passenger mile.

Transportation Mode	Load Factor	Energy Cost BTU per Passenger Mile	Relative Energy Cost with Walking
	Inter-City Transportation		
Car	2.9 people	5900	8.31
Plane	53% full	9800	13.80
Bus	47% full	2700	3.80
Train	37% full	4000	5.63
Electric commuter	31% full	9900	13.94
	Urban Transportation		
Car	1.0 people	8900	12.54
Bus	12.0 people	5300	7.46
Motorcycle	1.1 people	4200	5.92
Bicycle	1.0 people	480	0.67
Walking	1.0 people	710	1

Table 3

a) What do you think is meant by a load factor?

b) Why is the load factor different for automobiles on inter-city compared to urban transportation?

c) What is meant by the energy cost being measured in BTU per passenger mile?

d) How would the relative energy cost with walking differ when the load factor changed? Calculate the relative energy cost compared to walking if the average load factor for urban transportation was doubled to 3.8 people.

Now let's look at these data more carefully. If people shifted from one mode of transportation to another there is an increase or decrease in energy expressed as BTU per passenger mile. Tables 4 and 5 present information from which you can determine the BTU per passenger mile saved in changing modes of transportation for inter-city and urban transportation.

Inter-city transportation. The energy that would be saved in BTU per passenger mile by shifting from each transportation mode to another for each traveler. Plus or minus signs indicate an increase or a decrease in energy use respectively. Calculated from Table 3

Shifting from	Shifting to: Car	Plane	Bus	Train
Car	-	+3900	-3200	-1900
Plane	-3900	-	-7100	-5800
Bus	+3200	+7100	-	+1300
Train	+1900	+5800	-1300	-

Table 4

Table 5 is completed in the Teacher's guide but has only the top line and the two extreme right columns completed in the student materials.

Urban transportation. The energy that would be saved by shifting from each transportation mode to another for each traveler in BTU per passenger mile. Plus or minus signs indicate an increase or a decrease in energy use. Calculated from Table 3

Shifting from	Shifting to: Car	Bus	Motorcycle	Bicycle	Electric Commuter
Car	-	-3600	-4700	-8620	+1000
Bus	+3600	-	-1100	-4820	+4600
Motorcycle	+4700	+1100	-	-3720	+5700
Bicycle	+8620	+4820	+3720	-	+8620
Electric Commuter	-1000	-4600	-5700	-9420	-

Table 5

Can you suggest ways that energy costs can be reasonably reduced in passenger transportation? One example is that a greater number of people using urban bus transportation will increase the average load factor and result in reduced energy costs in BTU per passenger mile.

Ask the students to make suggestions for ways that energy costs can be reasonably reduced in passenger transportation. For example, a greater number of people using urban bus transportation will increase the average load factor and result in reduced energy costs in BTU per passenger mile.

As Hannon writes:

> "All costs are very sensitive to load factors. In terms of dollars and energy, the plane is easily the most expensive, and the train is the most employment intensive. The inter-city bus costs the least in dollars and in energy. The urban passenger has a variety of modes to choose from, as shown in Table 3. These modes are increasingly unpopular but decreasingly energy expensive as one moves down the list. Energy consumed in walking was that used to supply the food consumed by the average person for the energy used in excess of that used by the body in the resting position.
>
> It has been pointed out by Bullard that the important factor in energy conservation is the rate at which energy is saved on the transfer from one activity to another. Tables 4 and 5 show rates of energy savings (British thermal units saved per passenger mile) for shifts from each transportation mode to the other. The rates vary from about 480 to 9900 BTU per passenger mile. In all cases except in the urban transportation shifts from car to bus, dollars are saved if energy is saved, and vice versa. For example, the traveler who switched from urban bus to bicycle would save energy (and dollars) at the rate of 4820 BTU per passenger mile. If he were not careful to spend his dollar savings on an item of personal consumption which had an energy intensity greater than 4820 BTU per passenger mile then his shift to the bicycle would have been in vain.
>
> In every instance, a change in transportation mode that would conserve energy would also save dollars (except in the case of changing from urban to bus transportation)."(Hannon, 1978, p. 101).

a) Do you consider that energy savings by conservation and/or changing modes of personal transportation will become more important as time progresses? Why do you think this?

b) Calculate the energy savings for all incomplete spaces in Tables 4 and 5.

**To review Part III, ask the students what they have understood by net energy in the context of changing modes of transportation. An important point to make is that reducing energy expenditure on transportation only results in an overall net energy savings if the consumer does not use all the energy saved on other personal consumption activities.*

*Part IV deals with energy efficiency in transportation primarily in terms of improved driving habits and automobile maintenance. Two excellent films are available on this subject: "Running on Empty" and "Featherfoot" and it is well worth your time to show one of them.

To realize just how much energy could be saved with improved driving habits and automobile maintenance, we draw your attention to the attached annual report from the Michigan Travel Bureau. A cursory glimpse at the tables on pages 44 and 45 gives an indication of where money and BTU's can be saved if people continue to use private transportation as their chief means of travel. The article about the Michigan Travel Bureau presents this information in terms of dollar profit to the State of Michigan. A message that we wish to convey to students is the fact that continued growth is not necessarily beneficial in terms of BTU of energy consumed and that each BTU consumed should provide transportation as efficiently as possible.

Part 4

Now for a change in gear; let's consider ways in which we can simply improve the energy efficiency of the car we drive. Read Unit 13. Energy Efficiency in Transportation. Keep a record of when these efficiency maintaining items are put into operation on your family car and on your own car if you own one. How does each efficiency maintenance item contribute to an increase in your total net energy increase?

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REFERENCES

1. Based on Unit 45: Transportation: Car Pooling at School. Ideas and Activities For Teaching Energy Conservation: Grades 7-12. University of Tennessee Environment Center, 1977. (Used with permission of the authors.)

2. The tables were based on the ideas and tables originally developed by Bruce Hannon, 'Energy Conservation and the Consumer.' Energy II: Use Conservation and Supply. Edited by P.H. Abelson and A.L. Hammond. American Association for the Advancement of Science, Washington, D. C., 1978.

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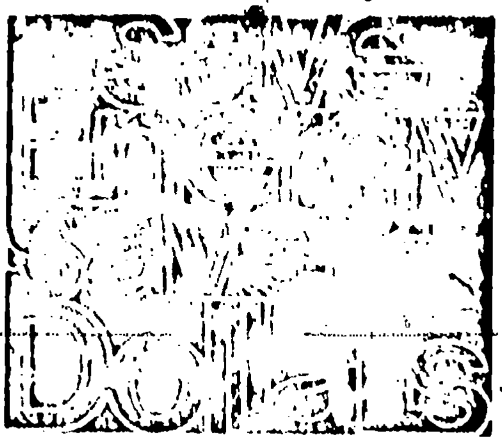
Energy efficiency in transportation



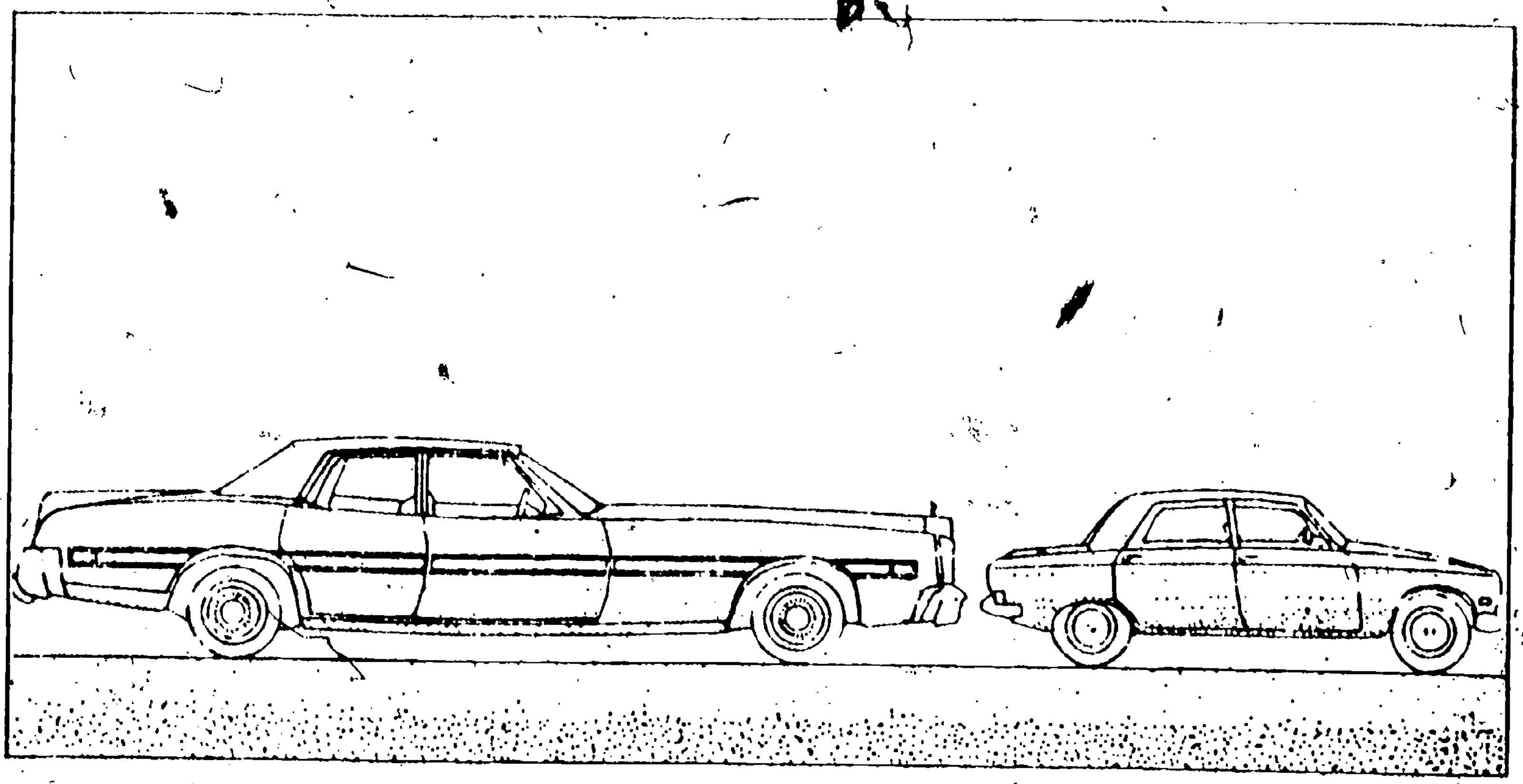
- **Automobiles use 14 percent of *all* energy consumed in the United States.**
- **Probably, the most expensive item in your personal energy budget is the operation and maintenance of your car(s).**
- **The United States accounts for approximately 6 percent of the world's population and over 46 percent of the world's automobiles.**
- **It is estimated that more than 21,000 square miles (54 600 square kilometers) of land have been paved over to accommodate this country's 100 million cars.**

Shocking facts aren't they?

It would be difficult for Americans to imagine life without a car. The problem is not that we have automobiles, but rather that we must learn how to use automobiles efficiently and save energy in the process.

Purchase an Energy-Efficient Car

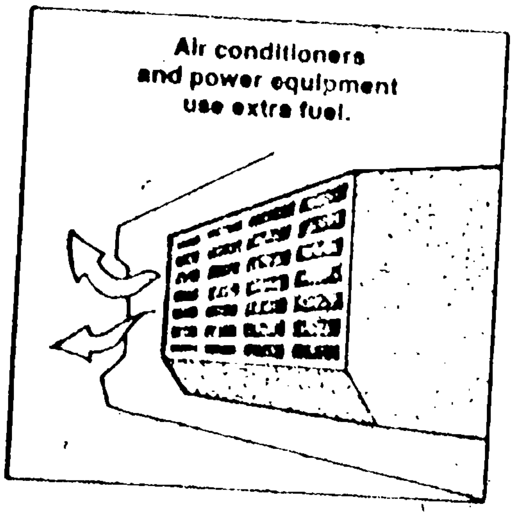
An automobile's fuel economy is determined by weight, engine type and size, and maintenance. Before you buy an automobile, familiarize yourself with the fuel economy of various models. The information can be found in the **Gas Mileage Guide**, published annually by the



Environmental Protection Agency (EPA) and the Federal Energy Administration (FEA). All new car dealers are required by law to have the Guide available in their showrooms. Or, you can request a free single copy of the Guide from: Fuel Economy, Pueblo, Colorado 81009. EPA tests are conducted under controlled conditions, therefore a driver can expect some variation from the test results.

As you read the Guide, you will see that small, lightweight cars are more economical to operate than full-size, heavy cars. In general, in city driving, a 5,000-pound (2250-kilogram) car uses twice as much fuel as a 2,500 pound (1125-kilogram) car.

Buy a car on the basis of minimum-size requirements, purchase price, and estimated fuel costs. Be reasonable about optional features. An air conditioner reduces fuel economy 10–20 percent when used in stop-and-go traffic. If you must have air conditioning, use it only when absolutely necessary. Automatic transmission and power steering also use more fuel than standard transmission and steering. Power brakes, motor driven windows, and power seats and radio antennas don't require much energy to operate, but the weight added to a vehicle reduces fuel economy.



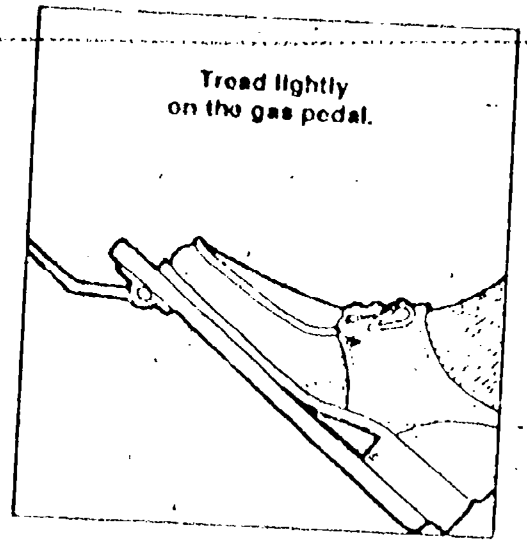
Air conditioners and power equipment use extra fuel.

Save Fuel as You Drive

Fuel economy decreases in direct proportion to air drag on a vehicle. For example, if you increase your automobile speed from 55 miles per hour (mph) (90 km/h), the legal limit, to 65 mph (105 km/h), the increase in the car's drag resistance goes up by 30 percent and fuel economy decreases. Best fuel economy occurs at speeds of 30–40 mph (50–65 km/h) with no stops or rapid speed changes.

Develop driving habits to help you save fuel. Accelerate smoothly to save gasoline and wear and tear on the engine and tires. Drive at a steady pace and anticipate speed changes, sudden changes in speed waste gasoline. For example, take your foot off the accelerator as soon as a red traffic signal is spotted ahead. Drive slowly for the first mile (couple of kilometers) instead of letting your car warm up by idling; an idling average-size engine burns about a pint (500 milliliters) of gasoline every 12 minutes. Avoid overfilling a car's gas tank; fuel spillages are wasteful, too. Don't carry unnecessary weight in or on a car; the heavier the car, the more gas it uses.

You probably have an idea of the current gas mileage of your car. As you develop energy-efficient driving techniques, check the car again to see if you are getting better mileage. There are five steps to follow for an accurate mileage test. (1) Fill the gas tank full and make a note of the mileage on the odometer. (2) Keep a record of all gasoline added during the test period. (3) At the conclusion of the test, again fill the tank full. (4) The gas added during the test, plus the gas required to refill the tank at the end of the test, is the total gas used for the test. (5) The gas mileage is equal to the number of miles (kilometers) driven during the test divided by the total gas used. For accuracy, the test should be conducted over 600 to 1,000 miles, or 3–4 tanks of gasoline. (In the metric system, gasoline consumption may be given in liters per 100 kilometers.)



Tread lightly on the gas pedal.

Automobile Maintenance

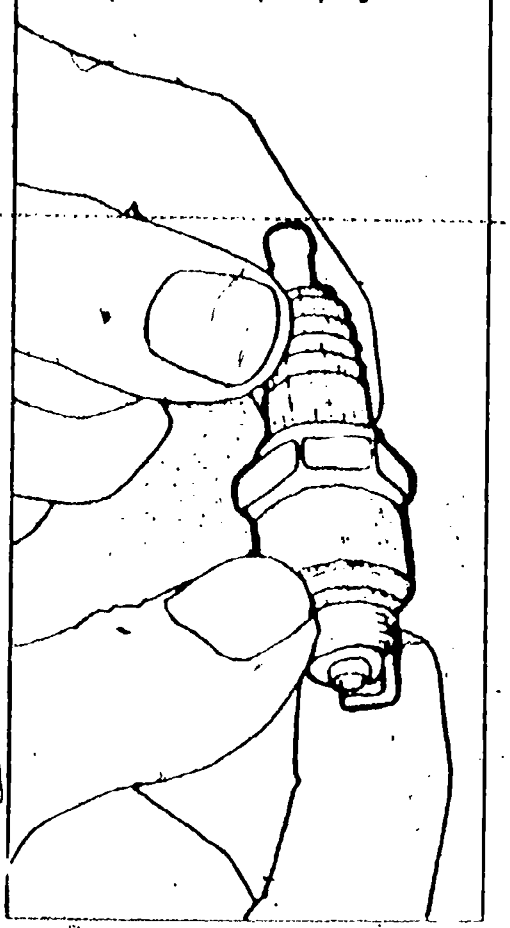
An automobile cannot maintain energy-efficient performance without proper maintenance. Automobile tune-ups not only save fuel, they also provide easier starting and smoother operation. A car that is properly maintained averages 6 percent better mileage per gallon of gasoline than a car that needs new ignition points and spark plugs.

Gasoline engine components that are the most common cause of poor power and increased fuel consumption are the spark plugs, ignition timing, the air cleaner, and carburetor adjustments. A spark plug that is not functioning properly can waste as much as 1 gallon (3.8 liters) of gasoline in every 10 (38). Ignition points in the distributor that are out of adjustment or deteriorated from use can result in starting difficulties and poor performance. The air cleaner is a passive device, but for each gallon (3.8 liters) of gasoline burned, approximately 10,000 gallons (38 000 liters) of air must pass through it. A dirty and partially clogged air cleaner starves the carburetor of air; therefore, the optimum fuel–air mixture is not obtained, and the fuel is not used at its optimum efficiency. Carburetors require regular adjustments in order to maintain automobile performance.

New-car owners' manuals recommend tune-up frequency; faithfully follow the suggested plan. You can do this by finding a reliable automobile mechanic, familiar with your particular car, to do the work or by doing tune-ups yourself. Most community colleges and adult education programs offer courses in automobile maintenance.

In order for your car to operate at highest efficiency, it is also important to use the recommended gasoline octane rating and oil grade. Check your owner's manual.

Carefully inspect points and spark plugs.

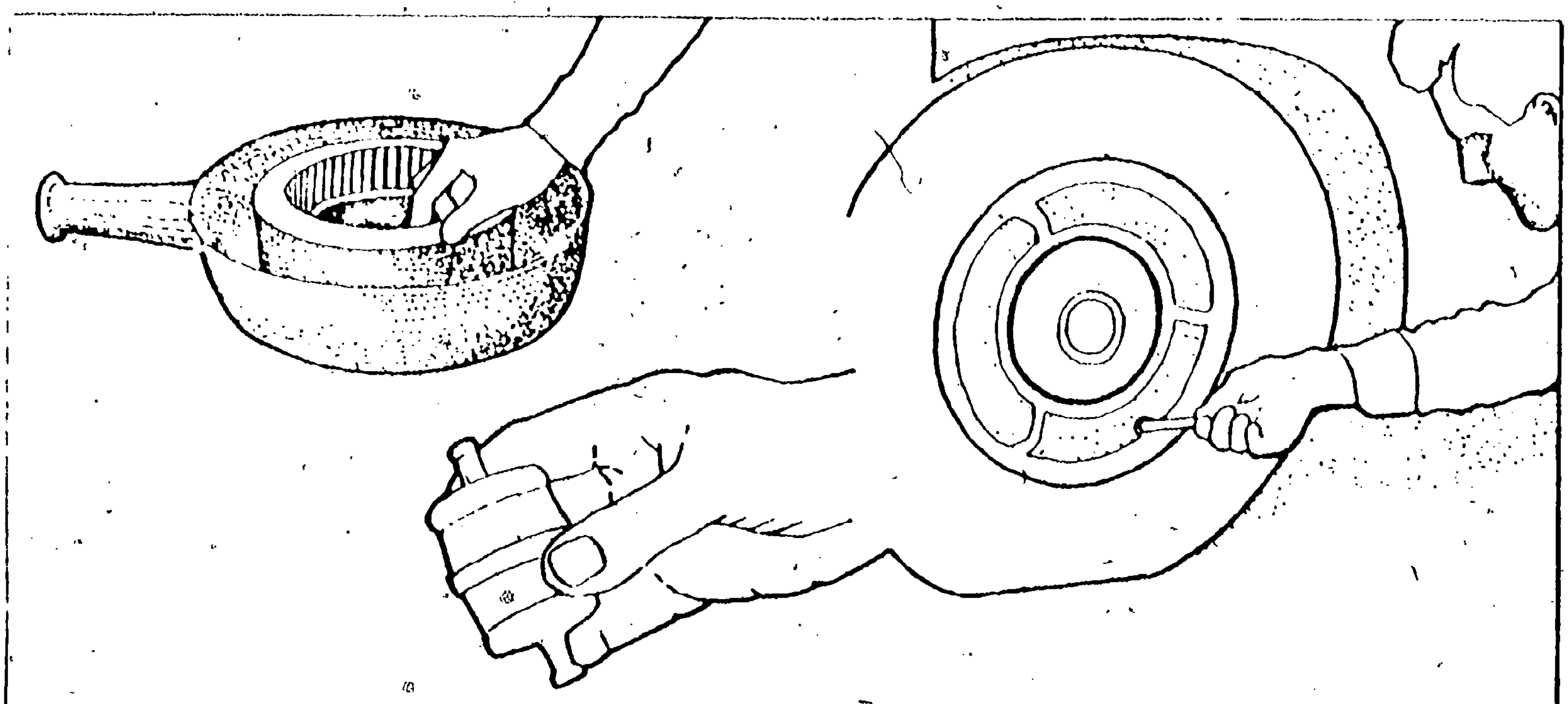


Tires Affect Fuel Efficiency

Proper inflation and type of automobile tires can provide better gas mileage and can save you money. Underinflation is probably the greatest cause of tires wearing out too fast. Underinflation also increases the rolling resistance of a tire, thus it requires more energy per mile (kilometer) to roll the car along the highway. Some tests show that 30 percent underinflation — and that is far from being a flat tire — reduces tire life by about 50 percent.

Radial tires, because of their design, develop less rolling resistance than standard tires. One can expect a 5 percent improvement in fuel economy by switching to radial tires.

A very useful accessory for good tire life is an accurate air gauge. In particular, radial tires, when properly inflated, often appear to have a "flat" appearance. It is difficult to distinguish by eye when



Regularly check air cleaner, fuel filters, and tires.

a radial tire is underinflated. Get in the habit of checking regularly the inflation of your car's tires.

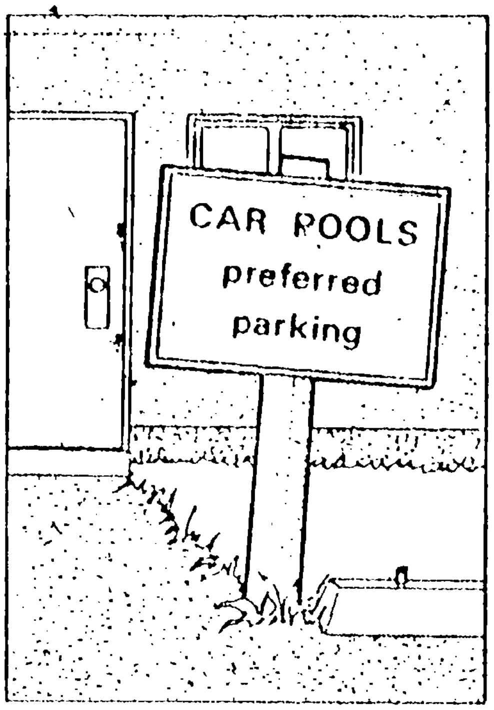
Synthetic Oils

Synthetic engine oils, used in some automobiles today, belong to two basic classes: one, called esters, is made by reacting alcohol with certain types of acids; the second, synthesized hydrocarbons, is fabricated from various hydrogen- and carbon-containing molecules found in natural petroleum. Mineral oils, the oil used in most automobiles today, are usually changed after 6,000 miles (10 000 kilometers) of use. It is believed synthetic oils can safely be used with oil changes at 12,000-mile (20 000-kilometers) intervals. Although synthetic oils cost 4–5 times as much as mineral oils, cars lubricated with synthetics show an average 5 percent improvement in gas mileage over those using conventional motor oils.

Car Pools Can Save Money

Over 80 percent of working Americans commute to work by automobile; more than 50 percent of them drive alone. A car pool to and from work not only saves gasoline and money, but also saves wear and tear on cars. Ask your employer to help establish car pools at your place of business.

Another type of car pool frequently overlooked is better scheduling of family trips by automobile. Family automobile travel — shopping, visiting, trips to the doctor, to music lessons, or to athletic events, for example — accounts for nearly one-third of all passenger trips in this country and averages 5½ miles (9 kilometers) one way. If, by planning ahead to combine errands and appointments, a family took one less trip per week (7 trips instead of 8), that family could save $75 per year. To take it a step further, if every automobile in the United States consumed 1 less gallon (3.8 liters) of gasoline per week, national demand for gasoline would be reduced by about 7 percent!



Transportation Alternatives

Engineers often measure energy in British thermal units (Btu), the amount of energy required to raise 1 pound of water 1 degree Fahrenheit; or joule, the amount of energy required to produce 1 watt for 1 second. A comparison of these energy units for various modes of transportation is revealing. Walking requires about 300 Btu's (316 200 joules) per person per mile (1.6 km); a bicycle requires 200 Btu's (210 800 joules) per mile (1.6 km). In contrast, driving an average-size automobile with no passengers requires 8,100 Btu's (8.5 million joules) per mile (1.6 km) in the city and about 3,400 Btu's (3.5 million joules) per mile (1.6 km) on the highway. In terms of energy usage, bicycling and walking are obviously very energy efficient means of individual transportation. Fully loaded buses and trains are much more efficient modes of transporting people than the automobile. In order to save energy and dollars, use alternative means of transportation whenever possible and, if it is feasible, advocate the establishment or improvement of mass transportation systems in your locality.

Energy consumption must be reduced in this country. A good place to start is with the family automobile.

michigan travel bureau

ANNUAL REPORT

Travel generates billions

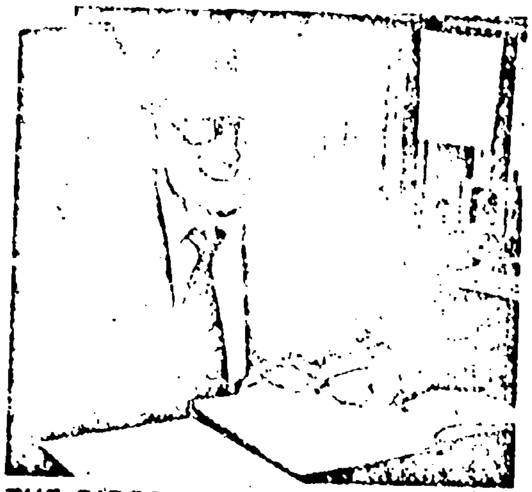
This report of the Michigan Travel Commission for calendar year 1977 summarizes the role and responsibilities of the Travel Bureau, describes its major accomplishments and delineates the economic impact our industry has had on the State of Michigan. The report addresses the travel industry's potential for future growth and development as well as some of the problems faced by the industry. Every effort has been made to provide information of significance to all Michigan residents about the diversified responsibilities of the Travel Bureau.

NON-RESIDENT TRAVELERS SPENT $2.1 BILLION IN MICHIGAN IN 1977

Visitation- 51 million trips were made to Michigan in 1977. The travelers represented a cross-section of all 50 states and a score of foreign countries. Our prime market area consists of Illinois, Indiana, Ohio, Wisconsin, Michigan, the Minneapolis-St. Paul area and Canada. This market generated 80 percent of the travel to Michigan in 1977.

While Michigan attracts an extreme high proportion of its own residents to travel within their home state, approximately 40 percent of trips made here are by non-residents who account for nearly 50 percent of travel expenditures. This is of vital economic consequence for several reasons: 1) the non-resident generally stays longer and, therefore, spends more; 2) the non-resident generates tax revenues, but places little demand on the many state services supported by those taxes; and 3) the "new" money brought in has a great multiplier effect on economic activities. The importance of the out-of-state traveler cannot be overstated.

Where They Go And What They Do. There is tremendous tourist participation in all areas of the state.



THE DIRECTOR: Jack Wilson

The largest share of Michigan visitors participate in outdoor recreation activities (34 percent), with fishing and swimming ranking as the most popular activities.

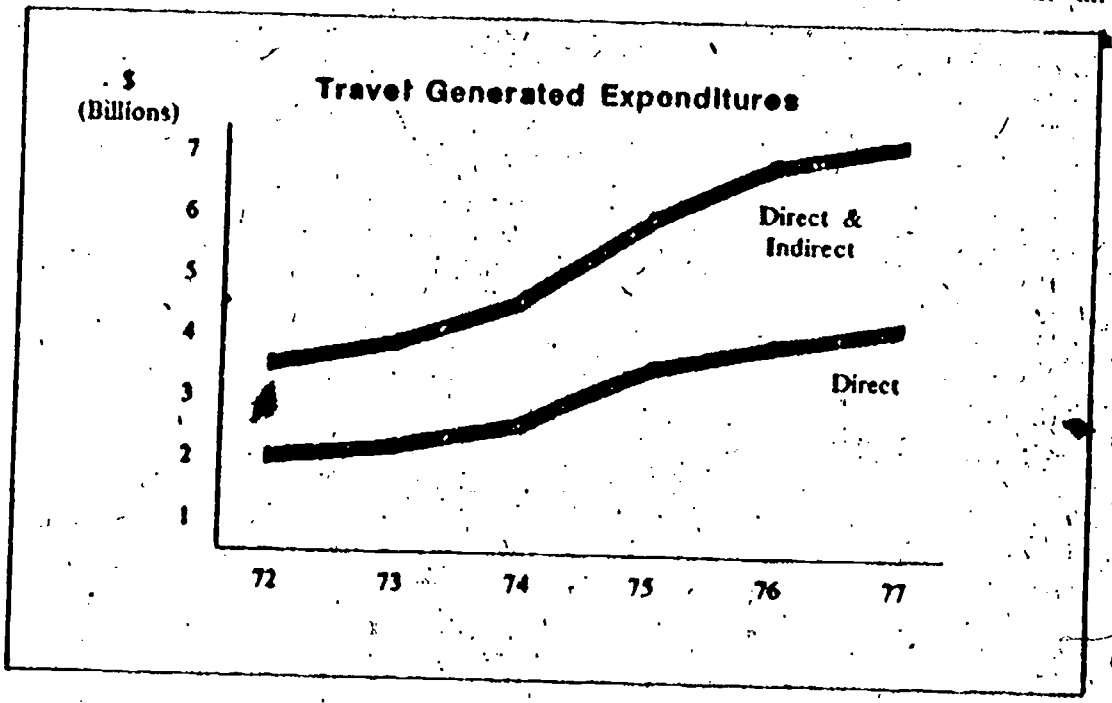
Sightseeing is a particularly prevalent activity in Michigan, drawing 16 percent of vacation travelers in 1977. The most visited attractions are Greenfield Village, the Soo Locks and Mackinac Island.

A very high percentage (74 percent) of vacation trips to Michigan were return visits, indicating an excellent degree of satisfaction with Michigan's travel product and hospitality.

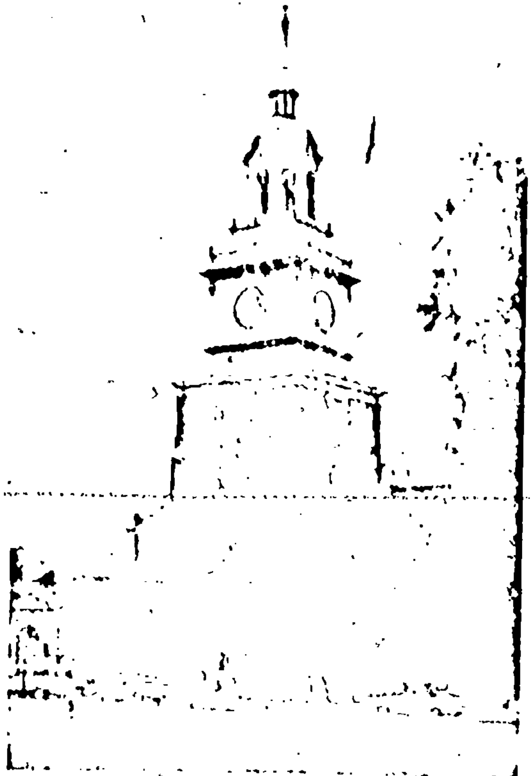
WHAT DOES TRAVEL ACTIVITY MEAN FOR MICHIGAN?

Business! Travel is a multi-billion dollar business in Michigan. In 1977, travelers spent in excess of $4.2 billion while on trips in the state. This is an increase of $300 million over 1976 when spending was approximately $3.9 billion. More than 35,000 businesses in Michigan directly benefit from these expenditures.

Travel dollars touch every citizen, since for every dollar spent here, 78 cents is generated and ripples through the entire state economy. Through this rippling effect, the travel industry, which begins as a $4.2 billion business in direct expenditures, results in an



COMMERCE REGISTER: October, 1978



GREENFIELD VILLAGE: Henry Ford Museum

industry totaling in excess of $7.5 billion overall.

Jobs. The travel expenditures directly and indirectly support 208,000 jobs in the state. In comparison with other states, Michigan ranks sixth in the total number of jobs supported through the expenditures of travelers. Over $2.3 billion in direct and indirect income was generated as a result of 1977 travel expenditures in Michigan.

Convention Activity. During 1976-77, the Convention Bureau Grant Program recipients hosted 743,717 convention delegates who spent more than $105 million in Michigan. During this time these convention bureaus sold $126 million in future convention business. Based on the amount of state funding of $250,000, the Convention Bureau Grant Program returned a *net profit* of more than $330,000 to the state, as well as supporting the development efforts of new bureaus.

Tax Revenues Generated. The travel dollar becomes the Michigan dollar when expenditures are converted to tax revenues.

Taxes generated from travel spending increased from $131 million in 1976 to $141 million in 1977. This is a conservative estimate since it does not include corporate income tax.

Michigan currently ranks fifth nationwide in taxes generated by the travel industry.

A SUMMARY LOOK AT MAJOR ACHIEVEMENTS OF MICHIGAN'S TRAVEL PROGRAM

• Operated an aggressive program which, in conjunction with the Michigan travel industry, generated over $[illegible]2 billion in direct travel expenditures, supported 208,000 direct and indirect jobs and generated over $141 million in tax revenues.

• Answered over 323,500 individual and group inquiries about Michigan travel opportunities, representing an increase of 16.5 percent over 1976.

• As of the end of 1977, inquiry response time had been reduced to an average of 3 to 7 days from 5 to 9 days in 1976.

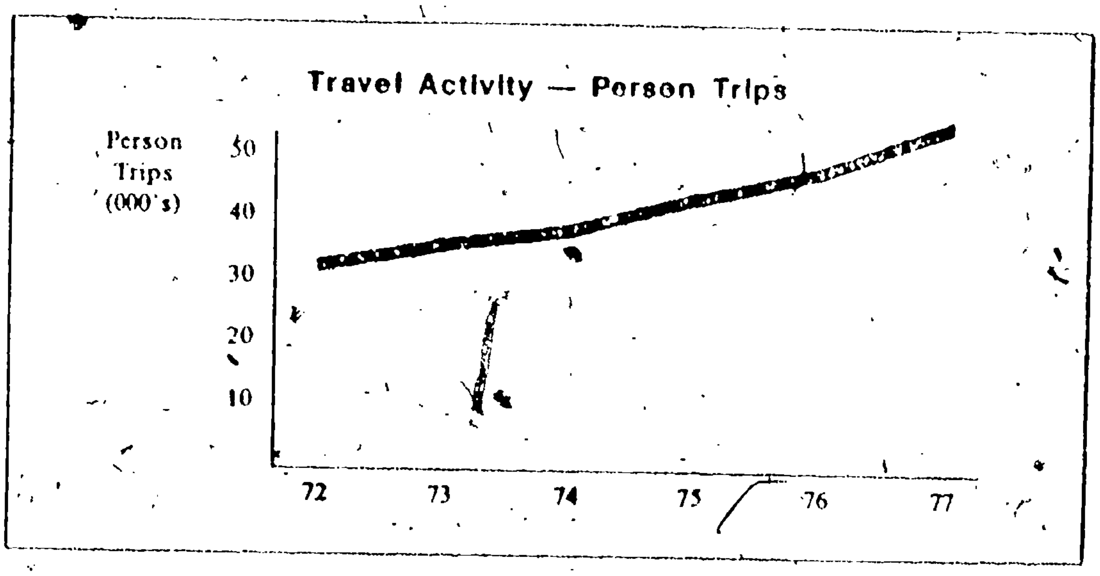
• Increased the percentage of inquiries by telephone from 46.7 percent in 1976 to 54 percent in 1977, thus increasing the effectiveness of information servicing by qualifying the caller's interest, which cannot be done with written or coupon requests. A dramatic increase in prospective travelers' use of the bureau's instate and out-of-state toll-free WATS line service was recorded with 1977 inquiries up 48.6 percent over 1976.

Michigan was selected as one of 10 major tourism states in the nation to be surveyed by the Council of State Governments under a grant from the U.S. Department of Commerce. The study, designed to develop a model state tourism program, was completed by the research team in December 1977.

• Initiated an advertising campaign designed to promote the mid-week ski experience. Preliminary surveys indicate that this campaign is building mid-week business and a record winter season is anticipated barring adverse weather conditions.

• Completed a statewide survey of accommodations to determine accessibility to the handicapped and initiated the development of a directory of these facilities for handicappers.

• Increased participation in ski/travel shows throughout the major Midwest market area from 14 to 1976 to 18 in 1977.



• Expanded efforts in the group tour marketing program in Chicago, Cleveland and Lansing, resulting in excess of 130,000 persons involved in group excursions.

The efforts of the Chicago and Cleveland offices with respect to group movements alone continued to generate travel expenditures which produced sufficient tax revenues to cover the year-round operation of both offices.

• Expanded public service program efforts, including radio and T.V. interviews and appearances, press releases, feature articles, radio and T.V. spot announcements, FAM trips, etc., increased promotional exposure in Michigan by 20 percent over the previous year. Many Michigan and out-of-state radio and television stations now carry Travel Bureau snow/ski, fall color and fishing condition reports, and weekly festivals and events programs as a result of aggressive public service efforts.

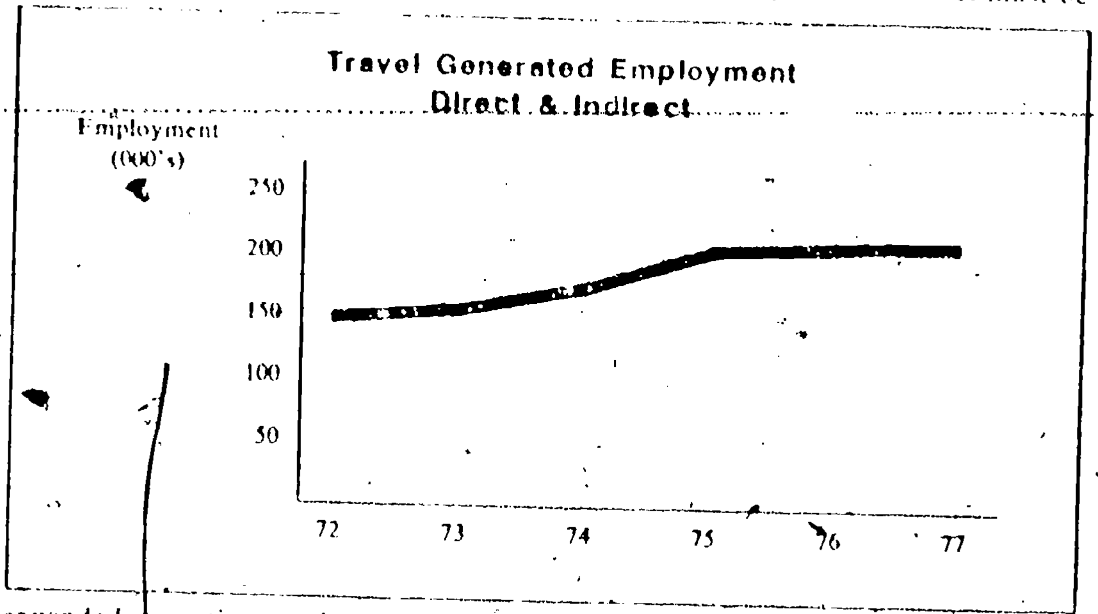
• Continued to expand product development and technical assistance efforts which:

Substantially assisted tourism businesses in efforts leading to construction or renovation of over $17 million in new travel products which will result in:

— $7 to $10 million in increased travel expenditures annually.
— Over 540 construction jobs.
— Over 270 full-time jobs
— Ultimately produce over $6 million in state tax revenues.

• Responded to more than 180 individual requests for travel activity data and general product development information and technical assistance, and undertook and continued efforts on more than 60 product development assistance projects at the request of businesses and local communities with a total construction potential of more than $130 million.

• Undertook 75 general technical assistance projects at the request of tourism businesses and local communities, including group tour marketing seminars, marketing and promotion program development, operations consultation, and festival and fishing contest development. These projects resulted in increased business and local area promotion and marketing efforts, expanded operations and new festivals and fishing contests.



• Completed development and publication of a tourism development manual which provides local areas with a step-by-step self-help process for increasing tourism activity.

• Completed a comprehensive analysis of the convention and meetings market for Michigan, which analyzed present activity and future market potential. The market analysis provides businesses and communities interested in developing convention activity with an objective assessment of market opportunity.

• Initiated development of a self-help fishing promotion manual designed to provide communities with necessary information and techniques for taking advantage of abundant opportunities for increasing fishing based tourism.

• Initiated a special tourism development study for northeast Michigan designed to identify, analyze and recommend the best means of increasing tourism activity.

LOOKING TO THE FUTURE

Many Opportunities The potential for expanded growth of Michigan's travel industry is tremendous. Increasing travel activity is a means to develop and diversify the state's economy as well as to generate increased tax revenues.

• The vacation/pleasure segment of the travel market accounts for more than $1.7 billion in travel expenditures. Market analysis studies have shown that a significant potential market exists that can be attracted to Michigan. This potential market is more than twice as large as the present vacation/pleasure market. Attracting it means increased travel expenditures, increased jobs, increased tax revenues and economic diversification. To increase present vacation/pleasure travel activity in Michigan by 10 percent, only 4.9 percent of the potential market must be attracted. Attracting this would result in:

—An additional $170 million in travel expenditures.

—$5.7 million in additional tax revenues.

—8,500 direct and indirect jobs supported in the long run.

• Michigan urban areas and resorts have a wide variety of excellent convention facilities and have been very successful in drawing convention activity. Attracting conventions produces the same type of benefits as attracting vacation/pleasure travelers. The potential to attract more conventions to Michigan exists, and convention activity is a direct economic stimulus for the urban core.

• If only one-half of the present vacation/pleasure travelers could be convinced to spend $10 more per person in Michigan, an additional $80 million in travel expenditures would be generated.

• If only one-third of the present vacation/pleasure travelers could be convinced to spend $10 more in our urban areas, $55 million would be infused into their economies.

• A substantial potential exists to increase group travel to Michigan from our entire prime market area and fringe markets.

• A large number of local areas and investors/developers have shown interest in developing new travel products. These new products range from new festivals and special events, special attractions and accommodations to major multi-activity destination complexes offering a variety of activities including nightlife and entertainment. There is opportunity to develop these types of products that has not yet been recognized by local areas and investors. By doing so, a greater portion of the market can be attracted. Realization of the present product development potential would result in:

—$180 million in new construction.

—Additional travel expenditures of $185 million per year.

—Over 6,800 new year-round and seasonal jobs

—Generate annual tax revenues of $6.3 million.

• An increasing number of local areas and travel industry businesses are interested in improving and increasing their own promotion, advertising and marketing efforts. This presents a substantial opportunity to increase the magnitude and quality of Michigan's overall promotion, advertising and marketing efforts by providing professional technical assistance.

Some Problems In addition to numerous opportunities, there are several problems that the Michigan travel industry must cope with. The ability to take advantage of the opportunities is dependent upon finding solutions to these areas of concern. Several of the key problems from a statewide perspective are listed here. In many cases, efforts are already underway to address

BAVARIAN INN: draws tourists to Frankenmuth

	1972	1973	1974	1975	1976	1977	%
Travel Generated Expenditures (Billions)							
Direct	2.041	2 225	2.542	3.366	3.942	4 200	106
Indirect	1 590	1.735	1 983	2.625	3.074	3.276	
Total	3.361	3 960	4.525	5.991	7.016	7.576	
Travel Generated Employment (000's)							
Direct	98 9	101.7	109.5	136.9	137.8	140 5	42
Indirect	47.5	48 8	52.6	65.7	66.2	67 5	
Total	146 4	150.5	162.1	202.6	204.0	208.0	
Travel Generated State Tax Revenue (000's)	68 4	74.5	85.2	112.8	132.1	140.7	106
Travel Activity — Person Trips (Millions)	33 5	34.6	36.5	43.5	47.6	51.0	52

these areas of concern. There are other problems beyond those listed which are common among all industries in Michigan.

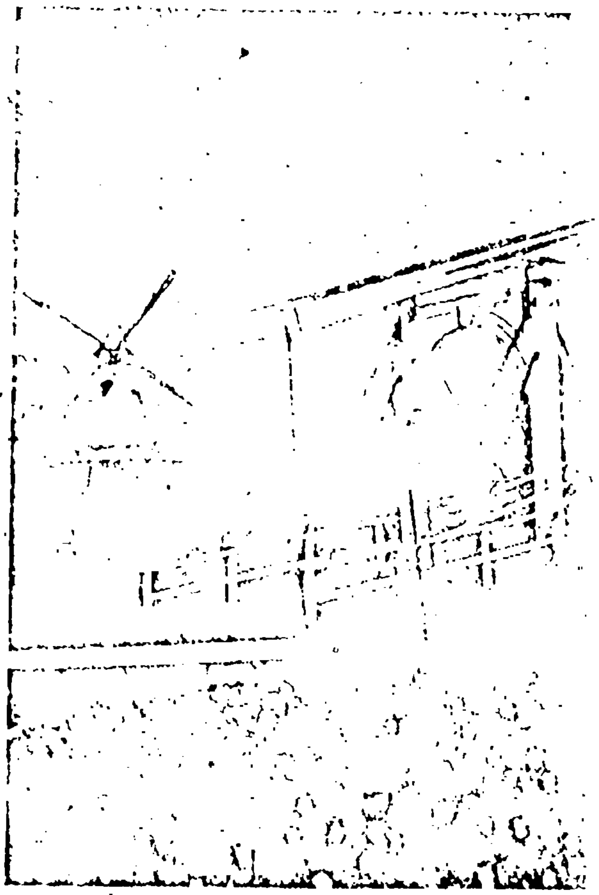
• Possible enactment of the currently proposed national energy policy is of prime concern to Michigan's travel industry. Apparently the industry ranks as low priority among competing interests in terms of energy allocations. At present, 95 percent of all travel related activity is by automobile. The institution of rationing or weekend closure of gasoline stations would have a *drastic* impact, resulting in the loss of tens of thousands of jobs, extensive small business bankruptcy and loss of capital investment that would severely impact all of northern Michigan and the Upper Peninsula — an area heavily dependent upon tourism.

• Although legislation has not been introduced in Congress, several leading political figures have proposed the elimination of specific personal income tax deducations. Of major concern to the travel industry is the proposed curtailment of allowable deductions for business entertainment and travel deductions. Curtailment of these deductions would have a serious economic impact on Michigan's convention/travel industry, particularly its major components such as hotels, motels and restaurants. Treasury Department estimates in the food and beverage entertainment area alone indicate that job loss would be as high as 2 to 3 percent for food service employment. A 1976 levels nationally, this would equate to a 77,000 to 116,000 job loss in the unskilled or semi-skilled areas — already the highest rate of national unemployment.

• Michigan continuesto face fierce, increasing competition in the market place. Illinois, Ohio, Minnesota and Wisconsin will receive increased funds in 1978 while the State of New York will have a massive budget — it could be in excess of $10 million. This is in addition to the continuous heavy pressure from Ontario with its $12.5 million budget in 1978. Michigan's response to this competition must be vigorous to avoid severe economic loss to the state.

• Highway signing in general and billboard removal in particular continue to plague the travel industry. The Travel Commission, in conjunction with the Travel Bureau, scheduled a series of five public hearings throughout the state during 1978. These hearings were designed to provide a forum for travel industry input into the problem.

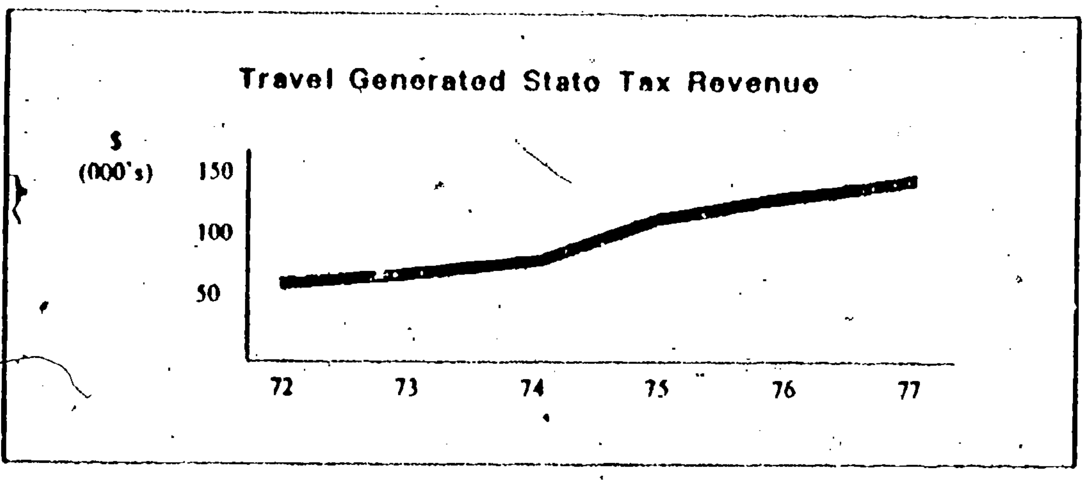
• Michigan tourism is seasonal with a major portion of activity occurring in the summer. Although skiing, winter sports activities and special promotional efforts with emphasis on year-round events have helped offset the seasonality factor, it is still a problem in many areas of the state. We must continue to address ourselves to it, or suffer the consequences.



WINDMILL DEZWAAN: on Windmill Island in Holland

• Additional problem areas include:
—The need for product improvement and upgrading.
—The single business tax.
—The high rate of cost increases in the area of promotion and advertising.

The Challenge. The challenge to Michigan and its travel industry is clear. Significant opportunities exist, offering a beneficial impact on the state in terms of economic development, urban area vitality and generation of tax revenues. The problems, however, could undermine the viability of the state's travel industry and negatively impact the st[illegible]e's economy. Michigan's travel in[illegible]try, local areas, regional tourist [illegible]ciations, convention bureaus and t[illegible] state must continue to increase c[illegible]ordinated efforts to meet the chall[illegible]nge. All will benefit if the challenge is [illegible]t. All will suffer if it is not. ■



Module Title: Transportation

In this module the costs involved in various modes of transportation in terms of both dollars and energy are presented.

Part 1 (See Reference #1)

Let's look at the dollars saved if you car-pooled to school. Carry out the calculations for your own travel alone and by car-pooling as described in this activity. Also compare passenger miles per gallon for varying the number of occupants.

Car Size	Total Cost Per Mile
Standard	17¢
Intermediate	16¢
Compact	13¢
Subcompact	11¢

Table 1

EXAMPLE: How to figure your present commuting cost (Standard car-Ford LTD) traveling 30 miles round trip.

1.	MULTIPLY (.17) x (30) Cost per mile, Miles per day	= $ 5.10
2.	ADD - Daily parking cost	+ 0
3.	TOTAL DAILY COST	+ $ 5.10
4.	MULTIPLY DAILY COST by number of school days per month	X 21
5.	COST PER MONTH TO DRIVE ALONE	= $107.10
6.	DIVIDE BY NUMBER OF PEOPLE IN CARPOOL	÷ 4
7.	NEW INDIVIDUAL COST BY CAR-POOLING	= $ 26.77
8.	MONTHLY CARPOOL SAVING ($107.10 - $26.77)	= $ 80.33

Your Calculation:

1. MULTIPLY ________ X ________ = $ ________
   Cost per Mile   Miles per day

2. ADD - Daily parking cost = $ ________

3. TOTAL DAILY COST = $ ________

4. MULTIPLY DAILY COST by number of school days per month X $ ________

5. COST PER MONTH TO DRIVE ALONE = $ ________

6. DIVIDE BY NUMBER OF PEOPLE IN CARPOOL ÷ $ ________

7. NEW INDIVIDUAL COST BY CARPOOLING = $ ________

8. MONTHLY CARPOOL SAVING (#5-#7) = $ ________

a) What do you suspect is the rationale for calling the largest cars standard?

b) How is the total costs per mile of each car size determined; in other words what factors do you think comprise the total cost for each mile the car is driven?

c) The financial advantages of carpooling are obvious; what are some disadvantages?

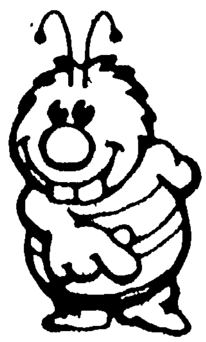
Part II

How could you reduce your own gasoline consumption by 15% even without car pooling? Keep a careful record of each driver in your family and keep a record of every trip for a week: Be sure to include yourself if you drive. Record the purpose and mileage of each trip from and back to home. The charts you keep might look something like this.

Table 2

DRIVER A DATE	PURPOSE	CAR 1 MILES
Monday	Work	14
Tuesday	Work	14
Wednesday	Work	14
Thursday	Work	14
Friday	Work	14
Saturday	Lumber Yard	20
Sunday	Church	8

DRIVER B DATE	PURPOSE	CAR 2 MILES
Monday	Grocery Store	4
Tuesday	Little League Practice	3
Wednesday	Gas Station	4
Thursday	Piano Practice	6
Friday	(Not used)	0
Saturday	Grocery Store	4
Sunday	Visit Aunt Jane	35



DRIVER C DATE	PURPOSE	CAR 2 MILES
Monday	School	6
Tuesday	School, Basketball Practice	12
Wednesday	School,	6
Thursday	School, Grocery Store	10
Friday	School, Work	14
Saturday	Work, Movies	10
Sunday	Country Drive	54

a) When the week is over, study the number of trips, their purpose and the total miles driven.

b) Develop a plan with your family that will reduce the number of trips and the miles driven. Get each driver to agree to the plan.

c) How much gasoline has been used in the week?

Determine the mileage rating (miles per gallon) of your family's cars and calculate the dollars spent.

d) How much money is saved with a 15% reduction in miles driven per week.

e) How could you reduce miles driven per week by 20%, 25% and not greatly inconveniencing members of your household?

f) Did you know that over 50% of all automobile trips in the United States are less than 5 miles in length. In time trials comparing bikes and cars for urban trips average 5 miles, bicycles won 21 out of 25 races. Do you think that bike paths or reserve lanes on major streets and highways should be required and supported by federal funding from the Highway Trust Fund?

Part 3 (See Reference #2)

Consider the data on inter-city and urban transportation presented in Table 3 and compare the energy cost of each mode of transportation.

Selected results on the energy impacts of consumer options in transportation during 1971. Data are expressed in terms of BTU per passenger mile.

Transportation Mode	Load Factor	Energy Cost BTU per Passenger Mile	Relative Energy Cost with Walking
	Inter-City Transportation		
Car	2.9 people	5900	8.31
Plane	53% full	9800	13.80
Bus	47% full	2700	3.80
Train	37% full	4000	5.63
Electric commuter	31% full	9900	13.94
	Urban Transportation		
Car	1.9 people	8900	12.54
Bus	12.0 people	5300	7.46
Motorcycle	1.1 people	4200	5.92
Bicycle	1.0 people	480	0.67
Walking	1.0 people	710	1

Table 3

a) What do you think is meant by a load factor?

b) Why is the load factor different for automobiles on inter-city compared to urban transportation?

c) What is meant by the energy cost being measured in BTU per passenger mile?

d) How would the relative energy cost with walking differ when the load factor changed. Calculate the relative energy cost compared to walking if the average load factor for urban transportation was doubled to 3.8 people.

Now let's look at these data more carefully. If people shifted from one mode of transportation to another there is an increase or decrease in energy expressed as BTU per passenger mile. Tables 4 and 5 present information from which you can determine the BTU per passenger mile saved in changing modes of transportation for inter-city and urban transportation.

Inter-city transportation. The energy that would be saved in BTU per passenger mile by shifting from each transportation mode to another for each traveler. Plus or minus signs indicate an increase or a decrease in energy use respectively. Calculated from Table 3

Shifting from	Shifting to: Car	Plane	Bus	Train
Car	-	+3900	-3200	-1900
Plane	-3900	-	-7100	-5800
Bus	+3200	+7100	-	+1300
Train	+1900	+5800	-1300	-

Table 4

Urban transportation. The energy that would be saved by shifting from each transportation mode to another for each traveler in BTU per passenger mile. Plus or minus signs indicate an increase or a decrease in energy use. Calculated from Table 3

Shifting from	Shifting to: Car	Bus	Motorcycle	Bicycle	Electric Commuter
Car	-	-3600	-4700	-8420	+1000
Bus		-		-4820	+4600
Motorcycle			-	-3720	+5700
Bicycle				-	+9420
Electric Commuter				-9420	-

Table 5

Can you suggest ways that energy costs can be reasonably reduced in passenger transportation? One example is that a greater number of people using urban bus transportation will increase the average load factor and result in reduced energy costs in BTU per passenger mile.

As Hannon writes:

"All costs are very sensitive to load factors. In terms of dollars and energy, the plane is easily the most expensive, and the train is the most employment intensive. The inter-city bus costs the least in dollars and in energy. The urban passenger has a variety of modes to choose from, as shown in Table 3. These modes are increasingly unpopular but decreasingly energy expensive as one moves down the list. Energy consumed in walking was that used to supply the food consumed by the average person for the energy used in excess of that used by the body in the resting position.

It has been pointed out by Bullard that the important factor in energy conservation is the rate at which energy is saved on the transfer from one activity to another. Tables 4 and 5 show rates of energy savings (British thermal units saved per passenger mile) for shifts from each transportation mode to the other. The rates vary from about 480 to 9900 BTU per passenger mile. In all cases except in the urban transportation shifts from car to bus, dollars are saved if energy is saved, and vice versa. For example, the traveler who switched from urban bus to bicycle would save energy (and dollars) at the rate of 4820 BTU per passenger mile. If he were not careful to spend his dollar savings on an item of personal consumption which had an energy intensity greater than 4820 BTU per passenger mile then his shift to the bicycle would have been in vain.

In every instance, a change in transportation mode that would conserve energy would also save dollars (except in the case of changing from urban to bus transportation)." (Hannon, 1978, p. 101).

a) Do you consider that energy savings by conservation and/or changing modes of personal transportation will become more important as time progresses? Why do you think this?

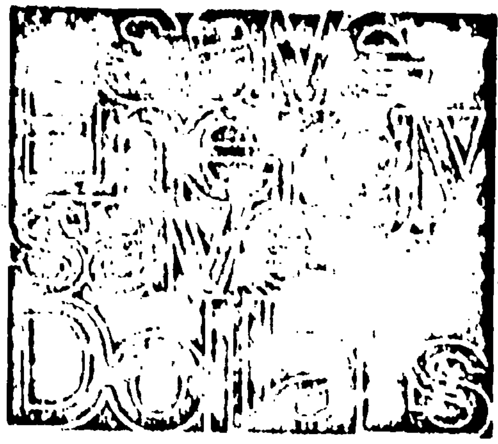
b) Calculate the energy savings for all incomplete spaces in Tables 4 and 5.

Part 4

Now for a change in gear; let's consider ways in which we can simply improve the energy efficiency of the car we drive. Read Unit 13. Energy Efficiency in Transportation. Keep a record of when these efficiency maintaining items are put into operation on your family car and on your own car if you own one. How does each efficiency maintenance item contribute to an increase in your total net energy increase.

13

Energy efficiency in transportation



• The United States accounts for approximately 6 percent of the world's population and over 46 percent of the world's automobiles.

• It is estimated that more than 21,000 square miles (54 600 square kilometers) of land have been paved over to accommodate this country's 100 million cars.

• Automobiles use 14 percent of *all* energy consumed in the United States.

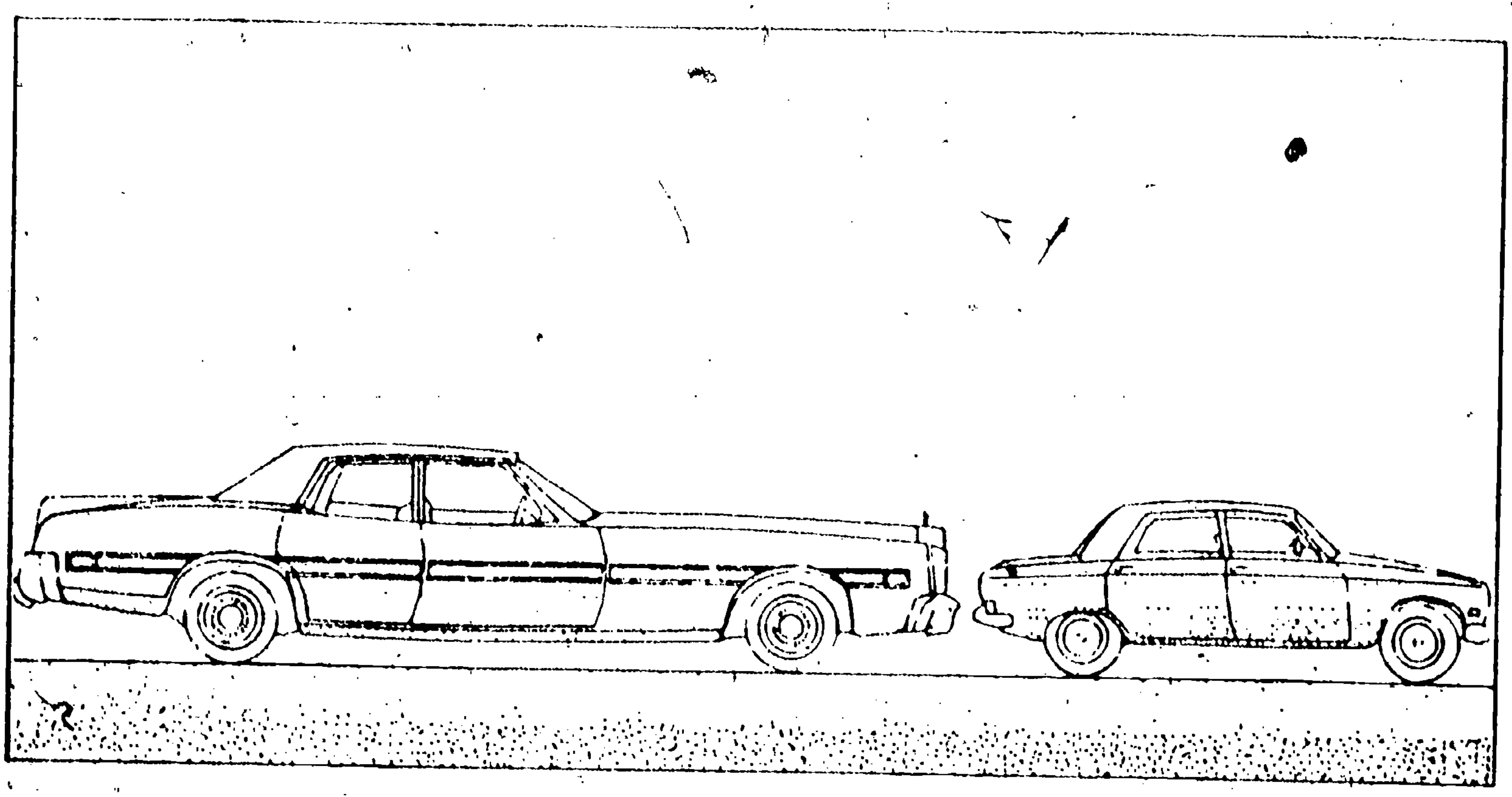
• Probably, the most expensive item in your personal energy budget is the operation and maintenance of your car(s).

Shocking facts aren't they?

It would be difficult for Americans to imagine life without a car. The problem is not that we have automobiles, but rather that we must learn how to use automobiles efficiently and save energy in the process.

Purchase an Energy-Efficient Car

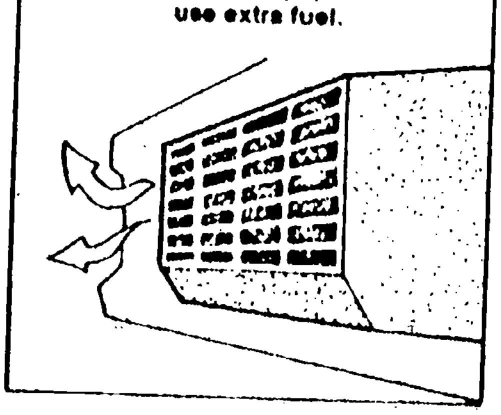
An automobile's fuel economy is determined by weight, engine type and size, and maintenance. Before you buy an automobile, familiarize yourself with the fuel economy of various models. The information can be found in the **Gas Mileage Guide**, published annually by the



Environmental Protection Agency (EPA) and the Federal Energy Administration (FEA). All new car dealers are required by law to have the Guide available in their showrooms. Or, you can request a free single copy of the Guide from: Fuel Economy, Pueblo, Colorado 81009. EPA tests are conducted under controlled conditions; therefore a driver can expect some variation from the test results.

As you read the Guide, you will see that small, lightweight cars are more economical to operate than full-size, heavy cars. In general, in city driving, a 5,000-pound (2250-kilogram) car uses twice as much fuel as a 2,500-pound (1125-kilogram) car.

Buy a car on the basis of minimum-size requirements, purchase price, and estimated fuel costs. Be reasonable about optional features. An air conditioner reduces fuel economy 10–20 percent when used in stop-and-go traffic. If you must have air conditioning, use it only when absolutely necessary. Automatic transmission and power steering also use more fuel than standard transmission and steering. Power brakes, motor driven windows, and power seats and radio antennas don't require much energy to operate, but the weight added to a vehicle reduces fuel economy.



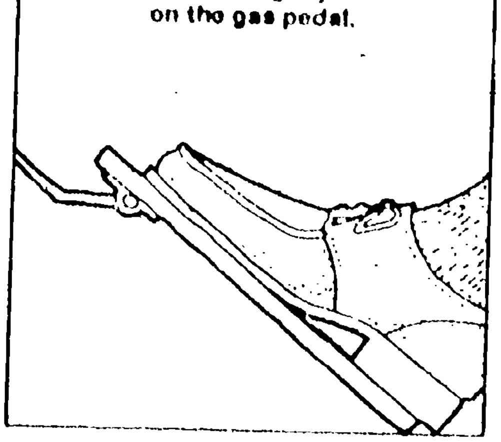
Air conditioners and power equipment use extra fuel.

Save Fuel as You Drive

Fuel economy decreases in direct proportion to air drag on a vehicle. For example, if you increase your automobile speed from 55 miles per hour (mph) (90 km/h), the legal limit, to 65 mph (105 km/h) the increase in the car's draft resistance goes up by 40 percent and fuel economy decreases. Best fuel economy occurs at speeds of 30–40 mph (50–65 km/h) with no stops or rapid speed changes.

Develop driving habits to help you save fuel. Accelerate smoothly to save gasoline and wear and tear on the engine and tires. Drive at a steady pace and anticipate speed changes; sudden changes in speed waste gasoline. For example, take your foot off the accelerator as soon as a red traffic signal is spotted ahead. Drive slowly for the first mile (couple of kilometers) instead of letting your car warm up by idling; an idling average-size engine burns about a pint (500 milliliters) of gasoline every 12 minutes. Avoid overfilling a car's gas tank; fuel spillages are wasteful, too. Don't carry unnecessary weight in or on a car; the heavier the car, the more gas it uses.

You probably have an idea of the current gas mileage of your car. As you develop energy-efficient driving techniques, check the car again to see if you are getting better mileage. There are five steps to follow for an accurate mileage test: (1) Fill the gas tank full and make a note of the mileage on the odometer. (2) Keep a record of all gasoline added during the test period. (3) At the conclusion of the test, again fill the tank full. (4) The gas added during the test, plus the gas required to refill the tank at the end of the test, is the total gas used for the test. (5) The gas mileage is equal to the number of miles (kilometers) driven during the test divided by the total gas used. For accuracy, the test should be conducted over 600 to 1,000 miles, or 3–4 tanks of gasoline. (In the metric system, gasoline consumption may be given in liters per 100 kilometers.)



Tread lightly on the gas pedal.

Automobile Maintenance

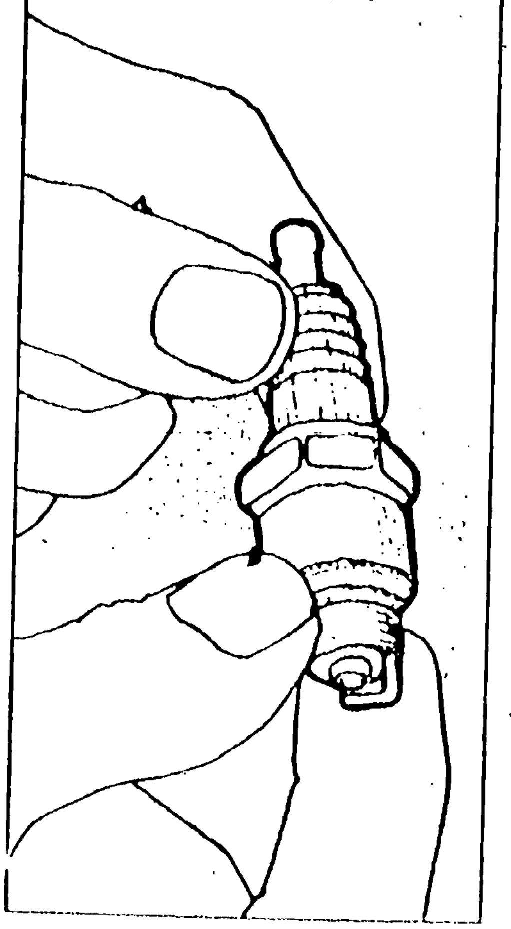
An automobile cannot maintain energy-efficient performance without proper maintenance. Automobile tune-ups not only save fuel, they also provide easier starting and smoother operation. A car that is properly maintained averages 6 percent better mileage per gallon of gasoline than a car that needs new ignition points and spark plugs.

Gasoline engine components that are the most common cause of poor power and increased fuel consumption are the spark plugs, ignition timing, the air cleaner, and carburetor adjustments. A spark plug that is not functioning properly can waste as much as 1 gallon (3.8 liters) of gasoline in every 10 (38). Ignition points in the distributor that are out of adjustment or deteriorated from use can result in starting difficulties and poor performance. The air cleaner is a passive device, but for each gallon (3.8 liters) of gasoline burned, approximately 10,000 gallons (38 000 liters) of air must pass through it. A dirty and partially clogged air cleaner starves the carburetor of air; therefore, the optimum fuel–air mixture is not obtained, and the fuel is not used at its optimum efficiency. Carburetors require regular adjustments in order to maintain automobile performance.

New-car owners' manuals recommend tune-up frequency; faithfully follow the suggested plan. You can do this by finding a reliable automobile mechanic, familiar with your particular car, to do the work or by doing tune-ups yourself. Most community colleges and adult education programs offer courses in automobile maintenance.

In order for your car to operate at highest efficiency, it is also important to use the recommended gasoline octane rating and oil grade. Check your owner's manual.

Carefully inspect points and spark plugs.

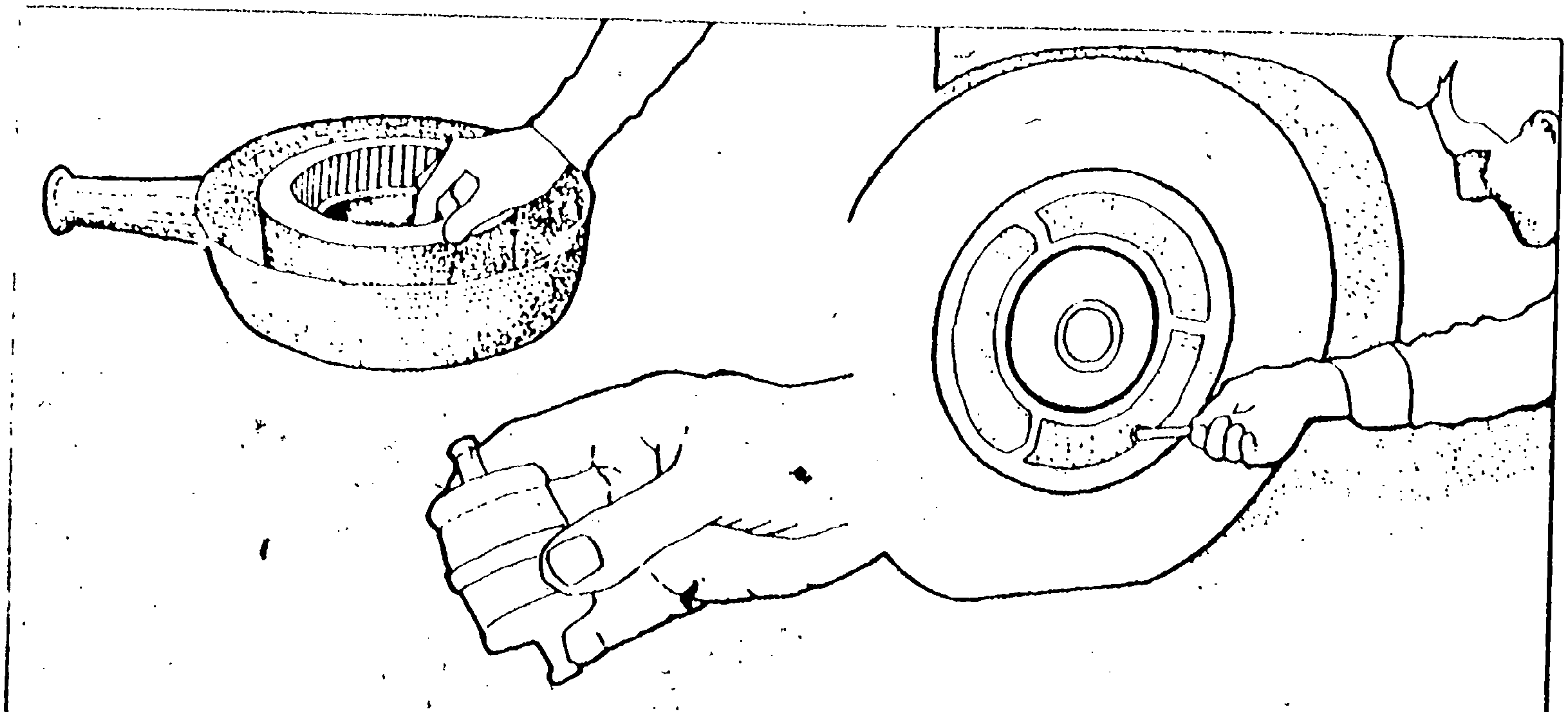


Tires Affect Fuel Efficiency

Proper inflation and type of automobile tires can provide better gas mileage and can save you money. Underinflation is probably the greatest cause of tires wearing out too fast. Underinflation also increases the rolling resistance of a tire; thus it requires more energy per mile (kilometer) to roll the car along the highway. Some tests show that 30 percent underinflation — and that is far from being a flat tire — reduces tire life by about 50 percent.

Radial tires, because of their design, develop less rolling resistance than standard tires. One can expect a 5 percent improvement in fuel economy by switching to radial tires.

A very useful accessory for good tire life is an accurate air gauge. In particular, radial tires, when properly inflated, often appear to have a "flat" appearance. It is difficult to distinguish by eye when



Regularly check air cleaner, fuel filters, and tires.

a radial tire is underinflated. Get in the habit of checking regularly the inflation of your car's tires.

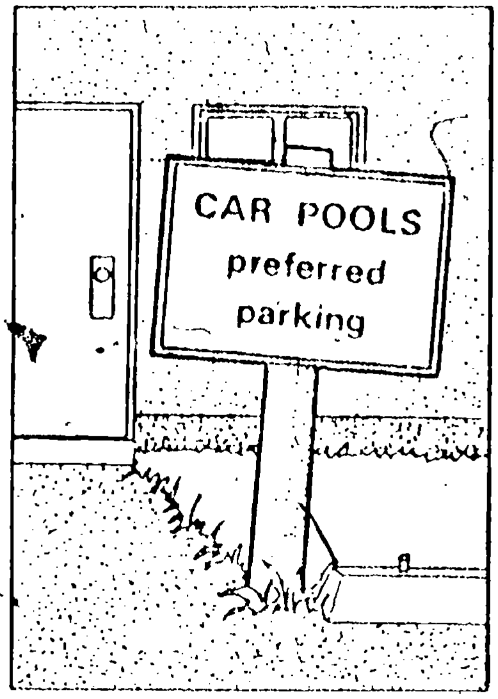
Synthetic Oils

Synthetic engine oils, used in some automobiles today, belong to two basic classes: one, called esters, is made by reacting alcohol with certain types of acids; the second, synthesized hydrocarbons, is fabricated from various hydrogen- and carbon-containing molecules found in natural petroleum. Mineral oils, the oil used in most automobiles today, are usually changed after 6,000 miles (10 000 kilometers) of use. It is believed synthetic oils can safely be used with oil changes at 12,000-mile (20 000-kilometers) intervals. Although synthetic oils cost 4–5 times as much as mineral oils, cars lubricated with synthetics show an average 5 percent improvement in gas mileage over those using conventional motor oils.

Car Pools Can Save Money

Over 80 percent of working Americans commute to work by automobile; more than 50 percent of them drive alone. A car pool to and from work not only saves gasoline and money, but also saves wear and tear on cars. Ask your employer to help establish car pools at your place of business.

Another type of car pool frequently overlooked is better scheduling of family trips by automobile. Family automobile travel — shopping, visiting, trips to the doctor, to music lessons, or to athletic events, for example — accounts for nearly one-third of all passenger trips in this country and averages 5½ miles (9 kilometers) one way. If, by planning ahead to combine errands and appointments, a family took one less trip per week (7 trips instead of 8), that family could save $75 per year. To take it a step further: if every automobile in the United States consumed 1 less gallon (3.8 liters) of gasoline per week, national demand for gasoline would be reduced by about 7 percent!



Transportation Alternatives

Engineers often measure energy in British thermal units (Btu), the amount of energy required to raise 1 pound of water 1 degree Fahrenheit; or joule, the amount of energy required to produce 1 watt for 1 second. A comparison of these energy units for various modes of transportation is revealing. Walking requires about 300 Btu's (316 200 joules) per person per mile (1.6 km); a bicycle requires 200 Btu's (210 800 joules) per mile (1.6 km). In contrast, driving an average-size automobile with no passengers requires 8,100 Btu's (8.5 million joules) per mile (1.6 km) in the city and about 3,400 Btu's (3.5 million joules) per mile (1.6 km) on the highway. In terms of energy usage, bicycling and walking are obviously very energy efficient means of individual transportation. Fully loaded buses and trains are much more efficient modes of transporting people than the automobile. In order to save energy and dollars, use alternative means of transportation whenever possible and, if it is feasible, advocate the establishment or improvement of mass transportation systems in your locality.

Energy consumption must be reduced in this country. A good place to start is with the family automobile.