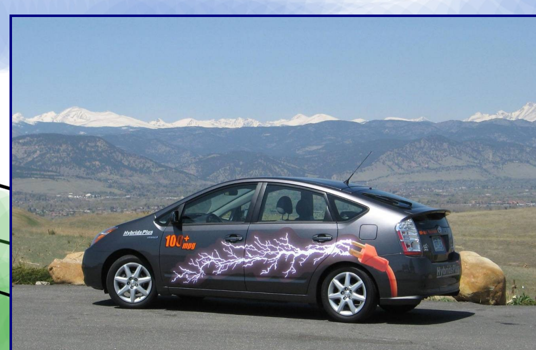
Green Mobility

70 Ways to Save Gasoline



By Carl E. Lawrence

Green Mobility
70 Ways to Save Gasoline

The Guide to Better Fuel Economy and Driving Alternatives

Carl E. Lawrence

First Edition

Published by EnergySense
Boulder, Colorado

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Written By:

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Published by:

EnergySense
2810 Olson Drive
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First printing 2008

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Dedication

This book is dedicated to my folks,
for without them this author would not have been possible

"If you would not be forgotten
Soon as you are dead and rotten
Either write things worth the reading
Or do things worthy of the writing."
Poor Richard's Almanac

About the Author

Carl E. Lawrence studied mechanical engineering and received a Bachelor's Degree in physics from the University of Colorado in 1985. He also holds a Masters Degree in Business Administration.

Over his career Carl has converted many vehicles from gasoline to battery power, prepared studies on alternative fuels, and rebuilt several electric vehicles. In 1996, he founded Columbine Bus, a company to design and build hybrid-electric buses for the Denver Regional Transportation District. The resulting bus fleet was the nation's first full-revenue service hybrid-electric bus fleet. He was also lead founder of Eetrex, one of the first companies in North America to build plug-in hybrid-electric conversion kits for the Toyota Prius and Ford Escape hybrid. Eetrex now manufactures battery systems and chargers for many types and sizes of electric vehicles.

Carl is the owner of EnergySense, a consulting company focused on energy efficiency for transportation. He has also been the president of the Denver Electric Vehicle Council for a decade, and has served on the boards of the American Lung Association of Colorado, the Breathe Better Foundation and the Denver Metro Clean Cities Coalition. Currently, he is a member of the Boulder County Clean Air Consortium, the International Human Powered Vehicle Association and CORE (Colorado Organizations for Renewable Energy).

Carl owns Otivia which manufactures accessories for bicycles and other human powered vehicles. Otivia started with cargo carrying products and will move on to lighting systems and velomobiles in the future. Velomobiles are fully enclosed, two and three-wheeled bicycles.

Carl sometimes teaches classes and lectures on alternative fueled and hybrid-electric vehicles, and ultra-efficient vehicle design. He has also been working on a book on velomobiles and other ultra-efficient vehicle engineering and design, which he might even finish some day.

Warning – Disclaimer

This book is designed to provide information about saving gasoline used in personal automobiles and light trucks. It is sold with the understanding that the author and the publisher are not engaged in legal, accounting or professional services.

This book does not contain all of the available information known to the author and it is suggested that the reader continue to gather any additional information needed, possibly by following up on resources listed in the appendix.

Every effort has been made to make this book as complete and accurate as possible, however, there may be mistakes both typographical and in content. The text should be used only as a guide and not as the ultimate source of fuel economy and driving.

The purpose of this manual is to educate and entertain. The author and EnergySense shall not be liable nor responsible to any person or entity with respect to any loss or damage caused, or alleged to be caused, directly or indirectly by the use of the information found in this book.

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Preface – 2008

It is June 2008 and now that the price of gasoline has soared to four dollars a gallon, there is more discussion on finding ways to increase fuel economy. The “miles per gallon” numbers have always been important to me. When I was a child my folks would always calculate and record their mileage after every fill-up. When the first gasoline shortage hit Denver in 1973 I was driving a 365 horsepower GTO and getting twelve miles to the gallon. At that time most American cars were getting about ten to fifteen miles per gallon. The price was between 30 and 45 cents per gallon, but the big concern that year was the scarcity.

In Denver that summer it was hard to find a gasoline station that had enough fuel to last through the day. On east Colfax, the main street through town, I could only find one station selling gasoline after two in the afternoon. This situation right after graduating from high school – driving a GTO, a limited income and a gasoline shortage – convenced me that energy for transportation could be very unreliable. This, along with my childhood, shaped a person with a lifelong concern for efficient transportation technologies and systems.

Over the years I have owned a half dozen electric vehicles including motorcycles and mini-cars. Most recently I was the proud owner of a three-ton, self-contained motor home that averaged just better than 25 miles per gallon on diesel fuel. And for a cleaner exhaust I burned biodiesel (made from vegetable oil) when I could get it.

I’ve been the president of the Denver Electric Vehicle Council and served on boards for the Denver Metro Clean Cities Coalition and the American Lung Association of Colorado. In the mid-nineties I founded a company to produce hybrid-electric buses for a free shuttle service on Denver’s 16th Street Mall.

In 2006 I led the formation of Hybrids Plus to produce battery systems and bi-directional chargers. We build conversion kits to convert hybrids like the Toyota Prius and Ford Escape hybrid into plug-ins, cutting their gasoline consumption in half by displacing it with cleaner, cheaper electricity.

Having worked in this field for most of my career, I realized that during the last quarter of the twentieth century America actually enjoyed a glut of petroleum. Now with other nations emerging as high-energy users, such as China with petroleum imports growing at about thirty percent per year, it won't be long before worldwide shortages start.

To make matters worse, it seems that every few years a new alternative fuel is touted as the savior energy source and we can go on consuming at our current rate. It has been ethanol, methanol, natural gas, propane, electricity, and now it's hydrogen. For a colorless, odorless gas, hydrogen makes a pretty good smokescreen to hide the need for better efficiency in the transportation sector. Energy has to come from somewhere, though, and in the long run the only solution that will allow us to maintain anything close to this quality of life will be increased energy efficiency in all sectors.

Carl E. Lawrence

Second Preface 2010

It is now early 2010 and much has changed. The last three years have seen economic failures around the world close to the Great Depression of seventy some years ago. Sales volume for automobiles and trucks in the US were cut in half – down to nine million from an average 18 million per year. Oil is back down to about $75 a barrel and much of the concern about high gasoline cost has faded. Most projections are that this will not last long and soon prices will start to climb again. A recent conference on "Peak Oil" gave fair warning.

On the positive side, essentially every major automaker on the planet has an electric or hybrid-electric vehicle under development. GM is scheduled to release the Volt within the year. Nissan plans on delivering the first Leaf all-electric vehicle before the end of 2010. The global switch to electric drive for most vehicles (including light aircraft) is ushering in a new paradigm of fuel efficient transportation. Down the road this will need to be followed by "right sizing" - using the right size vehicle for a particular mission. A vehicle does not need to be any heavier than the users and cargo for in-town speeds. Some new light sport aircraft have already achieved this.

Happy mobility.

Carl

Chapter 1 – Introduction

Gasoline is now over four dollars a gallon and petroleum has just peaked at $130 a barrel. It is expected to increase to four and a half dollars per gallon throughout the US by the summer of 2009. From most indicators this will be the trend for the foreseeable future. The cost of gasoline will take a giant step at the beginning of each spring/summer driving season and then relax a bit into fall and winter. But every year will be higher than the last.

Over the last fifty years or so, most of the world has enjoyed somewhat of an energy glut. Gasoline was cheaper than bottled water. A large part of this was due to the oil shortage of 1980-81 and the giant spike in the price of a barrel of crude oil. The response was a dramatic increase in exploration and production. But since that time there have not been any additional refineries built in the US. There has been an increase in US consumption for transportation though – from 17 million barrels per day in 1973 to 20.6 million barrels per day in 2006. The current situation shows USA refineries operating at near capacity. This is good for those who own the refineries, but not so good for those who buy the product.

Up until about 1975 the US government regulated the price of gasoline through the Interstate Commerce Commission. Additionally, the government has attempted to ensure low prices for motor fuel through its actions around the world. This government policy is used as a way to drive growth and increases in the gross domestic product (GDP). And the GDP growth is seen as an indicator of the success of governments' economic and political policies. Even though sound market forces may not drive these policies, they were used to subsidize major US industries. Take the production of petroleum from the Middle East, for example. The General Accounting Office reported in the late 1990s that taxpayers paid about $36 billion dollars for the military to protect about $19 billion worth of Middle East oil.

The untaxed price for a gallon of gasoline is pretty much the same around the world. But the Europeans pay almost four times as much at the pump. It is all in the taxes. In places like Europe and Japan where the fuel taxes attempt to recover all of the related costs, and possibly more, there has been a call for more fuel-efficient vehicles. About half of the cars and light trucks sold in Europe are diesel fueled because of the greater efficiency of the diesel engine. In the US with transportation costs subsidized by other taxes there is little demand for more fuel-efficient vehicles. Surveys show that most Americans would like to see higher fuel economy standards imposed by the government, but up until recently, most Americans were still voting with their wallets for bigger and less efficient cars, trucks and SUVs.

The federal government appears to suffer from multiple personalities. At the same time there are tax credits for high efficiency and low emission cars there are credits for some of the most inefficient vehicles ever produced for daily use. Currently there are federal tax breaks of a few thousand dollars for hybrid and electric vehicles, and some states provide up to eighty-five percent tax credits for the incremental cost difference for zero emission vehicles. Match that against the tax break of about $75,000 for the business use of a full dress H1 Hummer – even if the Hummer is used by a real estate agent to take customers across town to view condos.

As the cost of gasoline starts to climb while such a great number of large, inefficient vehicles are on the road, this appears to be a condition similar to the 1970s just before the first oil embargo from the Middle East. This reminds me of that child's game with the ticking "bomb". The toy was more like an alarm clock but whoever had it when it went off would lose the game. The grownup version of that is "Who is left holding the gas-guzzler?" The sales volumes of the larger SUVs are falling and several models are being discontinued. Folks are talking about reducing their trips and buying smaller cars.

There are many ways to reduce the expense of driving, or more broadly, the expense of getting around. We will explore options in depth throughout the rest of this book and provide a list of resources at the end. The next chapter covers the cost of driving. What are the fixed and variable costs to you and your community, and how do you measure them?

Chapter Three provides the basic science and engineering that are part of the fuel economy equation. I will describe how the energy from gasoline is used to provide acceleration and overcome wind and tire rolling resistance.

Chapter Four will discuss how driving techniques affect your fuel usage. It will also illustrate other points such as where the vehicle is parked and the best way to warm up a car.

Chapter Five discusses the vehicle usage and the type of community it resides in. Also discussed are such things as how a roof rack or car top box affects the fuel economy.

If it is time to choose a new automobile, Chapter Six will explain some of the key points in making that decision. The discussion includes more than selecting the most fuel-efficient car; it includes how to determine the most effective vehicle for the lifestyle of the purchaser. We will dispel some of the myths about the safety of big cars and discuss cures for MAD Car Disease.

Chapter Seven is for those with a desire to learn about the benefits and shortcomings of the alternative fuels. Is there a sustainable fuel that can see the world through the next hundred years? What are the costs to our way of life and the impact on the world as politicians attempt to placate societies' thirst for more energy on a planet with finite resources? Increasing energy efficiency in transportation, industry and residence is the long-term solution.

The last chapter covers alternatives to driving a private automobile. We will explore most everything from renting to buses to walking. New, fun and extremely efficient alternatives will be shown. The health as well as the economic benefits will be compared. Lifestyle changes that come about with career changes can support a refocusing away from the car-centric American dream of three vehicles in the garage and empty highways.

And finally the book concludes with a list of references. Both printed and web based books that were sources of data for this work are listed. Some websites can even help the user determine the fuel economy of theoretical hybrid cars.

Chapter 2 – The Cost of Driving

A lot of factors go into determining the actual cost of driving. These include the cost of the vehicle, the fuel, loan expenses, insurance, and maintenance. Other more indirect costs would be the garage, cleaning, parking fees and tolls. The hidden costs of owning and using a private vehicle include time, health and happiness. In this chapter we will start with a discussion of the obvious expenses and conclude with many of the hidden costs.

Average American cost –

For illustration purposes we can calculate the general cost of owning a car, based on national averages data from the US Department of Energy. The average annual miles traveled per household vehicle is 11,100. The average household allocates 8.9 percent of their annual expenses to buying their vehicles. They spend an additional 2.9 percent on gasoline and oil, and another 6.0 percent on other miscellaneous vehicle expenses.

That adds up to 17.8 percent of the national average $42,557 total household expenses. That is $7,575 per year per household. With an average of 1.89 vehicles per household we get $4,008 per vehicle. So $4,008 is the average annual cost of owning a personal vehicle.

Dividing the annual cost by the number of miles driven we get $0.36 per mile. So a ten mile round trip to the hardware store costs the average vehicle owner $3.60. If a two-dollar paintbrush were purchased, that would make the paintbrush actually cost $5.60.

Let's now assume that the overall average speed of the vehicle is 40 mph when all the stops and slow residential area driving is taken into account. That means that the actual time behind the wheel is about 277 hours per year.

Average USA Household Vehicle	
Miles per year	11,100
Cost per vehicle	$4,008
Cost per mile	$0.36
Driving hours per year	277
Cost per hour	$14.47

$4,008 per year in expenses divided by the hours of use, gets you about $14.50 per hour. The average vehicle is costing the average owner about $14.50 per hour to use. If your vehicle is more expensive or more fuel-hungry, your hourly costs are going to be higher.

Calculating your gasoline mileage –

To determine the fuel economy of your vehicles, the amount of gasoline used to travel a particular distance will have to be calculated. In performing this calculation it is assumed that the amount of fuel used over a given distance is exactly the amount replaced at the next fill-up.

At each complete fill-up record the gallons purchased and the miles driven since the last fill-up. Divide the number of miles driven by the number of gallons added at that refill to get the miles per gallon. $miles\ per\ gallon = (\frac{miles}{gallons})$ To increase the accuracy of this calculation do this at every refill over several months. At the end of a couple of months worth of data gathering, average the results together. Do this by adding up all of the miles-per-gallon numbers collected at each refill and then divide by the number of refills.

Personally, I use a free program for my PDA (personal digital assistant) that performs all of the calculations after each refill. It also carries a running average since the first fill-up.

To get accurate results you will need good data. Always reset your trip odometer, or write down your regular odometer reading at each fill-up. If you only do a partial fill-up then don’t reset the odometer but do record the gallons added. Continue to record the gallons added until the next complete fill-up. Then divide the total miles driven since the last complete fill-up by the total gallons added since that same last complete fill-up. This method will even get you a more accurate result.

Relying on the results of a single fill-up is the least accurate way to determine the miles per gallon. The problem is caused by the inaccuracies of the gasoline pump automatic shutoff. The shutoff sensors are not all calibrated the same or the nozzle may not be positioned the same each time. One pump may cutoff when the gasoline in the tank reaches 24 gallons and another pump may cutoff at 24 ¾ gallons. These inaccuracies are averaged out over repeated refills. Never try to curtail this situation by topping off at the pump. This wastes fuel and dumps raw gasoline vapors into the air as the fuel warms and expands during the day.

The real-world miles-per-gallon numbers calculated using this method are more accurate than the federal system used to determine the mpg numbers shown on the new car stickers. First, the real-world numbers take into account the driver's driving style, and second, they take into account the driving environment. The sticker mpg numbers were determined through lab testing based on something called the Federal Urban Driving Schedule (FUDS). FUDS is an acceleration, deceleration and idling profile that someone might actually see while driving in Detroit. It is probably not what you would see driving in Manhattan, Kansas.

Other driving expenses -

Other driving expenses can be divided between fixed and variable costs. Fixed costs include those items that do not depend on how much the vehicle is used. These include things such as loan expenses, garaging, periodic maintenance, and insurance. Even though the insurance rate is determined by how much the vehicle is used it should still be considered a fixed cost since day-to-day usage will not affect it.

Fixed expenses can be reduced through long-term planning. Avoid impulse buying and search for the best loan rates when it is time to buy another car. Take a few minutes to calculate and evaluate loan deals. There are several websites that will do the calculations for you. This is also an appropriate way to compare the cost of a loan to leasing.

Better yet, buy a less expensive vehicle. More on this is covered in Chapter Six. Over the years I have owned about 45 personal vehicles but I have not invested a lot. I can generally follow my personal rules – pay cash, don't buy another vehicle just because it is newer, and don't spend more than you make in two months.

The fixed expense of insurance can be held to a minimum in several ways:

- Search for the best rates,
- Stay away from traffic tickets,
- Carry the highest deductible you can afford,
- Only carry liability if you don't have a loan,
- Don't have any accidents.

Periodic maintenance is set to a time schedule so driving less does not affect it, but finding a reliable, less expensive shop and sticking with them can help. Finding a home for your car to occupy while it is not being used is a fixed expense that is hard to lessen. It is best to park it in a garage if one is available. Vehicles left out in the elements will age faster and require more maintenance.

The variable expenses associated with a vehicle include fuel, oil, tires and maintenance. Reducing the expense of fuel is the focus of the next two chapters. If a vehicle is kept in good shape through proper maintenance then oil should not become much of an expense. Most maintenance will pay for itself in the long run, but can be reduced by finding an independent shop with a good reputation and sticking with them.

Tires are a variable expense that, like gasoline, can be affected by the driver's habits. When I was a teen I could go through a set of tires in six months – bad driving technique, I think. To reduce the expense of tires always keep them properly inflated and check the pressure every other month. Most of the time the recommended tire pressure is on a label inside the door jam of the driver's door. More importantly, drive well. Do not corner hard, do not accelerate hard with the wheels turned, and brake smoothly – with finesse. More on these issues are covered in their appropriate chapters.

Our society's costs –

This is not the place to preach here but. . . The cost to our society and the rest of the world for our driving habit is enormous. Americans are a little less than four percent of the world population but consume a little more than a quarter of the entire world's petroleum production.

Some figures have shown that if the health costs associated with the pollution from all this driving were added in taxes to a gallon of gasoline it would be more than a dollar. Others have calculated that the cost to US taxpayers for the military protection of petroleum around the world would be yet another dollar.

It is not just the health effects from air pollution but the lack of good personal health caused by a sedentary lifestyle. Sitting on your butt in a car is really not improving your health.

About half of the landmass in a town or city is dedicated to the automobile. That is a great cost to your community. Most communities have strict guidelines for the number of parking spaces required for a business establishment. Across the country there is little consistency in these numbers, but most building departments consider them sacred. At an average cost of about $20,000 per space, the businesses must pass this cost on to the consumers, whether the spaces are used or not. Parking structures are probably the most blatant waste of money – notice how the top floors show little wear and few oil stains as compared to the ground level.

Free parking costs everyone money. In addition to passing on the actual cost of the parking space to the consumers, whether they drive or not, there is also the cost associated with driving farther. In the expanded suburbs, people are forced to drive greater distances, past acres and acres of asphalt to simply get to a store.

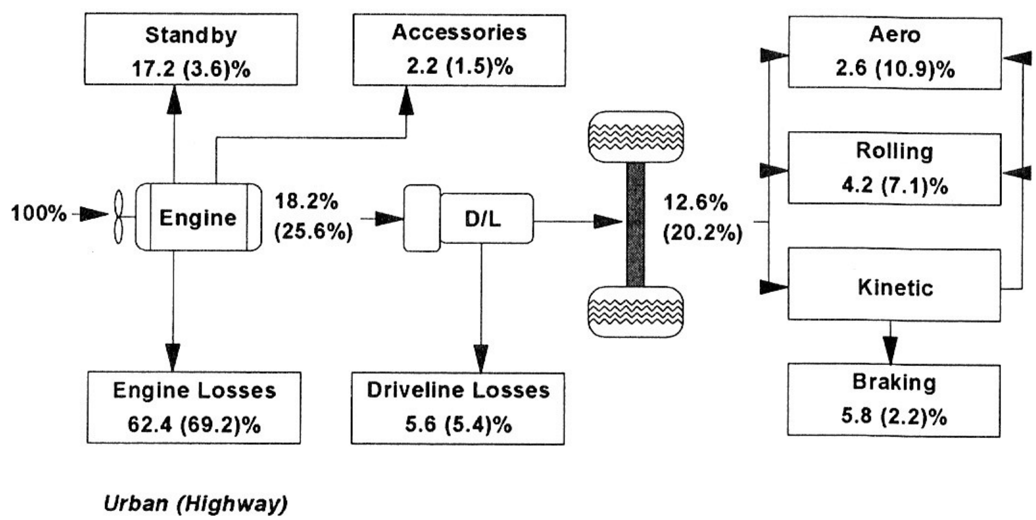
It is not being suggested that we do away with all of the cars, trucks and SUVs, but that we incorporate alternatives into our daily lives. Using our vehicles less often can make us healthier, wealthier and a little wiser.

Now I will jump down off this soapbox.

Chapter 3 – Driving Energy

Where does all of the energy go that was in the gasoline that you paid for at the service station? Sad to say, but most all of it goes to heating up the air in one way or another. In this chapter we will discuss the science and engineering of the energy used in automobiles and trucks.

The energy in gasoline is used for accelerating the vehicle, climbing hills, pushing the air and rolling the tires. But most of the energy is lost in heating the engine and drive train within the vehicle.



Energy Distribution in a Mid-Size Vehicle

Acceleration –

The most energy demanding part of driving is accelerating. For example, a small car may require 70 or 80 percent of its rated horsepower to race away from a traffic light. That may be about 55 kilowatts (73 horsepower). But most small cars only need about eight kilowatts (10.7 horsepower) to cruise at 55 mph.

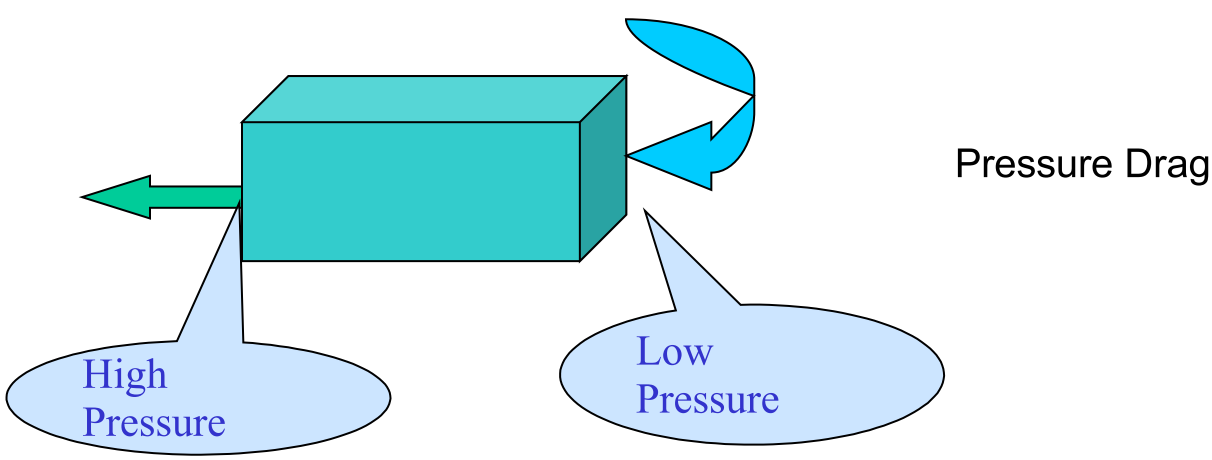
Theoretically, the energy required to accelerate a vehicle depends on its mass, final speed and its acceleration rate. The acceleration takes a certain amount of *power* over a certain period of *time*. So *power* times *time* is equal to the amount of energy used. And energy (fuel) is what you paid for at the service station.

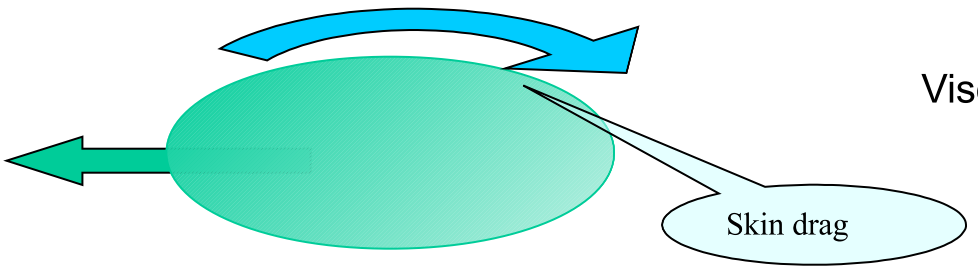
Our small example car may be using 55 kilowatts (73 horsepower) to accelerate to 60 mph in 10 seconds. So the energy required to do this is 55 kilowatts * 10 seconds, or 550 kilowatt-seconds or 0.153 kilowatt-hours. Kilowatt-hours is the common unit of energy used when buying electricity, usually costing between 5 and 15 cents each, depending on the location in the country. A gallon of gasoline contains 33.8 kilowatt-hours of energy. A ten percent efficient car can burn up a gallon of gasoline in 22 accelerations. Ninety percent of the energy in the gasoline is wasted and simply turns to heat. The nice thing is that the 0.153 kilowatt-hours of energy is still in the vehicle in the form of kinetic energy, which will eventually be converted to heat by the air drag or by applying the brakes.

When gasoline costs $3.00 a gallon, each acceleration at this rate will cost 13 ½ cents. The faster you accelerate, the greater amount of your gasoline is turned into wasted heat. Accelerating from 0 to 60 in 10 seconds requires 55 kilowatts in our example. The 10 percent efficiency makes 495 kilowatts of wasted heat. The cost of the gasoline that went up in smoke is 12.2 cents out of the 13 ½ cents. If your car could accelerate faster using 110 kilowatts (146 horsepower), then 990 kilowatts of wasted heat would be produced. This waste costs you 24.4 cents while only 2.6 cents goes into moving your car.

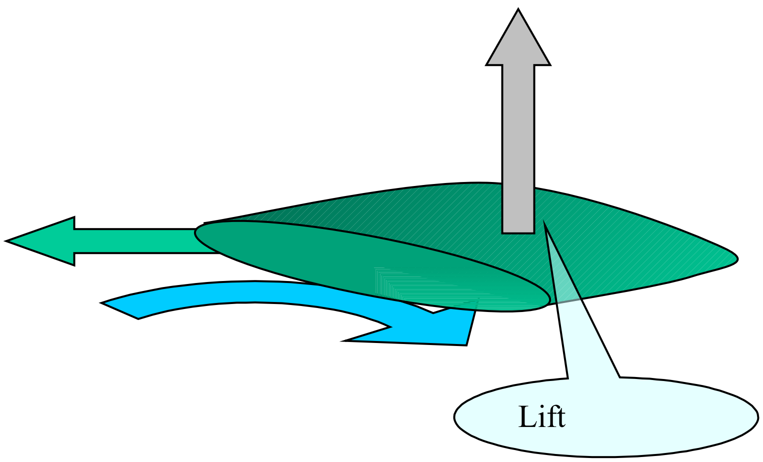
Wind resistance –

Once your vehicle reaches cruising speed it still needs to provide power to overcome the wind resistance. At speeds above 25 to 35 mph most of the energy is used to fight the drag of the air. And where does the energy actually go? It goes to stirring up the air, and this just heats the air. There are three forms of aerodynamic drag.





Viscous Drag



Induced Drag

A certain amount of force is required to push a vehicle through the air. This force is required just to maintain the set speed.

Force = ½ x(density of air)x(frontal area)x(coefficient of drag)x(velocity squared)

This is the equation commonly used in designing cars. The density of air is outside of the designers' control, but the area and drag coefficient are variables used by the designer. The frontal area is determined by the silhouette of the front view of the vehicle. The bigger the silhouette, the more air the vehicle will bang into while moving down the highway.

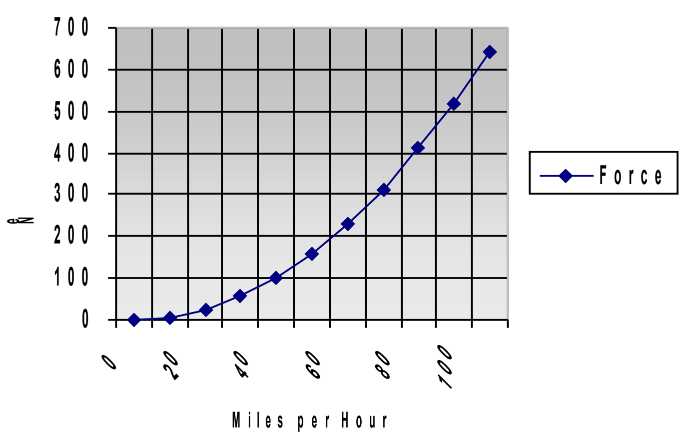
The coefficient of drag is determined by two main characteristics for car design. The first is the general shape of the vehicle – is it square and boxy, or is it rounded and sleek? The more a vehicle is shaped like a shark, the lower its coefficient of drag. The front end can be

bulbous, but the tail end should narrow down to a point. This will reduce the pressure drag. Secondly, the protrusions and gross roughness will slow the airflow. Items like mirrors that stick out and exhaust pipes that stick up affect the air resistance. An awful lot of air drag comes from the *underside* of most vehicles where the axles, framework and exhaust systems disturb the airflow.

This truck has a higher drag than the streamlined RV behind it.

It is extremely difficult to determine the actual coefficient of drag analytically. That is what wind tunnels are for. But, in general, a smaller pickup truck can easily have twice the aerodynamic drag of a small sports car.

The equation described above will determine the force required to overcome air resistance. Since the velocity number is squared, the force increases much faster than the velocity. The force actually goes up by the square of the velocity. This chart should help.



As the chart shows, the force required to increase speed is greater the faster the vehicle goes. To go from 70 mph to 80 mph takes three times the force as going from 20 mph to

30 mph. And driving at 70 mph requires more than three times the force as traveling at 40 mph.

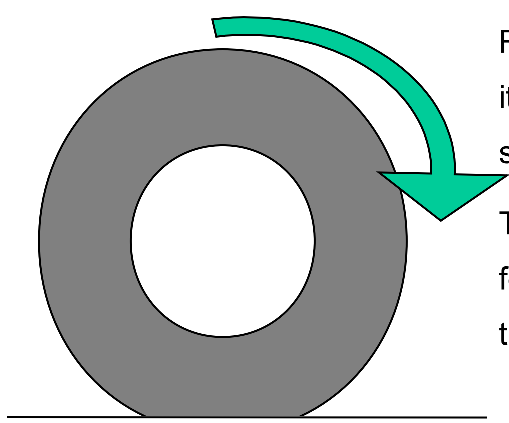
When the force to move through the air is multiplied by the velocity then you get power. In our sample chart above the vehicle required about 230 Newtons to push through the air at 60 mph. The 230 Newtons times the 26.8 meters/second (60 mph) is 6,193 watts, or 8.30 horsepower. **Power = Force x Velocity**

Knowing the *power,* it is easy to determine the amount of energy that will be used over a set period of time. The energy is the *power* times *time*, or simply multiplying the *power* by the amount of *time* the power is being used. So driving for two hours will use up (2 x 6,193) 12,386 watt-hours. The more standard term is 12.4 kilowatt-hours, which can be found in about a third of a gallon of gasoline. **Energy = Power x Time**

Rolling resistance –

The rolling resistance from the tires is where most of the power goes at slow speeds. Tires are actually flexing every time they roll and deform on the pavement. This generates heat in the tire. This heating becomes important at very high speeds. Cruising over a hundred miles per hour requires speed rated tires. Passenger car tires on an Indy race car would blow out simply due to the heating at those high speeds.

Some tires are designed to have less rolling resistance. The bias ply tires of the mid-1900's had significantly more rolling resistance than today's steel-belted radials. Coast-down tests were advertised where identical cars having brand X and brand Y tires were coasted down shallow inclines to illustrate which manufacturer produced the better tire.



Deformation of tire

Rolling resistance is generally quantified for each tire by its coefficient of rolling resistance, or C_{RR}. The C_{RR} of some tires can be found by searching the Internet.

To determine the force caused by the rolling resistance for a set of tires, multiply the weight of the vehicle by the C_{RR} of the tires. Generally the drag from the tires' rolling resistance does not change with speed. Only when real precise calculations are needed is the speed dependent C_{RR} used.

Let's use an example of a one-ton car running on tires with a C_{RR} of 0.01. One-ton (2,000 pounds) times 0.01 is 20 pounds force. In metric dimensions that is 89 Newtons.

The rolling resistance force of 89 Newtons means that at 60 mph approximately 2,384 watts of power are used for tire heating. After two hours of driving 4.77 kilowatt-hours of energy have been used to heat the tires (or 0.14 gallons of gasoline). Hopefully the heat has been transferred to the air and the road.

At the end of this chapter the power and energy numbers for aerodynamic drag and rolling resistance will be compared to the overall efficiency of a sample vehicle.

Hills –

When a car is driven up a hill a lot of power and energy is used to overcome the force, or acceleration, of gravity. As shown earlier in the acceleration section of this chapter once energy was expended to reach a highway speed part of that energy would still be in the car as kinetic energy. In a similar fashion when a vehicle is driven up a hill part of the energy used to get it up the hill is retained in the vehicle as potential energy.

Potential energy is found in things like batteries, a match, gasoline or an object raised to a higher elevation. The raised object has potential energy because it can fall and have kinetic energy. Water behind a dam has potential energy that will be released to turn turbines and produce electricity as it falls.

Imagine a heavy ball on a cord. As it is pushed hard it will swing back and forth. When it swings up and momentarily stops it has no kinetic energy but a lot of potential energy. As it swings back down to its lowest point all of the potential energy has been converted to kinetic energy.

When the vehicle climbs a hill the potential energy is retained until the vehicle comes back down. On the trip back down most of the potential energy is converted to the kinetic energy of the vehicle. Some or all of the kinetic energy will go to heat the air and the tires. The kinetic energy left over at the bottom of the hill shows up as speed. But if the car needs to slow more, the brakes can be applied and the excess kinetic energy will be converted to heat in the brakes.

How much potential energy is gained in climbing a hill can be determined with the simple equation $PE = mgh$. The mg is the weight and the h is the gain in elevation. For our one-ton car driving up a 1,000 meter hill we get 2.73 kilowatt-hours gain in potential energy. That is the amount of energy that can be converted back to kinetic energy on the way down the hill, less the inefficiencies of the vehicle.

To determine the power required to climb the hill we will need to know how long it took to get to the top, how efficient the vehicle is, and how much power it took to overcome wind and rolling resistance. If we don't concern our work with the wind and rolling resistance right now and assume that it takes 10 minutes (600 seconds), we can determine the power. Power is equal to change in energy over time. The potential energy gain at the top of the hill was 2.73 kilowatt-hours. 2.73 kilowatt-hours divided by 600 seconds equals 16.4 kilowatts. That is 21.8 horsepower required at the wheels. More horsepower will be required from the engine as the inefficiencies of the transmission and differential are taken into account. For a one-ton car to climb a 1,000 meter hill in 10 minutes takes an additional 21.8 horsepower – above the power required just to cruise on a level road.

Engine/driveline losses –

By far the greatest amount of energy taken from a gallon of gasoline is wasted inside the engine. This table shows where the energy goes as a percentage of the energy extracted from the gasoline.

	Urban	Highway
Engine losses	62.4	69.2
Standby	17.2	3.6
Accessories	2.2	1.5
Driveline losses	5.6	5.4
Aerodynamic losses	2.6	10.9
Rolling resistance	4.2	7.1
Braking	5.8	2.2

The engine losses are in the form of heat. As modern engines have become more efficient than those of fifty years ago the radiators have become smaller. The less efficient an engine the more heat the radiator must be able to handle – for a similar horsepower engine. Diesel engines are about 30 percent more efficient than gasoline engines - thus 30 percent less fuel energy is wasted as heat.

Standby-loss is the amount of energy wasted when the vehicle is at idle, both during any warm-up or waiting at traffic lights. Accessories include devices such as the air conditioner, headlights, heater, radio, power steering and electric beer cooler. Even the lights require energy and get it by placing a load on the alternator, which places a load on the engine.

The drive-line losses are mostly due to the heating of fluid in an automatic transmission. Additionally, when gears are driven by other gears in the transmission and differential, they heat up because of friction. This is why some of the better lubricants can improve a vehicle's energy efficiency.

The aerodynamic and rolling resistance losses were discussed above. The braking losses occur when the brakes are used. Again, this is the conversion of the kinetic energy of the moving vehicle to the heat energy in the brake discs or drums.

Energy comparisons –

Let’s take a ride in our one-ton sports car. It has a single gallon of gasoline – which contains 121,756 kilojoules of potential energy. Of that, 87.4 % is wasted inside the engine and drive-line of the vehicle as heat. In cold weather this waste heat is used to warm up the interior of the vehicle. That leaves about 15,341 kilojoules to move the car. Where should this energy go?

As the air drag and rolling resistance combine for the car going 60 mph, the 15,341 kilojoules of energy will be consumed in less than a half hour. Then the car will continue to coast until all of its kinetic energy is converted to heat in the air, drive-line, tires or maybe brakes.

Chapter 4 – Driving Techniques

By discovering how you drive and then learning new techniques, you should be able to save enough gasoline to pay for this book many times over. Your driving techniques determine how much gasoline is wasted, or saved, daily. Changing habits, learning new skills and even modifying attitudes are all part of the driving techniques that can lead to saving gasoline. The techniques and habits covered include acceleration, transmission shifting, highway driving, merging, tactics and cooperation with others. Even how you park your vehicle and when you use your air conditioner affects your consumption of gasoline.

Driving Habits –

Driving habits include how you accelerate your vehicle, when you shift, the smoothness of your driving and how you fit with the driving environment.

Way #1
Accelerate more slowly

Accelerating quickly has become ubiquitous in most urban and suburban areas, but not so much in the rural areas. This rushing wastes a lot of gasoline. If you have a desire to save the most gasoline with the least amount of effort, then simply modify this driving habit. Accelerate a little slower – never push the pedal more than half way down. Some folks like to imagine a raw egg between their foot and the acceleration pedal. Press the pedal slow enough that the imaginary egg survives. Over time this will become your habit, and you will be rewarded at the gas pump.

Way #2
Imagine running low on gasoline

My personal approach used to gauge economic driving comes from different imagery. This particular system can be applied to accelerating as well as moving though traffic or cruising on the highway. I pretend that the gasoline gauge is sitting on “E”, my wallet is empty and there is not a gasoline station in sight. Incorporating this imagined situation into an encompassing driving technique has allowed me to save money while saving my health through lower stress while driving. I no longer need to use the imagery as I now understand and appreciate the total feeling of driving this way.

Accelerating slowly does not mean crawling along 20 mph under the speed limit. The vehicle should be accelerated smoothly without the use of excessive horsepower. As described in chapter 3, acceleration uses five to ten times more energy than cruising at a steady pace. During acceleration you may be getting only four to ten miles per gallon, depending on the weight of your car and the rate of your acceleration. Accelerate up to the speed of the rest of the traffic, just do it over a greater period of time.

For a vehicle with an automatic transmission you may notice that it is up-shifting at lower speeds than you are used to. This is a good thing. The earlier the vehicle shifts, the less fuel is being used. If you maintain an awareness of the speeds at which your car is shifting, you can gauge the rate at which you are accelerating – assuming level roads.

Way #3
Shift your standard transmission sooner

Shifting a standard transmission vehicle can be a little more complicated. You will want to shift it as soon as possible without lugging, or straining, the engine. In many cases, shifting too early and lugging the engine will actually use more gasoline. Check in your vehicle owner's manual for suggested shift points and speeds. Use these recommendations as starting points as you develop your own economical shifting pattern. If documentation is not available then trial and error will do. My rule of thumb is to shift at rpm points where the engine could respond well if the accelerator pedal were pushed half way down. Then I actually accelerate with only a quarter pedal, or less, most of the time.

Way #4
Drive smoothly, with finesse

Driving smoothly is the sign of a skillful driver. Operate the vehicle with finesse and grace to both save on gasoline and reduce the stress on you and your passengers. Your vehicle should move along smoothly without any abrupt accelerations or decelerations. Any habit of shifting the pedal position absentmindedly leads to excess fuel consumption, vehicle wear and annoyed passengers.

There are different attitudes that tend to prevail on different roadways. In most cases the attitudes generally work OK, but in many situations the wrong attitude is applied. On a limited access highway drivers may maintain a selfish mindset. The roadway belongs to them and other high-speed vehicles. Any slow moving car is met with aggression. And any non-highway vehicle or person or thing will receive the wrath of the more aggressive highway users. This attitude creates its own set of wasteful behaviors. These include tailgating as well as heavy acceleration as a driver attempts to telegraph his displeasure concerning someone else's poor driving style.

Way #5
Do not tailgate

Following closely behind another vehicle requires continuous shifting of the acceleration pedal – wasting fuel. Maintain a following distance that creates a cushion of space. If the front driver slows or accelerates randomly then the cushion should be large enough to absorb these oscillations. In general, when the following distance becomes too small and cannot absorb the random oscillations of the lead vehicle a dangerous and inefficient situation is created. At a minimum, just keep your following distance large enough to allow for slow pedal movements in reaction to changing speeds of the vehicles ahead.

Years ago the recommended following distance was one car length for each ten miles per hour of speed. That is about 100 feet at 60 mph. If this advice were followed today there would not be enough highway in most major cities to handle the traffic. There are just too many vehicles today to fit on the available concrete in congested areas.

Those who study traffic flow have discovered an interesting phenomenon. When a long string of vehicles is tightly packed and attempt to move in unison they create a sound wave effect within the group. As a space opens up in front of a car the driver accelerates to catch up to the car in front and as the space disappears the driver may brake. This creates the same effect as air molecules banging into each other as a sound wave passes – only in reverse order.

Experiments have shown that one way to eliminate this bouncing effect, or "oscillating creep", and get traffic moving at a steady pace is to stop all of the vehicles at once – allow the traffic to clear ahead – and then let the cars accelerate as they normally would from a stop light. Without the leading traffic slowing in response to its leading traffic, the vehicles accelerate smoothly to the road speed and the traffic jam-up is eliminated. This has actually been shown to move more traffic in a given time than allowing the cars to continuously accelerate and decelerate as they crawl along.

Way #6
Merge at the designated merge point

A very inefficient driving culture has been developing over the past couple of decades in many locations. That is the premature merging on multi-lane roads. The earlier the merge takes place, the longer it will take for everyone to get through a bottleneck. And the oscillating creep dramatically increases the time everyone will spend in line. The quickest way to get everyone through the bottleneck is to merge only just before the lanes merge. Having two lanes being used reduces the occurrences of oscillating creep and in many situations will even eliminate it all together.

Another problem caused by premature merging is traffic congestion. The road workers try to choose a merge location that will impact the traffic the least. Generally, they will not place a lane closure right after an intersection, because this will jam traffic back into the intersection and completely hose-up the cross-street flow. In this case the lane will be closed prior to the intersection and only allow one lane through the intersection – keeping it clear for cross-flow traffic. I have witnessed many, many occasions where the road workers have placed lane closures far after intersections only to have premature mergers jam up the intersection anyway (while leaving the second lane completely empty). A lot of fuel is wasted as cross-street traffic gradually works its way through intersections jammed up by the premature mergers. Do all the rest of the drivers a favor and use the lanes as they were intended – merge at the designated lane merge point.

Way #7
Cooperate with others

Cooperative driving is an indication of a high quality driver. Work with the other drivers to accomplish a smooth traffic flow. Pay attention to pedestrians, bicyclists and everyone else sharing the roadways.

In selected locations around the world (including New Jersey), intersections are being de-controlled. The signs, traffic signals and curbs are being removed to create less constrained mixing of different mobility modes. Cars, trucks, buses, bicyclists and pedestrians are mixing at the intersections. Without the controls found at most intersections the users have turned to cooperation. Contrary to common preconceptions the pedestrians and bicyclists feel safer and the volume of cars, trucks, pedestrians and bicyclists through the intersections has actually increased.

It has been shown that children learn to deal with their environment by watching their parents or other older folks. A child will pick up habits and reactions from their adults. When a teenager is about to get their driver's license they may have had years of informal training from their folks. And if the folks have been driving aggressively – tailgating, speeding, yelling – then the kids will easily do the same. They wouldn't really know otherwise.

> **Way #8**
> ***Display good driving habits to kids and teens***

It is felt that when kids pick up these more aggressive habits they are really not prepared to handle them. An adult with twenty years of driving experience is better skilled at avoiding an accident when their own poor driving habits cause the situation. Even with faster reactions, a sixteen year old will be at a distinct disadvantage while trying to control an SUV during a skid. Since your children may imitate you once they are driving without you, teach them well by driving how you would like them to drive.

Planning Ahead –

Following a change of habit to a more sensible acceleration, planning ahead is another low-effort path to increased gasoline economy. You can plan ahead as you drive, you can plan ahead before you ever leave the house, and you can plan ahead before you acquire another vehicle.

> **Way #9**
> ***Plan ahead***

Planning ahead as you drive requires a conscious effort to maintain awareness of your situation and environment. If you know that the traffic signal is going to change up ahead, or that another car will be pulling into your lane, take your foot off the accelerator. Even slowing a hundred feet before a stop sign will save fuel. And you will generally lose less than a couple of seconds. Test this yourself. Count the seconds from, say a mailbox or tree, to your full stop at a stop sign as you normally would brake. Then try it again slowing much sooner. You will find little difference in the time. Driving like this may cost you sixty seconds a day but it can save you dollars at the gas pump.

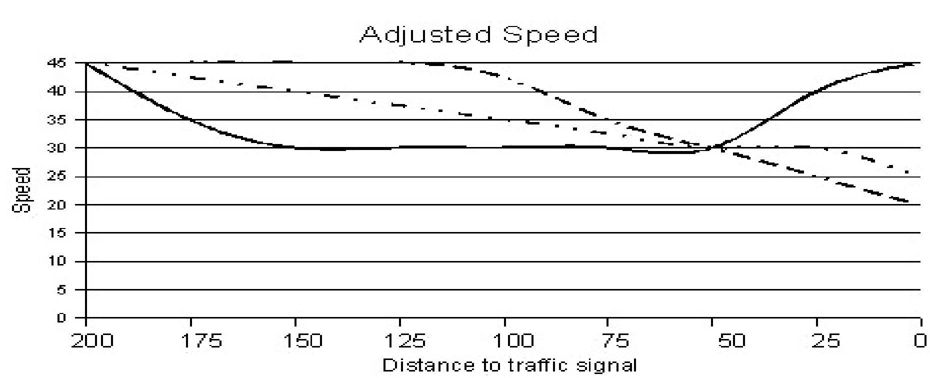
Staying ahead of the car is a good phrase to describe this driving technique. This is an idea commonly used in the piloting of small aircraft. Pilots describe getting in trouble by getting behind the airplane. When you are ahead of the airplane you are planning ahead and have time to evaluate your options.

Way #10
Anticipate traffic signals

Traffic lights are excellent opportunities to save fuel. The challenge is to learn to judge their timing. With practice the whole stopping thing can be reduced also. Try to gage when the upcoming traffic signal is going to change to green. The tactic is to slow down the least amount. You pay for the speed that you need to regain. If the speed limit is 40 mph and you slow to 30 mph instead of 20 mph then you will only have to regain 10 mph instead of 20. It will take about twice as much gasoline to regain 20 mph instead of 10 mph (excluding aerodynamic losses).

Way #11
Maintain momentum

In some cases you will actually need to brake harder initially in order to maintain the highest minimum speed. If the light changes to red when you are close then quickly braking can set the car's speed to, say 15 mph below the cruising speed. In the same situation, slow braking may cause the car to gradually slow to 25 mph below the cruising speed before the light changes to green. Regaining the additional 10 mph will use more gasoline. Thus the goal is not to decelerate the slowest but to adjust your speed such that you can maintain the highest minimum speed as you wait for the light to go green just as you are reaching the intersection.



In this chart the solid line represents a quick deceleration and then a steady 30 mph. The other two lines show that the vehicles slowed to 20 and 25 mph. In all three approaches it took 4.5 seconds but the vehicle following the solid line saved the most fuel AND went through the traffic signal faster.

Learning to maintain the highest minimum speed will also reduce your gasoline consumption in other situations. If pedestrian is crossing the street in a crosswalk, then slow down sooner and maintain the highest minimum speed without creating a hazardous or threatening situation. If another car is backing out of a driveway, gauge their progress and slow appropriately to maintain the highest minimum speed. Yield signs, cross traffic, animals, bicyclists, spaceships, and transit buses can all be approached with this tactic. I have also found that this will reduce my stress of driving, especially when in a hurry.

The second planning action to save money is daily planning. Try to save up all of your driving and do it all at once. It takes about ten minutes of driving for most cars to reach operating temperature. At this point the engine is operating at its rated efficiency and the catalytic converter is hot enough to function. Any single car trip under ten minutes wastes gasoline and the catalytic converter is passing through excessive pollution. That is why your car exhaust smells different when the engine is cold. After reaching operating temperature most engines will stay hot for at least a couple of hours. Use that residual heat in the engine to save you money – don't waste it – you already paid for it. If you are trying to save gasoline (money), don't waste it throughout the day by heating up your engine over and over.

Way #12
Combine errands and trips

Way #13
Plan errands in a logical order

Planning your daily driving to combine as many trips as possible will also save money and time by eliminating redundant legs. When possible, combine your trips in a continuous loop. Try not to backtrack. A little logic in the planning should eliminate a situation of melting ice cream in the minivan as you stop to watch a couple of hours of the kids' soccer matches.

Highway Driving –

Highway driving can be economized in several ways. Use a steady pedal, or better yet, cruise control, air-conditioning, tactical planning and cooperation.

Way #14
Use cruise control

Probably the simplest way to reduce gasoline consumption on the highway is to use cruise control where appropriate. Cruise control reduces any tendencies to vary the pedal position absentmindedly. Since the cruise control adjusts the throttle position in finer increments than a human foot usually can, there is less wasted fuel. An ever so slight amount of fuel is wasted each time the throttle is opened or closed a small amount. It takes a finite bit of time for the vehicle computer to register, react to a change in air intake and adjust fuel injections to match. During that time, the fuel mixture is slightly off and not at optimal efficiency. Larger shifts in throttle position create larger momentary drops in efficiency. Even though each event is very small they add up over time. Using the cruise control minimizes this.

Way #15
Anticipate hills while using cruise control

Proper use of the cruise control will sometime require the driver to override it. When approaching and climbing hills most vehicles will use less fuel if they are accelerated prior to the hill. It is always more efficient to increase your speed while going downhill or flat, than while climbing a hill. Especially for smaller engines, gain speed prior to the hill and then allow the speed to bleed off on the ascent. Most cruise controls will accept this input from the driver's foot without disengaging. The goal here is to minimize the power required from the engine, since higher power equates to high waste. Also, during a pass on the highway, a driver can simply accelerate without disengaging the cruise control and then release the accelerator after the other car is passed and the vehicle will return to the set speed.

Way #16
Plan ahead to overtake other vehicles

Cruise controls can also make it easier to plan ahead while on the highway. When overtaking other traffic while using the cruise control, plan your move well in advance. Judge your approach speed and that of any other nearby traffic. You may need to add a couple miles per hour with your foot in order to reach the overtaking point without conflict with the rest of the traffic. The farther ahead you plan, the easier it will be to keep the cruise control engaged and save fuel.

Way #17
Keep the windows closed on the highway

I guess most people have heard this by now – keep your windows up on the highway. The aerodynamic drag of cars is minimized with the windows closed. On most modern cars at highway speed the air-conditioning uses less gasoline than driving with the windows down. In some cases this is also true with sunroofs but not all of them. And most convertibles get poorer fuel economy with the tops down. So, while on the highway keep your top up, but in town put it down. The opposite is true at low, in-town speed. It is better to open your windows, or sunroof, or put down the convertible top at speeds of less than 40 or 45 mph. The load of the air conditioner during the repetitive accelerations in town will outweigh any increase in fuel consumption created by the higher aerodynamic drag.

As mentioned earlier, the approach to a hill should be taken with a little extra speed. There are several technical reasons for this. First, gaining the extra momentum on level ground is easier than trying to gain it while climbing. You can push the accelerator down just a little bit to gain speed on the flat, but you will need to push it down more on the hill just to maintain your speed. Second - and this is truer for smaller engines - a minimum amount of horsepower is required to climb the hill efficiently. The amount of power produced by a gasoline engine is very dependent on engine speed (rpm's). When you hit the bottom of the hill at a certain speed your engine is spinning at a certain speed. If the horsepower at that engine speed is below the required horsepower needed to climb the hill, then the vehicle will have to downshift to get to the higher engine speed, and this wastes fuel. Each vehicle is different, so find a legal speed that gets you up hills without downshifting whenever possible.

Way #18
Increase your speed before you start up a hill

Way #19
Avoid traffic

Way #20
Use the HOV lanes

Way #21
Avoid poor or dirt roads

Way #22
Avoid rain and snow

Traffic can have a very significant impact on your gasoline economy. Slowing and then accelerating to get through the herds of other vehicles, oscillating creeps, unexpected lane slow-ups, or just plain, old "dead in the water" traffic jams all cause excess fuel waste. If you have a choice, do your driving at off peak times. Take a friend and use the HOV lanes found in most metro areas these days. Again, combine your errands to reduce your time and contribution to the traffic. There may not be a lot you can do about these last effects on your highway fuel economy but they do have an impact. Different road surfaces create more or less drag on your tires. Smoother, harder surfaces and concrete are a little more efficient. Any loose surface such as sand, gravel or dirt will increase your fuel consumption.

Way #23
Avoid headwinds and crosswinds

Weather has its effects also. Rain and snow will increase the tires' rolling resistance, and the wind can either help or hinder. Obviously, a headwind requires more energy (gasoline) to push through and a tailwind requires less. Crosswinds also require more energy since the tires are driving in a skewed direction trying to overcome the force of the wind. In approximate terms a direct headwind of 20 mph on a vehicle doing 60 mph will cause the vehicle to get the fuel economy as if it were driving at 80 mph.

Parking –

Way #24
On cold days park in the sunshine

Where you choose to park your vehicle also has an impact on your fuel economy. And this changes season to season. In the colder weather it makes more sense to park in the sun during the day. This will keep your car warmer and less gasoline will be used to heat up the engine and interior. Again, a warm engine is an efficient engine, and a hot catalytic converter is a functional catalytic converter.

Way #25
On cold nights park under cover

On cold nights it is best to keep your car under cover, especially on cloudless nights. The clouds help insulate your vehicle from the very, very (-270 degrees centigrade in space) night sky. The colder your car gets at night the more gasoline is used to get it up to operating temperature the next day.

Way #26
On hot days park in the shade

During the hot times it is best to keep your car cool. This is not so true for the engine operating temperature – the engine still needs to be at operating temperature – but for the air conditioner loads. Automobile air conditioners are bigger than many house air conditioners. This is because they are required to cool a car that has been baking in the sun for hours, and cool it down in minutes. This takes a whole lot of gasoline, and much of the time it is being done before the engine has had a chance to get to its efficient operating temperature.

Way #27
First, put the windows down to remove the hot air before staring the air conditioner

You can reduce this waste of gasoline by adapting a few simple habits. First, and again, combine your trips so that your car does not sit in the sun heating up the interior while cooling down the engine and catalytic converter. Second, when it's hot outside, park in the shade whenever possible and leave a small opening at the top of the windows, when appropriate. Third, whenever you get in a vehicle that has been baking in the sun, put down all the windows and get the heat blown out before starting the air conditioner. This will also allow time for the engine to get to operating temperature.

Chapter 5 – Vehicle Usage

This chapter covers "fixed issues." That is, items that are not your daily driving techniques but how your vehicle is kept and maintained. This includes fueling, cleaning and servicing. Or, what is the economic impact of leaving your kayak on your roof rack as you commute to work during the off-season.

Care and Feeding –

The cleanliness of a car's exterior will affect its fuel economy. Granted, it will have a very small effect, but the more aerodynamically efficient the vehicle is to start with, the more surface dirt will affect it. As a percentage, leaving mud caked on the sides of a Dodge Ram pickup will have a far smaller impact than leaving road splash on a Honda Insight. The designers of the super efficient solar powered sun-racers could measure aerodynamic drag differences simply in the placement of decals on the vehicle bodies.

Way #28
Keep your car clean and waxed

For the highest fuel efficiency keep your vehicle clean and waxed. Remove any caked-on mud as soon as possible, and don't forget the wheels and underside. RainEx on the glass helps by reducing the use of the windshield wipers and allows the rainwater to flow off. A shiny car is not only a happy car; it is also an efficient car.

Way #29
Stop at the click

When feeding your car or truck, one of the easiest ways to save is to "stop at the click." Do not top off your tank. The practice of topping off wastes the fuel you just paid for as well as forcing raw gasoline (hydrocarbon pollution) into the air. A lot of engineering in modern vehicles went into keeping raw gasoline from escaping from fuel tanks and systems. This effort is wasted if the tank is overfilled. The lost gasoline will show up as poor fuel economy.

Most gasoline is stored in underground tanks, and the ground temperature is generally in the 50 degree Fahrenheit range. So the fuel is pretty cool when it is pumped into your tank. As the fuel warms up during the day it expands and builds pressure throughout the fueling system. If there is any small defect in the system then the raw fuel will escape to the atmosphere. The gas cap is generally the culprit and is pressure tested during emissions testing in some locations. Don't place the extra burden on your vehicle by topping off your tank, even if it is a new car or truck. The gasoline you may lose is already paid for.

Excess Baggage –

Way #30
Remove unneeded cargo

Another big waste of gasoline is caused by hauling around extra stuff you don't need. Keeping extra weight in the car costs you every time you accelerate from a stop or drive up a hill. Most cars, small pickups and small SUVs are designed to carry about 850 pounds. The anticipated layout is four 150 pound folks up front and up to 250 pounds of luggage in the trunk. At maximum loading, the fuel economy will show the strain. On smaller engines this may mean a drop of a quarter in range. A small 40 mpg car could become a 30 mpg car when fully loaded.

If we attempt to prorate these numbers it would appear that carrying an extra 85 pounds would cause a 1 mpg gallon reduction in gasoline economy. Adding this up for an average 15,000 miles per year – 375 gallons – and a 375 mile shorter range. You will need about 9.6 more gallons costing you $40 per year. These numbers are very rough approximations, but you get the idea. Bigger vehicles will see less of an impact and smaller vehicles in hilly terrain may see a greater impact.

Roof Racks –

Way #31
Remove roof racks when unneeded

Probably a bigger waste of gasoline is from leaving ski racks and storage boxes on the top of the car when they will not be used for months. Remove those ski and board racks during the summer months.

Way #32
Remove car top boxes when not in use

Car top boxes can create a very large drag on smaller cars. Some folks will buy small economy cars and add monster sized boxes to make up the difference in cargo capacity. Some times the boxes look bigger than the cars. Unless these boxes are removed when not in use, the vehicle owner should just get a bigger car and save the money being wasting on gasoline. So if you only stow stuff in your car top box on vacations, then remove it at other times. Most of them are made with quick mounting devices.

The big issue is aerodynamic drag. The older style ski racks are probably the worst culprit since they have a flat, vertical section that is used to clamp the skis, or snowboard. As the vertical section moves through the air, air pressure build up in front of it and a vacuum builds up behind it. This pressure differential puts a great force on the rack creating a great drag force on the vehicle.

An associate of mine was telling me about his concern with respect to his Toyota Prius. He was never able to achieve the advertised fuel economy for the car. Once I saw the car it was obvious – it was sporting a set of the older style ski racks. He had been leaving them on winter and summer. For a car like the Prius, with very low aerodynamic drag, roof racks can cause a big difference in the fuel economy.

Way #33
Carry bicycles on back instead of on roof racks

Bicycles on the tops of vehicles are another big drag. It turns out that bicycles, like motorcycles, have a very large coefficient of drag. But, because their frontal area is pretty small the drag is generally smaller. For a given amount of frontal area, or general size, bicycles create more aerodynamic drag than a brick. This is because of all of the tubes, cables, spokes and such that are in the air stream. If you cannot carry your bikes inside your vehicle then the rear is still better than on top. Some small car drivers have seen significant drops in fuel economy when bikes were placed on their roof racks.

Way #34
Put your car top box on with the pointed end to the rear

As a little side note – most of the car top boxes are installed with the wrong end forward. It is true that they are designed and styled for the pointy end forward and the big end to the rear, but from an aerodynamic drag standpoint they are on backwards. Just like an airplane or submarine body, things have less drag if the tail end is pointed. That's why the fastest fish were designed that way.

Maintenance –

And let's not forget about maintaining your car for its maximum efficiency. Tire pressure is a very big issue for those concerned about fuel economy. Over the past decade, and starting with large trucks, the industry has been developing and installing chips inside tires that monitor the pressure. Originally a wand was passed near the tire to read the pressure, but now the data is picked up by the vehicle's system even as the vehicle is moving. Within the next few years systems to monitor tire pressure and notify the driver will become standard equipment. Some systems on cars and light trucks with ABS (anti-lock braking system) use the ABS wheel sensors to monitor the speed of each wheel to detect a low tire.

As for now, most drivers still need to check their tire pressure manually. Running low tire pressure wastes millions of barrels of oil nationwide every year. Use at least the minimum pressure recommended for your vehicle and tire size. A sticker can usually be found in the inside door jam of the driver's door or sometimes on the passenger door jamb. For better fuel economy, increase the pressure to the maximum recommended for the vehicle. Sometimes it is appropriate to inflate the tires to the maximum pressure that is embossed on the side of the tire. Using this pressure should achieve the best fuel economy at the possible expense of greater tire wear and a harsher ride. If you do not find the stickers on the door jambs then check in your owner's manual. On a well-maintained vehicle, the tire pressure should be checked every three months or more often if you have older tires.

Way #35
Maintain proper tire pressure

When it comes time to replace your tires be aware that different tires have different rolling resistances. I have not found it easy to determine the rolling resistance coefficients on most tires – the data is just not readily available. But for most cars, the original tires from the auto manufacturer will have the lowest rolling resistance. This is because most cars are part of the CAFE (Corporate amalgamated fuel efficiency) requirements and the best tires would have been used to help meet that requirement for the manufacturer. Alternatively, research the tire manufacturers and models used on similar new cars if the original tire information is not available for your vehicle.

Way #36
Use low rolling resistance tires

Another little side note here – most of what makes up a tire is petroleum. Large, aggressive tires used on many trucks and SUVs not only waste more fuel on the roadway, but they also require more petroleum to manufacture the tires. And after being used for a few years and worn down, where has all that rubber (petroleum) gone? It is on the streets and in the air. People are breathing it. The smaller and more long-lasting a tire is, the less petroleum is wasted and left floating around the environment.

Way #37
Maintain good wheel alignment

Following tire pressure, wheel alignment is the most likely cause of systematically poor fuel economy. Most modern cars and light trucks require the alignment of all four wheels. When a vehicle's wheels are out of alignment, one or more wheels are not aligned with the traveling direction of the vehicle. Much of the time this can be felt by the steering wheel pulling to one side or the other, or seen as uneven wear of the tires.

A car or light truck can be knocked out of alignment by hitting a curb, a pothole or even a hard chunk of frozen snow. So you may not always know if your vehicle is in alignment without checking your tire wear or looking for other telltale signs. Include an inspection of your tire wear every time you check your tire pressure – every three months.

Way #38
Change oil on schedule

Oil changes need to be performed at intervals suggested by your vehicle's manufacturer. As oil ages it looses a small amount of its friction reducing capabilities (lubricity). Part of this is due to the breakdown of the long chain molecules that make up the oil. Additionally, lubricity is reduced as contaminates accumulate in the oil. Reduced lubricity means increased friction and increased friction means reduced efficiency, which leads to higher fuel consumption.

Way #39
Use slicker oil

Some oils and additives have greater lubricity than others. Using oils and additives from reputable companies that clearly state that the product will reduce engine friction is a good idea. Be aware that there is a lot of "wishful thinking" by many manufacturers in this field.

Way #40
Keep your vehicle tuned up

Along with your scheduled oil changes don't forget your tune-ups. Stick with the manufacturer's schedule for plug replacement, air filters, and everything else. As your spark plugs age, the spark gap tends to widen, changing the reliability of the spark that ignites the fuel. A poor fuel burn shows up as increased fuel consumption, increased emissions and a loss of performance.

If your vehicle is used in harsh or dusty locations then consider cutting down on the time intervals of the scheduled air filter replacement. In some cases very dusty roads can fill up an air filter in a few weeks. Once clogged, your airflow is diminished and fuel economy goes down.

Way #41
Keep a clean air filter

And finally, have your brakes checked on a regular basis. Dragging brakes are not as common as they were years ago but it still happens. On drum brakes the return springs would weaken, slip or break and cause the brake shoe to drag on the brake drum. The general failure of disk brakes is either a stuck piston or a stuck caliper. The stuck piston usually requires a rebuild but the stuck caliper can usually be fixed by knocking it loose, cleaning it and lubricating it.

Way #42
Maintain healthy brakes

Dragging brakes will cause the brake to overheat during normal driving. If a wheel feels hotter than the others or smokes, have it check out immediately. In some cases, dragging brakes can cause intermittent low brake pedal or failure. The overheated brake can cause the brake fluid to boil and create air bubbles and when activated the air bubbles will compress and not transmit the pressure. This can cause a very low brake pedal or severe pulling to one side of the car during even moderate braking. Again, this situation will require immediate servicing.

Be very, very cautious about “magic” fuel savers. Fake fuel saving devices show up all the time. From the magnet on the fuel line to the atomizing screen under the carburetor. If any of these devices actually worked some vehicle manufacturer somewhere would be using them. The big manufacturers may be slow but they are not stupid, especially if they are trying to produce a high-mileage car like an Insight or Prius.

Living Locations and Commuting –

Along with keeping your vehicle in good working order and uncluttered, the location of your driving will affect your gasoline usage. Spending your rush hours stuck in crawling traffic will waste a lot of fuel. Driving up and down mountain roads will use a lot more gasoline than commuting to work in a flat land like Florida. There is not a lot you can do about this except move. But when you do move you can take these issues into account when you select your home, work or community.

Way #43
Live closer to town and work

Many times it costs more to live nearer work and cultural centers, and people will move to the distant suburbs for a larger, cheaper house. In making this choice, include the additional fuel and vehicle costs (small) as well as the cost for your time (large). A house $50,000 cheaper outside of Boulder, Colorado is thirty minutes away during rush hour. This savings is not a savings unless the owner makes less than $25 per hour. The $50,000 savings divided over five years is $10,000 per year or $40 per day. Subtract from this the average American cost of using a vehicle - $14.50 per hour and you are down to about $25 per hour. Additional travel expenses include the costs for other shopping or entertainment trips back into town.

Chapter 6 – Vehicle Selection

There are plenty of vehicles to choose from these days, and there is even more advertising telling you what vehicle you "deserve". Your challenge is to get through the din and make a choice that works best for you. A casual survey of TV advertising will show a disproportionate number of high profit vehicles compared to the less profitable. Consider the manufacturer's profit on a mid-sized SUV of about $10,000 and compare that to the few hundred dollars profit on a small car. It is pretty obvious why the SUVs and light trucks are so heavily advertised.

Way #44
Determine your true needs before getting your next vehicle

In making your choice of a vehicle you should consider the utility, safety, costs and technologies. Of course, these somewhat objective criteria are best balanced against your subjective considerations. Comfort and styling may be completely subjective while even utility and safety are partially subjective. Discovering the balance between these criteria and sticking with them can lead to a more fulfilling and satisfying choice even after the new car smell has evaporated.

Cargo Hauling

Historically, utility was thought of as the primary reason for investing in an automobile or truck. This has changed somewhat. Utility is no longer completely objective simply because it is too easy to rationalize how a vehicle may be used. Some folks like to imagine (just like the ads show) that they will be hauling large loads of lumber or pulling their 30 foot yacht – they end up buying an oversize vehicle that they can't park, can't afford to fuel, and can't fit into their townhouse garage.

Way #45
Forgo a pickup truck unless you really need it

Pickup trucks are seen as the quintessential cargo vehicle for the landed gentry. Pickup trucks are advertised for their hauling capabilities yet few of them will ever pull that six thousand pound boat or carry two thousand pounds of bricks. And when it's raining, the truck is as useful as a two-seater sports car. Many of the smaller pickups are rated with a payload of only 850 pounds. That is the same as most mid-size and larger cars. Check the actual specifications in the owner's manual before you buy.

The fuel consumption of a pickup truck is notably higher than an automobile of the same weight class. This is primarily due to the poor aerodynamic drag of the truck. While a similar era car may have a drag coefficient of 0.35, a smallish pickup would have 0.42 – that is a twenty percent increase. The cab of a pickup truck sticks up into the air stream in such a way as to shoot the air flow up and over the roof. When the air flow is forced away from the vehicle in this manner there is a large vacuum (low ambient pressure) created. Short cab pickup trucks are the worst. By the time the air flow comes back down to the top of the truck the cab has passed, creating a greater vacuum behind the cab. The longer the cab the better the aerodynamics. A secondary source of excessive drag comes from the "cool-looking" oversize wheel wells.

As for hauling lumber, bricks or furniture, I have found an inexpensive trailer behind a car more capable and I don't need to worry about scratching the paint. If heavy or bulky hauling is only needed every other month or so then a cargo trailer makes a lot of sense. They do not require separate insurance, inspections, engine maintenance or fuel, and the annual license fees are much more reasonable.

Way #46
Use a trailer instead of owning a truck

Other advantages to owning a trailer is that they are generally lower loading height and can haul more than small or medium pickup trucks. To compare: a $600 trailer can carry 2,400 pounds compared to 1,200 in a Ford Ranger. And finally, it should be less worrisome to loan out a trailer to your friends versus your shiny new, expensive pickup truck.

A little safety note about using trailers – always load them with the tongue heavier than the tail end. A heavy tail end can cause the trailer to wag and has led to many, many accidents.

Passenger Hauling

Now if you need to haul a lot of kids or adults around you will either need a larger car or a van. Two, three or four adults or kids are well suited for a car, and this should deliver the best fuel economy. For more versatility, a minivan is best. I know that minivans have developed a bit of a stigma, but they are still the most useful vehicles for hauling around a half dozen kids. Some minivans will get thirty miles per gallon if driven properly – driven as described in this book. An SUV may look cool but will always lose out when compared to a minivan's fuel economy and interior volume.

Way #47
Avoid the SUV trap

Sport utility vehicles are my least favorite vehicles. Many are shown in the TV ads blazing through snowdrifts or backcountry trails. Only a few of these vehicles really ever see this usage. The rest simply try to weave their way through grocery store parking lots looking for a space big enough to park in.

Consider your real needs before purchasing one of these vehicles. Snow? Essentially all city streets are cleared of any depth of snow in short order. An SUV is only an advantage when the snow is deeper than six inches on the roads; otherwise they slide like any other vehicle on ice or packed snow. Off-road? Consider the destruction to the wilderness before breaking a new trail.

The concern I have about SUVs stems from their lack of actual usefulness when weighed against their shortcomings. Here is a short list to think about prior to acquiring an SUV or light truck:

- They use more fuel while delivering less interior space.
- The headlights are higher and shine into the eyes and rearview mirrors of car drivers.
- Their center-of-mass (center-of-gravity) is higher and will override the center-of-mass of a regular car during a collision.
- The higher center-of-mass also makes them prone to rollovers.
- The aerodynamics are generally very poor, leading to excessive noise which leads to fatigue.
- Bigger tires will still wear away, putting more ground up rubber into the air for others to breathe.

In choosing your next vehicle, review how you have been using your past vehicles. Was it 90 percent commuting? Five percent hauling building supplies? Or 25 percent hauling the kids around? Your future utilization will probably be the same – get what is truly needed.

Commuting

If ninety percent of your driving is commuting then consider this first. Are you a single occupant all of the time, most of the time, or almost never? If you carpool then an economical sedan will be best. If you drive alone most of the time you might consider a motorcycle – but I wouldn't.

Way #48
Consider a motorcycle or motor scooter

Motorcycles have the image of being fuel efficient, but they are not very. It is the aerodynamics. For moving only one or two people, a motorcycle only delivers the fuel economy slightly better than a small, efficient car. Many motorcycles achieve 50 to 75 miles per gallon, but a lot deliver far less than that. Compare this to a Honda Insight which get about 75 mpg on the highway when driven correctly. The Toyota Prius averages over 50 mpg in town and 45 mpg on the highway – while being able to carry four or five people.

Some advantages other than fuel economy can be found in using a motorcycle. First, the license plate taxes tend to be lower, insurance is generally a lot lower, and parking is usually free where the cars are metered. One last consideration about motorcycles – historically, 65 percent of the fatalities of motorcycle drivers happened within the first six months of getting a license.

Safety

Safety can be a somewhat objective criterion in selecting a vehicle. There are a lot of myths concerning the safety for different types of vehicles. Some of these misconceptions are spread by the manufacturers and some, sad to say, by the government. Research at websites such as the Union of Concerned Scientist and the Insurance Institute can help dispel the misinformation.

It turns out that the car with the least number of fatalities is a luxury sedan and the vehicle with the most fatalities is an SUV. The Insurance Institute states:

Large cars and minivans dominate among vehicle models with very low death rates. The models with the highest rates are mostly small cars and small and midsize SUVs, many of which also have high rates of death in single vehicle rollover crashes. The model with the highest death rate of all — the two-door, two wheel drive Chevrolet Blazer with 308 driver deaths per million registered years — also had the highest rollover death rate (251 per million).

The weight of a vehicle has a lot of bearing on its safeness but there are several more factors at play. The location of the center of mass (or center of gravity) has a lot to do with how a vehicle reacts during an impact as well as how it handles during quick maneuvers.

If the center of mass is at the same height as the center of mass of the other vehicle then the crumple zones will absorb most of the impact energy. All modern automobiles are designed with crumple zones. These are expendable parts of the vehicle like the trunk and the hood area that are designed to crumple during impact and provide a cushioning for the safety cage – the cage that holds the humanoids.

When cars hit cars and trucks hit trucks the crumple zones and the safety cages can do their jobs. But when cars hit trucks and trucks hit cars the crumple zones are misaligned. Cars can easily go under trucks, and worse, trucks can go over the crumple zones of cars.

Technologies

Way #49
Consider a hybrid vehicle

Some technologies have an inherent effect on fuel consumption. The hybrid technologies developed by Toyota and Honda have provided quantum leaps in energy efficiency, but not by themselves. The hybrid vehicles from Toyota and Honda are both significantly more aerodynamic than comparable cars. On the other hand, when Ford hybridized their small SUV without changing the body there was a small increase in efficiency, and GM claimed to hybridize a pickup truck yet only increased mileage by about two percent.

Way #50
Consider a new-technology diesel

Diesel engines have always been more energy efficient than sparked-ignition gasoline engines. Originally designed to run on cleaner peanut or vegetable oils, the diesel engine is about 30 percent more efficient than the gasoline engine and built a lot stronger. The diesel engine will last a lot longer but will cost more up front.

Way #51
Consider a manual transmission

Manual transmissions are not all that common in the USA, but are in the majority of cars sold in Europe where gasoline prices have been high for some time. A manual transmission will give you higher fuel economy than an automatic in the same vehicle. The manual will also provide the feeling of more power and faster accelerations.

Way #52
Avoid all-wheel-drive or 4-wheel drive

A technology that is becoming very common today and wasting a lot of fuel is all wheel drive. Although AWD is useful in some locations and during some driving conditions, I don't feel that it is worth the additional fuel costs. A small car with AWD may achieve 25 miles per gallon on the highway, and the same car with only two-wheel drive should see 30 miles per gallon. That is a large price to pay for a technology that is only used occasionally, if at all.

When you select your next vehicle consider the operating costs as well as the initial capital and financing costs. The operating costs include the fuel, of course, as well as the insurance, maintenance, parking, cleaning and finance charges. For a car that averages twenty miles per gallon with gasoline at four dollars, the cost for 100,000 miles is $20,000.

@ 100,000 miles	$2.50/ gallon	$3.00/ gallon	$3.50/ gallon	$4.00/ gallon
10 mpg	$25,000	$30,000	$35,000	$40,000
20 mpg	$12,500	$15,000	$17,500	$20,000
30 mpg	$8,333	$10,000	$11,667	$15,000
40 mpg	$6,250	$7,500	$8,750	$10,000
50 mpg	$5,000	$6,000	$7,000	$8,000
60 mpg	$4,167	$5,000	$5,833	$6,66

Pick your estimated fuel cost over the first 100,000 miles you plan to put on your next auto and add it to the other operating expenses you are budgeting for. (The $2.50 per gallon is still in the chart for historical purposes – the original chart had $1.50 per gallon)

Chapter 7 – Alternative Fuels

There are several transportation alternatives to gasoline and diesel fuel. They are all cleaner but do not have the same energy content as the petroleum based fuels. Most of what put these alternative fuels on the market was two federal laws – the Clean Air Act and EPAct. The Clean Air Act developed requirements and programs that used alternative fuels as a way to reduce the nation's transportation related pollution. EPAct sought to reduce the nation's dependence on foreign oil. Both programs mandate and support the use of alternative fuels with slight differences. The Clean Air Act would favor the use of reformulated gasoline because it would lead to cleaner air, but EPAct would not, since it would not reduce oil imports.

Propane, or LPG, is the most widely used alternative fuel followed by compressed natural gas, E-85 ethanol, electricity, M-85 methanol and liquefied natural gas. Fuels like biodiesel and other renewables are becoming very popular also.

Propane –

Way #53
Use a propane powered vehicle

Liquefied petroleum gas (LPG), commonly known as propane, contains propane and butane and is usually derived from natural gas. It is estimated that there are nearly three hundred thousand LPG vehicles and 2,500 refueling sites in the USA. LPG is stored at ambient temperatures and low pressures of about one hundred pounds per square inch (100 psi). With gasoline containing about 115,000 btu/gallon, LPG contains about 83,500 btu/gallon. Even though the emissions are much lower, the fuel tank would need to be much larger to travel the same distance.

Natural Gas –

Way #54
Use natural gas

Compressed natural gas (CNG) is the second most common alternative fuel with about 127,000 vehicles and 834 refueling stations. The storage tanks on vehicles are either 3,000 psi or 3,500 psi units. A common tank design consists of an aluminum cylinder wrapped in a fiberglass band. Compressed natural gas has an extremely low energy density on the order of 1,000 btu/gallon. For larger and/or heavier vehicles, compressed natural gas would require extremely large tanks and take hours to fill. For these vehicles, the natural gas is liquefied by cooling it to a very low temperature. Overall, the emissions from natural gas vehicles are very low. The Honda Civic GX CNG car was one of the first vehicles to have an exhaust cleaner than the ambient air in some major cities.

E-85 –

Way #55
Use ethanol for cleaner air

Ethanol is a fuel derived from vegetable matter and is basically a grain-spirit alcohol. It is sold as a vehicle fuel mixed with 15 percent gasoline (E-85) or as an additive mixed with 90 percent gasoline (E-10). As an additive, the ethanol raises the octane and oxygen levels for a cleaner burning fuel. As an alternative fuel, ethanol can work well at 100 percent but it is sold denatured with the 15 percent gasoline to remove any consumer confusion about it being consumed as a beverage. In other words, the feds add the gasoline to keep folks from drinking this 200 proof moonshine. Ethanol has about 76,000 btu/gallon energy content compared to gasoline at 115,000 btu/gallon.

Most of the major automobile manufacturers produce vehicles that can use E-85; few of them highlight that point during the sales pitch. These vehicles are called Flex-fuel Vehicles or FFV. The only way to find out about it in many situations is to read the owner's manual. Or, on some Fords, there is a small medallion in the shape of a green leaf and highway that is used to indicate a vehicle capable of using alternative fuels such as ethanol.

Diesel –

Way #56
Diesels are more efficient than gasoline fueled vehicles

Even though diesel fuel is not considered an alternative fuel it does compare well to gasoline except in the area of emissions. Petroleum based diesel fuel (Dino diesel) contains 128,700 btu/gallon – twelve percent more than gasoline. Three alternative diesel fuels are emerging.

Biodiesel –

Way #57
Biodiesel reduces petroleum consumption

Biodiesel is made from vegetable oils like soybeans, peanuts, or sunflower seeds and has significantly lower emissions, particularly in the area of particles. It is such a clean fuel that it will even clean out the vehicle's fuel system when used. The biodiesel can be used in any combination with petroleum diesel in most diesel engines. The energy content is about ten percent less than petroleum diesel. Biodiesel has also spurred the growth of "home brewers". These are folks who collect used cooking oil from restaurants and process it to create biodiesel fuel. This is a very cheap process with some locations producing tens of thousands of gallon per year.

GTL Diesel –

The second alternative diesel fuel is GTL (Gas To Liquid), or Fischer-Tropsch diesel. GTL fuels are created when natural gas or biogas is converted to liquid fuels that can be refined into gasoline and diesel. Typical GTL diesel fuels have near zero sulfur and aromatic content and very high cetane numbers. The near zero sulfur content can allow for the use of advanced emission control devices on the exhaust. Because GTL is derived from gases it can greatly reduce nitrogen oxides and particle emissions.

Straight Vegetable Oil –

Way #58
SVO use reduces petroleum consumption

A Diesel engine can operate on straight vegetable oil (SVO) if the oil has low enough viscosity to flow through the injectors. Converting oil to biodiesel makes the oil thin enough, or the oil can be warmed up to about 80 or 90 degrees Fahrenheit. Conversion kits are available to use SVO in many Diesel powered vehicles. The kits heat the SVO while the vehicle is operating, but biodiesel is used right after startup and just before shutdown to keep the SVO from solidifying in the injectors. Two drawbacks are that you need two fuel tanks and the vehicle needs time to return to biodiesel before shut-down.

Electricity –

Way #59
Electricity is clean and cheaper than gasoline

Electricity was one of the earliest fuels for automobiles. In the late 1800's most of the self-propelled taxis in New York City were battery powered. At the turn of the twentieth century a gasoline fueled car and an electric car were generally considered to have the same range – that was because the electric would run out of juice in thirty to fifty miles and the gasoline vehicle would break down. The largest land vehicles in the world are electric powered. Both the super large trucks used in strip mining and the diesel fueled locomotives are driven by electric motors. Before General Motors crushed all of their EV-1 cars, the generation 2 models had a range of about 125 miles per charge using Nickel-metal batteries.

To make things clear – there are two general configurations for electric fuel for an automobile. First, there are battery powered cars that are recharged from stationary sources such as plugging in at home. Second, there are vehicles that are actually powered by electricity that is produced on board the vehicle as it is needed. But in both cases the vehicle is actually propelled by an electric motor.

For a battery powered vehicle, there is plenty of charging capacity in the United States; it just needs to be charged at night. Overall in the US only about ten percent of the electricity generating capacity is used at night. That leaves a surplus of nearly ninety percent that would be enough to charge over 100 million cars. Additionally, the total emissions from an electric vehicle are very low compared to a similar gasoline fueled vehicle. Even when compared to the electricity produced in a coal fired power plant, the electric vehicle produces only a few percent of the major pollutants compared to the gasoline vehicle. The single exception is sulfur, which is significant from a coal fired plant but not an issue from gasoline vehicles.

Plug-in Hybrids –

Hybrid vehicles may be very efficient, but they are not alternative fueled vehicles unless you can plug them in. Plug-in hybrids, either conversions or factory built, offer the advantages of offsetting the use of gasoline with electricity. These PHEVs benefit both from the increased efficiency of being a hybrid, as well as using the cheaper, cleaner fuel electricity.

In practice, conversions of the Toyota Prius or the Ford Escape hybrid saw the halving of their gasoline consumption. The Prius plug-in conversions were getting between 100 and 125 miles per gallon in town and about 90 mpg on the highway. Many Prius were modified with the addition of the EV mode button allowing the vehicle to be driven on the electric batteries only, when at speeds of less than 34 miles per hour.

Way #60
Use a plug-in hybrid

Factory built plug-in hybrids also included the range extended hybrids. These vehicles were primarily electric vehicles with some sort of generator that would extend the range of the vehicle when the batteries got low.

Hydrogen –

It is said that hydrogen is the most abundant element in the universe and this is true. It is also true that it is the smallest and hardest element to hold on to. But hydrogen is not a real fuel (except in a fusion reactor). Hydrogen is an energy carrier in the same way electricity is an energy carrier. Hydrogen must be isolated or captured, and stored and this takes energy. Most of that energy can be recovered when the hydrogen is used in an engine or put through a fuel cell.

The major difficulty with hydrogen is storing it. When it is compressed there is only a small amount of energy stored in a large and heavy tank. It takes about five times more volume to store compressed hydrogen compared to gasoline. This would require a fuel tank as big as the vehicle's cargo area to travel the same distance as 15 gallons of gasoline.

Liquefying the hydrogen will require lowering its temperature to near absolute zero. At this temperature it is very dangerous to your skin and most other materials. Special handling training and gloves are generally required to refuel with super cooled, liquefied gases. Also, to reach temperatures this cold will require a lot of energy – about 70 percent of the energy content of the hydrogen – to run the cooling units.

Another storage system being researched today for hydrogen is carbon nanotubes. Also known as hydrides storage, this system is composed of a material that will allow the hydrogen atoms to stick to it. This keeps the hydrogen atoms from flying around, banging into each other and creating the gas pressure. The hydrogen atoms are released with the application of heat. Near and mid-term research on hydrogen storage is focused on achieving a two thousand pound fuel tank at a cost of about $2,000. This future fuel tank would become a major part of the car body and a major expense.

Since hydrogen is an energy transporting system rather than an actual fuel source, it becomes important to know where the energy originates. Currently, most hydrogen comes from natural gas. This process produces byproducts that are released into the atmosphere. Many other hydrogen production schemes are in research today and include solar electrolysis, algae waste gas, and super high temperature cracking of water. These processes are not expected to be cost competitive with the natural gas system any time soon. “Hydrogen is the fuel of the future, and always will be.”

Energy Efficiency –

Energy efficiency is not really a fuel but it is probably the only long term sustainable system. All of the fossil fuel sources will be drying up over the next hundred years with a trend toward scarcity driving up prices. Biofuels like ethanol and biodiesel will have a limited impact on the world’s energy needs since the production capabilities are just not large enough to feed such high energy needs. Hydrogen and electricity must be made from something and the only things left are wind, solar and nuclear. Wind and solar are great sustainable energy sources but, again, the capacity is just not there yet. Nuclear may have the capacity in the long run but who wants either the reactors or the spent fuel rods near their homes?

In a perfect world all the personal transportation devices would travel all day on a few kilowatt-hours. All of the energy would be derived from wind and solar. And in the distant future this will probably be a reality. There are single passenger vehicles that can travel at sixty miles per hour and use a tenth of the energy of the average American car.

Chapter 8 – Alternatives to Driving

Most Americans have a driving lifestyle. That is to say that driving is like eating three meals a day or sleeping at night – it is just part of our American lifestyle. Young people wait for the day they can learn to drive or the day that they get their first car. About half of our cities are dedicated to the use of automobiles. It takes about fifty percent of the land within a city to provide for roads and parking lots. A two thousand square foot house generally has a four hundred square foot garage. That's about a fifth of the average house.

Choosing an alternative to driving essentially requires a change in lifestyle. This is definitely a challenging task. With so much land, time and money invested into a personal automobile, motivation to change needs the hope of substantial treasures. But drive and discipline will be rewarded with better health, more wealth, lower stress, stronger community and more free time.

Carpools –

Carpooling is one of the simplest way to give up at least a little of the driving. This will not work for most folks for one reason or another. But for those who can carpool they will be able to spend less money on their own car, meet new friends and neighbors, and lower their drive time stress. Of course, lowering the drive time stress will ultimately depend on how fast and crazy the other drivers in the carpool drive. Carpooling also reduces the number of cars on the highway or at the neighborhood stop sign, and this makes everyone a little happier.

> **Way #61**
> ***Carpooling reduces gasoline use and increase friends***

Most major cities within the US have a carpool organization that promotes and facilitates carpooling. They will attempt to match up folks based on starting points, destinations and times. The 2002 census reports that 11.2 percent of commuters carpooled to work while 76.3 percent drove alone.

Car Share –

Car sharing is a newer concept popping up in some towns. Members join the local car share groups and when they need a car it is reserved for their use. The cars are usually kept in the neighborhoods and a member can easily get to the nearest one. If a different type of car is needed that may reside in another neighborhood then the member will have to take a bus or walk to the other vehicle. Generally car share members are well versed in using mass transit and other alternative forms of local transportation.

Way #62
Car share reduce vehicle expenses

Monthly membership fees, hourly use fees and mileage fees go to support the reservation system, insurance, vehicle acquisition, fuel and maintenance. Most of the car share organizations are not-for-profit or member owned. Generally the cars are donated or purchased used.

Car sharing is a benefit to the users by having lower, shared fixed vehicle costs and a benefit to the community by having fewer cars parked on the street. Being that most cars are only used a couple of hours per day and the rest of the time they simply sit, it makes good economic sense to allow them to be used more hours out of the day.

E-Com –

E-Com is a car system developed in Japan and tested in a couple of communities in the USA. The E-Com cars are small, two passenger electric cars that are completely highway compatible. Their home is a covered parking lot where they are plugged in for charging. A user would reserve a car over the Internet and either pick it up at the parking lot or some other location known to the system. Each vehicle has a GPS to let the system know its location. The entire operation is completely automated.

Way #63
Time sharing electric cars to reduce costs

By having the cars ready to go anytime with another user, they are in service more hours of the day than a private automobile. At the end of the workday, users would be able to drive a vehicle home, and may plug it in at home for recharging. The next morning the car is driven to town and is placed back in stock for others to use throughout the day.

Renting Cars –

Way #64
Only pay for a car when you actually need it

The total expense of owning a private automobile are becoming somewhat standardized these days. About 70 percent of the US households own between one and two vehicles. Each household uses about 17 percent of their expenditures on their vehicles. That is approximately $4,000 per year for purchasing and feeding a car, for the average household. Or that is $11 dollars per day.

For people in this situation that have access to other forms of transportation and live near a car rental agency, renting as needed may be cheaper. If one only used a car every third day on average, then renting would generally be cheaper than owning a car. This is assuming that the average car rents for about $25 per day including gasoline. And the reward for the little additional hassle is a clean car every day, a different vehicle to fit the current needs, and always driving the current model year.

Mass Transit –

Way #65
Ride the bus or commute by airplane

Mass transit has somehow gotten a negative image in this country. The term itself tends to bother some people even though being a passenger in an airline or a bus only differs in the views out the window. Additionally, mass transit in cities has not received the political and financial support it should have based on its benefits to the rest of the community. The 2000 census reported that 6,575,000 (5.2 percent of the commuters) people got to work on public transportation. The public transportation included buses, trolley cars, subways or elevated trains, railroads, ferryboats and taxis.

Mass transit is also a health benefit to most people since they generally have to walk some distance to catch their ride. If that is fifteen minutes of walking each way then they have a minimum of the daily recommended exercise for an adult. Public transit also allows people to meet more folks, and get to know their communities more. It creates a stronger sense of connectedness.

Motorcycles –

Way #66
Use a motorcycle

Motorcycles are a good alternative form of transportation mainly because they take up less space. But for their size and carrying capacity they are not very efficient. Compare a reasonable sized motorcycle capable of carrying two people to a small four passenger hybrid car. They both get about 45 to 55 miles to the gallon. It simply turns out that a motorcycle has about the poorest aerodynamic drag of any vehicle. If they were put under a smooth skin, their fuel economy could double to over 100 mpg.

But for moving one or two people at highway speeds it is hard to beat a well designed motorcycle. Only about 158,000 commuters used motorcycles to get to work, according to the 2000 census. That is just over 0.1 percent of all commuters.

Bicycles –

Way #67
Use a bicycle

Bicycles are overall the most efficient form of human transportation readily available today – even with their poor aerodynamics. It only requires about 180 watts to bike along at 15 miles per hour. That is the power of three regular light bulbs, or less than a lot of car stereo amplifiers. There are about 563,000 people who commute to work by bicycle.

For any trip under three miles, weather permitting, a bicycle is the most sensible form of transportation. In a distance that short, the regular automobile will be running with a cold engine and cold catalytic converter – wasting gasoline and spewing pollution.

The bicycle was one of the truly world changing inventions. It essentially amplifies human power to carry people farther and faster than humans can travel on their own. It is more efficient than walking. There are more bicycles in the world than any other machine. Even in car-centric United States there are more bikes sold each year than cars and light trucks ~ 18 million.

A few years back, mountain bikes accounted for 41 percent of new bike sales. This has dropped back to about a third today. Comfort bikes (20.6%) and road bikes (5.3%) have seen a growth in sales over that time frame. The average 2002 price for a comfort bike was about $340 and road bikes averaged almost $1,200. Of course cheaper bikes are still sold through discount chain stores at much lower prices.

When selecting a bike for transportation, care must be taken to get one of sufficient quality to do the job well. Cheaper bikes may look the same as a more expensive one from a specialty bike store but there is a big difference. The lack of quality components will show up in things like ease of shifting, smoothness in braking, rolling resistance, or efficiency of the drive train. A flexing frame will be more fatiguing. A quality bike is lighter and feels good. It feels like it wants to go fast. The braking and cornering are steady and sure. It's been observed that owners of cheaper bikes ride less. They just don't feel like putting the effort into it.

If commuting and shopping by bike are new to you, it would be wise to contact the local government or bicycle advocacy group for a booklet of riding rules and advice. Many states have excellent and complete booklets covering most everything you need to know about biking.

Final point – switching from a car driver to bicycle rider for your daily transportation needs is probably the healthiest thing you can do for yourself. For the cost of a few months at a gym you can buy a very nice bike that can keep you in shape year after year. You might step out of the shower one morning, look in the mirror and catch yourself asking 'Whose body is that?'

Velomobiles –

Way #68
Use a velomobile

Even though the bicycle is the most efficient form of transportation commonly available, the velomobile beats it by a mile. Velomobiles are recumbent bicycles with streamlined shells to cut the wind drag. Most of the velomobiles are found in Europe these days. They generally have three wheels – two up front and one in the rear, and may be partially enclosed or fully enclosed. The driver's head sticks out of the partially enclosed models.

The enclosure protects the driver from the elements and serves as a place to store cargo. Some models come with headlight, turn signals, and even hand operated windshield wipers. A couple of manufacturers have added electric drive units to assist the driver at normal road speeds.

A key advantage of a velomobile is the reduced aerodynamic drag afforded by the shell/enclosure. The shell can cut the drag so much on an average vehicle that the speed can almost double. A normal rider on a mountain bike may be pedaling hard and putting out 200 watts. Their speed would be about 18 miles per hour. Put that same rider in a streamlined velomobile with a power output of an identical 200 watts, and the vehicle will be going nearly 35 miles per hour. The world record for an unassisted conventional diamond frame bike is about 43 miles per hour. Compare that to the world record holder, Sam Whittingham, in a fully streamlined, two-wheeled velomobile at 81 miles per hour.

All of the known manufacturers of velomobiles are in Europe at this time. Most of them cost between 4,000 and 6,000 euros. Some are more upright for commuting with traffic while others are more laid-back and streamlined. As mentioned earlier, some have an electric motor for assistance in climbing hills or cruising with automobile traffic.

Walking and Running –

Way #69
Walk or run to work

Well, if it is too cold to bike and you don't yet have a velomobile, walking is the next best thing. A shortcoming of the efficiency of a bicycle is that the rider may not work hard enough to stay warm in the winter. That is when walking will be most appropriate. The benefits of walking are known the world over. It has been shown that American workers that do a lot of walking have the lowest levels of heart disease.

In the US about five percent of walking trips are to and from work. By far most walking is done for social and recreational reasons. This is followed by family and personal activities, shopping, visiting friends and relatives, school and church, and lastly vacations. About 3.4 million people walk to work. This exceeds all other forms of transportation to work except buses, carpools and single occupant vehicles.

Personal Mobility Devices –

Way #70
Use a Personal Mobility Device

A PMD is any small, single-person device that can propel a rider along at near walking speed. The most famous and most expensive PMD is the Segway. The Segway is a very sophisticated and elegant people mover. It almost looks as if the rider is standing on a futuristic version of an old fashioned reel mower. The Segway is controlled with subtle inputs from the rider. As the rider starts to lean forward ever so slightly, the Segway will move forward. To slow or stop, the rider simply leans back and the device slows, stops and may even reverse. Turns are made by a twisting of a collar on one of the handles. The Segway is small enough and light enough to easily fit into the trunks of most cars.

The Segway and other PMDs have a place in the mix of transportation modes in many parts of the country. At around $5,000 each they are not for most people, but they do provide a quicker way to get to the office than walking. And they will be a benefit to a community as they replace cars and trucks for inner city commuting.

Appendix – Resources

Books –

The whole truth about Economy Driving by Doug Roe © 1975 by H.P. Books

Transportation Energy Data Book, Edition 24, U.S. Department of Energy, Energy Efficiency and Renewable Energy [Now available as a downloadable pdf file.]

Websites – you might find interesting

Segway.com

Calcars.org

GEMcar.com

Teslamotors.com

EnergySense.com

AFDC.energy.gov – The Alternative Fuels Data Center

Bibliography

(1) Energy Information Administration (updated 2/29/2008)

Do You Want More Miles per Gallon?

Discover the factors controlling your gasoline consumption like . . .

~ Driver's skill and habits
~ Vehicle selection and condition
~ Rooftop carriers and excess baggage
~ Lifestyle and communities
~ and more.

Learn the alternatives to Driving

~ Carpool and car-share
~ Velomobiles and bicycles
~ Personal mobility devices
~ Walking and running
~ Mass transit and E-com
~ and more.

The plug-in hybrid Prius on the front cover gets about 100 mpg. It may be many years before the average car will do that well, yet you can improve your gasoline milage by following the information in this book.