Strategic Automotive Technologies: The Eco-Friendly Revolution

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Abstract

This paper is a compilation paper, in that it compiles credible sets of information available on the various aspects of the subject with an educational purpose in mind. It also has analytical aspects.

From evolution to revolution

Transportation systems have been key to human progress and are the basis of the modern civilization hinging on the Industrial Revolution. The invention of the internal combustion engine was an absolute turning point; even today its use is crucial despite significant development of other technologies powering cars, trucks, buses

Origin of the internal combustion engine

The first person to experiment with an internal-combustion engine was the Dutch physicist Christian Huygens, about 1680. But no effective gasoline-powered engine was developed until 1859, when the French engineer J. J. Étienne Lenoir built a double-acting, spark-ignition engine that could be operated continuously. In 1862 Alphonse Beau de Rochas, a French scientist, patented but did not build a four-stroke engine; sixteen years later, when Nikolaus A. Otto built a successful four-stroke engine, it became known as the "Otto cycle." The first successful two-stroke engine was completed in the same year by Sir Dougald Clerk, in a form which (simplified somewhat by Joseph Day in 1891) remains in use today. George Brayton, an American engineer, had developed a two-stroke kerosene engine in 1873, but it was too large and too slow to be commercially successful.

In 1885 Gottlieb Daimler constructed what is generally recognized as the prototype of the modern gas engine: small and fast, with a vertical cylinder, it used gasoline injected through a carburetor. In 1889 Daimler introduced a four-stroke engine with mushroom-shaped valves and two cylinders arranged in a V, having a much higher power-to-weight ratio; with the exception of electric starting, which would not be introduced until 1924, most modern gasoline engines are descended from Daimler's engines.

> Read more: internal-combustion engine: Evolution of the Internal-Combustion Engine http://www.infoplease.com/encyclopedia/science/internal-combustion-engine-evolution-internal-combustion-engine.html#ixzz3ashgAzhf

See E. F. Obert, *Internal Combustion Engine* (1950); C. F. Taylor and E. S. Taylor, *The Internal Combustion Engine* (1984); and J. B. Heywood, *Internal Combustion Engine Fundamentals* (1988).

Quantum leap

- US and UK were driving forces
- The Ford Model T-1
- Mass production
- Development of new models
- Abundance of fossil fuel; low cost
- Growth in usage

Fast forward to the 70s

- **Problem with the availability of fossil fuel**
- **Necessity is the mother of invention: the Japanese approach: smaller (than American) cars with enough room; improved aerodynamic design resulting in greater fuel efficiency**

Two crucial factors: design and engine efficiency

1) Lee Iacocca contributed to the redesign revolution at Chrysler: K cars

The K car was already in development when Iacocca became a part of Chrysler. The fuel-efficient, front-wheel-drive car was purposely designed to be under 176 inches in length so that more could fit on rail cars – another way to cut costs.

The Reliant and Aries were rated at 25 mpg in the city and 41 mpg on the highway, and were light enough to maintain its superior fuel economy while carrying a family of six; yet, their internal dimensions were almost as great as the Volare and Aspen they replaced. Buyers could easily fit into parking spaces designed for much longer cars; the length was a mere 179 inches, versus Chrysler’s prior “smallest car” at 206 inches.

Despite the high mileage, their light weight resulted in acceleration similar to the slant six Volare/Aspen, too — with 0-60 times ranging from 10.6 to 14 seconds recorded by enthusiast magazines (driving automatics), and a lone outlier of 16 seconds recorded by *Consumer Reports*. The standard Toyota Corolla, in contrast, was tested at 14-16 seconds by the enthusiasts, with the "hot" SR5 (automatic) at 12 seconds.

(inches; 4-doors)	**1972 Valiant**	**1977 Volare**	**1986 Reliant**
Front shoulder room		55.2	56.3
Rear shoulder room		55.2	56.7
Front Legroom	41.5	42.5	42.2
Rear Legroom	34.7	36.6	35.4
Trunk (cubic feet)	14	16	15
Length	199.6	206	178.6

In 1981, *Motor Trend* awarded the Aries and the Reliant its "Car of the Year" Award; the cars were created expressly for American conditions, while imports tended to have far less torque and a less compliant ride, and were considered both better to drive and more reliable than GM's and Ford's equivalent cars. In 1981, they sold over 300,000 K-cars — a number they kept up through 1988, the year before the K cars were replaced; had they remained in production, they might well have remained at that level. Things were starting to look up for Chrysler.

Chrysler still had to draw another $400 million in loan guarantees in 1981, and each time Chrysler went back to the government for help, sales dropped. In desperation, Iacocca attempted a merger between Chrysler and Ford in 1981. Ford would have been the surviving company and Chrysler, Plymouth, and Dodge would have become divisions under Ford. The top bankers in New York liked the plan, but Ford quickly declined.

Later in the year, on November 1, Iacocca found that Chrysler only had $1 million in its bank account. Some suppliers stopped shipping items, and Iacocca shut down the Jefferson Avenue plant for a couple days. But payroll was never missed, and suppliers, although sometimes paid slowly, always saw their money.

Soon, Iacocca signed print advertisements that Kenyon & Eckhardt were putting out, and began appearing in television commercials, including the famed “if you find a better car – buy it” campaign. The turnaround started to become obvious, and as the front man, Iacocca was subject to a “draft Iacocca for President” campaign, which he put to rest by signing a three-year contract with Chrysler in 1983.

Lee Iacocca leads Chrysler’s recovery

The break-even point was reduced from 2.3 million units in 1979, to 1.1 million units in 1982. Chrysler earned the best profit in its history, $925 million, in 1983. Plants had been modernized with the latest technology, and employment was maintained for half a million workers.

Iacocca brought back the convertible in 1982 with the Chrysler LeBaron. He skipped market research, and in its first year, 23,000 were sold – much more than the 3,000 Chrysler thought they would sell [full story], and Chevrolet and Ford trailed with convertibles of their own. And two years later, the T115 minivan was brought into the spotlight. Chrysler was leading the crowd.

The minivan’s design process had started in the early 1970s, when front-wheel-drive technology was virtually non-existent. With the arrival of the Horizon from Chrysler Europe, and then the larger, more suitable K-cars, Chrysler could go to front-wheel drive, dramatically increasing interior space with the same small outer dimensions. Iacocca was immediately enthused, and gave the “go ahead,” even though Chrysler didn’t have the money to produce the new vehicle. The whole project cost an estimated $700 million, and Iacocca received $500 million to get the project going. The minivan was highly successful, with 209,895 sold in 1984 — not a large number compared with the K-cars, but they were sold at a higher margin.

On July 13, 1983, exactly five years after he was fired from Ford, Iacocca announced the payback of the loans at the National Press Club. He presented a huge check to bankers in New York, written for $813,487,500.

Source: http://www.allpar.com/corporate/bios/iacocca.html

2) 5 Technologies that Make Internal Combustion Engines Better

Michael Graham Richard (@Michael_GR)
Transportation / Cars
August 7, 2008

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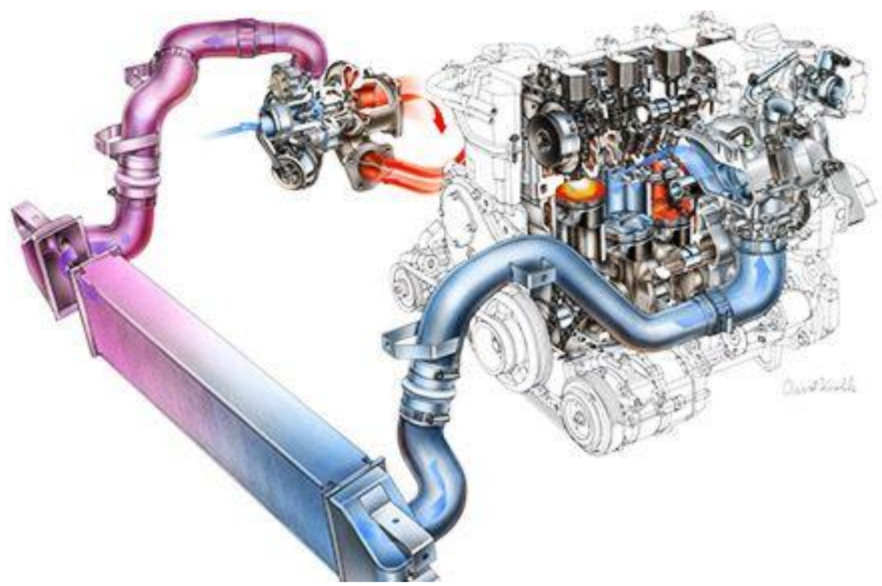


5 Fuel-Saving Technologies

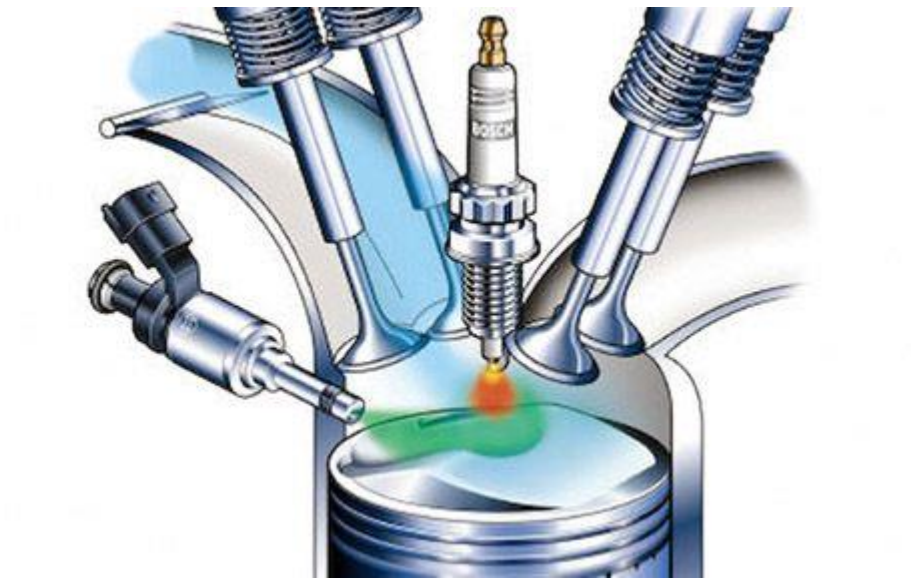
In the long run, the internal combustion engine (ICE) is on the way out and electric motors are on the way in, but ICEs have been around for so long that we should be careful about announcing their demise. They're going to stick around a while longer, and so it's very important to make them as efficient and clean as possible.

Car and Driver looks at **5 fuel-saving technologies** that are keeping the ICE relevant (if far from ideal). As they say, they still work on basically the same principle as they ever did, but old 4-cylinder engines produced about 20 horsepower while modern ones can generate up to 250 hp *while* being cleaner and burning less gas. Read on for more details on the 5 fuel-saving technologies: **Clean diesel**, **direct injection**, **cylinder deactivation**, **turbochargers**, and **variable valve timing and lift**.

Clean Diesel

Various advances such as the availability of ultra low sulfur diesel fuel, better catalysts and particulate matter traps, better control over combustion are making diesel engines cleaner, so you can expect a new wave of diesel passenger vehicles to come to the US in the next few years.

Diesel engines are certainly far from perfect, but they have inherently better thermal efficiency than gasoline engines, and they are usually more durable (if also more expensive and heavier). Another benefit is that they can run on **biodiesel**, which if you can find fuel made from waste cooking oil or (in the next few years) from **algae** can be very green.



Direct Injection

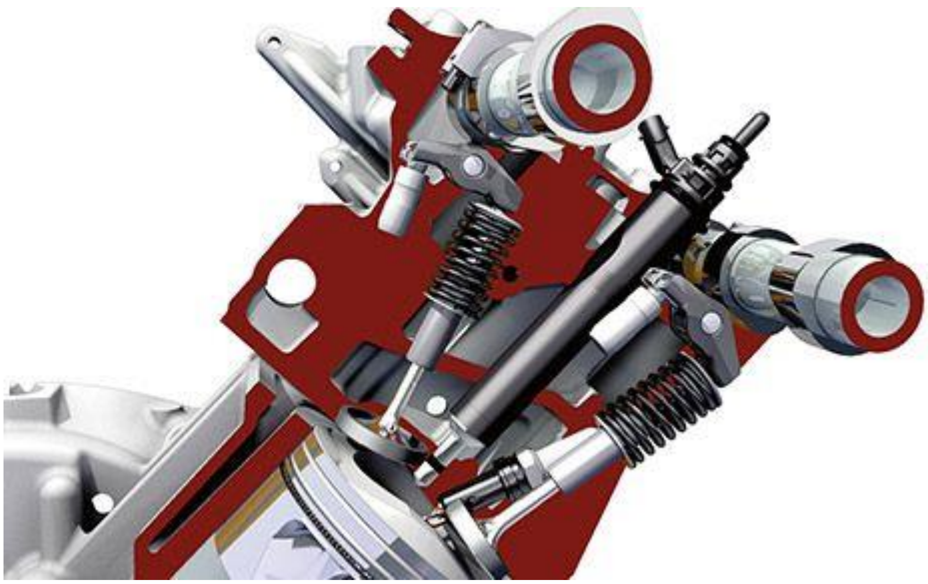
Before direct injection, the fuel was mixed with air in the car's intake manifold. Now, with direct injection, the fuel is mixed with air inside the cylinder, allowing for better control over the amount of fuel used, and variations depending on demand (acceleration vs. cruising). This makes the engine more fuel efficient.

Cylinder Deactivation

The name says it all. ICEs with this feature can simply deactivate some cylinders when less power is required, temporarily reducing the total volume of the engine cylinders and so burning less fuel. This feature is found on V6 and V8 engines.

Turbochargers

Turbochargers increase the pressure inside cylinders, cramming more air and allowing combustion to generate more power. This *doesn't* make the engine more economical in itself, but since a smaller displacement engine can generate more peak power, you can more easily downsize and save there.



Variable Valve Timing and Lift

Valves open and close to allow air and fuel to enter cylinders and for the products of combustion to exit. Different valve timings produce different results (more power, better fuel economy). Traditionally, you couldn't vary that timing, so the choice had to be made once when the engine was designed. But many modern engines can vary valve timing, allowing for example the default low RPM range of the engine to have more economical timing, and the higher RPM range to go for max power. This allows a smaller displacement engine to produce more peak power, so it allows for downsizing and fuel savings.

One Big Problem with All of This

The problem is that most of the gains from these technological breakthroughs have been used to increase power instead of reducing fuel consumption. At best, **fuel economy stayed the same while power increased**.

Now that environmental awareness is increasing, that global warming is on everybody's mind and that oil is very expensive, we can hope that carmakers will end the horsepower arms race and finally use these technologies to truly make more efficient cars.

A Second Life for the Internal Combustion Engine

All the technologies listed above (and more, like **Homogeneous Charge Compression Ignition**) could be useful for longer than we think. If series plug-in hybrids like the **GM Volt** become popular and **battery-only electric cars** (or **hypercapacitors**) take a while to mature fully and come down in price, many cars could still have an ICE as a range-extending generator that only kicks in when the batteries are low. The more efficient and clean these are, the better.

Hypermiling & Fuel Efficiency

Number of the Day: 38 MPG

Hypermiling Causes Road Rage? Hypermiling a Fad?

Honda Insight Hybrid Wins Hypermiling Competition with 124 Miles per Gallon

Hypermiling Couple Gets Two Entries in Guiness World Records Book

Hypermiling Becoming More Popular as Gas Prices Rise

More on these 5 Fuel-Saving Technologies

Car and Driver Magazine

Source: http://www.treehugger.com/cars/5-technologies-that-make-internal-combustion-engines-better.html

Improving Aerodynamics to Boost Fuel Economy

(Published Aug 22, 2005)

Automakers have been interested in aerodynamics at least since the introduction of the Chrysler Airflow in 1934. But the need to improve fuel economy in recent years has pushed aerodynamics toward the top of automakers' priority lists.

It turns out we — the car-buying public — have helped cause this emphasis on aerodynamics. You see, the easiest way to improve a vehicle's fuel economy is to make it smaller and lighter and give it a smaller engine. But we want 400-hp sports cars and seven-passenger SUVs and 5,000-pound-capacity tow vehicles — and we want good gas mileage, too.

Lucky for us automakers have found a way to do that: by making their vehicles slip more smoothly through the air.

"The main driver for lower aerodynamic drag is fuel economy," says Max Schenkel, General Motors technical fellow, aerodynamics. "As long as federal standards for fuel economy increase and fuel costs go up, aerodynamic drag will have to be improved."

Automakers focus on aerodynamics for financial reasons, too. "Aero benefits can almost be cost-free to some extent — just how you bend the metal and how you execute gaps and joints, and…a lot of that is design," says Rick Aneiros, Chrysler Group's vice president of Jeep and truck design. "If you're trying to reduce weight by adding expensive exotic materials, that's not easy to do. And improving engine efficiency, that's not easy to do. So the leading strategy is to improve aerodynamics whenever possible. That's why we built our own full-size wind tunnel here."

In fact, today's wisdom says you can't start measuring a vehicle's aerodynamics too early in the design process. From the earliest conceptual stages on through the working-prototype stage, automakers rely on computer software and wind tunnels to ensure vehicles meet their aerodynamic targets.

How Drag Affects Mileage When you consider aerodynamics from a fuel economy standpoint, you're primarily looking at coefficient of drag (known in the business as "Cd"). Essentially, this is how easily a vehicle moves through the air, though drag isn't the only factor that is considered. "There's more to aerodynamics than just drag," says Doug Frasher, strategic design chief at the Volvo Monitoring & Concept Center. "There's downforce and lift. And there is yawing moment, which is basically when you're in a crosswind, how much does the vehicle get steered by the wind that is pushing on it? And then there's noise. So we try to look for all of those factors.

"For a full-size truck, a change in drag coefficient of 0.01 is approximately equal to an improvement in fuel economy of 0.1 mpg on the combined city/highway driving cycle," says GM's Schenkel. "The same drag coefficient reduction can improve a car's fuel economy by approximately 0.2 mpg."

Volvo's Frasher says the force acting against a car by the air it moves is a function of:

Cd x Frontal Area x Density of Air x Speed SquaredSpeed clearly is an important part of the equation. At stop-and-go speeds, drag isn't a big deal, but the faster you go, the more it matters. At 70 mph, you've got four times the force working against your vehicle that you have at 35 mph.

To put Cd changes in perspective, Frasher put some numbers to a hypothetical sedan. Our imaginary car has a curb weight of 3,527 pounds, a Cd of 0.30, a frontal area of 23.7 square feet and 9 pounds of rolling resistance for every 1,000 pounds of weight.

According to Frasher, "If we put a gas-burning engine in this car, expect reasonable performance and drive it on a combined driving cycle, we can expect to get 23.8 mpg…. Add 10 percent to the drag coefficient, we'll now get 23.3 mpg…. Take 10 percent from the drag coefficient, we'll now get 24.3 mpg."

Comparing Vehicles' Drag Numbers It's easy to get a feel for drag numbers by comparing Volvo sedans. According to Frasher, during Volvo's boxy-but-safe era, a Cd of 0.36 for the 960 model was typical for a sedan. Today's Volvos have come a long way, with the much sleeker S80 coming in at just 0.28.

"Not too long ago, anything below 0.3 was considered a sports carlike silhouette," says Bill Kwong, Toyota's product communications administrator. Now, Toyota has several vehicles in the sub-0.3 range, including the Avalon and Camry at 0.28 and the Solara at 0.29.

Vehicles for which fuel economy is a primary goal receive even more focus on aerodynamics. For instance, Toyota's Prius is rated at 55 mpg (combined), and it has an outstanding drag coefficient of just 0.26.

Cars typically have a much lower Cd than pickups and SUVs, which sit higher, are bigger and have greater cooling needs. Cooling is a big deal, aerodynamically speaking, since it requires airflow into the vehicle through the radiator, which increases drag.

Steve Wegryn, manager of Ford Motor Co.'s aerodynamics department, says, "For trucks, we're anywhere in the range of 0.40 to 0.43, 0.44…. For cars, on the order of 0.30 to 0.34. And SUVs are somewhere in between 0.36…to…0.41."

How Automakers Improve Aerodynamics While some shapes are inherently more aerodynamic than others, aerodynamicists and designers subtly shape every vehicle to reduce drag. "We look at all areas of the car that come in contact with the air. Upper surface shape, under floor, wheels and even cooling and engine bay," says Ian Anderton, aerodynamicist at the Jaguar Design Studio in Gaydon, England. Automakers fine-tune the way the air attaches to the vehicle's surface, and the way it leaves the rear end.

To improve Cd, designers may make the following changes:

- Round the edges of the front end
- Tune the grille and fascia openings
- Tune the wheel openings
- Place spats (small spoilers) in front of the tires to reduce turbulence
- Tune the size and shape of the outside mirrors and their attachment arms
- Reshape the water channel on the A-pillars
- Adjust the front fascia and air dam to reduce drag under the vehicle
- Add side skirts
- Tune the deck height, length and edge radius
- Install a rear spoiler
- Adjust the angle of the rear window
- Tuck up the exhaust system
- Use a diffuser to tune air coming off the underside
- Install "belly pans," underbody panels that cover components and smooth airflow

Ford's Wegryn also predicts increased use of active aerodynamic devices in the future, such as:

- Active air dams that drop lower at higher speeds (when driveways and speed bumps are not an issue)
- Active rear spoilers that pop up to reduce lift at higher speeds, as on the Porsche 911 Carrera
- Active ride height that lowers the vehicle at speed, which Ford employed on the Lincoln Mark VIII and which appears on Mercedes-Benz vehicles with Airmatic suspensions.

According to Mercedes, "Lowering the ride height at speed results in a 3-percent improvement in drag."

How to Improve the Aerodynamics of Your Car Automakers spend a lot of time optimizing vehicles' aerodynamics. But is there anything we can do to improve — or at least not degrade — the aerodynamics of our own vehicles?

It turns out the biggest gains are to be found on pickups — not by dropping the tailgate (a common misconception), but by installing a tonneau cover. "A tonneau cover improves the aerodynamics dramatically — on all pickup trucks," according to Ford's Wegryn. "In general, a tonneau cover can provide a drag reduction of 2 to 7 percent, depending on cab style, box length and overall vehicle Cd. Average fuel economy improvement ranges from 0.1 to 0.3 mpg." From an aero standpoint, it doesn't make a difference if you choose a soft or hard cover.

You'll also improve aerodynamics by:

- Reducing the use of roof racks
- Rolling up your windows and turning on the air conditioner at higher speeds, typically above 35 mph
- Replacing a broken or missing front air dam
- Lowering your vehicle
- Running narrower tires
- Choosing smoother wheels (ideally, flush discs like those on vehicles trying to set land speed records)

You can reduce your vehicle's aerodynamics by:

- Lifting it — "an inch of increased ride height degrades the coefficient of drag by about 10 drag counts [.01]," says Wegryn.
- Adding wider tires
- Choosing more "open" wheel designs (although, for many owners, this advantage will be offset by the fact that "open" wheels promote better brake cooling)
- Installing a bug shield
- Adding a rear spoiler, in some cases

As a rule, an increase in noise is a sign of increased drag that is reducing your aerodynamics.

Slippery Styling Several automakers recently unveiled concept cars that are dramatically more aerodynamic than today's production vehicles — concepts like Volvo's 3CC (with a Cd 30-percent better than the S40) and Mercedes' bionic car (at 0.19 Cd). Could these companies be trying to gauge buyers' reactions to strikingly different designs — or even prepare us for more radical-looking vehicles to come?

Aerodynamics — and aerodynamicists — certainly are influencing designers more than ever before. Hitoshi Takagi, an engineer in the Nissan Aerodynamics Performance Engineering Department, says, "We seek to proactively propose many aerodynamic models to our designers. It is our goal to stimulate new ideas for design, rather than to wait for their proposed design and then seek an aerodynamic solution."

Still, most automakers predict a slow and steady evolution, rather than a huge leap forward. A Mercedes spokesperson says the company's "engineers and designers are always striving for improvement, but the constraints placed on the designers by consumer tastes, practicality, legislation and production technologies will prevent giant strides."

Or, as Chrysler Group's Aneiros says simply, "We're not about to make the world's most aero vehicle that no one would buy."

Concern about the environment

- Negative effect of growing usage of fossil fuels
- Awareness of the negative effects of such usage leading in some area to decree stricter carbon emission rules (e.g. California)

Fuel emission legislation (case study)

The US Environmental Protection Administration (EPA) regulates the emissions from mobile sources by setting standards for the specific pollutants being emitted. EPA established progressively more stringent emission standards for carbon monoxide, hydrocarbons, nitrogen oxides, and particulate matter, starting in the mid-1970s for on-road vehicles and in the early 1990s for nonroad engines and equipment. Emissions standards set limits on the amount of pollution a vehicle or engine can emit.

EPA realizes that to reduce mobile source pollution we must address not only vehicles, engines, and equipment, but also the fuels they use. So we have set sulfur standards for gasoline, on-road diesel fuel, and nonroad diesel fuel.

The road to clean air also depends on extensive collaboration between EPA and vehicle, engine, and fuel manufacturers; state and local governments; transportation planners; and individual citizens. This integrated approach to mobile source emission control is responsible for greatly reducing mobile source air pollution during the last 30 years. Technological advances in vehicle and engine design, together with cleaner, higher-quality fuels, have reduced emissions so much that EPA expects the progress to continue, even as people drive more miles and use more power equipment every year.

Source: http://www.epa.gov/otaq/standards/basicinfo.htm

The Future of the Internal-Combustion Engine

Despite the green hype, internal-combustion engines will keep powering vehicles for the foreseeable future. More: http://www.caranddriver.com/features/the-future-of-the-internal-combustion-engine

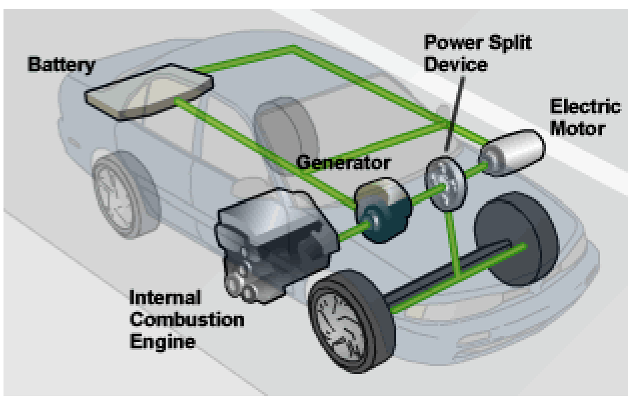
On the other hand, significant contribution was made by Japanese automobile companies

Honda and Toyota came forth with the so-called hybrid technology making less use of fossil fuel alternating with the use of electrical technology

The big traditional companies 'skeptical' of this approach

The 'Insight' and the 'Prius': pioneer hybrids

How Hybrids Work



Flash Animation: How Hybrids Work
(Requires Flash 6.0 or higher)

HTML Version: How Hybrids Work

Hybrid-electric vehicles (HEVs) combine the benefits of gasoline engines and electric motors and can be configured to obtain different objectives, such as improved fuel economy, increased power, or additional auxiliary power for electronic devices and power tools.

Some of the advanced technologies typically used by hybrids include

- **Regenerative Braking.** The electric motor applies resistance to the drive train causing the wheels to slow down. In return, the energy from the wheels turns the motor, which functions as a generator, converting energy normally wasted during coasting and braking into electricity, which is stored in a battery until needed by the electric motor.

- **Electric Motor Drive/Assist.** The electric motor provides additional power to assist the engine in accelerating, passing, or hill climbing. This allows a smaller, more efficient engine to be used. In some vehicles, the motor alone provides power for low-speed driving conditions where internal combustion engines are least efficient.
- **Automatic Start/Shutoff.** Automatically shuts off the engine when the vehicle comes to a stop and restarts it when the accelerator is pressed. This prevents wasted energy from idling.

For fuel economy information on these vehicles, please visit the Compare Side-by-Side section.

Source: https://www.fueleconomy.gov/feg/hybridtech.shtml

Hybrid technology

Cost is a factor

However with rising fuel cost, hybrid became cost-efficient; economy of scale

Honda and Toyota kept on refining the hybrid technology

The Three Main Types Of Hybrids Explained
by **Jeff Cobb** **May 8, 2014:** http://www.hybridcars.com/the-three-main-types-of-hybrids-explained/

Increased comfort at a cost

GM and Ford went for SUVs: use was all right while fuel was on the cheap, but with rising cost of fuel these companies faced difficulties; GM had to be bailed out by the US Government while it faced bankruptcy; Ford on the other hand decided to go hybrid and diversify producing its own models which became very popular (no need for bail out)

With growing concern about CO2 emission

Other companies also adopted the use of hybrid technology proven to be reliable and cost friendly

Diversification

Significant efforts were made at diversification with the use of natural gas and clean diesel impacting not just cars but also buses and trucks

Bus running on gas

Public transportation across the country has been using CNG (compressed natural gas) for decades. Currently, about 12-15% of public transit buses in the U.S. run on natural gas (either CNG or LNG – liquefied natural gas). That number is growing, with nearly one in five buses on order today slated to run on natural gas. States with the highest consumption of natural gas for transportation are California, New York, Texas, Georgia, Massachusetts and Washington, D.C.

(Source: http://www.cngnow.com/vehicles/Pages/information.aspx

More on CNG

CNG is a readily available alternative to gasoline that's made by compressing natural gas to less than 1% of its volume at standard atmospheric pressure. Consisting mostly of methane, CNG is odorless, colorless and tasteless. It's drawn from domestically drilled natural gas wells or in conjunction with crude oil production.

Natural gas powers more than 12 million vehicles on the road today. Unfortunately, only about 250,000 of these are being used in the U.S., according to GE. The average growth rate in the U.S. shows a 3.7% increase per year since 2000, as contrasted with a booming global growth rate of 30.6% per year.

Expanding the numbers of CNG fueling stations would allow for the increase of CNG vehicles on U.S. roads. There are 12,000 around the world, yet the U.S. claims about 500 public stations. New technologies and greater demand mean that the number of new stations is climbing rapidly.

Source: (Source: http://www.cngnow.com/vehicles/Pages/information.aspx

Research

Pure: many universities expanded research on transportation systems
Applied: specialized institutions emerged
R&D: many companies found it worthwhile to expand their Research and Development effort at times with government subsidy or tax breaks.
Read more: International Journal of Automotive Technology

University of Michigan Transportation Research Institute

The University of Michigan Transportation Research Institute is dedicated to achieving safe and sustainable transportation for a global society. With a multimillion-dollar research program, broad faculty expertise, and multiple collaborators, UMTRI is committed to interdisciplinary research that will ultimately increase driving safety and further transportation systems knowledge.

www.umtri.umich.edu

MIT: The future of vehicular transportation propulsion, fuels and emissions: research and professional education

Our transportation systems face many challenging issues as we look ahead. Critical among these are the fuels and energy sources that will drive our vehicles, and the air pollutant and greenhouse gas emissions that result as we attempt to reduce our petroleum consumption. There are several promising options: improving mainstream internal combustion engines and the gasoline and diesel fuels they utilize; propulsion system electrification using hybrid internal combustion engine, battery, and electric motor, combinations in charge-sustaining and plug-in versions that draw electricity from the power grid; pure battery/motor electric drive systems; natural gas fueled vehicles; and fuel-cell powered vehicles operating on hydrogen. For all of these, vehicle weight and tire and aerodynamic friction can be significantly reduced. This course will examine the performance and emissions characteristics of these options, addressing the engineering basics of how these various propulsion systems with their associated fuels perform, and their future development potential. It will also explore the impacts that deploying these propulsion technologies in vehicles, in use, would have on future petroleum consumption, other energy streams, and emissions. It will also discuss the factors that govern the market attractiveness and constraints that affect the deployment of these more efficient propulsion system technologies, and the fuels and energy sources they would need.

http://web.mit.edu/professional/short-programs/courses/future_vehicular_transportation.html

International Institute for Strategic Research and Training

> Project on new aerodynamic device for cars, trucks and buses: a new generation of eco-friendly transportation systems (currently in the formulation process)

www.strategicresearch.info/default.aspx

ASUA (Japan): Eco drive brand)

EcoDrive is a mindset. EcoDrive is a skill set. EcoDrive is a motorist retraining method that helps drivers from all countries and cultures improve habits and behaviors to make the automotive experience more pleasurable while saving gasoline, minimizing pollutants, and reducing the number of vehicular accidents. EcoDrive is enlightened global driving, 21st century style.

In conjunction with the Japanese government, Asua has developed the theory and practice of the EcoDrive Propulsion Project:

The theory and practice of EcoDrive got its start in Japan. Asua company founder Hiroshi Maji theorized that stress, an intrinsic part of the urban driving experience, encouraged aggressive driving which increased emissions and traffic accidents. In 2005, Mr. Maji worked to prove this theory with the help of Nobuyo Kasuga, Professor at Shibauru Institute of Technology, and Professors Ishi Taroh and Yashuhiro Taisel from Waseda University. The research team was able to prove that carbon dioxide and other air pollutants that originated from car emissions were substantially reduced when drivers motored with care (i.e. they minimized idling and drove smoothly without jamming the gas or the brakes). They also proved that careful driving reduced gasoline consumption.

But the following data was particularly striking: if a driver saved 8.7% of the fuel normally used, there would be 49% less traffic accidents.

Asua continues to research and investigate the EcoDrive method

Emboldened by this research, Asua started trials with a device (patent # 3314870) that provided a driving evaluation method for assessing the fuel consumption rate on the basis of real time data acquired while driving. From collected data, the optimum driving methods can be understood and drivers can strive for an ideal driving experience that saves fuel costs and has the added benefit of avoiding automobile accidents.
EcoDrive is championed by the Society for Automotive Engineers of Japan and has been implemented by the City of Tokyo's delivery vehicle industries. At present, major car manufacturers are working with Asua to develop customized methods to improve the driving experience utilizing 'probe data', the data generated by vehicles about current position, motion, and time stamp.

EcoDrive training contests have been initiated in conjunction with The Ministry of the Environment of Japan, and substantial research on EcoDrive and its ability to reduce CO2 emissions has been undertaken with Japan's Ministry of Land, Infrastructure, Transport and Tourism.

In addition, Asua currently works with Japan's Ministry of Economy, Trade and Industry; The Local Authorities System Development Center; major manufacturing companies and major trade organizations to promote safer driving.

*www.**asua**.ne.jp/english/*

The Alliance of Automobile Manufacturers

Is the voice for a united auto industry, committed to developing and implementing constructive solutions to public policy challenges that promote sustainable mobility and benefit society in the areas of environment, energy and motor vehicle safety. The Alliance of Automobile Manufacturers, the leading advocacy group for the auto industry, represents 77% of all car and light truck sales in the United States, including the BMW Group, Fiat Chrysler Automobiles, Ford Motor Company, General Motors Company, Jaguar Land Rover, Mazda, Mercedes-Benz USA, Mitsubishi Motors, Porsche, Toyota, Volkswagen Group of America and Volvo Cars North America.

Source: www.autoalliance.org

Meanwhile, the manufacturers themselves have been active

GM Volt: "With its ingenious propulsion system, unlike traditional hybrid cars, Volt lets you drive on pure electricity for your everyday commute and seamlessly switches to gasoline for longer trips. In fact, owners who charge regularly are averaging more than 900 miles between fill-ups."

Nissan Leaf

"The Nissan LEAF® is 100% electric. That means no gas. None. So forget about the cost of a gallon, and say hello to freedom from the pump. Because the only time you'll be going to the gas station is whenever you need to put air in your tires."

The C-Max
"The C-MAX Hybrid and the C-MAX Energi Plug-In Hybrid offer two distinct choices that maximize style, power and efficiency. The main difference between the C-MAX Hybrid and the C-MAX Energi is the plug-in capability, the latter offering the option of plugging for a recharge. Both models feature a 2.0L hybrid I-4 power train combined with an electric motor, and can operate in electric mode up to 85 mph."

TESLA
"**Tesla Motors, Inc.** is an American automotive and energy storage company that designs, manufactures, and sells electric cars, electric vehicle powertrain components and battery products."
"Tesla first gained widespread attention following their production of the Tesla Roadster, the first fully electric sports car.[8] The company's second vehicle is the Model S, a fully electric luxury sedan, and its next two vehicles are the Models X and 3."
Source: Wikipedia

Technological breakthrough: Toyota does it again
Implementation of the fuel cell technological revolution:

http://www.toyota.com/mirai/

MDI
Cars that run on 'compressed air'

http://zeropollutionmotors.us/

The sky is the limit 1
Ford has stirred up the truck industry with the all new F-150 truck that replaces the steel body panels with lightweight aluminum to shed weight=more performance and better fuel efficiency=also the only light truck in the industry with an available CNG/propane powered V8 engine

Source: www.slashgear.com/tags/ford

The sky is the limit 2

The 2015 Green Transportation Summit and Expo (Portland, Ore) showcased a variety of alternative fuel vehicles (AFVs)
Propane-fueled Blue Bird School Bus powered by Ford 6.8 liter engine using ROUGH CleanTech's autogas fuel system
CNG-powered F-550 Ford truck
CNG-powered Freightliner Cascadia featuring dual tanks
American Power Group: Freightliner Columbia glider with a dual-fuel diesel/liquefied natural gas system

Conclusions

Human creativity is endless!
Looks like the environmentalists may have less to worry about the future
About the damage already done: here again there are solutions being worked on: Sucking CO2 from the sky with artificial trees
(Source: http://www.bbc.com/future/story/20121004-fake-trees-to-clean-the-skies)

Appendix 1

Scientists are looking at ways to lower the global temperature by removing greenhouse gases from the air. Could super-absorbent fake leaves be the answer?

- By Gaia Vince (4 October 2012)

It may be a colourless, odourless and completely natural gas, but carbon dioxide is beginning to cause us a lot of problems. It only makes up a tiny fraction of the atmosphere (0.04% of all the gas by volume – or 395 parts per million) but it has a huge effect on the Earth's temperature. That's because unlike nitrogen or oxygen, carbon dioxide molecules absorb the Sun's heat rays even though they let light rays pass through, like a greenhouse.

Scientists are looking at ways to modulate the global temperature by removing some of this greenhouse gas from the air. If it works, it would be one of the few ways of geoengineering the planet with multiple benefits, beyond simply cooling the atmosphere.

Every time we breathe out, we emit carbon dioxide just like all other metabolic life forms. Meanwhile, photosynthetic organisms like plants and algae take in carbon dioxide and emit oxygen. This balance has kept the planet at a comfortably warm average temperature of 14C (57F), compared with a chilly -18C (0F) if there were no carbon dioxide in the atmosphere.

In the Anthropocene (the Age of Man), we have shifted this balance by releasing more carbon dioxide than plants can absorb. Since the industrial revolution, humans have been burning increasing amounts of fossil fuels, releasing stored carbon from millions of years ago. Eventually the atmosphere will reach a new balance at a hotter temperature as a result of the additional carbon dioxide, but getting there is going to be difficult.

The carbon dioxide we are releasing is changing the climate, the wind and precipitation patterns, acidifying the oceans, warming the habitats for plants and animals, melting glaciers and ice sheets, increasing the frequency of wildfires and raising sea levels. And we are doing this at such a rapid pace that animals and plants may not have time to evolve to the new conditions. Humans won't have to rely on evolution, but we will have to spend hundreds of billions of dollars on adapting or moving our cities and other infrastructure, and finding ways to grow our food crops under these unfamiliar conditions.

Even if we stopped burning fossil fuels today, there is enough carbon dioxide in the atmosphere - and it is such a persistent, lasting gas – that temperatures will continue to rise for a few hundred years. We won't stop emitting carbon dioxide today, of course, and it is now very likely that within the lifetime of people born today we will increase the temperature of the planet by at least 3C more than the average temperature before the industrial revolution.

Seek and capture

Hence, the idea of finding ways of removing carbon dioxide from the atmosphere. One way to do this is to grow plants that absorb a lot of carbon dioxide and store it. But although we can certainly improve tree-planting, we also need land to grow food for an increasing global population, so there's a limit to how much forestry we can fit on the planet.

In recent years there have been attempts to remove the carbon dioxide from its source in power plants. Scrubber devices have been fitted to the chimneys in different pilot projects around the world so that the greenhouse gas produced during fossil fuel burning can be removed from the exhaust emissions. The carbon dioxide can then be cooled and pumped for storage in deep underground rock chambers, for example, replacing the fluid in saline aquifers. Another storage option is to use the collected gas to replace crude oil deposits, helping drilling companies to pump out oil from hard to reach places, in a process known as advanced oil recovery.

Removing this pollution from power plants – called carbon capture and storage – is a useful way of preventing additional carbon dioxide from entering the atmosphere as we continue to burn fossil fuels. But what about the gas that is already out there?

The problem with removing carbon dioxide from the atmosphere is that it's present at such a low concentration. In a power plant chimney, for instance, carbon dioxide is present at concentrations of 4-12% within a relatively small amount of exhaust air. Removing the gas takes a lot of energy, so it is expensive, but it's feasible. To extract the 0.04% of carbon dioxide in the atmosphere would require enormous volumes of air to be processed. As a result, most scientists have baulked at the idea.

Fake plastic trees

Klaus Lackner, director of the Lenfest Center for Sustainable Energy at Columbia University, has come up with a technique that he thinks could solve the problem. Lackner has designed an artificial tree that passively soaks up carbon dioxide from the air using "leaves" that are 1,000 times more efficient than true leaves that use photosynthesis.

"We don't need to expose the leaves to sunlight for photosynthesis like a real tree does," Lackner explains. "So our leaves can be much more closely spaced and overlapped – even configured in a honeycomb formation to make them more efficient."

The leaves look like sheets of papery plastic and are coated in a resin that contains sodium carbonate, which pulls carbon dioxide out of the air and stores it as a bicarbonate (baking soda) on the leaf. To remove the carbon dioxide, the leaves are rinsed in water vapour and can dry naturally in the wind, soaking up more carbon dioxide.

Lackner calculates that his tree can remove one tonne of carbon dioxide a day. Ten million of these trees could remove 3.6 billion tonnes of carbon dioxide a year – equivalent to about 10% of our global annual carbon dioxide emissions. "Our total emissions could be removed with 100 million trees," he says, "whereas we would need 1,000 times that in real trees to have the same effect."

If the trees were mass produced they would each initially cost around $20,000 (then falling as production takes over), just below the price of the average family car in the United States, he says, pointing out that 70 million cars are produced each year. And each would fit on a truck to be positioned at sites around the world. "The great thing about the atmosphere is it's a good mixer, so carbon dioxide produced in an American city can be removed in Oman," he says.

Social cost

The carbon dioxide from the process can be cooled and stored; however, many scientists are concerned that even if we did remove all our carbon dioxide, there isn't enough space to store it securely in saline aquifers or oil wells. But geologists are coming up with alternatives. For example, peridotite, which is a mixture of serpentine and olivine rock, is a great sucker of carbon dioxide, sealing the absorbed gas as stable magnesium carbonate mineral. In Oman alone, there is a mountain that contains some 30,000 cubic km of peridotite.

Another option could be the basalt rock cliffs, which contain holes – solidified gas bubbles from the basalt's formation from volcanic lava flows millions of years ago. Pumping carbon dioxide into these ancient bubbles causes it to react to form stable limestone – calcium carbonate.

These carbon dioxide absorption processes occur naturally, but on geological timescales. To speed up the reaction, scientists are experimenting with dissolving the gas in water first and then injecting it into the rocks under high pressures.

However, Lackner thinks the gas is too useful to petrify. His idea is to use the carbon dioxide to make liquid fuels for transport vehicles. Carbon dioxide can react with water to produce carbon monoxide and hydrogen – a combination known as syngas because it can be readily turned into hydrocarbon fuels such as methanol or diesel. The process requires an energy input, but this could be provided by renewable sources, such as wind energy, Lackner suggests.

We have the technology to suck carbon dioxide out of the air – and keep it out – but whether it is economically viable is a different question. Lackner says his trees would do the job for around $200 per tonne of removed carbon dioxide, dropping to $30 a tonne as the project is scaled up. At that price – which has been criticised as wildly optimistic (the American Physical Society's most optimistic calculations for direct air capture are $600 per tonne of carbon dioxide removed, although the UK's Met Office is more favourable) – it starts to make economic sense for oil companies who would pay in the region of $100 per tonne to use the gas in enhanced oil recovery.

Ultimately, we have to decide whether the cost of the technology is socially worth the price, and that social price is likely to fall as climate change brings its own mounting costs. Economically too, if the price of carbon rises, then this could lead to two effects. Investing in air capture will likely be seen as an equivalent to "avoided emissions". And then it will become a worthy investment.

(Source: http://www.bbc.com/future/story/20121004-fake-trees-to-clean-the-skies)