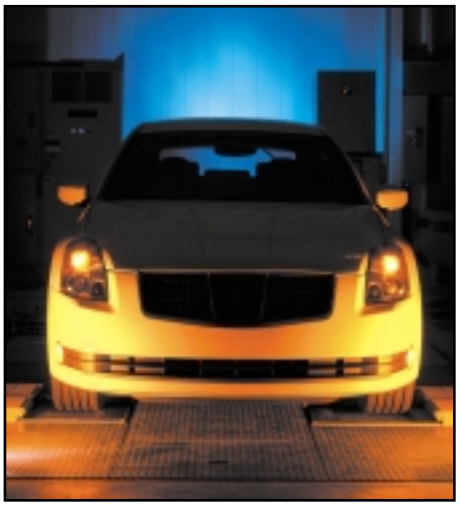
Sharp Turns in the Road Ahead

New fuels and vehicle designs could be in the future as oil supplies begin to dwindle



What about alternative fuels as the answer to both problems?

Some have proposed a so-called "hydrogen economy" as a solution to our problems. However, although hydrogen is the most abundant element on Earth, it is mostly trapped within molecules such as water and hydrocarbons. To extract hydrogen from chemical compounds such as these requires significant amounts of energy. At this time, it appears that nuclear power offers the only economically viable means to produce sufficient energy to make enough hydrogen for use in automobiles and other mobile transportation systems. Nuclear power would be used to raise the temperature and pressure of water so that its constituent hydrogen and oxygen atoms will become dissociated and can be collected separately. Other means of producing hydrogen would generate greenhouse gases in the process. Even if abundant nuclear power were used for hydrogen production, hydrogen remains a very difficult transportation fuel because compared to fuels such as gasoline, it occupies a large volume relative to the amount of energy it produces, even when it is cooled to its liquid form. This means that the fuel tank of a hydrogen-powered car would have to be quite large and quite heavy to deliver the same range that a tank of gasoline gives the average passenger car. However, fundamental work on storing hydrogen within nanostructured materials, such as carbon nanotubes and metal organic frameworks, as well as other innovative materials, is progressing at SwRI; so far energy storage densities one-fifth that of gasoline have been realized in the laboratory for materials conceptualized only recently.

Can fuel consumption be reduced?

After having worked for the past 40 years to decrease exhaust emissions from vehicles, it is likely that automotive engineers now will have to redirect their efforts to improving fuel consumption. Experience tells us that there will be no unique solution — no "silver bullet" — to solve the problem all at once. More likely there will be multiple innovations and incremental technological steps that, when combined, will make a significant impact so that we can perhaps delay, or at least mitigate, the Big Rollover and smooth the transition away from a carbon-based energy economy. One obvious improvement would be to simply reduce the number of miles traveled. The traditional assumption used to be that economic growth and energy consumption go hand-in-hand. However, with the great improvements in worldwide communications today, it may not be necessary to take as many trips as we did before, because we can communicate so much better electronically. Telecommuting already is a reality; it is an important part of many businesses.

Another rather simple step is to reduce the mass of current vehicles, either by decreasing their size or by making them from lighter-weight materials. Technologies have been available for some time to reduce vehicle mass, but so far we have seen that consumers are not quite willing to pay the accompanying higher price.

What about other alternative fuels besides hydrogen?

There are indeed other alternative fuels, and also alternative engine designs that can burn those fuels as well as traditional gasoline and diesel. The High Efficiency Dilute Gasoline Engine (HEDGE) consortium is using innovative technologies to combine the diesel engine's favorable fuel consumption with the gasoline engine's low emissions characteristics, and to do it at significantly lower cost than a diesel engine. SwRI is joined in this consortium by 12 major industry companies including PSA, Renault, Ford, DaimlerChrysler, Hino, Nissan, Cummins, John Deere, Corning, Valeo, Volvo and Volkswagen. Current results appear very encouraging.

We often think of gasoline and diesel fuel as the natural products of the oil refining process, but this is not necessarily the case. At one time, automotive engineers developed new engines and then specified what fuel they should use to provide peak efficiency. Both diesel and gasoline fuel are made from rather narrow portions of the available crude oil. It could be possible that another combustion system would require a different fuel that could come from a wider "slice" of the available crude oil, thereby obtaining more fuel from the same barrel of oil and thus dramatically improving overall fuel efficiency. Gasoline requires a great deal of refining to achieve the high octane ratings required by today's engines. This high-octane gasoline is needed to avoid pre-ignition, otherwise known as engine knock or detonation. SwRI has been working for 20 years to develop an engine that uses auto-ignition, which actually is a form of detonation, rather than the traditional spark plug to initiate combustion. This is known as Homogeneous Charge Compression Ignition (HCCI), and it is now the subject of intense activity in SwRI's long-running Clean Diesel IV consortium. It provides very low emissions without expensive aftertreatment devices, yet it has the efficiency of a diesel engine. The ideal fuel for an HCCI engine is in fact a low-octane gasoline, which is easier to obtain in a refinery process than the current fuel mix. We are therefore a lot closer to achieving a new kind of fuel that can possibly be extracted more efficiently, and in greater quantity from a barrel of crude oil than high-octane gasoline.

How do hybrids fit into the picture?

The fuel efficiency benefits of hybrid vehicles are well known. The key element of a hybrid vehicle is its energy storage system, which in most cases is a battery. A hybrid vehicle can provide better fuel economy by capturing excess power from the engine, and sometimes excess kinetic energy from braking, and converting that power to electrical energy that is stored in the battery. This stored energy is released as needed, such as during vehicle acceleration. A vehicle that does a lot of stopping and starting, then, would benefit the most from a hybrid configuration. This is why there is a lot of interest in hybrid applications for vehicles such as garbage trucks, city buses, and mail and package delivery vehicles.

However, most batteries and energy storage devices have limitations in the amount of energy they can store and how quickly they can absorb and release it. Because of these limitations we can only realize up to about a 40-percent improvement in fuel economy from a hybrid vehicle. An important area of research would be the improvement of batteries or other energy storage systems so that hybrid vehicles can provide even greater fuel efficiency. With sufficient capacity, such a system could store enough energy to operate the vehicle for a full working day. A hybrid vehicle with such an efficient energy storage system could be charged overnight, when electrical power is cheap, and it would only need its internal combustion engine to provide occasional supplementary power. This concept is known as a "plug-in" hybrid; but again, its future depends on the development of more efficient batteries. I believe that a high priority should be placed on research in such energy-storage devices.

How do you predict industry will respond to these future challenges?

Industry operates within the framework of government regulations and market forces. As the cost of energy rises, industry will respond by making more fuel-efficient vehicles available. However some innovations that require significant changes in direction are beyond the capability of industry to undertake without government initiatives. For example, if a new and better fuel is to be made available, vehicles must be designed and marketed to use it. However no one would buy these vehicles unless the fuel for them was readily available at the gas pump. This kind of "chicken or egg" situation must be addressed by an involved government**.** Policies that pursue oil production as a means to reduce prices do not address the real issue, which is how to make existing reserves go farther for future generations. Furthermore, countries that foster the development of fuel-efficient technologies will create more competitive industries and therefore achieve greater national prosperity as other countries seek those technologies and products.

There has been a lot of discussion and work on alternative energy sources such as wind power and biodiesel. These are important and will make a difference, but by themselves they are insufficient to supply the world's total energy needs. Without petroleum the only currently viable energy source is nuclear power. With the appropriate safeguards, nuclear power can be reliable and safe, but its expansion would require overcoming a long-standing fear of nuclear power.

When we are placed under the challenge of necessity, we can become extremely resourceful and find solutions to problems that would otherwise appear insurmountable. To muster the extreme effort that would breed this kind of creativity, we must first acknowledge the situation that faces us. We must be concerned not only with the price of gas over the next few months, but also with the economic and energy situations over the next few decades. We must collectively come to terms with our situation in order to achieve a solution.

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