

Alternative Fuels Roundup

Who's not in favor of using less oil? From reducing dependence on the Middle East to the oil spill in the Gulf of Mexico to the price at the pump, there are many good reasons to want to make each barrel of oil go further, or to get away from petroleum altogether. Toyota and other automakers have been doing a lot of research into alternative ways of powering vehicles. Some of the vehicles with these new technologies are now getting close to market, so shoppers will likely be asking questions about the different technologies.

This Hot Sheet technology brief looks at some of the alternative designs and fuels being considered, along with their good points and bad points. This information will allow Associates to answer shoppers' questions accurately and professionally.

Alternatives In Use Today

■ Ethanol

Ethanol is an alcohol derived from the sugars in certain grains (usually corn). E85 is a blend of 85% ethanol and 15% gasoline. E85 can be used only in vehicles that have been designed to accommodate it.



What's good about ethanol?

- Ethanol can be derived from home-grown plants
- Plants are a renewable resource
- Ethanol produces fewer of some types of tailpipe emissions compared to gasoline

What are some issues with ethanol?

- **Total lifecycle emissions can be higher than those for gasoline**
Lifecycle emissions for ethanol include not only tailpipe emissions but also the emissions caused by growing, harvesting and fermenting the corn, then transporting the finished fuel to local pumps.

Lifecycle emissions for gasoline include not only the tailpipe emissions but also the emissions caused by drilling, transporting and refining the crude oil, then transporting the finished fuel to local pumps.

- **Ethanol could increase food prices**
Corn used for ethanol is corn not used for food. And there's only so much acreage that can be used for growing corn. Competition for the available corn could increase the price. Meanwhile, land used for other crops could be diverted to growing corn, which could increase the price of those other crops because there would be less supply.
- **Ethanol infrastructure is not in place**
Ethanol fuel is not compatible with the pipelines that distribute much of the nation's gasoline. Because of this, ethanol must be trucked to most parts of the country, and that's an expensive way to move fuel. Widespread use of ethanol would require the rebuilding of much of the fuel-distribution network.

■ Diesel/Biodiesel

Diesel is refined from crude oil, as is gasoline. Biodiesel is refined from vegetable oils and animal fats, sometimes including used fry oil from restaurants. Biodiesel is usually blended with petroleum diesel.



What's good about diesel/biodiesel?

- Biodiesel is renewable and home-grown
- Diesel has about 10-30% more energy potential per gallon than gasoline
- Diesel is widely available

What are some issues with diesel/biodiesel?

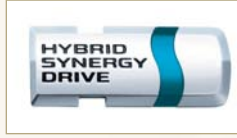
- **Some types of emissions are higher than those for gasoline**
Diesel produces fewer greenhouse gases per mile than gasoline, but it produces more soot and more smog-forming oxides of nitrogen (NOx).
- **Noise, vibration and harshness (NVH) issues**
Diesel engines, despite advancements, still produce significantly more noise than gasoline engines.
- **Jellied fuel is possible in cold climates**
In colder environments, diesel fuel may congeal, just as many fats do when placed in a refrigerator. This could be a significant issue for drivers in cold parts of the country.

Alternative Fuels

Alternatives In Use Today

■ Hybrids

Toyota's Hybrid Synergy Drive is probably the best-known example of a hybrid powertrain, but other automakers have their own designs. What they have in common is one or more electric motors supplementing a combustion engine.



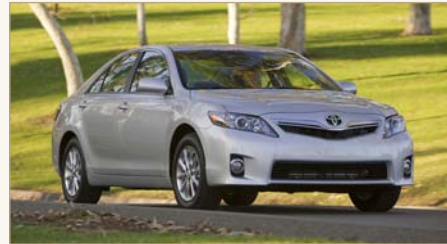
What's good about hybrids?

- Significantly better fuel economy, often about 20-30% improved
- Requires no new fueling infrastructure—just buy-and-drive
- The electric motor(s) can be paired with an alternative-fuel engine if one becomes more advantageous than a gasoline engine



What are some issues with hybrids?

- **Hybrids still burn fossil fuels**
Although fuel economy is improved, today's hybrids still burn gasoline, with the emissions and greenhouse gases that accompany it.
- **Purchase cost is higher**
The extra hardware and the battery pack combine to make a hybrid vehicle more expensive than a gas-only version. The added cost could take years to recoup, depending on annual mileage and the current price of gas.
- **Battery requires eventual disposal**
The battery pack lasts for years, but it still has to be disposed of at the end of its life. And the batteries contain materials that must be handled and disposed of carefully and safely.



Toyota's Take

Of the three in-use alternatives listed above, Toyota believes hybrids offer the greatest benefit for the lowest costs. Specifically, hybrids offer this combination of advantages not found in the other alternatives:

- Wide availability
- No new fueling infrastructure required
- Does not affect food availability or price
- Similar drivability to a gas-only powertrain

Alternatives Available in the Near Future

■ Cellulosic Ethanol

Ethanol is ethanol, but instead of being derived from corn, cellulosic ethanol is derived from the cellulose (starch) of plant matter that would normally be unused for food or go to waste.

What's good about cellulosic ethanol?

- It can be derived from home-grown plants
- No impacts on food prices because it doesn't use food grains
- By some measures, ethanol produces fewer tailpipe emissions than gasoline

What are some issues with cellulosic ethanol?

- **Inefficient distillation process**
Woody stalks and shoots are great candidates for conversion to ethanol. However, the cellulose is tightly bound with other plant materials and is difficult to extract. In other words, it requires a lot of energy to get to the energy being sought. Bottom line, cellulosic ethanol has a low net-energy gain.

■ Plug-in Hybrids

These are similar to regular hybrids, but feature a larger battery pack designed to allow for extra range when driving under electric power alone. Also, the vehicle can be plugged into an outlet to recharge the batteries.



What's good about plug-in hybrids?

- **All-EV operation within battery limits**
Plug-in hybrids allow for all-electric use within the range of the batteries. Should a driver have a short daily commute and access to electricity at night, it may be possible to do an entire week's driving without ever running the gas engine.
- **Onboard engine for extended range**
A plug-in hybrid offers the added security of an onboard gas engine for driving distances beyond the range of all-EV operation. This means, a driver never has to worry about being far from home with depleted batteries.
- **Dramatic cost savings**
Driving in EV mode can cost pennies per mile for electricity, dramatically less than driving the same distance using a gas engine.



• Vehicles must be reengineered

Ethanol requires changes to some fuel-system components and engine controls. Automakers have the ability to make these changes, but widespread adoption could require all buyers to pay for capabilities that very few drivers would use.

• Ethanol infrastructure is not in place

Ethanol fuel is not compatible with the pipelines that distribute much of the nation's gasoline. Thus, ethanol must be trucked to most parts of the country, and that's an expensive way to move fuel. Widespread use of ethanol would require the rebuilding of much of the fuel distribution network.

• Lower MPG

Setting aside the issues of creating and distributing cellulosic ethanol, the resulting fuel contains less potential energy per gallon. This means vehicles would achieve up to one-third fewer miles per gallon compared to gas.

What are some issues with plug-in hybrids?

• Bulky batteries

Plug-in hybrids have larger battery packs than standard hybrids. Depending on the particular design, the extra batteries can reduce the vehicle's payload and passenger space.

• Higher purchase cost

Plug-in hybrids can be expected to have a higher purchase price than either gas-only or standard hybrid vehicles. Some drivers may find the higher fuel economy isn't enough to recoup the difference in the sticker price.

• Electrical grid issues

Some areas of the country may not have spare capacity in the electrical grid to allow for daytime recharging of plug-in hybrids. This could be a particular concern during hot summers when air conditioners are running full-tilt.

Chevy Volt: What Is It?

Chevrolet is preparing to start sales of Volt. It's considered to be a plug-in hybrid by the SAE (formerly the Society of Automotive Engineers) because it has two or more on-board energy storage systems that provide propulsion (gas tank and battery). On the other hand, Chevrolet's marketing is positioning it as an "extended-range electric." Initially Volt was said to have its wheels powered only by an electric motor, with the gasoline engine used to recharge the battery, making it a series hybrid. But Chevrolet recently revealed that in some situations the gasoline engine provides a mechanical assist to the drive wheels—which make it a parallel hybrid (similar in broad concept to the Prius.)

The MSRP after tax credits will start at about \$33,500.

Alternatives Available in the Near Future

■ Electric Vehicles

This type of vehicle does without an engine, relying instead on one or more electric motors and a large battery pack.



What's good about an electric vehicle?

- **Very low cost per mile**
By some estimates, an electric vehicle can cost about 3¢ per mile for electricity, or less than \$3.50 to drive 100 miles. That's considerably less than the cost of gasoline per mile.
- **No tailpipe, no emissions**
An electric vehicle is emissions-free. And although electrical-generating plants produce emissions, those plants are subject to emissions-control requirements.
- **Chance for non-polluting electricity**
Recent legislation in many states mandates that a growing percentage of electricity be generated from non-polluting sources such as wind and solar. With that factored in, an electric vehicle can approach being an emissions-free vehicle.

Nissan Leaf

Nissan expects to begin delivering its Leaf electric vehicle in limited quantities to select markets around December 2010. Leaf is based on a heavily modified Versa chassis. In a layer below the front seats and in a rack below the rear seats are 660 pounds of batteries. Preliminary reports place the driving range anywhere from 60 to 140 miles depending on driving style. A full recharge from household current takes 24 hours, or eight hours from a dedicated 240V charging station. Leaf can also be "quick charged" from a special 500V charging station, but that won't be available for household installation, and Nissan warns that quick charging will reduce the lifespan of the batteries.

The MSRP after tax credits will start at about \$25,000.

What are some issues with electric vehicles?

- **Bulky batteries**
Batteries have what scientists call "low energy density." That means it takes a lot of battery mass to store enough electricity to make a practical car. It's a circular proposition: The batteries weigh a lot, which means the electric motor has to be extra powerful so it can move all that weight, which requires more energy, which requires even more batteries. And, all that battery mass can also reduce passenger room and payload.
- **Long recharge time**
Trickle-charge a battery and it may accept a thousand charge cycles or more. A faster charge rate will reduce the number of charge cycles the battery will accept. This means a "quick charge" while on the road will decrease the useful life of the battery. So, electric vehicles are best-suited to short drives before returning home for an overnight trickle charge.
- **Battery disposal**
The battery pack has to be disposed of at the end of its life. And batteries contain materials that must be handled and disposed of carefully and safely.



Prius Plug-in Hybrid research vehicle

Toyota's Take

Toyota is researching near-future alternatives to gain broad knowledge. So far, plug-in hybrids appear to have the most potential to be successful in the market. They offer this combination of benefits:

- No new infrastructure required
- No worries about running out of charge mid-trip
- Significant increases in fuel economy

In fact, Toyota is now field-testing a plug-in Prius design to learn more about the day-to-day usability of this type of vehicle.

Alternative Fuels

Alternative requiring extensive research

■ Hydrogen Fuel Cells

This is an electric vehicle that doesn't rely on batteries. Instead, it uses a device called a fuel cell which combines hydrogen and oxygen to make electricity.



What's good about fuel cells?

- The only emission is water
- No need to recharge or plug in
- Hydrogen can be extracted from renewable resources

What are some issues with hydrogen fuel cells?

- **Hydrogen sources**
The most common way of creating free hydrogen is to extract it from natural gas, which is a non-renewable resource.
- **Requires a new distribution and delivery infrastructure**
Free hydrogen is not compatible with the pipes and tanks used for gasoline, so an entirely new system would have to be built.
- **Durability**
Fuel cells have limited durability and are expensive to replace.



Toyota's Take

Fuel-cell research is ongoing, but there is still much to learn. Fuel cells are the furthest from market of any of the future alternative fuels discussed in this Hot Sheet.

In closing

There is no silver bullet. Every alternative has its pluses and minuses. That's why Toyota is pursuing multiple research projects to study the new technologies and their effects. Toyota will continue its leadership role in bringing to market the technologies that make the most sense for drivers and society alike.

For More Information

In eShowroom, look for these Hot Sheets under the Resources tab:

- 09 12 HS Prius Plug-in
- 06 HS July Ethanol (in Hot Sheet archives)

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