Green Vehicles Can Reduce Climate Change Emissions

PROBLEM - Carbon dioxide emissions, the major cause of climate change, are higher than at any time over the past million years. Many scientists and several nations have set the goal of reducing carbon dioxide emissions by 60-70% in the next 44 years, with the goal of not exceeding 450 parts per million.

- Transportation emits one third of all the climate change emissions in the USA.

SOLUTION - Choose the most fuel efficient mode of transportation or vehicle (see National Security page).

- Choose a vehicle that uses a fuel that emits less climate change emissions.
- Mandate change: Increase CAFE standards to increase fuel efficiency; regulate CO_2 emissions from vehicles; make biofuels part of gasoline or diesel fuel mix; support mass transit and biking.

Automotive Fuels and Technologies that Reduce Climate Change (CC)

Argonne National Laboratory has developed a computer model called the GREET (greenhouse gases, regulated emissions, and energy use in transportation) to help analyze the likely impact of alternative-fueled passenger cars compared to a conventional passenger car using gasoline.

In the table to the right, all greenhouse gas emissions from the full fuel cycle (including fuel extraction or production, refining, transport, and use (including particulates from tire and brake wear) are used. Carbon dioxide, the major greenhouse gas, can be reduced by increasing vehicle efficiency, using an alternative fuel, or through a combination of the two.

(ICE=Internal combustion engine vehicles. FCV=fuel cell vehicle)

*% Change in CC Emissions**	*Technology or Fuel*
- 100	Electric car (renewable source)
- 77	B100 (100% biodiesel)
- 20 to -50	Hybrid car (gasoline)
-32	Electric car (US grid)
-28	B20 (20% biodiesel + 80% diesel)
- 22	E85 (85% ethanol from corn, 15% gas)
- 15	Propane (LPG)
- 13	CNG (compressed natural gas)

ICE	*FCV*	-- *Vehilces using hydrogen* gas
-7	-53	Hydrogen (H_2) from CNG
+138	+21	H_2 from today's US electric grid
-100	-100	H_2 from renewable electricity

*negative CC numbers are good, positive are bad

Reaching the Ultimate Goal of a Zero Carbon Emission Vehicle

Reducing carbon emissions to zero, not just at the tail pipe but taking the full fuel cycle into consideration, will likely be necessary. However, carbon emissions are not yet regulated in the United States.

To address the need to reduce carbon emissions from transportation, California introduced the Pavley Bill and passed it in 2002. In March 2006, the National Research Council reported that the basis for the California law is "scientifically valid and necessary." On April 3, 2006 the California assembly introduced a first of its kind bill that would cap carbon emissions across all sectors statewide.

On a national level, the Department of Energy (DOE) is mandated to explore new sources of energy and fuels that can improve our national security and our economy. Several of these sources and fuels benefit the country in other ways, including lower carbon emissions.

BIOFUELS - The DOE, for example, is supporting research to develop biofuels, such as biodiesel and ethanol, made from plant materials. With the full fuel cycle taken into consideration, these fuels offer strong carbon emissions reductions because the plants, preferably low-impact no-till plants, take carbon dioxide out of the atmosphere when growing. When burned, carbon dioxide is re-released into the atmosphere. In comparison to gasoline, CO_2 emissions are reduced by 30-77%, *continued on reverse*

as shown in the table on page 1.

Biofuels can be used directly in vehicles that have been modified, but, if blended with gasoline or diesel fuels (5%-20%), they can be used by all vehicles presently on the road. If it were mandated that biofuels be blended with our existing fuels, no new vehicles or pumps would need to be installed and we would likely be able to use all the biofuels that we are able to produce, since production is limited by availability of feedstock and/or agricultural land.

NATURAL GAS - Another option being used by some vehicles is natural gas. This requires special fueling stations and vehicles, but many auto companies are interested in these vehicles because they can learn much about how we might use hydrogen to power our transportation system. Natural gas reduces CO_2 emissions by only 13%. Landfill gas (biomethane) could also be used in natural gas vehicles. While expensive to produce, it offers the benefit of reducing the release of methane into the atmosphere. Methane is a much more powerful climate change emission than CO_2. In fact, it is 20 times stronger.

ELECTRICITY AND HYDROGEN - Electricity and hydrogen have much in common. Neither of them are energy sources like biofuels, coal or oil. They are energy carriers and are both important because they can be made from a variety of sources and then used to power vehicles.

For example, electricity can be stored in batteries, ultracapacitors or hydrogen and used to power a vehicle. Recent improvements in battery technology are making the plug-in hybrid vehicle and battery-electric vehicles look more appealing than in the past.

Hydrogen can be made by using electricity to split water into hydrogen and oxygen, but this is expensive. It can also be made by stripping H_2 molecules from hydrocarbons like natural gas or coal, which makes H_2 and carbon dioxide, but this is also expensive. In both cases, the production of hydrogen is less efficient than storing energy in batteries or ultracapacitors.

Since hydrogen or electric vehicles offer the advantage of using a variety of fuels, this brings us to an analysis of what are the best ways of producing electricity without producing carbon emissions.

Fifty percent of our electricity comes from coal, and the US is very coal rich. Burning coal, however, emits large amounts of carbon dioxide, the major climate change emission. Several nations are working on methods to capture and store the carbon dioxide so that coal can be used during the transition to renewable energy.

Nuclear plants have the advantage of zero carbon dioxide emissions when in operation. However, they produce radioactive waste which must be stored for tens of thousands of years, they could emit toxic radiation if there were an accident or if they were a target of terrorism, and they could cause the proliferation of nuclear weapons.

Renewables such as wind, solar, landfill gas, low head hydro and geothermal emit zero carbon dioxide pollutants while in use and require only modest amounts of fossil energy to produce. The cost of wind power is on parity with a new gas-fired power plant. The cost of solar electricity is still high but coming down.

GOVERNMENT SUBSIDIES - In spite of windfall profits to the oil companies, subsidies for oil, coal, and nuclear together are 25 times greater than the subsidies for emerging renewable energy technologies with near-zero carbon emissions. Subsidies are $6,130 million for conventional energy vs $236 million for renewables, annually.

GETTING TO ZERO - The most robust plan to reduce carbon emissions and eventually get to zero is the “stabilization wedges” plan developed at Princeton University. Each wedge is a particular method and technology for reducing carbon emissions. The first step is gains in efficiency, because it is the least expensive way to reduce carbon emissions. In the transportation sector, carbon emission avoidance can be achieved by switching to less energy intensive transportation modes (walking, biking, mass transit, etc.) and increasing fuel efficiency (hybrid cars, lighter cars, etc.) The second step would be switching to less carbon-emitting fuels. The plan presently aims to reach zero in100 years with carbon dioxide stabilized at 500 parts per million. The plan could be accelerated should the need arise.