

## Alternative Fuels and Renewable Energy Strategies in the Energy Revolution

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The energy revolution advocates for gradual transition from fossil fuels to alternative or renewable forms of energy. The increased technological activities across the globe, the global nature of economy and increasing world population require proactive measures to meet the future world energy requirements. There is a wide spread concern for air quality and health issues associated with environmental pollution from automobiles. Every car on the road today outputs oxides of nitrogen- $\text{NO}_x$ , carbon monoxide-CO, hydrocarbon-HC, particulate matter- $\text{P}_m$ , oxides of sulfur- $\text{SO}_x$  and greenhouse gases-GHG into the atmosphere. Hydrocarbon and  $\text{NO}_x$  in the presence of sunlight cause photochemical smog. While  $\text{SO}_x$  and  $\text{NO}_x$  in the presence of moisture form acids. All these environmental pollutants impact health, vegetation, acidity of our surroundings and are a grave concern to the society.

Two-thirds of our daily oil consumption in the U.S., is in the transportation sector. While we value our inalienable freedom to movement without the Congress telling us our rights, the subtle issue is that the oil pool is dwindling as the Rest of the World (ROW) is reaching out for the same barrel of oil. This seamless demand makes the crude oil price to go up. The solution is to find alternatives to replace the current fossil-fuel based source of energy. United States uses 20, 680,000 barrels/day of crude oil which translates into \$1. 78 billion per day at \$86.4/barrel [1]. While U.S. produces 10.7% of the world oil and occupies 4% of the world population it uses 25.9% of the world oil. The solution to this lies in finding a domestic product that is renewable, sustainable and less polluting. That means an energy economy that supports alternative fuels and renewable energy for the 21st century economy. We will review the current alternative fuel options and their potentials.

### Alternative Fuels

These fuels by DOE parlance are: alcohols (Ethanol, Methanol) and their blends are (E10, E85, M85, etc.); bio-fuels, hydrogen, natural gas, propane and electricity including those from solar. Ethanol (E) can be used as a blend or as pure fuel in spark ignition (SI) engines. The most popular blends are E10 and E85; i.e., 10% ethanol and 90% gasoline and 85%E /15% gasoline respectively. E10- otherwise called gasohol is widely used in SI engines without modification of the fuel system. It improves the ignition quality of the blend with a subsequent reduction in emissions. E85 is popular with flex-fuel vehicles. The drawback is that the E-series require larger tanks than its gasoline equivalence and requires 1.5 times the amount of pure E by volume to gasoline, to cover same driving distance. Ethanol burns very clean in a diesel engine with spark addition, in what is referred to as spark assisted diesel engine-SADI. SADI can attain a brake thermal efficiency of 39% [2-4]. However, Methanol (M) does not find wide application as much as E in spark ignition engines. For these reasons: it is more corrosive than E and requires two gallons of M to a gallon of gasoline. With current advances in fuel cells, M finds a wide application as fuel in a direct methanol fuel cell-DMFC. DMFC is a candidate for portable devices such as; digital cameras, laptops, traffic and bacon lights, power sources for remote sensing stations, etc.

Ethanol is derived through fermentation of corn, beet, sugar cane, etc. The Brazil experience demonstrates the successful use of ethanol

technology in automobiles. Successful combustion of alcohol fuels in internal combustion engines is achieved by using lubricating oil grades that are compatible with alcohol fuels. Due to low lubricity of the fuel, blow-by fuel enters into the crankcase and degrades the lubricant. This leads to bearing failure. Alcohols have very high heat of vaporization. This contributes to slow vapor formation of the fuel in cold weather conditions and causes startability problems. Difficulties are experienced in operating gasoline engines converted to operate on alcohol fuel, if the temperature is below 7°C. Successful combustion of alcohol is achieved through using ignition system with multiple sparks/cycle [3] Injector nozzles with multi-holes with one spray directed towards the spark plug electrode has been found to remedy the combustion difficulties in either methanol or ethanol fueled engine [4].

Hydrogen is commercially produced through a well established technology of steam reformation, auto-thermal reaction and partial oxidation processes of hydrocarbon fuels. The main feedstock is natural gas which is obtained from oil wells. Natural gas is very abundant and relatively very inexpensive compared to liquid fuels. It can serve, at the interim, as a raw material to transition to cleaner technologies for power generation, such as, fuel cells. Hydrogen of 99.997% quality is also produced commercially through electrolysis of water.

Hydrogen is used as fuel for fuel cells. In the fuel cell of the proton exchange membrane type, hydrogen is delivered to the anode where it is oxidized at the catalyst sites with the release of electrons and protons. The electrons flow through the external circuit generating electricity while the protons pass through the membrane to reunite with the electrons at the cathodic catalyst site. Oxygen from atmospheric air is supplied to the cathode. The reaction is completed following a reduction reaction whereby the protons, electrons and oxygen react to form water with the release energy in the form of heat.

The high temperature fuel cells, namely-the Molten Carbonate Fuel Cell (MCFC) and Solid Oxide Fuel (SOFC) present another type of fuel cells with the capability of using various types of fuels to produce direct electricity. The fuels (natural gas, carbon monoxide, etc.) can be reformed internally and the waste heat used for co-generation, i.e., using the waste heat to power either a steam or gas turbine. The waste heat from the exhaust of these heat engines can in turn be used for process analysis in large industrial facilities, for heating utility water and swimming pools, space heating etc., thereby bottoming the cycle. Propane is produced from crude oil refining and is widely used as fuel for transportation. The use of solar energy to generate direct electricity

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is gaining public acceptability because it does not pollute, generate noise or waste by-products. Electricity can also be stored in various energy storage devices, e.g., batteries and later used to power electric vehicles.

The alternative fuel program serves to reduce our dependence on foreign oil, reduce environmental pollution and put back the money into the economy to develop newer forms of alternative fuels. A review of the U.S. Government's initiatives towards this goal reveals that the authority to regulate and standardize fuels for transportation lies with the Environmental Protection Agency (EPA). It is EPA's responsible to ensure that the minimum volume of alternative fuel is integrated into transportation fuel. These standards are set with refiners, renewable energy producers and others. The Renewable Fuel Standard (RFS) was set under the Energy Policy Act (EPA) of 2005. The EPA required from the RFS to blend 7.5 billion gallons of renewable fuel into gasoline by 2012. To further support the initiative, The Energy Independence and Security Act (EISA) was set up in 2007. Under this program RFS was expanded to cover both SI and CI fuels. EISA's projects to increase the volume of renewable fuel blend to 9 billion gallons by 2022. All these efforts are to reduce the quantity of imported petroleum fuels, Greenhouse Gases (GHGs) and gradually usher in an era of alternative and renewable fuels

## Conclusion

In conclusion, the gradual integration of these alternative fuels into

cleaner power systems either through combustion or electrochemical reaction to generate power is not going to be an easy task. Firstly, alternative fuel is regarded as a disruptive technology to the existing infrastructure. Secondly, the infrastructure is not in place. And finally, the transportation system should be made flexible to use multi-fuels, but little has been done to achieve such milestones. The use of waste heat from stationary power systems thereby bottoming the cycle could effectively reduce environmental pollution and reduce the amount of fuel burned. These steps would go a long way to reduce our overdependence on foreign oil and maintain air quality that our children deserve.

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