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# Environmental Issues and Possible Replacement of Petroleum Fuels: A Review

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**Abstract: Due to increase in fossil fuel consumption and stricter emission norms, a large number of alternative fuels have been searched for the replacement of diesel fuel. The possible liquid alternative fuels for diesel engine application are biodiesel, methanol, ethanol etc. The world is facing a challenging issue of solid waste accumulation which causes a severe environmental pollution. Used automobile tire, plastic wastes etc. are some of the major solid wastes that are dumped in huge amounts each day throughout the globe. These waste materials can be converted into useful form of energy by suitable technique. In this research article application of some of the important alternative fuels have been discussed.**

***Keywords*****:** Alternative fuel; Combustion; Diesel engine; Performance; Emission

## I. INTRODUCTION

Worldwide, the demand for energy is increasing exponentially with the increase in the population and improvement in living standards [1]. The source of energy for almost in all the sectors including domestic, transportation etc. is still fossil fuels. The huge consumption of the fossil fuels is contributing the global greenhouse gas (GHG) emissions which cause an adverse effect on the public health and climate change. Internal combustion (IC) engines used in transportation, power generation, and commercial sector are one of the significant contributors to the air pollution. In order to overcome this situation, alternative fuels and energy efficient combustion technologies are being explored and employed. Additionally, renewable alternative fuels might help in the reduction of global carbon emissions.

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### 1.1. Energy consumption and GHG emissions

The demand for energy increases with the growth in the environment development of any country. Nowadays, the combustion of petroleum fuels in most of the countries accounts for more than 2/3 of its energy consumption which accounts 2/3 of the world's primary energy utilization [2]. The world energy consumption by country and fuel source is shown in the Fig. 1 China consumes 23% (approx. one-fourth) of the world's total energy consumption followed by the US consumes 17.3%. India consumes 5.6% of the total energy consumption. The fossil fuels contribute to the majority of the fuel consumption with sources of are oil, natural gas, and coal. It is apparent from the figure that, fossil fuel accounts 86% of the total energy consumption.

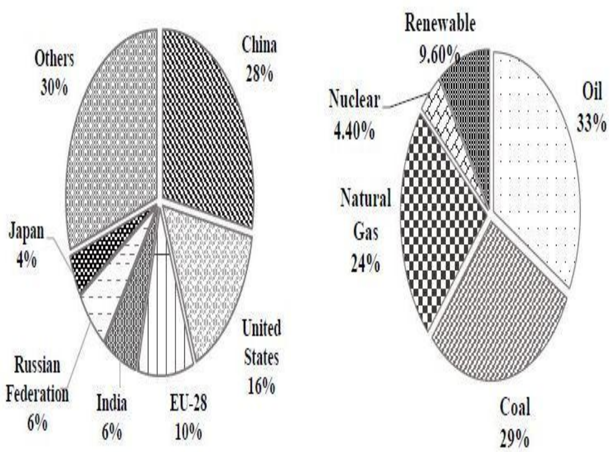


**Fig. 1 World energy consumption (2015) by country and source [2]**

The main concerns of the future energy strategies include the growing global population, the increasing population mobility, the increasing production and consumption of goods, and the goods transportation. Therefore, the need for efficient, clean, and inexpensive energy sources is perceived in contrast to the environmental and health issues connected with the use of fossil fuels. Fig. 2 shows the anthropogenic global greenhouse gas (GHG) emissions by gas. The main areas where energy is consumed are; (i) Transportation (ii) Electricity generation (iii) Farming (iv) Industrial (v) households. Fig. 1.3 shows the anthropogenic GHG emissions by economic sectors.

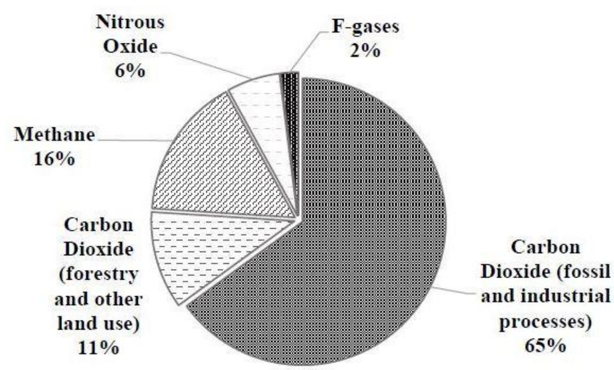


**Fig. 2 Global GHG emissions by gas in 2010 [3]**

The major GHG emission contributing sectors from the figure are electricity generation, agriculture, and industry. The transportation sector contributes 14% of the GHG emissions due to combustion of petroleum fuels burned. It is also reported that 95% of energy requirement for transportation section depends on petroleum based fuels, mainly petrol and diesel.

### 1.2 Air pollution and climate change

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Poor air quality and climate change are interconnected phenomena, which happens due to combustion of fossil fuels. It is necessary to take immediate initiative to reduce the pollution generated from the combustion of petroleum fuels. The issues such as climate impact of aviation due to $CO_2$ emission, ozone depletion, particulate matter (especially less than 2.5 microns size), and acid rain etc. are the severe issues which affects the air quality we breathe. Global climate change is known as the changes occur in the climate of the earth as an entire, caused due to human activities discharging excess amount of greenhouse gases (GHGs) into the climate. This excess emission of GHGs is the main reason for warming the earth's atmosphere.

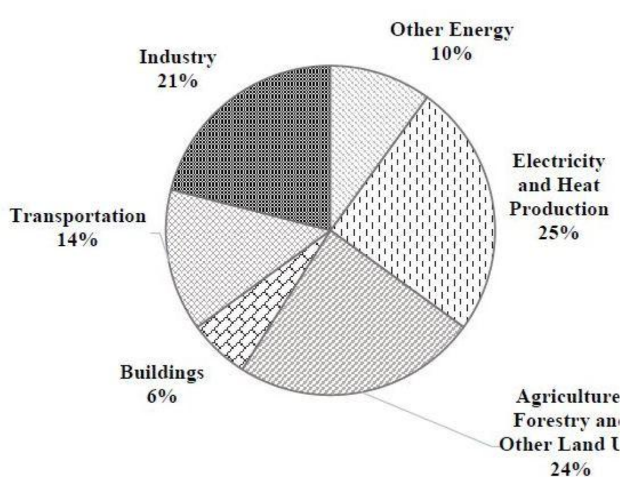


**Fig. 3 GHG emissions by economic sectors in 2010 [3]**

## II. ENERGY CONVERSION SYSTEMS

According to the first law of thermodynamics, energy can be converted from one form to another form. A system that transforms one form of energy to the human required energy form is termed as an energy conversion system (ECS). Fig. 4 shows the diagram of energy conversion system.

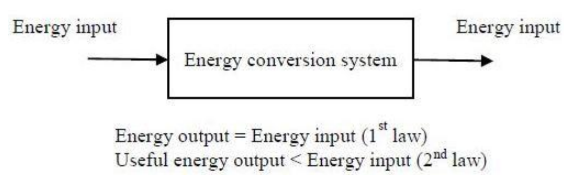


**Fig. 4 Schematic representation of energy conversion system**

A device/machine which derives heat energy from the combustion of the fuel and converts into useful mechanical work is known as heat engine. Based on the combustion of the fuel, heat engines are classified as external combustion and internal combustion engines. Fig. 5 shows the classification of heat engines. The advantages of IC engines over EC engines are compact, high power to weight ratio, safe to use, immediate startup, and high efficiency.

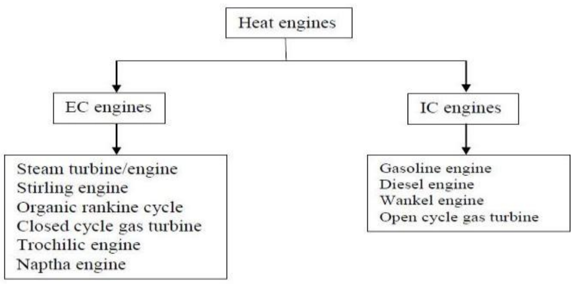


**Fig. 5 Classification of heat engines**

### 2.1 Internal combustion engines

Internal combustion (IC) engines are considered the heart of the automobile. Engines produce power by using heat energy of fuel by combustion. Along with the power the IC engines also emit harmful exhaust emissions such as unburned hydrocarbon (UHC), carbon monoxide (CO), carbon dioxide ($CO_2$), oxides of nitrogen ($NO_x$), and PM emission [4]. The main advantage of spark ignition (SI) engines are low smoke emissions due to homogeneous air/fuel mixture preparation, peppy drive (smooth, light and easy to drive), low maintenance cost, small initial investment, top speed, short gears, and silent drive. The disadvantages of SI engines are low torque, low volumetric efficiency, low thermal efficiency, worst idling performance, and frequent servicing. The main advantage of compression ignition (CI) engines was high thermal efficiency due to its high compression ratio [5-6]. Other advantages are high torque, high power, reliable, low CO emissions, and high part load efficiency. The disadvantages of CI engines are high noise, low speed, impossible retrofitting, high cost, and tradeoff emissions.

## III. POTENTIAL ALTERNATIVE FUELS

The energy conversion systems can use both non-conventional and conventional sources of energy. The energy developed by using wind, tides, solar, geothermal heat and biomass are considered as renewable energy. These resources are renewable, unlimited and also do not harm the environment. Fig. 6 shows the conventional and renewable sources of energy.

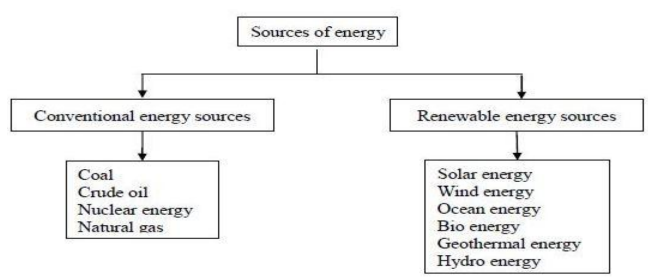


**Fig. 6 Non-conventional and conventional sources of energy**

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The main problems associated with the non-conventional sources of energy are limited availability in certain part of the world and the difficulty of transporting this form of energy to the place of its end use. The reserves of the crude oils are depleting exponentially due to the increase in the energy demand. The sustainable development is possible with the utilization of “green energy” obtained from the alternative fuel sources. The transformation for the utilization of alternative energy sources in the transportation sector is difficult with respect to its energy efficiency, and clean combustion process remains an important research topic. The influencing factors for the transformation of the alternative energy sources are (i) energy independence, (ii) possible decreases in the emissions of $CO_2$, soot, and unburned hydrocarbons (UHC), and (iii) fuel sources like agricultural residue, food waste, scrap tires [7-10] and algae biomass. The use of alternative liquid fuels in IC engines cause conflict with the modern exhaust gas treatment systems. The subsequent subsections discuss the commonly used liquid alternative fuels such as biodiesel, ethanol, and methanol that are used in the transportation sector.

### 3.1 Biodiesel

Biodiesel is a potential liquid fuel produced from organic substances that are composed of fatty acids. Triglycerides exist in the feedstock used are converted into mono esters by using transesterification processes. The potential feed stocks are edible and non-edible oils, animal fats, and algae. Biodiesel's physical properties are almost equal to those of fossil fuel, but it is considered as cleaner-burning fuel [11]. The additional features of biodiesel include better-lubricating properties, higher cetane number etc. [12]. Biodiesel is the non-petroleum fuel that can be blended with diesel to replace diesel fuel and is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics. It can be used in diesel engines without any significant modifications. The use of biodiesel in a CI engine results in potential decrease in hydrocarbon, carbon monoxide, and PM emission than that of emissions from diesel. Also, it is documented by the U.S. Department of Agriculture that biodiesel diminishes gross $CO_2$ emissions by about 78% than that of diesel. The major flaw observed with biodiesel is its poor oxidation

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stability, higher viscosity and density, cold flow property etc.

**3.2 Alcohols**

Utilization of alcohol based fuels is encouraged due to many reasons such as its easy production, transportation and can replace fossil fuels. The first four aliphatic alcohols i.e. methanol, ethanol, propanol and butanol are largely considered as fuel. Among those, methanol and ethanol are considered IC engine fuels by many researchers. As a fuel, alcohols have positive result and some flaw over fossil fuels. In SI engines, both alcohols can run at a much higher exhaust gas recirculation rates and with higher compression ratios. Both alcohols have a high octane rating, with ethanol at 109 RON (Research Octane Number), 90 MON (Motor Octane Number), which equates to 99.5 (antiknock index) AKI [13]. Alcohols as a CI engine fuel decreases emission of PM but because of low cetane number these fuels needs ignition improver.

**3.3 Methanol**

Methanol has received potential attention due to better combustion characteristics, ease of distribution and extensive accessibility throughout the world. Methanol is known as SI engine fuel because of its high octane number which results better combustion and enhances power output. Although methanol has a low cetane number but it has capability of replacing diesel fuel by adding some suitable ignition improver. By using methanol in dual-fuel technique harmful emission can be significantly reduced. In many countries methanol operated automotive has been successful when, these are run on M85, a blend of 85% methanol and 15% gasoline. In the future methanol can be used as a source of hydrogen for fuel cell vehicles.

**3.4 Ethanol**

Ethanol is an alcohol with two carbon atoms, between which there is a single bond (empirical formula $C_2H_5OH$). Other terms, such as ethyl alcohol, spirit or grain alcohol are also used. Ethanol produced from biomass is also described as bioethanol. Ethanol is one of the most widely used biofuels today. As a transportation fuel ethanol in the form of E-diesel (ethanol blend with 15−20% in conventional diesel), and gasohol (90% of gasoline and 10% ethanol blend). In gasoline engines, ethanol is used as E85 (85% ethanol blend) and gasohol in many countries. The largest production of ethanol fuel was in the United States, followed by Brazil. The global ethanol production was approximately doubled from 2007 to 2015.

## IV. CONCLUSION

In order to reduce GHGs emission and overcome depleting fossil resources, new fuels such as biodiesel, methanol, ethanol, and fuels derived from other organic substances such as waste tire pyrolysis oil, plastic oil derived through pyrolysis can be used as a partial or full replacement of petroleum fuels.

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