***Hydrocarbons (HCs)*** are formed from products made from crude oil. Petroleum and gasoline consist of blends of more than 250 diverse ***hydrocarbons***. Many of these are toxic; some, such as benzene, are carcinogens (cancer causing agents). ***Hydrocarbons*** escape into the air when refilling the gas tank, from the gas tank and carburetor during normal operation, and from engine exhaust. ***Hydrocarbons*** that evaporate from gasoline are sometimes called *volatile organic compounds (VOCs)*. If uncontrolled, transportation sources would make up 30-50 percent of the total hydrocarbon emissions in the atmosphere. The automotive industry has developed and is using various vehicle emission control systems that control hydrocarbon emissions. ***Hydrocarbons*** also contribute to the formation of ground level ***ozone***. Since ethanol is an alcohol, it does not produce ***hydrocarbons*** when being burned or during evaporation.

***Ozone*,** sometimes referred to as photochemical smog, is formed in the air when ***hydrocarbons*** and ***nitrogen oxides*** react in the presence of sunlight. It is more of a concern on warm, quiet, summer-like days when smog fills the air, creating a brownish haze in the lower atmosphere. This ground level ***ozone*** causes human respiratory stress and can cause plant damage, sometimes reducing crop yields. This ground level ***ozone*** does not increase the ***ozone*** that is in the stratosphere and does not block the sun’s harmful ultraviolet rays. Several U.S.- based studies conclude that, overall, the ***ozone*** forming potential of ethanol blends, which vaporize at lower temperatures due to higher volatility, is about the same as gasoline. In Canada, however, the volatility of ethanol blends must match normal gasoline.

***Aldehyde*** emissions from the combustion of ethanol blends are slightly higher than when burning gasoline alone. The concentrations are extremely small and are sufficiently reduced by the vehicle’s three-way catalytic converter found on all recent cars. The Royal Society of Canada termed the possibility of negative health effects caused by ***aldehyde*** emissions from the use of ethanol blends as being “remote.”

***Carbon monoxide (CO)*** is a poisonous gas formed by incomplete combustion. It is readily produced from burning petroleum fuels which contain no oxygen in their molecular structure. It is especially produced when excessive fuel-to-air mixtures are delivered and burned in the engine. More fuel and less air are necessary to start a cold engine and to keep it running until reaching normal operating temperature. Vehicles operating at colder temperatures (in winter months, during engine warm up, or in stop-and-go traffic) produce significant quantities of this toxic gas. By adding ethanol, which contains oxygen, combustion in the engine is more complete and CO is reduced. Research shows that reductions may reach as high as 30 percent depending on the type and age of the automobile, the emission system used, and the atmospheric conditions. Because of health concerns over carbon monoxide, the 1990 amendments to the Clean Air Act mandate the use of oxygenated fuels in many major urban areas (CO non-attainment areas) during the winter months.

***Carbon dioxide (CO2)*** is a normal non-toxic product of burning fuel, but it contributes to the greenhouse effect (global warming). All petroleum-based fuels cause increased atmospheric ***carbon dioxide*** levels. Using renewable fuels, such as ethanol, does not increase atmospheric ***carbon dioxide*** levels. The ***carbon dioxide*** formed during combustion is balanced by that absorbed during the annual growth of plants used to produce ethanol. Plants “breathe” ***carbon dioxide*** and give off oxygen. Therefore, increased use of renewable fuels made from plants will partially offset the global warming effect of burning gasoline. It is also worth noting that renewable fuel technology can result in a net reduction in atmospheric ***carbon dioxide*** levels. This is accomplished by transforming ***carbon dioxide*** into organic matter that is returned to the soil, thereby increasing soil fertility and reducing erosion. Ethanol use in gasoline has tremendous potential for a net reduction in atmospheric ***carbon dioxide*** levels.

***Nitrogen oxides (NOx)*** are produced when high combustion temperatures exist. NOx contributes to ground level *ozone* (photochemical smog). Several components of gasoline that impact NOx emissions, including olefins and aromatics, are reduced by adding ethanol to gasoline. EPA studies indicate the use of ethanol blends may slightly increase NOx emissions under some conditions, but the extent and effects are uncertain.