Ethanol as fuel,
Flex-fuel vehicle,
E85 conventional kit

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ETHANOL AS AN ALTERNATIVE FUEL FOR VEHICLES IN MALAWI

The dependence on the use of fossil fuel as a source of energy for driving vehicles has resulted in Malawi spending a lot of its foreign exchange in the importation of fossil fuel from other countries. The use of ethanol, which is locally produced in the country as an alternative source of fuel energy, might reduce the impact imposed by the importation of fossil fuel. Hence subject publication of the topic on the use of ethanol, as an alternative fuel to petrol will provide a literature review and assessment of the contemporary state of knowledge on the topic together with the prospect to convert the ordinary spark ignition engine to use ethanol as its fuel in the country.

ETANOL JAKO ALTERNATYWNE PALIWO W MALAWI

Źródłem energii dla samochodów w Malawi jest importowana ropa naftowa, co stanowi istotną pozycję w budżecie kraju. Alternatywnym rozwiązaniem jest produkcja alkoholu etylowego z produktów krajowych, przykładowo trzciny cukrowej. Przedmiotem wypowiedzi jest analiza zagadnienia z wykorzystaniem dostępnej literatury.

1. INTRODUCTION

Ethanol has been used as an alternative fuel worldwide for a long time, it is also called ethyl-alcohol, pure alcohol, grain alcohol, and it is a volatile, flammable, colorless liquid. It is psychoactive drug, best known as alcohol, found in alcoholic beverage which is simply referred as spirit [Blume, 2007].

The largest use of ethanol, as a motor vehicle fuel and fuel additive are USA and Brazil they have the largest national fuel ethanol industries, and together both countries were responsible for 89% of the world's ethanol fuel production in 2008 [Licht, 2008] - Table 1, Figure 1.

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Table 1. World fuel ethanol production, 2008

Country	Millions of gallons
USA	9,000.0
Brazil	6,472.2
European Union	733.6
China	501.9
Canada	237.7
Others	128.4
Thailand	89.8
Colombia	79.29
India	66.0
Australia	26.4
TOTAL	17,335.2

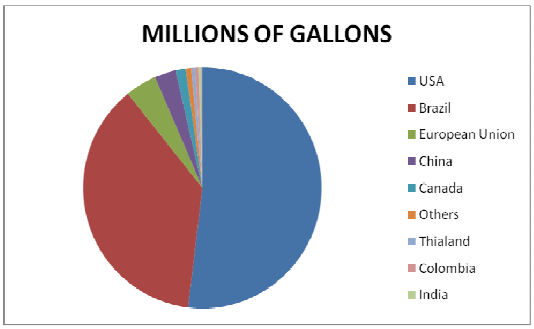

Fig. 1. World fuel ethanol production, 2008

Ethanol has been used in cars since Henry Ford designed his 1908 T model to operate on alcohol. An alcohol fuel provides high quality, high-octane rate for exceptional engine performance and reduced emission, thus making it a good option to combat climate change [Reel, 2006]. Ethanol is said to be much cleaner fuel than petrol/ gasoline (13) because of the following points [Jason et al, 2009]:

- ethanol is a renewable fuel made from plants,
- it is not a fossil fuel, so manufacturing and burning it does not increase the green house effect,
- it provides high octane at low cost as an alternative to harmful fuel additives,
- ethanol blends can be used in all petrol engines without modifications,
- ethanol is biodegradable without harmful effects on the environment,
- it significantly reduces harmful emissions,
- ethanol's high oxygen content reduces carbon monoxide levels more than any other oxygenate by 25 - 30 %,
- ethanol can reduce net carbon dioxide emission by up to 100 %,
- high-level ethanol blends can also reduce emissions by volatile organic compounds (VOC) by 30 % or more, VOC are major sources of ground-level ozone formation,
- as an octane enhancer, ethanol can cut emission of cancer causing benzene and butadiene by more than 50 % [Blume, 2007].

Demerits of ethanol production are as follows [Jacobson, 2008]:

- high production and use cost as compared to energy realized (energy balance),
- ethanol has smaller energy density as compared to gasoline,
- competition of land use for ethanol production and food production,
- increase emission of underground ozone layer movement (air pollution).

Malawi as a nation depends fully on fossil fuel as a source of energy for its vehicles. The escalation of the fuel prices per gallon on global market is the major cause of cost-push inflation in Malawi, and this is not sustainable for the economy of the country. Therefore the use of ethanol as an alternative source of fuel to petrol could reduce the impact

sustained by the importation of fossil fuel, hence saving the much-needed foreign exchange for other development activities.

According to the report [Licht, 2009] showing fuel imports into Malawi during 2008 is possible notice that the government bill is increasing every year. The import volumes of petrol have stabilized at 80-90 million litres per year over 10 years period (1995-2005), however the price has been increasing annually from MK1.8 billion (US$ 12.2 million) in 2000 to around MK5 billion (US$ 33.9) in 2005.

Since 1982 the countries fuel-blending programe has taken the advantage of the economically favourable conditions for ethanol production from sugar industry waste (molasses) and annual ethanol production over 10 million liters [Robinson, 2007].

According to recent report that was ushered in the national Malawi assembly of 2008, the current ethanol production is about 18.9 million liters, 8.0 liters produced by ethanol company limited in Dwangwa, while the other 10.9 million liters is produced by Presscane in Chikwawa. The production of ethanol is constrained by the low availability of molasses, which is a by-product of sugar production. However, each of the two factories has designed a capacity of 16 million liters per year.

The current use for ethanol is mostly for blending with petrol, though some is used for industrial purposes, such as pharmaceuticals and exported to neighbour countries like Botswana, Tanzania, Mozambique and Kenya. There is evidence that Malawi at the current production levels has excess ethanol, which can be used locally as fuel for motor vehicles. It is also possible to produce ethanol at full capacity by the two companies because there is room for expansion of sugarcane fields at Dwangwa, Nchalo and Kasinthula to produce more sugar that will result in more molasses for more ethanol.

This piece of work is aimed at assessing/ testing, discover and make a recommendation on the use of ethanol as an alternative source of energy for propelling engines to petrol in Malawi. In the study some adjustment and modifications will be made on already existing EFI engines, so as to become a Flex-Fuel vehicle (FFV).

Malawi is one of the least developing country in Africa its economy is agro-based and unstable. Looking at its unstable economy that is mostly affected by the escalation of fuel prices on global market, usage of ethanol as an alternative fuel to petrol will assist the country in the following areas:

- the government will save some of its foreign exchange that was used in the importation of fossil fuel for other development activities,
- the use of ethanol as an alternative fuel will demand an increase for sugarcane; the demand will result in high prices for sugarcane, thus attracting farmers to join the cane growers associations; hence the land under sugarcane growing will increase at Dwangwa, Banje scheme and Kasithula in Nchalo,
- expansion of sugarcane fields will offer more employment opportunities to local Malawians; Malawians will also get additional employment opportunities in sugar company as well as ethanol production and marketing, thus from the factory to the vehicle through pump stations [Mkoka, 2006],
- expansion of sugarcane estates will also demand on an increase in farming and irrigation engineering machinery, the demand will also mean more Malawian engineers, technicians and artisans will get employment,
- reduce the dependence on tobacco, tea and cotton as the only cash crop for local farmers.

2. LITERATURE REVIEW

Ethanol propelled engines (E100) has been observed to have an approximation of about 50 % fuel consumption than gasoline, since the energy per unit volume of ethanol is 34 % lower than for gasoline. However the higher compression ratios in an ethanol-only engine allow for increased power output and better fuel economy than could be obtained with lower compression ratios [Mkoka, 2006]. In general ethanol-only engines are tuned to give slightly better power and torque output than gasoline-powered engines. In flex-fuel vehicles, the lower compression ratio requires tunings that give the same output when using either gasoline or hydrated ethanol. For maximum use of ethanol's benefits a much higher compression ratio should be used which would render that engine unsuitable for gasoline engines [Stauffer, 2008].

In the history of flex-fuel vehicles, Brazil has been on the lead in trying to use flex-fuel vehicles than any other nation in the world; hence the country automakers put more emphasis on the improvement of the flex-fuel vehicle technology. Brazilian flex cars are capable of running on just pure ethanol (E100), or just on a blend of gasoline with 20 to 25 % to ethanol, or on any arbitrary combination of both fuels [Goettemoeller, Goettemoeller, 2007]. Pure gasoline is no longer sold in the country because these high ethanol blends are mandatory since 1993. Therefore, all Brazilian automakers have optimized flex vehicles to run with gasoline blends from E20 to E25, and with a few exceptions, these FFVs are unable to run smoothly with pure gasoline it produces an engine knocking sound, hence these vehicles are not suitable to other countries in the same region (South America).

A key innovation in the Brazilian flex technology was avoiding the need for an additional dedicated sensor to monitor the ethanol-gasoline mix, which made the first American M85 flex fuel vehicles too expensive. This was accomplished through the lambda sensor/ probe used to measure the quality of combustion in conventional engines: is also required to tell the engine control unit (ECU) which blend of gasoline and alcohol is being burned. To estimate brake thermal efficiency and fuel efficiency of various engine operation concepts or use of general drive test of the vehicle in comparison with a normal gasoline vehicle as a control, computer simulation can be used. For a normal engine to be converted to F-FV the engine should be fitted with conversional kit (E85 conversional kit). The E85 kit is connected between the engine's main electronic control unit (ECU) and the fuel injectors as illustrated in Figure 2 [Gabriel de Lima, 2008].

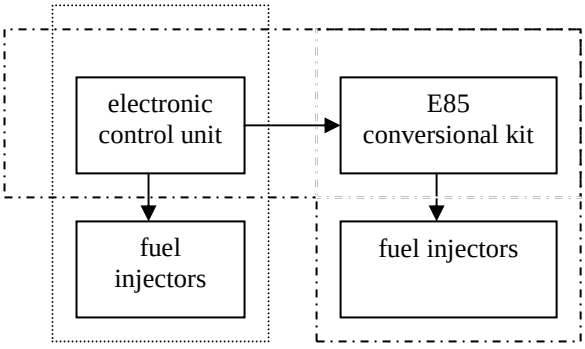

Fig. 2. Normal lay-out kit (left) and system fitted with E85 (right)

Ethanol has a low calorific value of about 30% as compared to gasoline, hence releasing less thermal energy per unit volume when involved in combustion process. To have equal amount of power released by ethanol to gasoline, there is need to increase the quantity of ethanol, hence the E85 kit increases the time the fuel injector delivers fuel in the engine, hence increasing the quantity too.

The above task is accomplished automatically through software developed by Brazilian engineers, called software fuel sensor (SFS), fed with data from the standard sensors already built-in the vehicle. The technology was developed by the Brazilian subsidiary of Bosch in 1994, but was further improved and commercially implemented in 2003 by the Italian subsidiary of Magneti Marell. A similar fuel injection technology was developed by the Brazilian subsidiary of Delphi Automotive Systems and it is called Multifuel, based on research conducted at its facility in Piracicaba, São Paulo [Gabriel de Lima, 2008]. This technology allows the controller to regulate the amount of fuel injected and spark time, as fuel flow needs to be decreased and also self-combustion needs to be avoided when gasoline is used because ethanol engines have compression ratio around 12:1, too high for gasoline.

Sweden is the leading country in Europe regarding the use of ethanol as fuel, though it has to import most of the ethanol. All Swedish gas stations are required by an act of parliament to offer at least one alternative fuel and every fifth car in Stockholm now drives at least partially on alternative fuels, mostly ethanol. The number of bioethanol stations in Europe is highest in Sweden, with 1,200 stations (11) and a fleet of 116 thousand flex-fuel vehicles as of July 2008 [Kroh, 2008] - Figure 3.

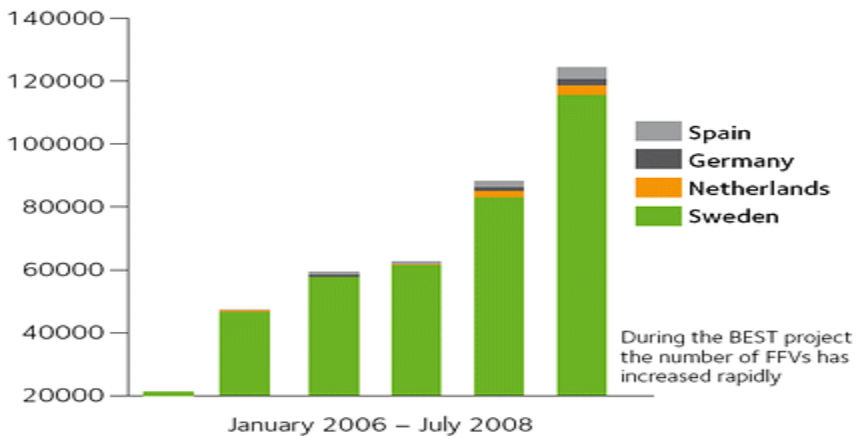

Fig. 3. Fleets of flex-fuel vehicles in Europe in a bar chart [Kroh, 2008]

3. FINAL REMARKS

The study discusses the impact of fossil fuel importation on the economy of Malawi, and the significance of using ethanol as an alternative fuel to petrol. It also looks on the effects of ethanol production to the environment. It has further discussed about other countries in Europe and America that use ethanol as a source of fuel energy and the recent technology involved in flexes fuel vehicles.

The study marks that Malawi's economy is agro-based; hence modeling and implementation of the project will boost the growth of sugarcane in the country and also resulting in more job opportunities to the citizens, both directly and indirectly by getting employment in cane growing estates and ethanol production companies, so is during marketing the ethanol as fuel.

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