Bio-diesel and Bio-gas: Alternatives of the present

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ABSTRACT

Today's world is extremely dependent on hydrocarbons for its energy requirements. Unfortunately, these resources are exhaustible and are being used up at a rapid rate. Thus, there is a need for alternative energy sources. Biofuels (biodiesel and biogas) provide an efficient and inexpensive alternative. This paper shows a cost comparison between biofuels and their hydrocarbon variants.

Introduction

Biodiesel and biogas are two very good propositions to replace non-renewable energy sources like petroleum, natural gas and coal in the future. It is therefore necessary to ask whether or not these are viable propositions even in this petroleum age. In this paper, the authors have tried to answer this question and tried to justify as best as possible why there is a strong case for adopting these two as alternatives in the present day.

Biodiesel

Biodiesel in this paper will refer to the biodiesel extracted from jatropha, unless otherwise mentioned. Jatropha is a drought-resistant perennial plant, growing well in marginal/poor soil. It is easy to establish, grows relatively quickly and lives, producing seeds, for 50 years. It produces seeds with an average oil content ranging from 37% up to 60%. The oil can be combusted as fuel without being refined. It burns with a clear smoke-free flame and has been tested successfully as a fuel for simple diesel engines.

The uses of jatropha are multiple. Though its main purpose is in the production of biodiesel, it has medical properties as well and can be used for the treatment of diseases and ailments like cancer, piles, snakebite, paralysis and dropsy. The press cakes that are formed when extracting oil from the seeds are good fertilisers. The oil extracted also has insecticidal properties.

There are many benefits of using biodiesel. Firstly, it is a clean fuel. By "clean", we mean it is friendly to the environment. The second major benefit of biodiesel is that it is highly biodegradable. Because of its very low degradability, crude is often a big problem in cases like oil spills. Biodiesel eliminates this problem. Biodiesel is also immensely helpful in reducing pollution as it significantly reduces CO_2 emissions compared to the conventional diesel. By using biodiesel, the emission of carbon dioxide is reduced by 80% and the emission of sulphur dioxide is reduced by 100%. Its use also results in a drop of cancer risks by 90%. Another major benefit is that it can be mixed with mineral oil diesel and the mixture can be used as fuel.

Biodiesel as an alternative to mineral oil diesel

It is interesting to ask, since a major chunk of petroleum in India goes to the transport sector, how effective biodiesel is as an alternative to mineral oil diesel, both in terms of performance and cost. A study[1] indicates that biodiesel can be used with mineral oil diesel in diesel engines. In fact, a mixture of 20% biodiesel along with 80% diesel, referred to as B20, has properties similar to the conventional diesel oil and can be used in normal diesel engines. It has also been established by experiments[2] that 2.6% biodiesel blended with diesel (B2.6) enhances the engine performance.

To be able to commercially produce and market biodiesel, certain prerequisites need to be adhered to. The whole process can be divided into two phases: the agricultural phase and the industrial phase. The agricultural phase includes the scientific cultivation of jatropha. The industrial phase includes the production of jatropha oil and mixing it with diesel. The industrial process includes the extraction of jatropha oil from the seeds as well as the biodiesel production which is done by transesterification of the jatropha oil and methanol in the presence of a catalyst like $NaOCH_3$.

From a business perspective, if a person were to follow the above procedure, the cost that would be involved in making jatropha oil is given in Table 1.[3]

This is quite close to the Indian public sector figure of ₹25/l. It has been already stated that B20 and B2.6 can be used in diesel engines and that B2.6 increases engine performance. B20's cost would amount to:

$(0.2 \times 100 \times 21.34 + 0.8 \times 100 \times 32)/100$ l $=$ ₹29.87/100 l.

This would mean a saving of ₹2.13 per 100 l compared to a base price of ₹32/l for diesel. Hence, it is definitely economically viable to use B20 as engine oil. It has also been proven that B2.6 increases the engine efficiency because the jatropha oil acts as an ignition-accelerator additive to the diesel oil. If one were to market this as high-quality diesel, the cost would amount to:

Table 1: Costs involved in making biodiesel

S. No.	For plant producing 530 l/day of biodiesel	Cost/Rupees
1.	Jatropha oil	17
2.	Methanol	0.83
3.	Catalyst (25% $NaOCH_3$)	0.48
4.	Neutralizer (HCl)	0.06
5.	Electricity	0.48
7.	Depreciation/Interest	1.00
8.	Maintenance	0.24
9.	Freight and transportation	0.95
10.	Blending cost	0.30
Total		21.34/l

Table 2: Engine emission results from the University of Idaho

Emission with respect to 100% diesel	B100 (100% jatropha oil) (%)	B20 (%)
Hydrocarbons	−52.4	−19
Carbon monoxide	−47.6	−26.1
Nitrous oxides	−10.0	−3.7
Carbon dioxide	+0.9	+0.7
Particulates	+9.9	−2.8

$(0.026 \times 100 \times 21.34 + 0.974 \times 100 \times 32)/100$ l $=$ ₹31.72/100 l.

This means a saving of ₹0.28 per 100 l, again, compared to a base price of ₹32/l for diesel. But if it were to be marketed as high-quality diesel and we add a further ₹3 to the base price for its cost, then it gives ₹3.28 profit per 100 l.

Thus, it can be pointed out that biodiesel is an alternative that has immense potential even today. It ought to be further pointed out that adding jatropha oil to diesel also makes it more eco-friendly as is illustrated in Table 2.[4]

Biogas

Biogas is another fuel that has huge potential. This paper is about the specific case for it as a substitute for cooking fuel, more specifically LPG in India. Biogas basically consists of methane with small amounts of other gases such as ethane and propane. It is produced from organic waste, which is referred to as biomass. Organic waste may include decomposable matter like animal and household waste, sawdust, glycerine, plant matter, etc. In a country like India which is highly dependent on imports (oil and gas) for energy production, it can prove to be an inexpensive and easily available alternative. The government spends huge amounts subsidising LPG for the consumers. If it were to lift that, it will place a huge burden on the common man. Using biogas instead of LPG would significantly reduce the expense incurred by both the public and the government. Also, the government is severely lagging behind in its aim to provide rural India with affordable and clean cooking fuel. Thus, biogas can also serve as a really good fuel for the rural population of India.

Biogas can be produced by creating slurry out of the biomass and allowing it to decay anaerobically in an underground tank. In this process, biogas is produced when the biomass decays. Then, the gas needs to be purified after which it can be compressed and either directly transported or marketed in cylinders.

Biogas as an alternative to cooking gas (LPG)

The cost of wood biomass with approximately 45% moisture is about \$2.14 (₹107) per MMBTU.[5] Considering a gasification efficiency of 70%, it amounts to \$2.14 (₹107) per 700 MBTU which is the same as \$ 3 (₹150) per MMBTU. Further, considering 14.6 kg of gas in a standard cylinder costing about ₹350 (say \$ 7) and considering the calorific value of LPG to be 46.1 MJ/kg,[6] the cost of LPG turns out to be \$ 11 (₹550) per MMBTU.

The calculations are shown below:

$46.1\ MJ/kg \times 14.6\ kg \times 1/1055\ BTU/J = 0.6379\ MMBTU$

A cylinder costs \$ 7 (₹350); therefore, the cost of LPG is:

$\$\ 7/0.6379\ MMBTU = \$\ 11$ (₹550) per MMBTU (approx.)

Even if we consider that the tripping and other costs are included in the LPG cylinder price and we take the price of the cylinder to be ₹300 (say \$ 6), the price by the same method would come out to be \$ 9.4 (₹470) per MMBTU which is still significantly higher than \$ 3 (₹150) per MMBTU of biogas.

Conclusion

Using biofuels as alternatives can decrease the dependence on conventional fuels like petroleum and natural gas even in the present day scenario. As has been discussed, biodiesel is inexpensive by around ₹10/l. Also, after blending with diesel, the costs of both normal fuel oil diesel and high-quality diesel reduce by ₹2.13 and ₹3.28 per 100 l, respectively. Biodiesel blends like B20 are significantly less polluting in comparison to mineral oil diesel with respect to hydrocarbon, particulates and noxious gas emissions. Biogas is also a cleaner fuel and is inexpensive by around \$6.4 per MMBTU in comparison to Liquefied Petroleum Gas (LPG). Thus, it can be used as a substitute for cooking gas in many places, especially the rural areas of India.

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