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Generation of Biofuels: Case of Bangladesh

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Energy is used in almost every economic activities and it also has imperative significance in the process of development. The reason behind the arrival of second generation biofuel is that it has no contradiction with food supplies, as it's generated from non-food crops whereas first generation biofuel has been criticized for this fact. Second generation biofuels can supply the required fuel as well as can alleviate poverty and rural development in Bangladesh. To the best of our knowledge, no study has been conducted on markets for second generation biofuel in Bangladesh's context. The main objective of this paper is to address the prospects of second generation biofuel for Bangladesh economy in light of market expansion on the basis of different case studies around the world.

Field of Research: Economics

1. Introduction

The increase in acceptance of biofuel around the globe has emerged for many reasons. One of the main reasons of climbing demand for biofuel is climate change. Excessive use of fossil fuel enhances carbon emission and thus has become a key contributor to global warming. The waves of global warming started to create negative impacts in many countries around the world (for example, increase in temperature, smog, acid rain etc.). To tackle the waves, an alternative source of fuel has come into the scenario. At present biofuel is considered as a potential renewable source of energy (Aguiler *et al*. 2011).

The term biofuel can simply be understood. It is the fuel that comes from biomass, organic matters of bio-organisms (plants) etc. (Coyle 2007). The earlier version of biofuel is known as first generation biofuel. A first generation biofuel is an agro-fuel created from crops conventionally projected for food production. It is more proficient in terms of greenhouse gas (GHG) emission which is considered as a major component of global warming. It can be a very effective source of energy for medium or long-term development planning. Countries like Brazil, Argentina, Colombia, Mexico, and United States have used biofuel with a view to reduce GHG emission. Almost 90% of the global bioethanol was produced by US, Brazil, and Europe. Applying agricultural techniques and strategies appropriate treatment, biofuels can provide

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emission savings of at least 50% compared to fossil fuels such as diesel or gasoline (Aguiler *et al*. 2011).

However, there is a major disadvantage which hinders further development of first generation biofuel. Most of them bear a high social cost (Aguilar *et al*. 2011). The increase in the food price, which emerged in 2008, was the outcome for giving more attention towards biofuel. To tackle the situation scientists have come up with a new variation of biofuel which is known as the second generation. The key difference between first and second generation biofuels is in their feedstock. Unlike first generation biofuel, second generation biofuel does not create any contradiction with food supplies, as it's generated from non-food crops. Also, it emits less GHG than first generation biofuels. It can be a very good source of energy for developing countries for upcoming decades because of its characteristics.

It is said that the desired level of access to energy shapes the destiny of a particular nation (Alam *et al*. 2011). It means the technological, socio-economic development highly depends on energy input. Bangladesh is an emerging developing country. The current energy requirement is taken care of by different types of fossil fuel, natural gas, coal etc. and is also dependent on imports, making the economy vulnerable to any shocks coming from the international market. Bangladesh imports about 1.3 million tons of crude oil, 1.45 million tons diesel, 380 tons kerosene, 215 tons jet fuel and 155,000 tons petrol and octane. (Wakil *et al*. 2012). After the oil shock of 1972 Bangladesh wanted to reduce import bill. As a result, the government of Bangladesh switched natural gas as a front line energy source (Amin, Ferdaus & Porna 2012). In 2012 Bangladesh extracted about 772 million cubic feet natural gas and the whole amount was consumed by internal markets. According to Petro Bangla (2015). Recent reserve estimation, current gas production and consumption rates and future demand suggest that known recoverable reserves of gas will not be able to cater the growing needs of the country. Gas reserves are expected to last till 2031. With this prediction, it can be said that Bangladesh is on the critical stage or threshold level.

Second generation biofuels can be a key factor in the further development of Bangladesh as it can ensure Energy security as well as can protect environmental degradation. Several studies such as (Saifullah, Karim & Karim 2016), (Nahar 2013) (Nahar & Sunny 2013), (Muhit, Baidya & Nahid 2014) have shown the geographical structure of Bangladesh is a suitable production site for second generation biofuel feedstocks such as Jatropha, Castor, Bahera, Karanj, Neem, Cotton seed, Aquatic plants (i.e. duckweed) etc.

There is no doubt that first generation biofuels have very little ability to achieve oil-product substitution. Their sustainability is under review because of the clash with the food supply. Overall impacts have increased the interest in developing a new fuel. Indeed there are challenges in developing the next generation/second-generation biofuels. A Proper examination of the cost of production, policies is needed before large-scale commercial production. However, no studies have been conducted in Bangladesh regarding the creation of a sustainable market, on which second generation biofuels make its entry into the economy of Bangladesh.

Case studies are an important tool for research as it often tends to critically examine situations that may not be a part of other empirical research methods. In this paper, the problems of

renewable energy have been focused upon specifically. This kind of analytical exercise can provide a very detailed information about a particular subject which otherwise would not be possible to acquire through a different type of experimentation. In this case, if the problems regarding different aspects of renewable energy in Bangladesh can be identified, it would be helpful for future references and can also be used to propose efficient policies. The potential benefits (which may include economic, socioeconomic or environmental benefits of renewable energy) need to be discovered so that it can be utilized to compare the costs and benefits. This would further assist the policymakers to estimate the net social gains from using the renewable energy. Since case study research brings the reader to a better and deeper understanding of an existing issue which is already somewhat known through previous studies, the concept of hypothesis testing is irrelevant here.

This paper would be discussing the market development of biofuels and the market feasibility for the second generation biofuel as a research question. The market for second generation biofuels can play a very big role in dissolving the mono-fuel dependency in Bangladesh as the nation is highly dependent on natural gas.

This paper has following structure. Section 2 will discuss some of the literature. Section 3 gives an overview of biofuel. Section 4 shades light on the biofuel energy scenario in Bangladesh. Section 5 discusses the prospects of second/next generation biofuels in Bangladesh. Section 6 will shade light on the main findings. Section 7 will provide conclusion and section 8 will show the reference.

2. Literature Review

According to Etim (2012), biofuels are biodegradable which produces less CO2 and NOx compared to other fossil fuels such as different kinds of petroleum. Hence, it is a great source of energy to protect the environment. On the other hand, overuse or exploitation of fossil fuels is characterized as unsustainable. Energy is the most crucial component of growth and development for any developing economy (Carriquiry *et al*. 2011).

For the upcoming decades, advanced/next generation/second generation biofuels can be a great tool for the policymakers of developing and developed countries around the world. In the near future, this sector will become one of the competitive sectors. These fuels are renewable as well as meet the demand of SDG7 goals. There should be a good market for the advanced/next generation/ second generation biofuels so that trading can be done domestically and internationally (Valles 2016).

Second generation biofuels can alleviate the energy crisis without harming the food supply, which is a great advantage over the first generation biofuels (Nahar & Sunny 2013) To reduce the cost of production, it is essential to look for the less costly feedstock. Jatropha is a great example. It is a stress tolerant plant and can be grown in tough conditions. More research has to be done to develop the optimal way to produce biofuels commercially (Nahar 2011). However, commercial viability needs to be assessed.

Before implementing a policy, policymakers have to think about various variables. Such as technological, social, environmental, economic and many more should be considered. In the first decade of the millennium, increase in the biofuel consumption was observed. As a result, policies were implemented which has driven the production of first generation biofuels. Although first generation biofuels emit less GHG, it came up with a negative impact on food supply. Furthermore, some of the fuel types are not economically viable. Thus, different models are created to solve this problem so that new policies can be taken (Janda, Kristoufek & Zilberman 2012).

Biodiesel actually gives parallel energy performance just like normal diesel in diesel engines (Ferdous *et al*. 2013). However, the difference between biodiesel and diesel is that former fuel emits less CO2, Sox, and different hydrocarbons at the time of combustion. Bangladesh has a good number of edible and non-edible feedstock for producing biodiesel (Ferdous *et al*. 2012). The non-edible feedstocks or in another way first generation feedstocks are not optimal to produce in Bangladesh because these sources need cultivation land which can create a negative impact on food supply (Muhit, Baidya & Nahid 2014). Bangladesh has about 47750 km of road and railway side arid lands which can be used for producing non-edible feedstock. (Saifullah, Karim & Karim 2016). The marginalized lands can also be used.

According to Eisentraut (2010), the first generation biofuel such as sugarcane ethanol will have an inadequate role to play as a transport fuel in the near future. Due to various limitations and non-economic viability raised the urge to search for a new variant of biofuel. It is the so-called second generation or next generation biofuel. Its feedstock and production technique makes it far more efficient than earlier versions of biofuel. It can be a very good source of energy for promoting rural development and job creation for emerging developing countries. However, this fuel can create an unstable economic situation if social standards are not taken into account. Hence, the framework for the market has to be done very carefully. Furthermore, the second generation biofuel requires more sophisticated processing equipment, more investment per unit of production, and larger scale facilities, in order to capture capital-cost scale economies than the first generation.

According to Chisti (2015), Energy has played an important role in the human race and economic development. In the 21st century, global demand for energy is increasing day by day as the growth of population and economic activities are increasing at an exponential rate, but supply side remains sticky. There are different kinds of varieties of energy. Such as, one can get energy from fossil fuels (for example, diesel), natural gas, nuclear energy, renewable energy etc. In renewable energy (RES) circle bioenergy is the oldest source. Almost 10% of the total RES is bioenergy. Among those, biofuel is one of the most rated sources at present because of its characteristics. It is sustainable and environmentally friendly (Bilgili *et al*. 2015). However, commercial feasibility needs to be analyzed.

At present, the world is facing a double challenge from the energy sector. First of all, there is a big absence of energy source which can provide an adequate level of energy to the world and will not affect the environment. Secondly, the emergence of vulnerability in this sector due to pricing problem and geopolitical agendas. Hence, advanced biofuels can be a great source of energy for the world in the upcoming decades (Kousksou *et al*. 2015).

According to the Izmir's case study on second-generation bioethanol, production from water hyacinth and duckweed is now essential as Turkey does not have enough petroleum reserve to be used as transportation oil and further extraction and uses of fossil fuel may lead to the destruction of biodiversity. Thus, an alternative energy that is renewable and sustainable (i.e. biomass, which is cheap and available) has become countries best option. Bioethanol has become popular than gasoline as it is clean and safe to use. The second generation biofuel use has solved the problem of raw materials available for the biofuel production (Bayrakci & Kocar 2014).

3. Biofuel: An Overview

The market for second generation biofuel is driven by the need to produce sustainable, affordable and clean energy with a minimal level of environmental impact (SDG7). It avoids the 'food vs. fuel' debate. Although some types of second generation biofuel are already in production, the large-scale commercialization is yet to be achieved until 2020. This needs government support.

North America is the largest producer of 2nd generation biofuel followed by Europe. Asia-Pacific is catching up with a few Chinese and Indian companies. Global laws to encourage clean energy is expected to advance this market. The US Energy Independence and Security Act (EISA) of 2010 guaranteed a market for advanced biofuel. The market will be 21 million gallons by 2020, of which 16 billion gallons are reserved for cellulosic biofuel. According to EISA regulation, cellulosic biofuel will be worth 2.5 times higher than corn ethanol (first generation biofuel). Financial incentives for producing, harvesting, storing, and transporting the residues to biorefineries will be provided. According to international energy agency, these 2nd-generation biofuels are relatively immature so they should have good potential for cost reductions and increased production efficiency levels as more experience is gained.

One of the key factors for turning all focus towards the development of second generation biofuels is CO2 emission. "In 2010 total consumption of fossil fuels in road passenger transport in EU-15 was about 6000 PJ. Total Corresponding CO2 emissions were about 520 Mill. tons CO2-eq" (Ajanovic *et al.* 2012). An estimate shows that by 2050 the number of emissions will reduce by 25% if the biofuel policies are properly administered. However, the cost of production is a question that still remains in Europe. Through an increase in different types of taxes governments can initially subsidize the market. Hence, second generation biofuels can be competitive between 2030. Three main aims are taken by Europe as follows,

1. Learning by doing. This will lead to considerably lower plant costs.
2. Improvement of conversion efficiency from feedstock to fuel.
3. The increase in the diesel and gasoline prices.

Only in Brazil, there is a well-developed market for biofuels (Aguiler *et al*. 2011). This market is actually based on ethanol fuels which are also known as first generation biofuels. Brazil is trying to develop an industry for second generation biofuels from present infrastructures (such as sugar mill) and feedstock. Most interesting fact is that some of the Brazil's sugar mills can produce lignocellulose material with a simple upgrade. These mills are basically the ones which are

outdated and inefficient in sugar production. It surely will lower the cost of production in some sense. If these mills are put in action with the new complex upgraded ones, it is estimated that by 2025 Brazil will be producing almost 5 million liters of second generation biofuel. At present Brazil's main concerns is not the internal consumption but to export biofuel to USA and Europe because there is a huge rise in demand for second generation biofuels in the USA and Europe. In line with it, the Indian government came up with a policy aiming at mainstreaming biofuel based on non-food feedstock to be raised on degraded or wastelands that are not suited to agriculture thus avoiding a possible conflict between fuel and food security. On the other hand, the market of Turkey is still in developing phase, but the progress is impressive. Water hyacinth and duckweed are useful for wastewater treatment. Also, the production of second-generation bioethanol from these plants is proper due to their cellulose ratios and carbohydrate potentials. Beside these major countries, there are some other countries which are trying to develop a sustainable market for second generation biofuels such as Colombia. The main reason for this country to produce biofuel is to promote energy security, minimize the destructive waves of global warming and rural development. Colombia started to find out the efficient feedstock. After many pilot studies, they found castor as the best and efficient feedstock. Now they are trying to develop a market structure.

4. Biofuel (Second generation) Energy Scenario in Bangladesh

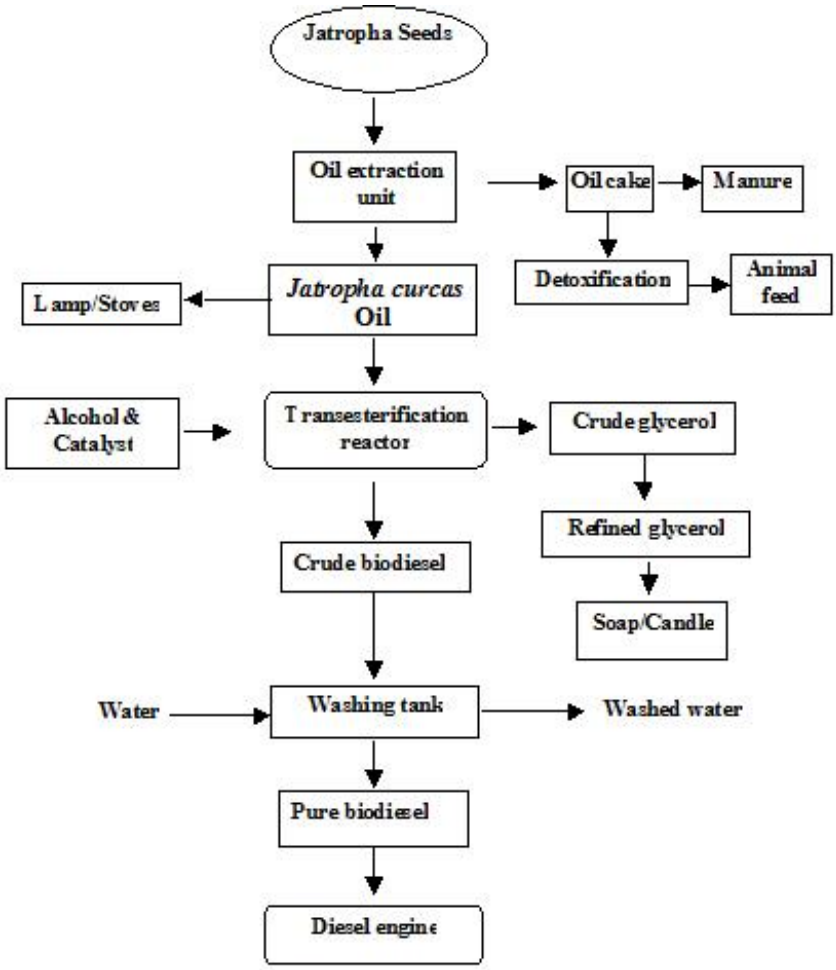
The government of Bangladesh is giving its best effort to develop the indigenous resources of energy. Energy consumption in Bangladesh is relatively lower than any peer developing countries of South Asia. In 2012 energy consumption was only about 0.20% of world's consumption. However, the growth rate of energy usage climbed at a very faster rate than other neighboring countries. Almost 5% per annum. Till 2008 Bangladesh was known as a mono-fuel dependent country (almost 62% of total energy). Hydropower and coal based energy consumptions are 2.5% each (BPDB 2015). The government of Bangladesh decided to take up a pilot project to assess the feasibility of producing biodiesel from Jamalgota. Private sector enthusiasts are also taking initiative for small and medium block-plantations of inedible oil-seed bearing trees to develop feedstock inventory. Research activities on plantation, harvesting, oil extraction, transesterification, and blending undertaken by academic and research institutions at this beginning stage will go a long way in contributing to the course of renewable fuel and energy in Bangladesh.

To foster the development of biofuel industry in Bangladesh, the government must play important role in order to adapt to the technologies for its own benefits but raises the issue of technology transfer. Bearing in mind both sustainable and environmental protection, second generation biofuel is imperative for Bangladesh. However, in spite of this valuable studies, projects no proper actions were taken for large scale R&D programs, commercial stage production and development of market either by the government or by other development-related organizations. Hence, in short, it can be said that development process for next generation biofuels in terms of market structure has not yet seen any light in Bangladesh.

5. Prospects for Biofuel Energy in Bangladesh

Among the feedstock mentioned above Jatropha (*Jatropha curcas*), Castor (*Ricinus communis*) in great numbers in this equatorial tropical climate. A mature seed is of 2.3cm and nearly 33% of can be obtained by crushing this seed. In five years a Jatropha tree can yield 10 to 15 kg seeds and with better nurture, 60% of the oil can be produced from the seeds.

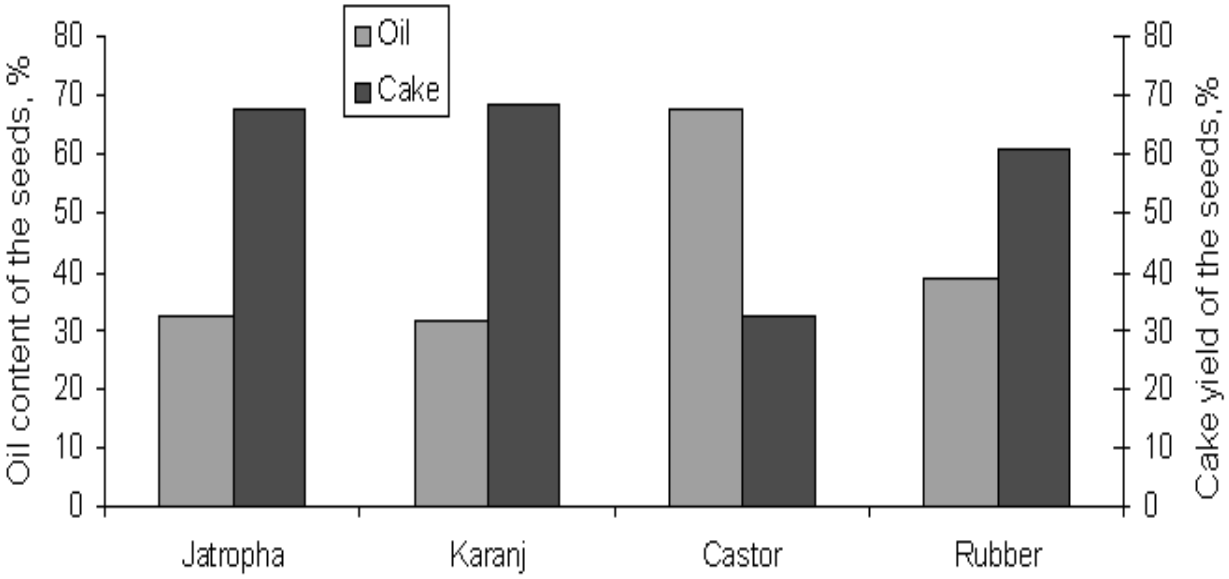
Figure 1: Production flow chart of second generation biofuel from Jatropha



At present one-liter oil of Jatropha cost $1.50 and the cultivation cost varies according to the seeds. The biodiesel made out of Jatropha will be environment-friendly as it is carbon neutral the usage of the diesel does not emit toxic fumes. Castor grows almost everywhere in Bangladesh. It can grow in stony, sandy and saline lands. Castor seeds contain 67.7% oil. Castor plant can live for many years. It can produce a huge amount of seeds every year. (Saifullah, Karim & Karim 2016). Total 36 liters of castor oil can be obtained from 100kgs of castor seed. At present, the castor oil price is $3.21 per liter which is higher than the price of Jatropha oil per liter (Shrirame & Panwar 2011).

Other than these two plants there are other plants which can be used as feedstock. Such as Bahera. Its seed contains about 30% by mass. Neem is available in Bangladesh and also regarded as a medical plant. Its seed contains 45% oil (Saifullah Karim & Karim 2016). According to Haque *et al*. (2009), Karanj has the potentiality for becoming the feedstock biodiesel and can reduce imported petroleum oil by 28%.Oil content of Karanja is 31.8% (Haque *et al*. 2009). Massive cultivation can be done in the southwestern or northern part of Bangladesh. Another huge potential plant is rubber plant. Seeds of rubber plant contain almost 38.9% oil.

Figure 2: Oil content and cake yield of seeds.



Source: Haque *et al*. 2009

Duckweed (*Landoltia punctata*) can be utilized to produce ethanol, butanol, and biogas, which are promising alternative energy sources to minimize dependence on limited crude oil and natural gas (Miranda *et al*. 2014).The advantages of this aquatic plant include high rate of nutrient (nitrogen and phosphorus) uptake, high biomass yield and great potential as an alternative feedstock for the production of fuel ethanol, butanol and biogas. Duckweed is widely available in Bangladesh, and under ideal conditions, its biomass gets doubled in 24 hours. Duckweed acts as an excellent biofilter to treat domestic wastewater. Fresh biomass of duckweed produced via domestic wastewater treatment plant and Duckweeds can tolerate a wide range of pH, somewhere between 4.5 and 7.5 with temperatures between 20 and 300C. Crude glycerin is one of the byproducts when biofuel is produced (about 10 to 15% of total production). Different types of market exist for glycerin in Bangladesh (Wakil et al. 2012). Refined glycerin is just as environmentally friendly as biofuel but crude glycerin is not environmental friendly at all. Thus, it has to be refined first. If biofuel producers can sell this to different existing markets then their revenue will increase. One of the large markets for glycerin is soap industry. Other known industries are poultry, pharmaceuticals, different chemical industries etc.

6. Main Findings

From the discussion, it can be clearly stated that the second/next generation biofuel in terms of commercial production is still in the developing stage. Most of the nations are trying to find a way for a low-cost production system which can be competitive as well. In this case, Brazil is ahead of all. Brazil is using their past knowledge with full precision to develop an effective market system. Some countries in Europe are trying a framework of tax on carbon-based fuels and transport vehicles to promote biofuel.

In Bangladesh, there are several feedstocks which can be used for the production of biofuel. Among those, Jatropha, and Castor are most popular according to the different studies. Oil content in castor is higher than Jatropha and Jatropha has the potential of yielding 67.7% of biocake, whereas, Castor can only yield up to 32.3%. By using both feedstocks, Bangladesh can produce biofuel which can be used in transport sector or in different industries and biomass cake can be used as cooking input in rural areas. Moreover, the glycerin is the byproduct of the production. Crude glycerin is not good for the environment so it has to be refined before anyone can use it as an input. Duckweed can be a very good feedstock in the context of Bangladesh. However negative impact may arise in poultry or fish industry (Kabir, Hossain & Rahman 2009). In Bangladesh problem can arise in the commercial production of biofuel due to the bad transportation system. If Bangladesh wants to export biofuel to certain OECD countries, certification will be required. However, certification for developing or emerging countries is more costly. The success of second/next generation biofuels can only be possible if the government can come up with a proper policy and regulatory authority which will be independent. With regard to addressing the research question on the market feasibility, the discussion indicates that Bangladesh has the suitable climate to grow the desired plants for commercial production of second-generation biofuel. However, this idea is still fresh and needs extensive R&D to access the potential market barriers.

7. Conclusion

The main findings of this paper are mostly in line with the findings of previous studies conducted in other developing countries. Due to its climate and geographical location, Bangladesh is a suitable country to grow Jatropha and Caster seed as well as different aquatic plants like duckweed for biofuel production. However, problem can arise due to bad transportation, certification, and low public awareness. Similar to other countries, Bangladesh has to develop an alternative energy source market, and second generation biofuel can be an excellent option for future energy security. Case studies are a marketing staple. This case study provides a way forward to more advanced research regarding this issue. Proper analysis can further create a deeper understanding of investment in the market for biofuel.

As it is mentioned in the beginning that energy has become an important limiting factor for modern economies. Therefore, energy can be a very good instrument to achieve the middle-income tag for Bangladesh. It not only helps to grow the economy but also is a prudential element for socio-economic development. However, the expansion of the economy, as well as socio-economic development, should not be achieved at the expense of environmental degradation such as climate change, an excessive amount of carbon emission etc. Thus,

introducing a new market for a sustainable energy source like biofuel is highly needed. One of the major limitations faced was the lack of credible data as the idea of market formation of new energy source is totally new in the context of Bangladesh.

Introducing a market for a new energy source is not an easy task but proper dedication and planning can create market structure. It is showed in this paper that, different countries around the world are trying to develop the market. The government should collaborate with private organizations for large-scale research and development program as Brazil is doing. Different universities across the country should be encouraged to conduct research in this sector. Sustainable Energy Development Authority (SREDA) should take initiatives to promote next generation biofuels as it was very successful in its promotion of different renewable energies in Bangladesh. SREDA can also help the government to lead the path for proper market development as well as for policy implementations. Even as the further scope of research, for third generation biofuels, Bangladesh can develop active research and development institutes to create a platform for utilizing the scopes for algae biodiesel.

References

Amin, SB, Ferdaus, SS & Porna, AK 2012, 'Causal relationship among energy use, CO2 emissions and economic growth in Bangladesh: An empirical study', *World Journal of Social Sciences*, vol.2, no.4, pp. 271-283.

Alam, MJ, Begum, IA, Buysse, J, Rahman, S & Huylenbroeck, GV 2011, 'Dynamic modeling of causal relationship between energy consumption, CO2 emissions and economic growth in India', *Renewable and Sustainable Energy Review,* vol.15, pp. 3243-3251.

Ajanovic, A, Jungmeier, G, Beermann, M & Hass, R 2012, 'Long term prospects of biofuel in EU-15 countries', *Energy Research, Engineering and Policy Journal,* vol.5, no.8, pp. 3110-3125.

Aguiler, LB, Campos, HM, Leyva, IR, Gutierrez, HL & Esquivel, RS 2011, 'Global social and economic impact on the use of biofuel and recommendation for sustainability', *Global Journal of Research in Engineering Automotive Engineering*, vol.11, no.5.

Bayrakci, AG & Koçar, G 2014, 'Second-generation bioethanol production from water hyacinth and duckweed in Izmir: A case study', *Renewable and Sustainable Energy Reviews,* vol.30, pp.306–316.

Bilgili, M, Ozbek, A, Sahin, B & Kahraman, K 2015, 'An overview of renewable electric power capacity progress in new technologies in the world', *Renewable and Sustainable Energy reviews,* vol.49, pp.323-334.

Coyle, W 2007. The future of biofuels- a global perspective, online available on 16/09/2008:http://www.ers.usda.gov/AmberWaves/November07/Features/Biofuels.htm

Bangladesh Power Development Board (BPDB), 2015, *Annual Report 2015-16*, Bangladesh, Power Development Board, Dhaka.

Chisti, Y 2015, 'Biodiesel from microalgae beats bioethanol', *Trends in Biotechnology*, vol.26, pp. 126-131.

Carriquiry, Miguel, A, Du, X & Timilsina, GR 2011, 'Second generation biofuels: Economics and policies', *Energy Policy* vol.39, no.7, pp. 4222-4234.

Eisentraut 2010, *Sustainable production of second generation biofuel*, International Energy Agency, Paris, France.

Etim, E 2012, 'The prospects of biofuels in complementing the Nigeria's energy needs', *International Journal of Environment and Bioenergy,* vol.4, no.2, pp. 74-85.

Ferdous, K, Uddin, MR, Islam, R, Khan, MR & Islam, MA 2012, 'Potentiality of biodiesel production from non-edible oil: Bangladesh perspective', *Journal of Chemical Engineering*, IEB, vol.27, no.2.

Ferdous, K, Uddin, MR, Islam, R, Khan, MR & Islam, MA 2013, 'Preparation of biodiesel from soybean oil by using heterogeneous catalyst'*. International Journal of Energy and Environment*, vol.4, no.2, pp. 243-252.

Haque, MA, Ismail, MP, Hussain, MD & Khan, F 2009, 'Physical, mechanical properties and oil content of selected Indigenous seeds available for biodiesel production in Bangladesh', *Agricultural Engineering International: the CIGR Ejournal.* Manuscript 1419, Vol. XI

Janda, K, Kristoufek, L & Zilberman, D 2012, 'Biofuels: Policies and impacts', *AGRIC. ECON. CZECH*, vol.*58*, no.8, pp. 372–386.

Kabir, ANMA, Hossain, MA & Rahman, MS 2009, 'Use of duckweed as feed for fishes in poultry culture', *Journal of Agriculture and Rural Development,* vol.7,no.1&2, pp.157-160.

Kousksou, T, Allouhi, A, Belattar, M, Jamil, A, Rhafiki, TE, Arid, A & Zeraouli, Y 2015, 'Renewable energy potential and national policy directions for sustainable development in Morocco', *Renewable and Sustainable Energy reviews,* vol.47, pp. 46-47.

Miranda, AF, Muradov, N, Gujar, A, Stevenson, T, Nugegoda, D, Ball, AS & Muradov, A 2014, 'Application of aquatic plants for the treatment of selenium-rich mining. Wastewater and production of renewable Fuels and petrochemicals', *Journal of Sustainable Bioenergy Systems*, vol.4, pp. 97-112.

Muhit, IB, Baidya, D & Nahid, N 2014. 'Prospect of agro biodiesel in Bangladesh: Overview From developed countries', *Journal of Mechanical and Civil Engineering*, vol.11, no.1, pp. 49-54.

Nahar, K & Sunny, SA 2011, 'Extraction of biodiesel from a second generation energy crop (Jatropha curcas L.) by transesterification process', *Journal of Environmental Science and Technology*, vol.4, no.5, pp. 498-503.

Nahar, K 2013, 'Castor Bean (Ricinuscommunis L.) - A biofuel plant: Morphological and physiological parameters propagated from seeds in Bangladesh', *Asian Business Review,* vol.4

Petro Bangla, 2015, Annual *Report 2015*, Bangladesh, Petrobangla, Dhaka.

Sheridan, C 2007. 'Big oil‟s biomass play', *Nature Biotechnology*, vol.25, pp. 1201-1203.

Shrirame, HY, Panwar, NL & Bamniya, BR 2011. 'Biodiesel from castor oil-A green energy Option'. doi:10.423/Ice.2011.21001.

Saifullah, AZA, Karim, MA & Karim, MR 2016, *'*Advancement of biodiesel in Bangladesh', *IOSR Journal of Engineering (IOSRJEN), vol* 6, no.6, pp. 59-64.

Valles, G 2016, *Second generation biofuel market: State of play, trade and developing country perspectives*, United Nation publication, New York.

Wakil, MA, Ahmed, ZU, Rahman, MH & Arifuzzan, M 2012, 'Sudy on fuel properties of various vegetable oil available in Bangladesh and biodiesel production', *International Journal of Mechanical Engineering,* vol.2, no.5, pp. 2277-7059.