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A Review on Generation of Liquid Bio-Fuels from Renewable Resources for Energy Security of India

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Abstract: Economic growth is always in need for any developing country, and demand of energy will also be always there for economic growth. Out of total energy consumption of India, oil consumption is 36 per cent. Today, India ranks amongst top ten nations in the world for oil consumption. Transport sector contributes to almost 24% of commercial energy consuming sectors.

The main objective behind energy security for India is to become self-sufficient in energy sources. This calls for diversification of sources of oil imports.

In India, Bio-fuels are gradually coming as major factor as the most important energy sources in sustainability and helps in restricting the greenhouse gas emissions. This review article gives an overview of different techniques and processes for liquid bio-fuels from renewable resources which strengthen India's energy security.

Keywords: Bio-Fuels, Bio-Ethanol, Bio-Methanol, Bio-Diesel and Bio-Gas

Introduction

This article is a literature review on the subject as there is a need to search alternate fuel due to quick vanishing fuel and reserves of oil in our country and gradually issues related to environmental connected with the use of petroleum products.

Bio-fuels are renewable and fewer pollution making fuels that takes attention in recent years, amongst them preferred being bio-methanol and bio-ethanol which are created from crop grains or sugarcane and bio-diesel that is created from vegetable oils and animals fats. In 1897, a German engineer, Rudolf Diesel prepared his engine which was run by using peanut oil at a Paris exhibition and also Henry Ford, an automobile manufacturer designed his equipment to run on ethanol (Paula-Bianca MARICA, 2009)

The most popular sources of the biofuels are as follows:

Cellulose, Algal oil, Corn, Soybeans, Sugar cane, Jatropha and Camelina, Rapeseed, Methane, Animal fats, Paper waste and Bio-mass.

Researchers' interest in bio-mass based fuels is increasing because logically at present it is the best option available. Bio-fuel resources as renewable sources are applied in majority of the countries as wastes and biomass residuals of agriculture and by means of processes available; this can be transformed into liquid form of bio-fuels. Chemical transformation process could be expensive which requires need for further study wherein process is economical and result oriented.

Literature Review

Search for Environmental Friendly Energy Resource

Transport sector has a consumption of 58% in the share of fossil fuels (Escobar JC *et al.*, 2009). As years pass, fossil fuel sources are gradually dimishing and to meet energy demand, GHG or Green House Gas emissions also increase (Zhao R., 2009; Singh A. *et al.*, 2010; Prasad S. *et al.*, 2009). Due to such emissions, many adverse effects also increase such as receding of glaciers, climate change as a whole, loss of biodiversity (Gullison R.E. *et al.*, 2007). Due to rise in the demand of energy, increasing cost of crude oil has played negative role economically at world level directly (He Y *et al.*, 2010). Gradual reduction of fossil fuels with ever-rising use of energy consumption and emissions of GHG indicated to go ahead to alternative, renewable but sustainable, efficient and economical energy sources (Singh A *et al.*, 2010; Prasad S. *et al.*, 2009; Singh A., Smyth B.M. *et al.*, 2010; Prasad S, Singh A *et al.*, 2010). Amongst energy alternatives, natural gas, syngas (synthesis gas), bio-fuels and hydrogen may come out as the precious fuel sources with sustainability in coming years. Amongst these four, bio-fuels are energy resources which are highly environment friendly. Bio-fuels are preferred as they are renewable, degradable and generate exhaust gases within desired limits (Bhatti HN *et al.*, 2008).

Bio-Mass as Renewable Source for Generation of Bio-Energy

The incorporation of agro-energy crops and bio-refinery industrialized technologies offers the potential for the growth of sustainable bio-power and bio-materials that will also lead to a new developed paradigm.

Bio-Fuels

Bio-fuels generated from bio-mass are answer to a fuel with sustainability. From bio-mass, variety of fuels such as Fischer-Tropsch diesel, bio-diesel, ethanol, methanol, methane and hydrogen can be produced (Demirbas A, 2008).

Classification of Bio-Fuels

Bio-fuels are mainly of two types: primary and secondary. Primary bio-fuels are generally used in the form which is not processed, mainly for electricity production, cooking, heating such as fuel wood and their chips etc. The secondary bio-fuels are generated by means of biomass process e.g. DME, bio-diesel, ethanol etc. which are applied in many industrial processes and vehicles. The secondary bio-fuels are divided into first, second and third generation bio-fuels on their production. Bio-fuels are also classified according to their type and source. Bio-fuels can be solid, such as fuel charcoal, wood and pellets made from wood; or liquid, such as bio-diesel, ethanol.

Main benefit of the utilization of renewable sources for the generation of bio-fuels is the consumption of natural bio-resources and produced bio-energy gives security and independence of energy availability. Bio-fuels produced from lingo cellulosic materials produce low GHG emissions resulting into reduction of effects related to environment.

In a report of United States Department of Agriculture (USDA) (United States Department of Agriculture, 2003) advantages of bio-diesel are: it is suitable substitute for diesel derived from petroleum, renewable, easy for use in engines running on diesel with negligible or very little modification. With little amount of biodegradability or toxicity it is made from recycled sources or agricultural sources. Low flash point is very important and bio-diesel has that quality better than diesel produced from petroleum products. It is very easy and safe in transportation sector (Demirbas A, 2009; Bajpai D *et al.*, 2006). Latest familiar categorization on liquid bio-fuels also covers "First-Generation" and "Second-Generation" bio-fuels (Larson ED, 2008).

Bio-fuels technology can be categorized into groups depending on the feed used for manufacture and the technology use to change that feedstock into fuel: first generation and second generation of bio-fuels. (G.R. Timilsina *et al.*, 2009)

a. Technology which generally make use of the sugar or starch part of plants as feed to create ethanol and those utilize crops of oil seeds to produce bio-diesel are known as first generation of bio-fuels.

b. Second generation of bio-fuels are produced using technologies that convert agricultural and forest residues, also bio-fuels produced from advanced feed like Jatropha and micro-algae. (A.L. Smith *et al.*, 2013; P. Singh Nigam *et al.*, 2011)

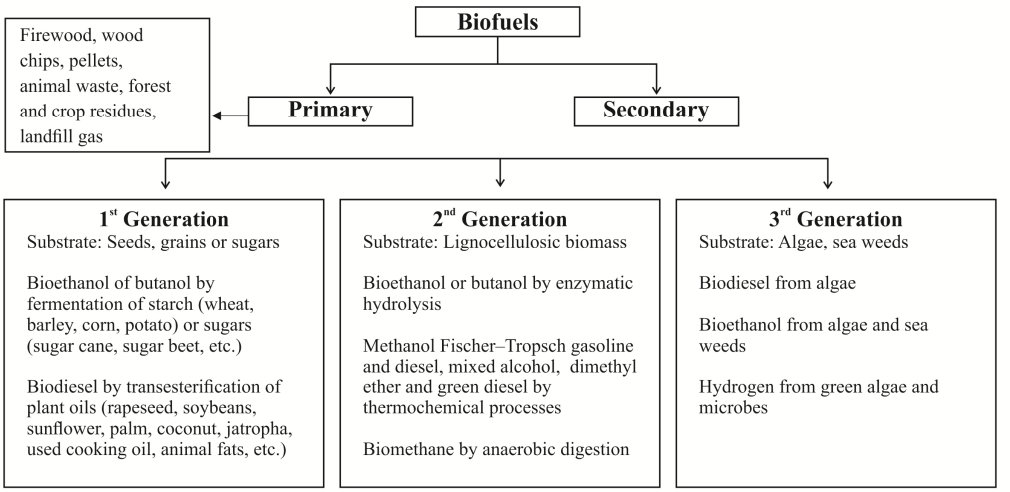

Fig. 1: Categorization of Bio-Fuels based on Technology (A.L. Smith, 2013)

First Generation of Liquid Bio-Fuels

Sugars used to produce liquid bio-fuels (Love G *et al.*, 1998; Nigam P *et al.*, 1997; Brady D *et al.*, 1997; Riordon C *et al.*, 1997; Banat IM *et al.*, 1992), grains or seeds (Zhao R *et al.*, 2009; Gibbons WR *et al.*, 1989; Suresh K *et al.*, 1999; Turhollow AF, Heady EO, 1986) are called as the

first generation liquid bio-fuels. The most recognized first generation bio-fuel is ethanol which is made from fermentation of sugar extract from plants of crop and starch provided with maize kernels or supplementary starchy crops (Larson ED, 2008). Generally, hydrolysis is used for changing or transforming the starch into glucose when grains are used as raw materials (International Energy Agency, 2004). The usual processes used the germs found in the seeds only or grains in ethanol manufacture which is a lesser amount of the total mass of the plant, producing a considerable quantity of residue (Escobar JC *et al.*, 2009).

Second Generation Liquid Bio-Fuels

There are two fundamentally different approaches by which second generation liquid bio-fuels are usually formed i.e. biological or thermo-chemical processing from agricultural ligno-cellulosic bio-mass, which is either non-edible whole plant bio-mass or non-edible residues of food crop production (e.g. grasses or trees planted for energy requirement). As stated by Larson (Larson ED, 2008) it is understood that the fundamental characteristics of feed stocks has prospective for lesser price, and important environmental and energy advantages will be there for the greater part of second generation bio-fuels. Second generation bio-fuels contribute to the characteristic of being created from ligno-cellulosic bio-mass, facilitating in the utilization of non-edible feed stocks of low cost resultant as a boundary among direct food and fuel struggle (Barron N *et al.*, 1996)

A small number of second generation bio-fuels like butanol and ethanol are generated from manufacturing process of bio-chemical and other than these fuels which are generated thermo-chemically are of second generation bio-fuels. Certain vital characteristics differentiate thermo-chemical process from bio-chemical process, including the easiness in feedstock which is easily adjusted with thermo-chemical process and the range of fuel product which is generated (Farias FEM *et al.*, 2007).

Third Generation Liquid Bio-Fuels

Bio-Ethanol

Now-a-days alcohol is made from wheat, sugar cane, corn, bio-mass, molasses, etc. Yeast is employed to ferment sugar into alcohol. The step of sugars obtained from carbohydrate was required earlier. Presently, the alcohol of corn trade is applied for a dry milling or a wet milling method (A. Demirbas, 2009, 2011; Energy Conversion and Management, 2009).

Ethanol is the great alternative of the gasoline. So many countries are using ethanol as the replacement of gasoline. Brazil uses ethanol 25% as fuel of their entire fuel consumption. India has large barren places which can be utilized to reach somewhat amount of demand (Energy Conversion and Management, 2009; Ayhan Demirbas, 2008). Ethanol has own good characteristics as a fuel such as it emits less pollutant than the gasoline, and reduces the knocking of the engine as it boosts octane.

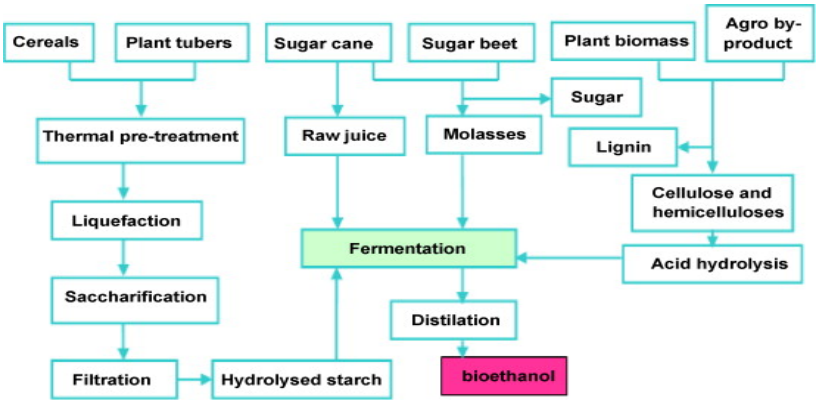

Fig. 2: The Detail Flow Sheet for Production of Bio-Ethanol (G. Najafi *et al.*, 2009)

Bio-Methanol

Methanol which has become popular as a fuel mainly applied for transport sector is a fuel blended in diverse extent. Methyl alcohol may be made from the bio-mass. Bio-mass is taken into account because the renewable supply so bio-methanol is additionally the vital in bio-fuels. Bio-mass containing any waste like agricultural waste, domestic waste, etc. per the 2001 report by the International Energy Agency (EIA), bio-mass presently shares 10.8% of globe energy (B. Amigun *et al.*, 2010). Generation of methanol from the bio-mass is shown in the figure.

Bio-Diesel

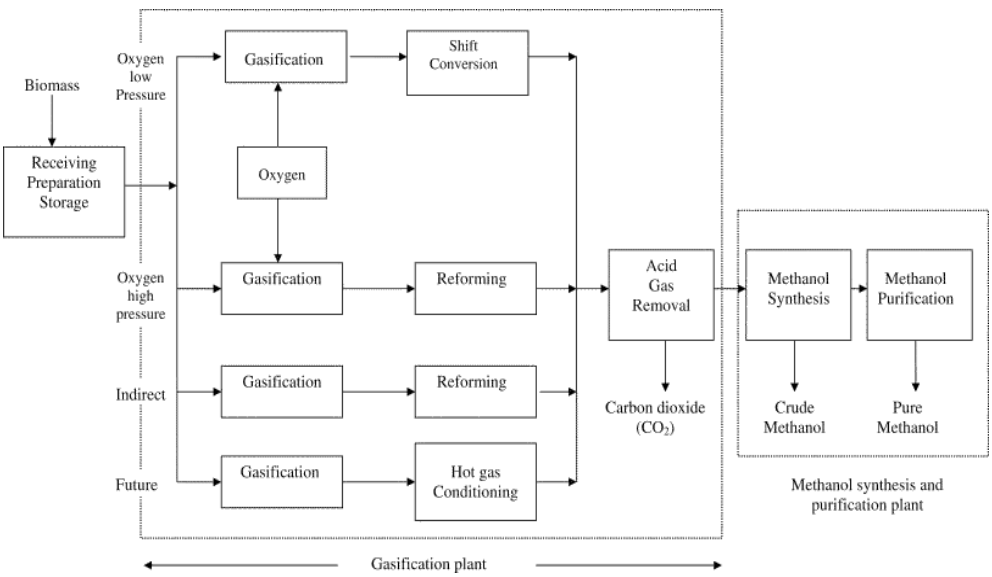

Fig. 3: Production Flow Sheet of Bio-Methanol (B. Amigun, 2010)

Bio-diesel is the direct alternative of the diesel itself. Diesel is mostly the primary fuel for the transportation sector. So, it is needed to find the alternatives for the diesel. There are so many sources for the bio-diesel production which are mostly vegetable oils such as Jatropha oil, algal oil, soybean, palm oil, Pinari tree, etc. and also from the animal fats. Bio-diesel is also manufactured from free fatty acids of these vegetable oils. The main source of bio-diesel in India is Jatropha seeds and soybeans because their production suits the Indian weather. There are some issues in production of palm oil and other options.

Table 1

Oil	FFA Content (%)
Jatropha seeds	14
Soybeans	18
Palm oil	3 to 6.5
Pinari oil	3.5 to 4

Bio-diesel is produced by the trans-esterification process. The process is very easy. Flow sheet for the production of the bio-diesel is shown in Fig. 4.

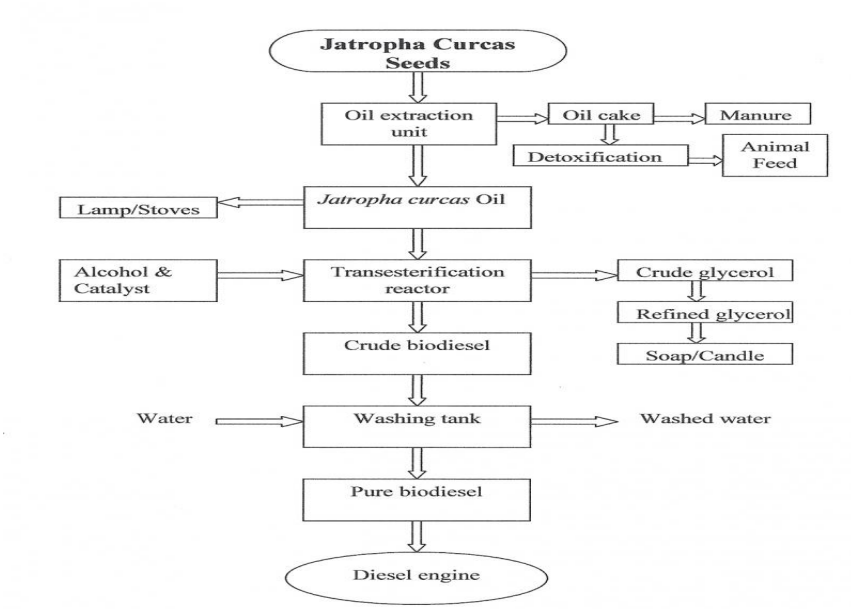

Fig. 4: Flow Sheet for the Production of the Bio-Diesel

The produced bio-diesel has good characteristics as the burning fuels. It is more viscous than the regular diesel but it is compatible with the diesel engines. Engine runs smoothly with bio-diesel and it shows less vibration and sound because of better lubricity and combustion characteristics and also gives high Cetane number compared to diesel.

Bio-Gas

Bio-gas is the alternatives for the natural gases. For the production of the bio-gas, the bio-mass is used which contain waste of agriculture, domestic waste, etc. (P. Purohit, T.-C. Kandpal, 2007; V.K. Vijay *et al.*, 1996) by the degradation of bio-mass in anaerobic condition the mixture of gases is produced in which the methane is the main component. The other components of bio-gas are ethane, propane, butane, which are used for the domestic purpose. The most popular production plant for the bio-gas is: Janata, Deenbandhu, Deenbandhu II (modified Deenbandhu) and Himshakti bio-gas plants. (R.S. Khoiyangbam *et al.*, 2004)

Energy Security and Challenges for India

Until the recent past, India was one of the marginal players in global energy. That story is quickly changing. India was, and still is, very much dependent on imports of mainly fossil energy resources. As a result, it was concerned about the macroeconomic impacts of global oil shocks. It is expected that by 2030, India's contribution in oil deal on a daily basis would be about 12.5 per cent. In 2014, it was only 7.4 per cent. India's energy demand will grow the fastest among major economies in the world. India's role in global energy in the 21st century will be almost similar to Europe's in the latter half of the 20th century.

"Energy Security" Redefined

Major economies of the world have redefined energy security based on their circumstances at national level.

The International Energy Agency desires its member countries to conceptualize energy security in the short term and long term ways. Briefly, while the desire to depend less on overseas suppliers continues, leading economies of the world have also realized that energy security and energy independence are not the same.

But at present there is no global energy organization. Global energy governance is split and often incoherent. It is a need of the hour that India should create a important platform for a global conversation reframing global energy governance and redefining energy security. For quite a few reasons:

First, the world of energy now looks very unusual from the oil crises of the 1970s.

New issues include the race for turbulence in oil markets. Arctic resources, the unsure future of gas, required transitions towards low-carbon energy, or transformed concerns over nuclear safety. Whereas diplomatic engagements on energy remains to continue, largely, on traditional narrowed definitions of energy security, discussions on these rising trends are trapped in techno-economic and scientific conversations.

Secondly, the lack of dialogue can be explained by the absence of frames, concepts and theories to understand the dynamic world of international energy.

Many discussions are conquered by the concerns of the present developed countries, not the opportunities and threats for the rising economies, which will again drive demand, generate innovation and shape patterns of energy investment and trade.

Thirdly, many international relations professionals and scholars inhabit a state-centric world even today.

The world of energy is far more complex than what it looks. A state-centric worldview looks energy security as a zero-sum game; resultant is in inefficient use of missed opportunities and resources in creating supportive frameworks for R&D related to energy, investment and commercialization.

Fourthly, many rising threats to the energy system have not been discussed much till date. These include: (i) climate risks related to energy infrastructure (water stress for many power plants, recent coastal flooding); (ii) cyber attacks on more and more integrated energy grids and systems; (iii) risks of financial fall down for established and rising energy firms (such as fossil fuels and renewable energy); and (iv) risks of limited access to critical minerals which are essential for the manufacture and operation aspects of new energy technologies.

Finally, there is lack of access to modern cooking fuels or electricity for billions of people which are hazardous to human health, on economic productivity and gender inequalities.

Discussions

Food *vs.* Fuel

Bio-fuels will be beneficial only if they are cultivated in a way keeping sustainability in mind with biodiversity and the 'food vs. fuel'" debate. One important review by Groom (Groom MJ *et al.*, 2008) focuses especially on managing the production of oil crops in environmental friendly ways. They suggest about rising bio-fuel crops with biodiversity as a focus and suggest encouragement of sustainable and mild effect feed stocks such as Karanja, Jatropha and Switchgrass, and promotion of bio-fuel crops with carbon as neutral.

Jatropha, Switchgrass and prairie grasses, oil-producing crops, can be grown-up on waste agricultural land and need low inputs for growth such as low fertilizers and can also use waste water for growth. Algae has oil content per hectare almost 200 times higher than the land which is more fertile.

Energy Security

Prominent sustainable development objective is access to inexpensive, dependable, sustainable recent energy services for all (glaringly omitted from the Millennium Development Goals). India has to find its voice, clearly talk about concerns, and navigate the intersection of important elements such as energy markets, energy transitions and energy diplomacy. It needs to visualize new ideas for global energy governance and it must drive this conversation because few others will.

Conclusion

To meet the future demands, bio-fuels should be produced at commercial level. The main drawback of production of bio-fuels is that it requires large land to produce the crop grains, Jatropha, Soybean etc; but there is a solution too. In India, 60 millions hectare lands are barren, so this can be utilized for the production of these crops. It will also help to promote agriculture sector and farmers will be major beneficiaries. Government of India also encourages by offering subsidy for it.

References

[1] Demirbas, A. (Sept, 2009). Biofuels Securing the Planet's Future Energy Needs, *Energy Conversion and Management*, 50(9), pp. 2239–2249.

[2] Smith, A.L., Klenk, N., Wood, S., Hewitt, N., Henriques, I., Yan, N. and Bazely, D.R. (Nov., 2013). Second Generation Biofuels and Bio Invasions: An Evaluation of Invasive Risks and Policy Responses in the United States and Canada, *Renewable and Sustainable Energy Reviews*, Vol. 27, pp. 30–42.

[3] Aggarwal, N.K., Nigam, P., Singh, D. and Yadav, B.S. (2001). Process Optimisation for the Production of Sugar for the Bio Ethanol Industry from Sorghum a Non Conventional Source of Starch. *World J Microbiol Biotechnol*,1, pp. 125–131.

[4] Demirbas, A. (Aug., 2008). Bio Fuels Sources, Bio Fuel Policy, Bio Fuel Economy and Global Bio Fuel Projections, *Energy Conversion and Management*, 49(8), pp. 2106–2116.

[5] Amigun, B., Gorgens, J. and Knoetze, H. (Jan., 2010). Biomethanol Production from Gasification of Non-Woody Plant in South Africa: Optimum Scale and Economic Performance, *Energy Policy*, 38(1), pp. 312–322.

[6] Banat, I.M., Nigam, P. and Marchant, R. (1992). Isolation of a Thermotolerant, Fermentative Yeasts Growing at 52C and Producing Ethanol at 45C and 50C, *World J Microbiol Biotechnol*, 8, pp. 259–263.

[7] Bhatti, H.N., Hanif, M.A., Qasim, M., Ata-ur-Rehman (2008). Biodiesel Production from Waste Tallow, *Fuel*, 87, pp. 2961–2966.

[8] Brady, D., Nigam, P., Marchant, R. and McHale, A.P. (1997). Ethanol Production at 45C by Immobilized Kluyveromyces Marxianus IMB3 during Growth on Lactose-Containing Media. *Bioproc Eng*., 16, pp. 101–104.

[9] Brady, D., Nigam, P., Marchant, R., McHale, L. and McHale, A.P. (1996). Ethanol Production at 45C by Kluyveromyces Marxianus IMB3 Immobilized in Magnetically Responsive Alginate Matrices. *Biotechnol Lett*, 18(10), pp. 1213–1216.

[10] Brady, D., Nigam, P., Marchant, R., Singh, D. and McHale A.P. (1997). The Effect of Mn2þ on Ethanol Production from Actose Using Kluyveromyces Marxianus IMB3 Immobilized in Magnetically Responsive Matrices. *Bioproc Eng*., pp. 17–31.

[11] Brennan, L. and Owende, P. (2010). Biofuels from Microalgae—a Review of Technologies for Production, Processing, and Extractions of Bio Fuels and Co-products. *Renew Sustain Energy Rev*., 14, pp. 55–77.

[12] Demirbas, A. Comparison of Trans Esterification Methods for Production of Biodiesel from Vegetable Oils and Fats. *Energy Converse Manage,* 208(49), pp. 125–130.

[13] Demirbas, A. (2009). Progress and Recent Trends in Bio Diesel Fuels. *Energy Conserve Manage*, 50, pp. 14–34.

[14] Bajpai, D. and Tyagi, V.K. (2006). Biodiesel: Source, Production, Composition, Properties and Its Benefits, *J Olio Sci.*, 55, pp. 487–502.

[15] Escobar, J.C., Lora, E.S., Venturini, O.J., Yanez, E.E., Castillo, E.F. and Almazan O. (2009). Biofuels: Environment, Technology and Food Security, *Renew Sustain Energy Rev*., 13, pp. 1275–1287.

[16] Farias, F.E.M., Silva, F.R.C., Cartaxo, S.J.M., Fernandes, F.A.N. and Sales, F.G. (2007). Effect of Operating Conditions on Fischer-Tropsch Liquid Products, *Latin Am Appl Res*., 37, pp. 283–287.

[17] Najafi, G., Ghobadian, B., Tavakoli, T. and Yusaf, T. (Aug.-Sept., 2009). Potential of Bio Ethanol Production from Agricultural Wastes in Iran, *Renewable and Sustainable Energy Reviews*, 13(6–7), pp. 1418–1427.

[18] Timilsina, G.R. and Shrestha, A. (April, 2011). How Much Hope Should We Have for Bio Fuels?, *Energy*, 36(4), 2055–2069, 5th Dubrovnik Conference on Sustainable Development of Energy, Water & Environment Systems.

[19] Gibbons, W.R. and Westby, C.A. (1989). Co Fermentation of Sweet Sorghum Juice and Grain for Production of Fuel Ethanol and Distillers' Wet Grain. *Biomass*, 18(1), pp. 43–57.

[20] Gullison, R.E., Frumhoff, P.C., Canadell, J.G., Field, C.B., Nepstad, D.C. and Hayhoe, K. (2007). Tropical Forests and Climate Policy, *Science*, 316, pp. 985–986.

[21] He, Y., Wang, S. and Lai, K.K. (2010). Global Economic Activity and Crude Oil Prices: A Co Integration Analysis, *Energy Econ*., doi: 10.1016/j.eneco.2009.12.005. http://www.lsbdholding.com/what-is-it/
[22] IEA (2004). Bio Fuels for Transport as an International Perspective, International Energy Agency (IEA). http://www.iea.org/textbase/nppdf/free/2004/biofuels2004.pdf
[23] Larson, E.D. (2008). Bio Fuel Production Technologies: Status, Prospects and Implications for Trade and Development, Report No. UNCTAD/DITC/TED/2007/10, United Nations Conference on Trade and Development, New York and Geneva.
[24] Love, G., Gough, S., Brady, D., Barron, N., Nigam, P. and Singh, D. et al. (1998). Continuous Ethanol Fermentation at 45C Using Kluyveromyces Marxianus IMB3 Immobilized in Calcium Alginate and Kissiris, *Bioproc Eng*., 18, pp. 187–189.
[25] Love, G., Nigam, P., Barron, N., Singh, D., Marchant, R. and McHale, A.P. (1996). Ethanol Production at 45C Using Preparations of Kluyveromyces Marxianus IMB 3 Immobilized in Calcium Alginate and Kissiris, *Bioproc Eng*., 15, pp. 275–277.
[26] Nigam, P., Banat, I.M., Singh, D., McHale, A.P. and Marchant, A.P. (1997). Continuous Ethanol Production by Thermotolerant Kluyveromyces Marxianus Immobilized on Mineral Kissiris at 45C, *World J Microbiol Biotechnol*, 13, pp. 283–288.
[27] Purohit, P. and Kandpal, T.C. (Aug., 2007). Techno-Economics of Biogas-Based Water Pumping in India: An Attempt to Internalize CO_2 Emissions Mitigation and Other Economic Benefits, *Renewable and Sustainable Energy Reviews*, 11(6), pp. 1208–1226.
[28] Singh Nigam, P. and Singh, A. (Feb., 2011). Production of Liquid Bio Fuels from Renewable Resources, *Progress in Energy and Combustion Science*, 37(1), pp. 52–68.
[29] Paula-Bianca MARICA (2009). Universitatea, Ştefan cel Mare", Suceava, România, "A Review of the Advances in Biofuels Production."
[30] Prasad, S., Singh, A., Jain, N. and Joshi, H.C. (2007). Ethanol Production from Sweet Sorghum Syrup for Utilization as Automotive Fuel in India, *Energy Fuel*, 21(4), pp. 2415–2420.
[31] Prasad, S., Singh, A. and Joshi, H.C. (2007). Ethanol as an Alternative Fuel from Agricultural, Industrial and Urban Residues, *Resour Conserve Recycling*, 50, pp. 1–39.
[32] Khoiyangbam, R.S., Kumar, S., Jain, M.C., Gupta, N., Kumar, A. and Kumar, V. (Oct., 2004). "Methane Emission from Fixed Dome Biogas Plants in Hilly and Plain Regions of Northern India", *Bio Resource Technology*, 95(1), pp. 35–39.
[33] Riordon, C., Love, G., Barron, N., Nigam, P., Marchant, R. and McHale, L. *et al.* (1996). Production of Ethanol from Sucrose at 45C by Alginate Immobilized Preparations of the Thermo Tolerant Yeast Strain Kluyveromyces Marxianus IMB 3. *Bioresour Technol*, 55, pp. 171–173.
[34] Sharma, Y.C., Singh, B. and Upadhay, S.N. (2008). Advancements in Development and Characterization of Biodiesel: A Review, *Fuel*, 87, pp. 2355–2373.
[35] Singh, A., Pant, D., Korres, N.E., Nizami, A.S., Prasad, S. and Murphy, J.D. (2010). Key Issues in Life Cycle Assessment of Ethanol Production from Lingo Cellulosic Biomass: Challenges and Perspectives, *Bioresour Technol*, 101(13), pp. 5003–5012.
[36] Singh, A., Smyth, B.M. and Murphy, J.D. (2010). A Bio Fuel Strategy for Ireland with an Emphasis on Production of Bio Methane and Minimization of Land-Take. *Renew Sustain Energy Rev*., 14(1), pp. 277–288.
[37] Singh, D., Dahiya, J.S. and Nigam, P. (1995). Simultaneous Raw Starch Hydrolysis and Ethanol Fermentation by Glucoamylase from Rhizoctonia Solani and Saccharomyces Cerevisiae, *J Basic Microbiol*, 35, pp. 117–121.
[38] Stevens, D.J., Worgetten, M. and Saddler J. (2004). Biofuels for Transportation: An Examination of Policy and Technical Issues, IEA Bioenergy Task 39, Liquid Bio fuels Final Report 2001–2003. Canada.
[39] Suresh, K., Kiran Sree, N. and Rao, L.V. (1999). Utilization of Damaged Sorghum and Rice Grains for Ethanol Production by Simultaneous Saccharification and Fermentation. *Bioresour Technol*, 68(3), pp. 301–304.
[40] Turhollow, A.F. and Heady, E.O. (1986). Large-Scale Ethanol Production from Corn and Grain Sorghum and Improving Conversion Technology, *Energy Agric*., 5(4), pp. 309–316.
[41] USDA (United States Department of Agriculture) (2003). Production Estimates and Crop Assessment Division of Foreign Agricultural Service, EU: Biodiesel Industry Expanding Use of Oilseeds, www.biodiesel.org/resources/ reportsdatabase/reports/gen/20030920_gen330pdf
[42] Verma, G., Nigam, P., Singh, D. and Chaudhary, K. (2000). Bioconversion of Starch to Ethanol in a Single-Step Process by Co-Culture of Amylolytic Yeasts and Saccharomyces Cerevisiae 21, *Bioresour Technol*, 72, pp. 261–266.
[43] Zhao, R., Bean, S.R., Wang, D., Park, S.H., Schober, T.J. and Wilson, J.D. (2009). Small-Scale Mashing Procedure for Predicting Ethanol Yield of Sorghum Grain. *J Cereal Sci*., 49(2), pp. 230–238.