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BIOMASS AS AN ALTERNATIVE ENERGY

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ABSTRACT:

The world energy consumption is expanding due to increase in population and is projected to increase by 44 percent from 2006 to 2030. China and India are the fastest growing non-OECD economies with their combined energy use increasing nearly twofold and making up to 28 percent of world energy consumption by 2030. The growing concerns over global warming forces us to find an alternative, renewable or sustainable source of energy, which can reduce carbon footprint in the environment and the most often considered are biomass resources—for example, prairie grasses, forestry and mill residues, nongrain parts of food crops, and urban wood wastes that are typically discarded in landfills. The paper focuses on analyzing the technology management issues while using biomass as an alternative energy source, discusses the importance of biomass energy to the future energy mix, provides current updates on the world energy consumption and the energy outlook for next 20 years. Further, the paper analyzes technology management issues with reference to technical, social, environmental, economical and political perspectives.

1.0 Introduction

The growing concerns over fossil fuels with reference to environmental issues related to them, rural prosperity and energy security have increased interest in biomass as alternative source for fuels and other forms of energy. A lot of economic and technological advances has been made in the bio-energy industry and is thus paving the way for biomass to become an important energy source in the not-too-distant future. Many OECD (Organisation for Economic Co-operation and Development) countries have government policies, including feed-in tariffs, tax incentives and market-share quotas that encourage the construction of renewable energy growth.

Biomass is the oldest source of renewable energy known to humans, used since our ancestors learned the secret of fire. According to the bioenergy context, it can be defined as any organic material e.g., wood, forest residues, municipal solid waste etc. These products are converted into usable end products such as fuels, heat, electricity etc., using conversion technologies (combustion etc.). The fig 1.0 lists some of the biomass feedstock, conversion process and the end products.

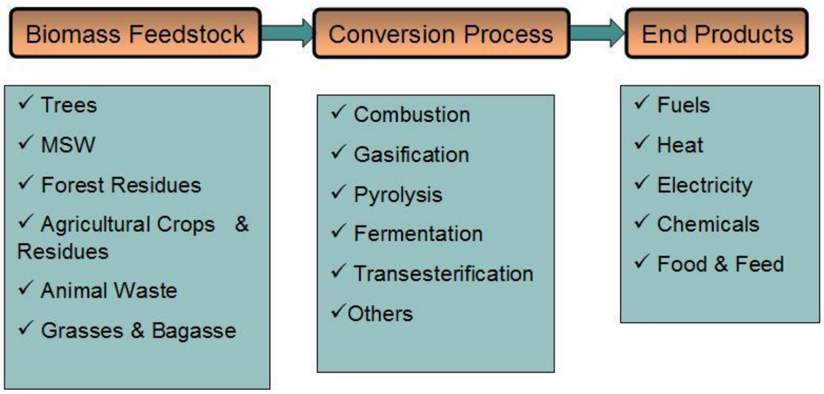


Fig 1.0: Biomass conversion

Biomass system:

The important elements of a biomass system are harvest, converting them to feedstock, conversion process and distributing the energy produced. The system starts with harvesting and then converting them to feedstock followed by feeding them to reactor and finally, the distribution of energy produced to the consumer. Fig 1.2 shows the biomass system in detail. The economic and technical viability of the biomass energy is dependent on feedstock supply, how efficient is the conversion technologies and the cost effective distribution system [1].

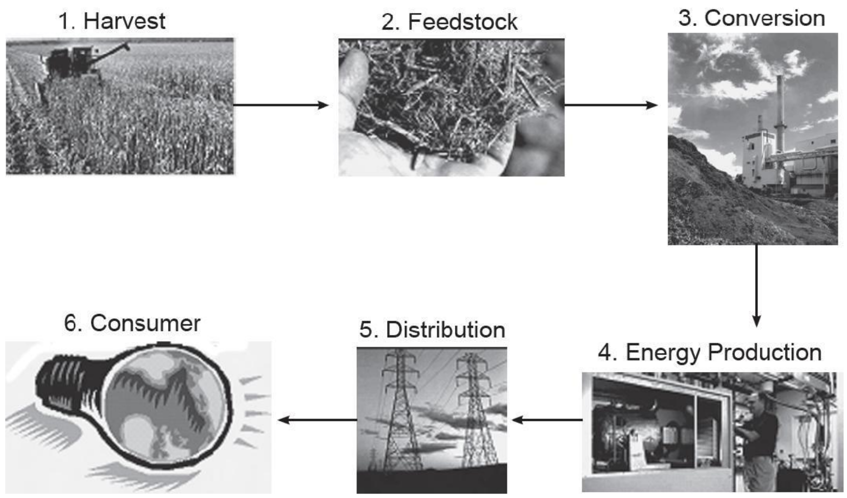


Fig 1.2: Biomass system **Source: EPA**

2.0 Importance

This section examines the importance of biomass energy to the future energy mix. It discusses the world energy consumption, outlook for next 20 years and the contribution of biomass to the energy mix. Further, it deals with the environmental benefits and the job creation potential of bio-energy.

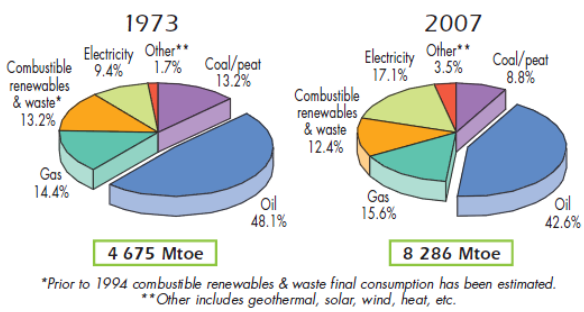
Biomass offers many advantages over conventional energy sources. To start, the biomass is abundant in nature and it's renewable. Since the feedstock is available domestically, growing our fuels at home reduces our dependency on importing oil and reduces our exposure to disruptions in energy supply. It in turn supports the energy sustainability.

2.1 Energy Consumption

Looking at the energy supply and demand for last few decades, it's evident that the overall world energy consumption has almost doubled in last decades. In 2007, the total energy consumption was 8286Mtoe, which is up by 80% from 1973[2]. Fossil fuels constitute about 80.9% of the total energy. Fig 2.1 shows overall consumption by fuels in 1973 & 2007[2].

2.2 Energy Outlook

The world marketed energy consumption is expected to increase by 44% from 2006-2030 [2]. It is also projected that the energy consumption in the OECD member countries is going to fall by 10% by 2030[2]. China and India, the two fastest growing non-OECD economies are expected to consume about 28% of the world energy [2]. The renewable energy use is expected to increase by an average of 2.9 % per year from 2006 to 2030 and much of the growth is expected in hydroelectric and wind power [2]. It is expected that biomass along with other renewable energies contribute ~ 33% of the total world energy demand by 2030 [3]. Fig 2.2 shows amount of various energy demands in both OECD and non-OECD countries.



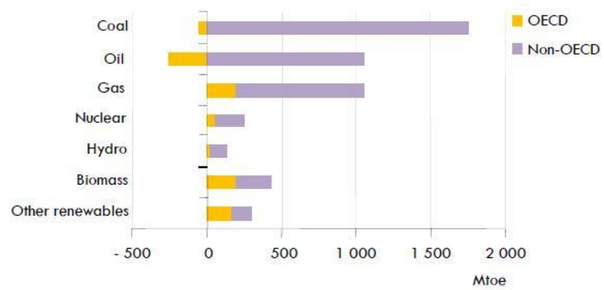


Fig: 2.1 Final energy consumption, Source: EIA

Fig: 2.2 Energy demand, Source: IEA

2.3 Environmental Benefits

Biomass energy has number of environmental benefits. Biomass is carbon neutral, the CO_2 absorbed by the raw material while growing offsets are turned back during combustion [4]. Therefore, there is no net increase in carbon dioxide emissions to the atmosphere while using biomass. In addition to this, it helps in reducing air and the water pollution. The environmental benefits are further discussed in detail in the environmental perspectives section.

2.4 Bridge to the Future

The most important difference between biomass and other renewable energy sources is that biomass can deliver energy in the forms that people need i.e., liquid, gaseous fuels, heat and electricity [5]. In addition, the crude oil not only provides fuels but also provides chemicals and other material. Thus, biomass energy can act as a bridge to future and the fig 2.3 depicts this.

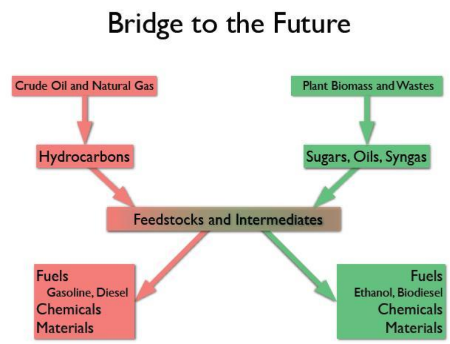


Fig: 2.3 Biomass, a bridge to the future, Source:

2.5 Job Generation Potential

Biomass has a higher job creation potential compared to the fossil fuels. In Brazil, 14 billion liters annual production of ethanol from sugarcane created 462,000 direct and 1,386,000 indirect jobs [5]. Goldemberg (2003) observed that biomass energy has created more jobs compared to conventional energy options [traditional bio-energy]. The Table 2.4 below compares job creation between biomass and other conventional energy options. The topic is further discussed in detail in social perspective section.

Sector	Jobs (person-years) Terawatt-hour
Petroleum	260
Offshore oil	265
Natural gas	250
Coal	370
Nuclear	75
Wood energy	1,000
Ethanol (from sugarcane)	4,000

Source: Goldemberg, 2003

Table: 2.4 Comparison of job creation – Biomass and Conventional Energy options

In conclusion, biomass is very important to our future energy mix due to its economic, social, environmental benefits and with proper technology, biomass can be competitive with the conventional sources.

3.0 Technologies

In the last few decades, the bioenergy industry has shown significant economic and technological advances with growing political support all over the world. This section focuses on some of the emerging conversion technologies, which are relatively in advanced state of development and their expected future contribution [1]. The conversion technologies can be grouped based on method of decomposition, process specifications and by engineering design specifications [1]. This report uses the highest level of classification i.e., thermochemical, biochemical & chemical conversion. Only emerging technologies are considered for research purpose.

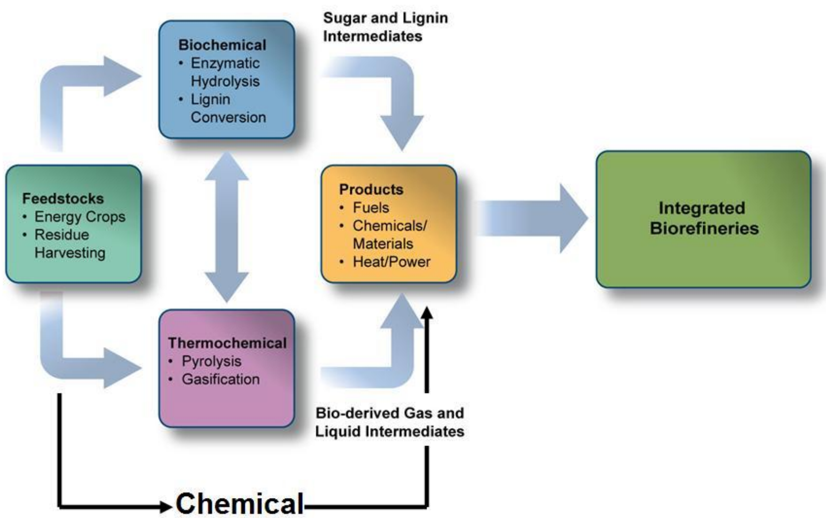


Fig. 3.1 Conversion technologies **Source: NREL**

3.1. Thermochemical Conversion

The base for thermochemical conversion is the pyrolysis process, which include all chemical changes occurring when heat is applied to materials with or without presence of oxygen [2]. Combustion, Gasification & Pyrolysis are the thermochemical conversion technologies. The products of biomass pyrolysis include water, carbonaceous solid, oils or tars, and permanent gases including methane, carbon monoxide, and carbon dioxide. Table 3.1 shows the feedstocks and their end products for all the three technologies.

			Feedstock	End Products	
				Final	co-products
Thermochemical technologies	Combustion	Stoker Grate	Any organic material (Eg: Trees, forest residues), Organic Waste & SMW	Electricity, Thermal Energy, Diesel type fuels	Bio-char & Ash
		Fluid Bed			
		Circulating fluid bed			
		Entrained flow			
	Gasification	Fixed Bed			
		Fluidized bed			
		Novel design			
	Pyrolysis	Fast Pyrolysis			
		Slow Pyrolysis			

Table 3.1 Thermochemical conversion technologies Source: EPA

3.2. Biochemical Conversion

Biochemical conversion uses biocatalysts, such as enzymes and microorganisms, in addition to heat and chemical catalysts to convert the carbohydrate portion of the biomass (hemicellulose and cellulose) into an intermediate sugar stream. The biomass sugars act as intermediate building blocks, which are then fermented to ethanol and other products. The remaining lignin portion of the biomass can be used for heat and power, or alternatively used to produce additional fuels and chemicals via thermochemical processing [6]. The Biochemical conversion technologies include starch and sugar fermentation, lignocellulosic fermentation, anaerobic digestion, aerobic digesters and landfill. Table 3.2 shows the biochemical conversion processes in detail.

			Feedstock	End Products	
				Final	Co-products
Biochemical	Ethanol	Wet-Mill fermentation	Grains: corn	Ethanol	Distiller grains plus soluble
		Dry-Mill fermentation	Grains (corn, sorghum &barley), Sugars(sugarcane & beets)		Corn-oil, corn gluten metal
		Lignocellulosic	Cellulosic /Woody biomass		Residual Cellulose and lignin, electricity and thermal energy
	Anaerobic Digesters	Thermophilic Processes	Any organic material (paper, grass clippings, animal waste, leftover food etc.,)	Biogas, Thermal energy	Liquid and solid biofertilizers
	Landfill	Bioreactor vessel	Organic Waste	Electricity, Thermal energy, methane,	CO2 & Biofertilizers
		Landfill Site			

				CNG	
	Aerobic	Static pile Enclosed Compost Turned Window In-Vessel compost Transesterification	Any organic Waste	Compost	Heat and CO2

Table: 3.2 Biochemical Conversion Technologies Source: EPA

3.3 Chemical Conversion

Chemical conversion uses chemical reactions to decompose feedstock into intermediate products.

			Feedstock	End Products	
				Final	**co-products**
Chemical			Oils, fats, used cooking oils, greases, methanol or ethanol	Biodiesel	Glycerin & Soaps

Table: 3.3 Chemical Conversion technologies Source: EPA

3.4 Technical Barrier Areas

This section examines the technical challenges in each of the conversion process. It has been observed that some of the challenges are inherent to the process itself and others are due to the use of new feedstocks such as grass, bagasse etc. Further, the technological challenges are classified into two levels: Pre-treatment technologies and those directly related to process [6]. In addition, some of these challenges are specific to the feedstock and the process and can not be applied to all processes or the feedstocks.

3.4.1 Thermochemical Conversion

Fig. 3.2 shows primary technical barriers in gasification and Pyrolysis process.

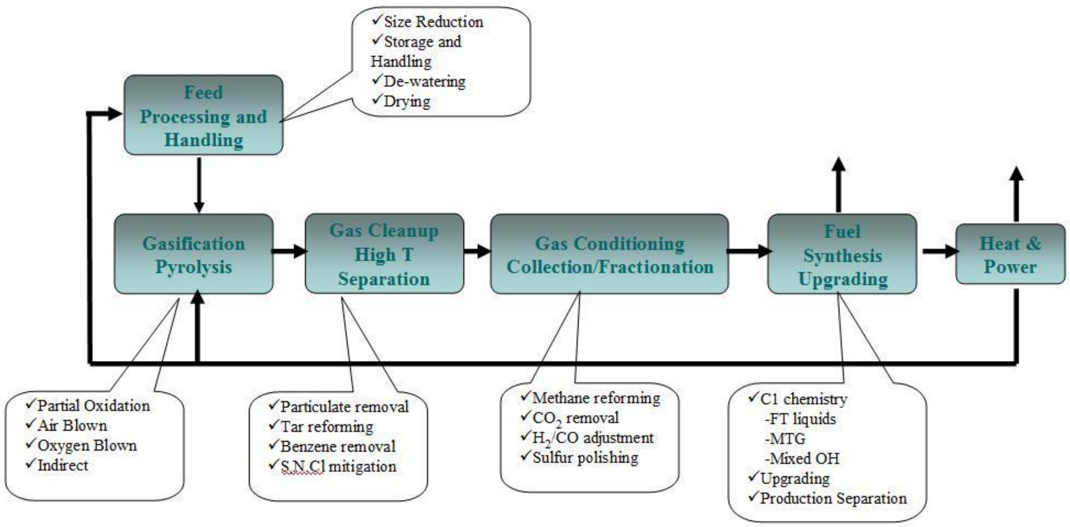


Fig: 3.2 Thermochemical conversion barrier areas Source: NREL

Pre-treatment Technologies:

Feeding dry biomass: - It's observed that the industry has attained a high degree of reliability for the pretreatment operations such as drying, size reduction and storage of most type of woody biomass [7]. Nevertheless, there is still need for improvement in the control area and develop efficient processes to maintain a consistent level of moisture in the biomass. The common method used to dry biomass feedstock would not work with other feedstocks due to organic and particulate emission [8, 9]. The feeding of pressurized systems need further improvements as it poses several problems such as mechanical, gas tightness etc.

With increased focus on grass and bagasse [10, 11)] as alternate feedstock, poses problems in all pretreatment operations [9]. Though densification is option, it incurs cost [11] and is not suitable for large scale industrial and commercial use [12].

Process:

(a) Reactor design: Biomass gasification technology has developed to the point of large-scale demonstration. However, widespread commercial availability of gasifier systems suitable for integration with fuel synthesis or hydrogen separation technologies has not yet been realized. In part, this is due to areas of fuel chemistry that require additional investigation to support the commercial demonstration programs and facilitate the development and scale-up of advanced gasifiers and gas clean-up systems [13]. Further, there is great need for developing fuel flexible gasifiers that are capable of converting fuels like high alkali and high ash content fuels [9].

(b) Tar removal: Tar removal is another challenge in gasification. Use of Nickel as a catalyst is likely to increase in the future, but still the technology needs large scale demonstration [9].

(c) Syngas cleanup and conditioning: There is a near-term need for gas cleaning and conditioning technology that can cost-effectively remove contaminants such as tar, particulates, alkali, and sulfur [9]. The interactions between the catalysts used for gas cleanup and conditioning, the gasification conditions and feedstock are not well understood. These interactions require careful attention to trace contaminants.

(d) Catalyst development: The production of mixed alcohols from syngas has been known since the beginning of the last century; however, the commercial success of mixed alcohol synthesis has been limited by poor selectivity and low product yields. Improved catalysts with increased productivity and selectivity to higher alcohols within the required gas cleanliness tolerances are required to enable viable capital costs. The development of robust catalysts for the upgrading of pyrolysis oil, for production of liquid transportation fuels is critical to the economic viability of the process [9].

(e) Instrumentation: There is a need to standardize measurements to maintain plant performance and emission target levels with varying load, fuel properties and atmospheric conditions. Laboratories have developed some sensor systems to get feedback, as the feedstock is run through the system such as on-line gas sampling analysis, sensors to measure the syngas composition within the gasifier etc [14].

(f) Pyrolysis: Development of new methods to control the pyrolytic pathways to bio-oil intermediates, in order to increase product yield and recovery, is needed. These product quality improvements are important to achieving stability specifications of the resulting bio-oil and may result in more favorable chemistry for processing conventional petroleum refineries. New methods to clean and stabilize the bio-oil intermediates are also needed to ensure the product is compatible with refining technology. These advances include improved hydrotreating catalysts and techniques for processing the bio-oil [6].

3.4.2 Biochemical Conversion

The fig. 3.3 provides primary technical barriers in biochemical conversion process.

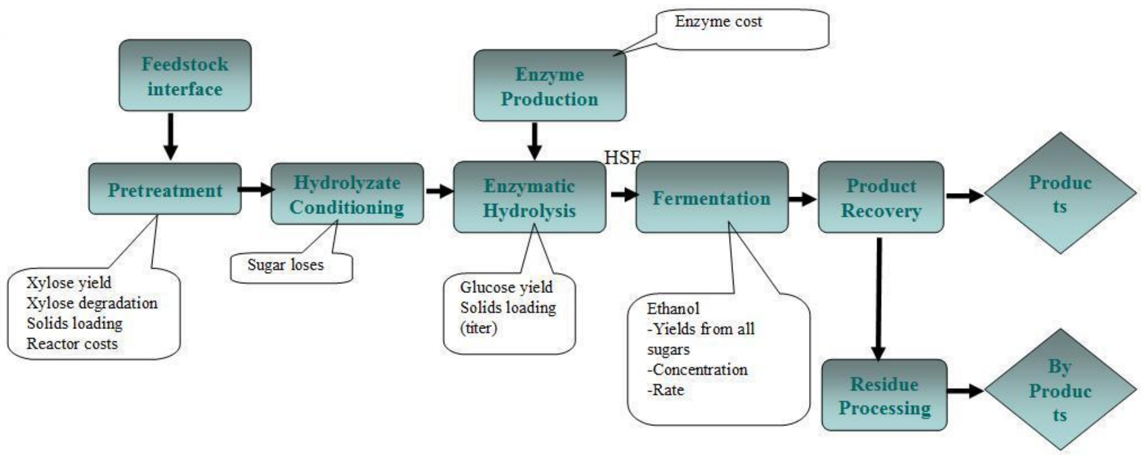


Fig.3.3 Biochemical barrier areas **Source : NREL**

Pretreatment:

(a) Pretreatment Chemistry: There is need to understand the critical physical and chemical properties that determine the susceptibility of cellulosic substrates to hydrolysis and the role that lignin and other pretreatment products play in impeding access to cellulose [15,16]. The Continued significant cost reductions in pretreatment technologies require developing a better understanding of pretreatment process chemistries [15, 16].

(b) Pretreatment Costs: There is need to develop pretreatment reactors with cost-effective material as the current design utilizes expensive material for construction in order to resist acid or alkali attack. Further, it is required to develop low cost pretreatments, which in turn is dependent on using reactors designed for maximum solid levels.

(c) Cellulase Enzyme Production Cost: Production cost for Cellulase enzymes from cellulosic biomass remain a major constraint for energy generation. Cost-effective enzyme production technologies are not currently available, although significant progress has been made through concerted efforts with industrial enzyme producers [15,16].

(d) Biomass Recalcitrance: Lignocellulosic biomass feedstocks are naturally resistant to chemical and/or biological degradation. However, the fundamental role of biomass structure, composition and the critical physical and chemical properties that determine the susceptibility of cellulosic substrates to hydrolysis are not well understood. This lack of understanding of the root causes of the recalcitrance of biomass, limits the ability to focus efforts to improve the cost-effectiveness and efficiency of pretreatment and other fractionation processes [15, 16].

3.4.3 Chemical Conversion

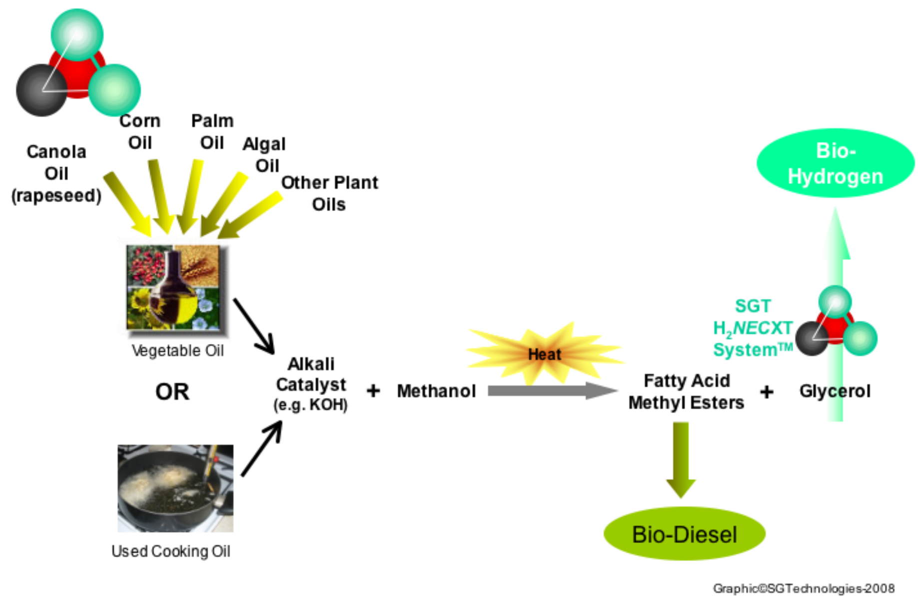


Fig 3.4 Chemical conversion challenges Source: Sustainable Green Technologies Inc

Some of the challenges in chemical conversion of biomass are [17]:-

(a) There is need for developing technology to treat any undissolved pellets of alkali catalyst (for example KOH) left in alcohol in subsequent Transesterification process.

(b) Technology development which would allow separation of glycerol and reduction of formation of soap, in turn increasing biodiesel production.

(c) Complete removal of alcohol, catalyst, water, soaps, glycerine, unreacted and partially reacted triglycerides and free fatty acids.

(d) Technology development for processing large variety of raw and refined vegetable oils with low effluent generation and adaptable to large range of production capacities.

(e) Pilot plant testing of heterogeneous Transesterification Process.

(f) Development of additives for Bio-diesel-Diesel blends.

4.0 Environmental Perspective

4.1 Benefits

(a) Reduce carbon footprint: Burning of petroleum and coal can bring energy, but it also releases carbon-dioxide into the earth's atmosphere, which has ultimately led to changes in earth's climate. Since hundred years, the carbon-dioxide emission has increased by 15 percent; thus affecting global climate. One of the effective ways to deal with it is to use renewable energy sources such as biomass.

In the other hand, human activities such as the burning of fossil fuels and the destruction of rainforests, add to the concentration of greenhouse gases, particularly carbon dioxide in the atmosphere. This increase in gases is having a warming effect and leading to climate change. The 1990s were the warmest decade on record [18]. Mitigation actions include changing the way we farm, by reducing carbon emissions for example, and by replacing processes that emit greenhouse gases with carbon neutral energy sources. Biomass crops are widely regarded as being almost "carbon neutral" because the carbon-dioxide released when these crops are burnt as a fuel for heat and/or electricity, is matched by the amount of carbon-dioxide the plants absorbed when they were growing, in the process of photosynthesis. Hence, there is no net increase to carbon dioxide levels in the atmosphere. As a fuel therefore, they are substantially more environmentally friendly than fossil fuels. Fig. 4.1 shows biomass energy can reduce 19%~85% of gas emissions than conventional fossil fuels.

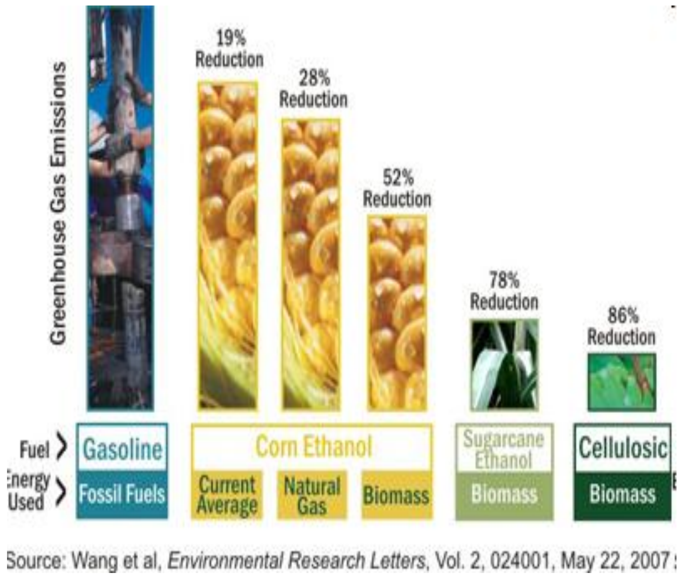


Fig. 4.1 Gas Emissions Comparison

(b) Waste recycling: The final goal for providing green solutions on renewable energy is to recycle wastes that produce biomass energy. Biomass energy production can make significant benefits to our environment specially for large agricultural, forestry sectors, and to its solid waste recycling industry. The agricultural and forestry industries are major producers of biomass residues, and their profitability depends in no small part on their success in turning these residues into useful resources. The most common feedstock for making biomass energy is from fired wood boilers is 3" (76 mm) minus ground wood, because it contains less moisture.

Figure 4.2: 3-inch Minus Wood Ground with a Peterson Horizontal Grinder [7]

Similarly, when fuel prices were high, urban biomass fuel producers were subsidizing many of their unprofitable recycling activities with the income available from the fuel market. The biomass energy industry provides a large market for the disposal of biomass residue materials, and in the past has been able to make this an income source for those who generate and handle these materials.

4.2 Challenges

The production of producing biomass energy involves many kinds of feedstock that include any organic material such as trees, forest residues, and organic waste, solid mixing with water, grains, cellulosic/woody biomass, and any organic waste. A minor problem is using water resource which causes water shortage in some countries on production biomass energy.

4.3 Deforestation

The cumulative energy and global warming impacts associated with producing corn, soybeans, alfalfa, and switchgrass and transporting these crops to central crop processing facility [20]. In order to fulfill the biofuel demand, farmers may need to switch to energy crops. The biggest deforestation which had significant contribution to the global warming (greenhouse gas emissions) is in Amazon at Brazil. [21] The biomass and carbon stock in Amazon area has been decreased by 35% since 1990.

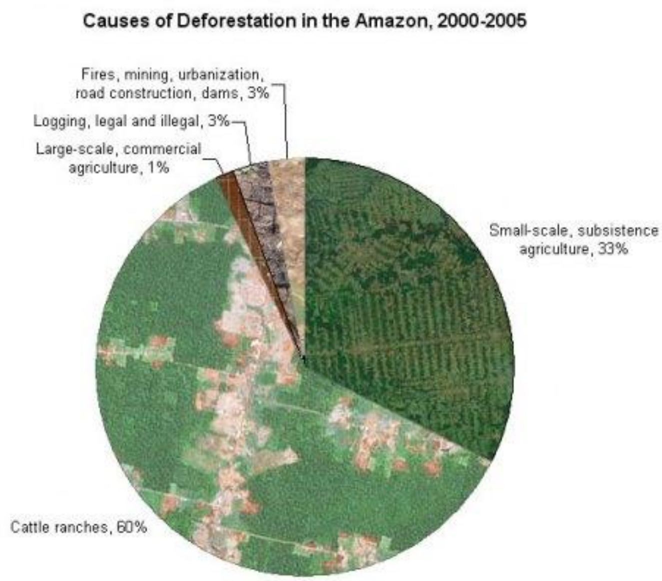


Fig. 4.3 Deforestation in Amazon, 2000 - 2005

Biomass burning includes the burning of the worlds' vegetation – forests, savannas, and agricultural waste that contribute as much as 40% of gross carbon dioxide and 38% of troposphere ozone [23]. Increases in other contributions account for only 15-40 percent; nevertheless, increased trace-gas emission from biomass burning has contributed to atmospheric chemistry changes during the study period. (O.C.)

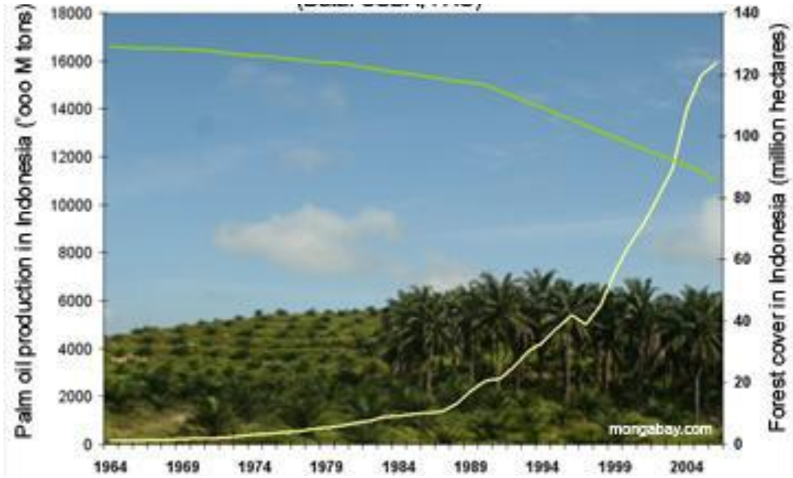


Fig. 4.4 Forest cover vs. Palm oil production in Indonesia, 1964-2006

4.4 Water Issue

First generation bio-fuels are resource intensive–land, water, fertilizer, and pesticides. Water and energy are inexorably linked; energy is needed to pump, treat, and transport water whereas large quantity of water is needed to support the development of energy. However, both water and energy may face serious constraints as demand for these vital resources continue to rise. Two examples that demonstrate the link between water and energy are the cultivation and conversion of feedstocks, such as corn, switchgrass, and algae, into bio-fuels; and the production of electricity by thermoelectric power plants, which reply on large quantities of water for cooling during electricity generation. Corn cultivation for ethanol production can require from 7 to 321 gallons of water per gallon of ethanol produced, depending on where it is grown and how much irrigation is needed [19]. Corn is also a relatively resource- intensive crop, requiring higher rates of fertilizer and pesticides than many other crops.

5.0 Economic Perspective

This section discuss on the economics of using biomass as alternative energy source. The main focus of this section is to analyze the economic benefits, market and its barriers. Further, it list and discuss on the barrier in supply chain.

5.1 Economic Benefits

- Increases demand for feedstock from farmers.

- Creates 50 to 75 jobs per new biorefinery.
- Yields a high value product with multiple application possibilities.
- Has the potential to provide growth in rural regions/Reinvigorates rural economies.

5.2 Current Markets

The major end-use markets for biomass-related products include transportation fuels, products and power.

(a) Transportation fuels: Some trends, such as high world oil prices, supportive government policies, environmental and energy security concerns, have provided favorable market conditions for biofuels in recent years. The market of ethanol from grains is nearly 8 billion gallons per year, and it has reached 13 billion gallons by the end of 2008.

(b) Products: There are only 10 percent biobased chemical products of the 100 million metric tons annually produced in the U.S. [25]. U.S. plastics manufacturing consumes nearly 2 million barrels of oil every day, about 10 percent of the nation's overall consumption, and these products are not biodegradable [26].

(c) Power: There is less than 1 percent U.S. power comes from biomass. Most of power is produced by fossil fuels, which account for about 77 percent of generation, with coal comprising 51 percent, natural gas 16 percent, and oil 3 percent.

5.3 Major Market Barriers

Production costs, investment risks, and infrastructure limitations are significant challenges for the emerging bioindustry. Cost-efficiency is the most important issue among them.

(a) Cost of Production: This is the most significant issue for the emerging biomass technologies. Compared to conventional energy supplies and their established supporting facilities and infrastructure, the biomass technology is just germination. Reductions in production costs along the biomass supply chain are needed to make biomass related products competitive in these markets.

(b) High Risk of Large Capital Investments: Since biomass technologies have been developed, they must be commercially deployed. Financial barrier is the most challenging element of technology deployment. Capital costs for commercially viable facilities are relatively high and building these facilities will be difficult because people are inexperienced.

(c) Supply Chain and Distribution Infrastructure: The uncertainty of a sustainable supply chain is the major barrier to procure capital for start-up biorefineries. In addition, the current lack of infrastructure to transport, store and dispense biofuels is also a significant disadvantage compared to conventional fuels that already have mature infrastructure.

5.4 Utilizing Barriers for Supply Chain

Biomass to biofuels supply chain, shown in fig. 5.1, has specific utilizing barriers for each sector which are discussed as below:

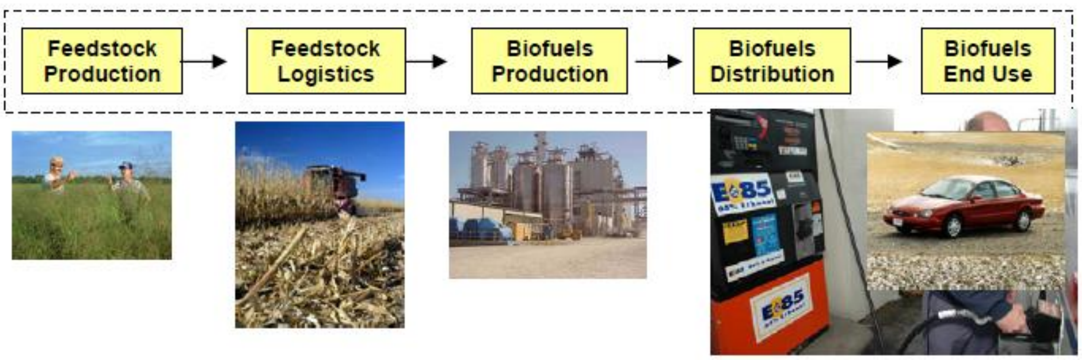
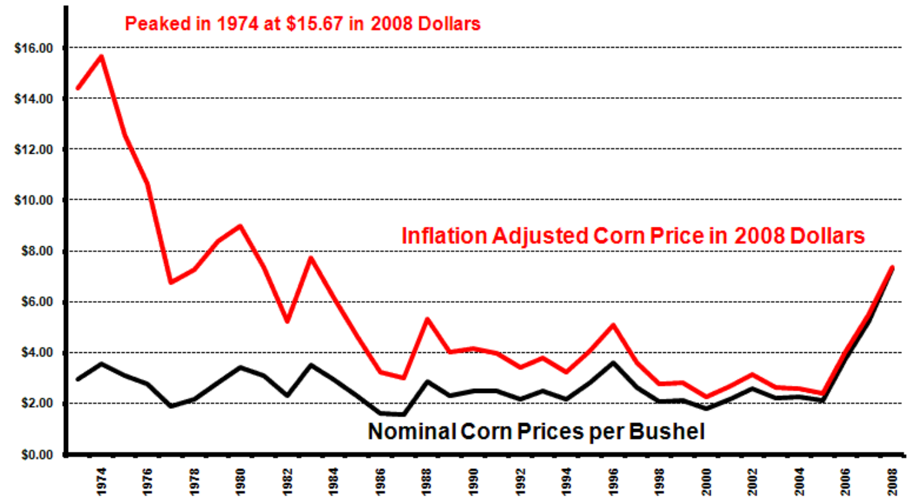


Figure 5.1. Biomass to Biofuels Supply Chain

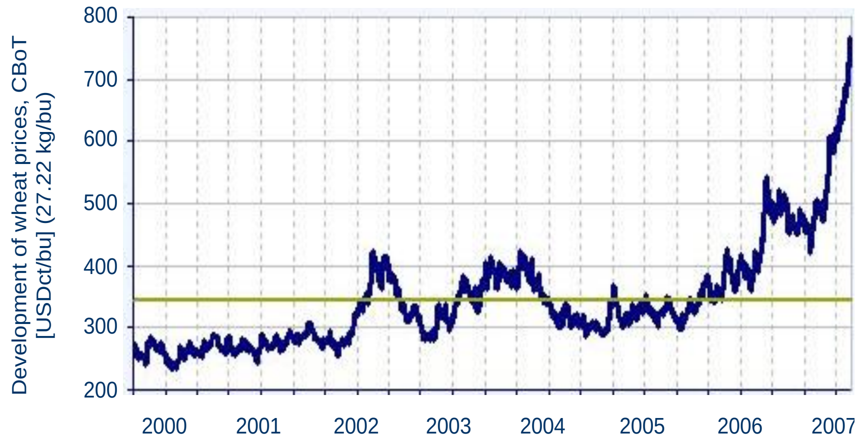
(a) Feedstock Production:

- **Resource Availability and Cost:** Feedstock supply is a significant cost component of bio-based fuels, products, and power. Ethanol demand has increased corn prices and led to expanded corn production. The prices of corn and wheat are an important issue for biomass production. (Fig. 5.2)



Source: Inflationdata.com (2008)

Fig. 5.2 Corn Prices



Source: USDA (2007)

Fig. 5.3 Wheat Price

(b) Feedstock Logistics:

- **Sustainable Harvest:** Current crop harvesting machinery is unable to selectively harvest desired components of biomass. Biomass variability needs high quality and functional harvesting equipment. In addition, current systems cannot effectively deal with the large biomass yields per acre of potential new biomass feedstock crops.
- **Biomass Material Handling and Transportation:** The capital and operating costs for the existing package-based equipment and facilities do not meet cost targets. Besides, most ethanol is currently produced in the Nation's heartland, but 80 percent of the U.S. population (and therefore implied ethanol demand) lives along its coastlines. (Fig. 5.4)

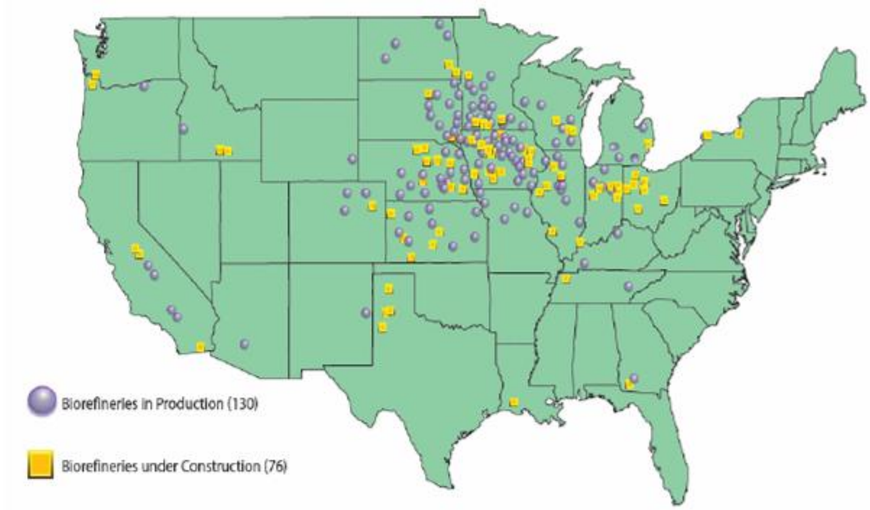


Fig. 5.4 The Need for Transportation Source: Renewable Fuels Association (2007)

(c) Biofuels Prodcution:

- **Pretreatment:** Pretreatment reactors require expensive materials of construction to resist acid or alkali attack at elevated temperatures.
- **High Risk of Large Capital Investments:** Since biomass technologies have been developed, they must be commercially deployed. Financial barrier is the most challenging element of technology deployment. Capital costs for commercially viable facilities are relatively high and building these facilities will be difficult because people are inexperienced.

(d) Biofuels Distribution/End Use:

- **Cost of Production:** This is the most significant issue for the emerging biomass technologies. Compared to conventional energy supplies and their established supporting facilities and infrastructure, the biomass technology is just germination. Reductions in production costs along the biomass supply chain are needed to make biomass related products competitive in these markets.
- **Ethanol Blend Vehicle Fuel Economy:** Since ethanol has a lower heating value than gasoline (83,000 Btu/gal for E85 vs. 113,500 Btu/gal for gasoline), compared to gasoline, E85 is a lower economy fuel. However, lower fuel economy can be counteracted by optimizing the engine design to obtain the higher octane rating of E85.

6.0 Social perspective

This chapter focuses on several social issues related to biomass production and consumption. Although biomass can be renewable energy which responds to society's energy demand, many studies research on some issues whether or not biomass energy affects human societies. Biomass energy can give several benefits to societies but there are some concerns about biomass production may have negative impacts to societies.

6.1 Benefits of usage Biomass energy

Regarding some countries having many large lands such as India or America, [28] these countries can utilize their degraded lands or some rural areas which used to be agricultural areas in order to produce biomass energy. However, [28] societies have to consciously choose the degraded lands which can produce bio energy but which are not used to contribute to food supplies for the societies. [29] Most potential lands to produce bio energy have many substances composed primarily of cellulose, hemicelluloses, lignin and proteins. Table 6.1 shows the substances which have the composition of biomass energy. Consequently, societies can develop invaluable lands to produce biomass energy. Societies also can consume biomass which can be produced in their areas in order to respond their energy demand.

In addition, [29] the types of biomass production are used as energy conversion to not only use agricultural residues but also utilize solid or industrial wastes to generate electricity. Therefore, the societies can reduce their social and industrial waste products to produce bio energy. Fig. 6.1 shows that societies can reuse their wastes, use residues which come from agricultural products or even animal wastes (e.g. cow dung) to generate electricity.

Biomass Component	Bermuda Grass (herbaceous) [% mass]	Poplar (woody) [% mass]	Pine (woody) [% mass]	Refuse Fuel (waste) [% mass]
Cellulose	32	41	40	66
Hemicellulose	40	33	25	25
Lignin	4	26	35	3
Protein	12	2	1	4

Table 6.1 Biomass composition. [28]

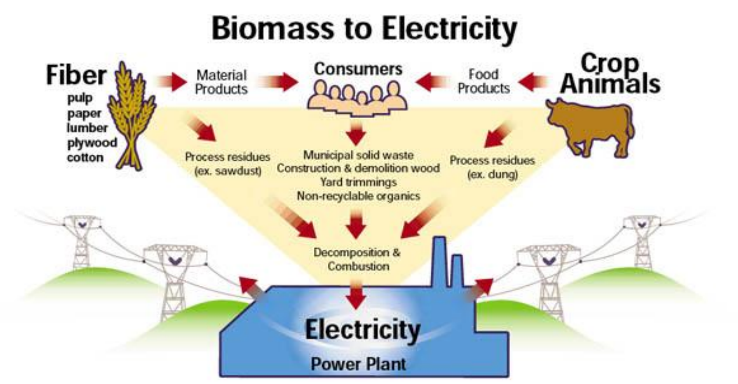


Figure 6.1 Wastes producing electricity. [29]

Another benefit is that citizens who live in rural areas and work as farmers have been increasingly employed to produce biomass energy. [30] The biomass feedstocks producing bio energy can be starched from corn, soybean oil, and agricultural crop residues. The demands of biomass feedstock have been increasing to adequately provide for biomass production. As a result, farmers can gain more jobs and incomes from agricultural feedstock cultivation and export to supply biomass production. Hence, the development of biomass industry can be significant opportunities to improve economic rural areas in both developing and developed countries. For example, [31] the U.S. Department of Agriculture predicted that 4,500 farm jobs will be created for every million liters of ethanol produced.

Moreover, biomass production can produce biodiesel such as ethanol which can be used in transportations. Therefore, societies can reduce dependency of using fossil fuel to improve energy security. Regarding the reduction of fossil fuel consumption by using ethanol, societies can decrease air pollution in their areas caused by fossil fuel consumption.

6.2 Some social concerns

When the demand of biomass energy consumption is rapidly increasing, biomass production may affect societies in rural areas or poor countries will face food security issue, and also extremely pressure natural resources (i.e. water, trees) which are supplied to biomass production. Next part, this paper will describe more details about these concerns.

6.2.1 Food Security

With regard to concerns about biomass production and consumption, some studies research whether societies might confront food security issue or not. Because biomass production consumes a lot of agricultural feedstocks (e.g. corn, soybean) for producing bio energy, there is some concern about biomass production which might influence to reduce food production. Article [32] gives the definition of food security which all people have to be able to access safe and sufficient nutritious foods when they need. There are four key dimensions to meet the definition of food security: availability, stability, access and utilization of food supplies.

(a) Food availability:

Food availability means whether or not food supply can fully respond to food demand. The demands of biomass consumption are rapidly increasing which might lead to lower food availability because biomass production will require a lot of agricultural feedstocks (i.e. corn, soybean) to produce bioenergy. Therefore, most farmers will use their resources (e.g. lands, water, labors) to cultivate agricultural feedstocks for biomass production more than cropping food products. As a result, food supplies will be decreasing and not enough to respond society's food demand.

However, the author [32] claims that biomass production may not have an influence to decrease food production. Although some biomass productions require using agricultural feedstocks, they just use saw, molasses (which are residues of agricultural products) and also even use animal wastes such as cow dung in order to produce biomass energy. Biomass productions also can use forestry feedstocks (trees, wood chips, etc.) which have been used for other industries. In addition, the revenues obtained from export agricultural feedstocks will return to societies to increase purchasing power of buying food products. Hence, if societies can efficiently balance between biomass production and food cultivation, biomass energy will improve food security issue in the societies instead of decreasing food supplies.

(b) Stability of food supplies:

Regarding stability of food supply, it is related to the risk of the society that cannot have adequate food supplies because of food price volatility. There is a concern whether or not agricultural prices are more unstable and higher caused by increasing demand of biomass consumption.

Nevertheless, the author [32] claims that higher demand of biomass might not lead to food prices variability. Energy market will not only make a floor price but also determine a ceiling price for agricultural feedstocks. The ceiling prices of feedstock have to maintain below the regular energy price (e.g. petroleum) in order to keep competitive position in the energy market. If agricultural feedstocks are too costly, biomass industries will not be able to buy feedstocks for producing biomass energy. For example, agricultural feedstocks can be budgets for 70-80% of total costs in sugar-based ethanol production. If sugar price is high, biomass industries will decrease or stop converting sugars to ethanol fuel because they can not obtain satisfying profits or even have deficits in ethanol production. Consequently, sugar price will be going down when the demand of ethanol production is declining. This phenomenon is a mechanism which stabilizes agricultural product prices. Therefore, agricultural costs should be controlled to be stable in appropriate prices to sufficiently supply biomass production and society's food demand equally.

(c) Capabilities to access food supply:

Agricultural products are not only used to be food supplies but also to generate income for farmers. In term of access to food supplies, the key factor is that people have to have a capability to receive adequate quantities of fully nutritious foods with appropriate prices following their incomes. The key challenges are that how biomass energy affects to change both real food price and real society's income, and whether or not capabilities of societies to access foods will decrease caused by raising demand of biomass consumption.

Article [32] suggests that although feedstock prices can increase when the demand of biomass consumption is rising, people who work as farmers in rural areas especially in developing countries will have more jobs and also can gain more revenues by cultivating and selling agricultural feedstocks. Consequently, income in rural areas will increase. Higher income is significant factor to improve food security issue because people can have more capabilities to access food supply [32]. Hence, societies can have good opportunities to use biomass energy to increase their incomes for buying higher food prices because of raising biomass production demand.

(d) Food supply utilization:

Food utilization focuses on food safety and quality of food which are used to serve for society food demand [32]. Good food supply does not mean that people who can gain adequate quantity of foods will have food security if they will be sick because of low quality of foods. In food utilization, if people have more purchasing powers to access to food products with their higher incomes, the quality of food will be improved to respond to the demand of food which is higher level than in the past.

In conclusion, the impact on food security should be analyzed not only in terms of higher food prices and lower food supply but also in terms of rising income for farmers and rural areas as well as changing agricultural prices. Even though agricultural prices can increase by rising of biomass production, societies especially in developing countries and rural areas will have more jobs and incomes from cultivating and trading feedstocks to supply biomass production. Thus, governments should have good policies to manage biomass production to not decrease food production and to control stable agricultural prices for sufficiently supplying biomass production and responding to society's food demand. In addition, governments should support or distribute agricultural jobs which crop feedstocks for supplying biomass production to increase society's income in rural areas. Consequently, food security issue can be improved by good bio energy policies.

6.2.2 Extremely Pressured Natural Resources

Regarding biomass benefits such as reduction in green house gases, energy security development and increasing farmers' incomes, most countries increase to consume biomass energy for responding society's energy demand and reducing dependency of fossil fuels consumption. However, there is a concern about when the demand of biomass consumption is rapidly increasing biomass production may extremely pressure natural resources. As a result, societies may face deficient natural resources such as water scarcity, deforestation in the near future.

[34] Water scarcity issue is already a problem in many areas around the world. Due to growing population and raising incomes, food supplies will be increasingly required to respond to society's food demand; therefore, water resource is mostly needed to cultivate food products. In addition, biomass production which produces biofuel or ethanol also needs to require usage of a lot of water in its production process. Thus, if societies do not well manage or control to consume water resource, they will face water scarcity. Moreover, article [35] reports that most countries grow biofuels on forests, wetlands and grasslands which store enormous amount of carbons to produce bio energy. Consequently, biofuel production might lead societies to confront deforestation issue because many trees are destroyed when the demand of biomass consumption is rapidly increasing.

In short, governments which have responsibilities not only to manage natural resources to respond to society demand but also to preserve natural resource condition should make regulations to prevent biomass production which does not extremely pressure natural resources. In addition, governments also should invest in developing biomass technology to reduce relying on natural resource, and increasing efficiency in usage of waste or chemical products to produce biomass energy instead.

7.0 Political Perspective

Governments can help stimulate the development and deployment of new energy technologies, next-generation ethanol fuels and advanced battery systems. However, the most critical role of governments is to set a policy framework to promote energy and environmental security and to balance these effectively. Developed countries such as US, Canada and Europe Union are committed to provide subsidies to promote energy efficiency. Developing countries are starting to get more concerned about Biomass and are making policies to promote and develop it and getting help from agencies.

Some of the areas covered by these policies to support Biomass include: Research and development; Dissemination and Policy Promotion; Environment protection; Portfolio Standards; Revenue generation through fossil fuel taxes.

In this report will be shown some of the policies and regulations that are being used to promote and support Biomass in United the States, Europe Union and Developing Countries.

USA: The number of Federal and state policies to support biomass in United the States is considerable; the policies have the function of guide and promote the development and use of biomass. They have the purpose of directing and funding biomass research, development, and deployment; ensuring interagency coordination of biofuels-related efforts; and requiring assessments of existing biofuels policies and programs. Other policies encourage the use of biofuels, or require their production, while still others guide the use of the resources used to produce biofuels. In spite of the specific purpose, most biofuels-related legislation is directed towards reducing dependence on foreign sources of oil, thereby increasing diversity and security of the nation's energy portfolio.

The Energy Independence and Security Act of 2007 is the most recent regulation. This Act creates a more aggressive Renewable Fuel Standard (RFS) calling for transportation fuel sold or introduced into commerce in the United States, on an annual average basis, contains at least the applicable volume of renewable fuel, advanced biofuel, cellulosic biofuel, and biomass-based diesel.

The Act authorizes $500 million for the period of fiscal years 2008 through 2015 for a grant program that makes awards to the proposals for advanced biofuels with the furthermost reduction in lifecycle greenhouse gas emissions compared to the comparable motor vehicle fuel lifecycle emissions during calendar year 2005, and not make an award to a project that does not achieve at least an 80 percent reduction in such lifecycle greenhouse gas emissions. It authorizes more $25 million for each of fiscal years 2008 through 2010 for grants for research, development, demonstration, and commercial application of biofuel production technologies in States with low rates of ethanol production, including low rates of production of cellulosic biomass ethanol, as determined by the Secretary.

The Secretary is establishing a program of research, development, demonstration, and commercial application for increasing energy efficiency and reducing energy consumption in the operation of biorefinery facilities. And it also authorizes $25 million for establishment of a competitive grant program, in a geographically diverse manner, for projects submitted for consideration by institutions of higher education to conduct research and development of renewable energy technologies (IEA).

Europe Union: The policy framework for encouraging bioenergy in Europe Union has several underlying objectives. First and foremost, the EU aims to reduce greenhouse gas emissions, reduce its dependence on imported fossil fuels, and diversify its sources of energy supply. However, bioenergy policies are also directed toward generating employment in agricultural and rural areas and promoting innovation and technological development.

The EU establish goals and targets that most be archived in the time framed, some of the targets are related to consumption of fossil fuel, promotion of bioenergy, and energy targets. Biofuels have received particular attention in the EU because they represent a promising alternative outlet for agricultural production and they are currently the only available renewable fuels for transport. After all, the transport sector is responsible for more than a quarter of all EU greenhouse gas emissions, and cars generate about 80 percent of the transport sector’s emissions [36]. Some of the policies that are now working in EU are: Promotion of biofuels for transport; Promotion of combined heat and power; European emission trading scheme; promotion of electricity produced from renewable energy sources; and waste management [37].

Developing countries: Many policy makers and researchers in developing countries are enthusiastic to see a progressive shift from traditional biomass use to improved use, and modern biomass use. In Africa countries are used only the traditional biomass, what counts of 60% of total final energy consumption; countries of Asia are been used improved biomass technology, where 25% is used in the energy sector; and in Latin America countries, the modern biomass technology is starting to be more used, Latin America still behind in the use of bioenergy, only 18% of the total.

Developing countries governments have some challenge related to biomass, such as: ensuring the biomass resources; how to widely disseminate improved biomass energy technology; and how to promote modern biomass energy technology to generate high quality fuels, gases and electricity. The development of modern biomass energy often requires significant capital investments and technical expertise, which may not be reality available in many developing countries. In addition, there are cases where the legal and regulatory framework in place does not support the development of modern biomass energy technology.

Designing and establishing an appropriate and effective institutional and associated legal and regulatory framework for biomass energy is a key challenge that decision makers and analysts need to urgently address. Policy measures that support the increased contribution of sustainable biomass energy to total energy supply are required. These measures could include modern forestry approaches, improved and modern biomass energy technology. Governments need to put in place policies that support the development and dissemination of improved biomass energy technology [38].

Bioenergy will become one of the most important roles to help developing countries to fight with the poverty and to create new jobs. The governments have the role to create policies to promote and disseminate biomass energy.

7.1 Support Agencies

IRENA - The International Renewable Energy Agency was officially established in Bonn on 26 January 2009. As of today, 137 states signed the Statute of the Agency; amongst them are 46 African, 36 European, 32 Asian, 14 American and 9 Australia/Oceania States.

Mandated by these governments worldwide, IRENA aspires to become the main driving force for promoting a rapid transition towards the widespread and sustainable use of renewable energy on a global scale. Acting as the global voice for renewable energies, IRENA envisages providing practical advice and support for both industrialized and developing countries, thereby helping to improve frameworks and build capacity. Moreover, the Agency intends to facilitate access to all relevant information, including reliable data on the potentials for renewable energy, best practices, effective financial mechanisms, and state-of-the-art technological expertise [39].

BRDI - The Biomass Research and Development Act established the importance of greater cooperation between Federal agencies in biomass research and development. The Act created The Biomass Research and Development Initiative, which is a solicitation for biomass research issued jointly by the U.S. Department of Agriculture and the U.S. Department of Energy. The Act also established the Biomass R&D Board (Board) and Biomass R&D Technical Advisory Committee (Committee) to help guide the multi-agency effort to coordinate and accelerate all Federal biobased products and bioenergy research and development [40].

GEF - The Global Environment Facility (GEF) unites 179 member governments — in partnership with international institutions, nongovernmental organizations, and the private sector — to address global environmental issues. An independent financial organization, the GEF provides grants to developing countries and countries with economies in transition for projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants.

These projects benefit the global environment, linking local, national, and global environmental challenges and promoting sustainable livelihoods. Established in 1991, the GEF is today the largest funder of projects to improve the global environment. The GEF has allocated $8.6 billion, supplemented by more than $36.1 billion in cofinancing, for more than 2,400 projects in more than 165 developing countries and countries with economies in transition. Through its Small Grants Programme (SGP), the GEF has also made more than 10,000 small grants directly to nongovernmental and community organizations [41].

DOE - The Department of Energy is committed to reducing America's dependence on foreign oil and developing energy efficient technologies for buildings, homes, transportation, power systems and industry. Its mission is to strengthen America's energy security, environmental quality, and economic vitality in public-private partnerships that: enhance energy efficiency and productivity; bring clean, reliable and affordable energy technologies to the marketplace; and make a difference in the everyday lives of Americans by enhancing their energy choices and their quality of life.

It leads the Federal government's research, development, and deployment efforts in energy efficiency. DOE's role is to invest in high-risk, high-value research and development that is critical to the Nation's energy future and would not be sufficiently conducted by the private sector acting on its own [42].

An integrated approach between government, community, industries and Universities is essential in order to implement biomass energy production and fully realize the potential benefits of bioenergy. Only through this collaboration can the varied and important benefits of biomass be obtained.

8.0 Opportunities

With regard to energy security and environment issues, people have to explore another renewable energy source to relieve these concerns. Biomass energy has a good potential which people can use biomass energy to replace or reduce conventional energy consumptions (e.g. fossil fuels). Thus, if governments or societies can effectively manage biomass production and consumption, biomass will be able to offer many opportunities improving energy security and environment problems caused by consuming fossil fuel. This paper distinguishes biomass opportunities to five groups.

8.1 Opportunities –Technology Perspective

The potential of biomass energy is huge as the availability of feedstock is abundant and can be easily converted into useable forms of energy. The improvement in pre-treatment technologies and in the conversion technologies, the cost production is expected to reduce thus making it more competitive with conventional sources of energy. Further, improvement in the technology have provided opportunity to efficiently use feedstock such a municipal waste, medical waste and grass etc.

Also, with further improvement in technology will allow to use lignocellulosic feedstock's to produce ethanol instead of using corn or other food crops in energy production. This will address some of the concerns regarding the food availability.

8.2 Opportunities – Environmental Perspective

- Production of more biomass energy will reduce use of fossil fuels that will help reduce global warming.
- Reduce the nation's dependence on foreign oil, and improve the environment by developing alternative energy source, increase use of agricultural crops to produce bio-fuels. [R1]
- Government should define rules on deforestation, and production of crops which can produce biomass energy.
- Plan trees every year to reduce carbon-dioxide emission level.
- Do classification on collecting waste which can help not only garbage problem but also production of biomass energy.
- Develop a better way to reuse rain water, and waste water.

8.3 Opportunities – Economical Perspective

Since biorefineries are built up in rural area, they can create job opportunities for local residents and improve the livelihoods of rural poor populations concentrated in marginal areas. In addition, biomass yields a high value product with multiple application possibilities. It increases demand for feedstock from farmers.

However, cost is the most significant issue for utilizing biomass technology. The cost development timeline shown in Table 8.1 summarized the key activities of the Biomass Program through completion of critical path technology development (D1). This overall performance goal reflects the addition of new feedstock, new conversion technologies, and new cellulosic biofuels.

<table>
<tr><th>Process</th><th>Activities</th><th>Goal in 2012</th></tr>
<tr><td>Feedstock Production</td><td>Reduce production processing costs(harvesting, storage, preprocessing and transportation)</td><td rowspan="2">$0.39/gallon
130 million dry tons/year</td></tr>
<tr><td>Feedstock Logistics</td><td>Reduce transportation cost</td></tr>
<tr><td>Biofuels Production</td><td>Reduce the processing cost of converting cellulosic feedstock to ethanol</td><td>$0.92/gallon</td></tr>
<tr><td>Biofuels Distribution</td><td>Develop capacity to transport and distribute</td><td>24 billion gallons of biofuel</td></tr>
</table>

Table 8.1. Biomass Cost Development Timeline

8.4 Opportunities- Social Perspective

Following biomass technology, biomass can use a variety of feedstocks to produce biomass energy (i.e. social and industrial wastes and agricultural feedstocks). Societies can reduce their wastes to supply biomass production to obtain bioenergy which can return social energy benefits. In addition, biomass production creates a lot of agricultural jobs to cultivate feedstocks and boost economic in rural areas. Consequently, people will have more revenues which support to decrease disparity of income problem between rural and urban areas. However, governments should limit to balance between food production and biomass production to not affect to decrease food supplies.

In short, societies can improve food and energy security issues to sufficiently respond both social food demands and biomass consumption demands. Moreover, societies can reduce to rely on fossil fuels leading societies to have environmental issues (i.e. climate change) and energy price volatility by consuming biomass energy instead.

8.5 Opportunities-Political Perspective

The increasing policy and regulation on use of fossil fuels around the globe is directly helping in promoting the renewable energy source. In addition to this, the green energy policies set by different countries are successful in (1) creating awareness among people (2) help Research and development (3) helping in building collaboration among the companies and universities (4) finally, because of tax incentives and initial funding provide by these policies are attracting more numbers entrepreneurs towards renewable energy thus promoting innovation.

9.0 Conclusion

In conclusion, biomass along with other renewable energies can help tackling the climate change and enhance energy security by reducing the dependency on fossil fuels.

The opportunities to create new technologies and ways to improve biomass efficiency are relevant, and with these technologies, the cost of biofuels and other co-products production can be reduced. This improvement in technology will allow biomass to be more competitive with other conventional energy sources in terms of cost and quality.

The environmental benefits from using biomass are huge. It helps in reducing the carbon footprint significantly. More importantly, with the use of municipal solid waste and medical waste as feedstock, it plays major role in reducing landfill. Though Deforestation is another concern, as per our research, the industry is trying to address this concern by focusing more on short rotation forestry (SRF) in order to get the needed feedstock.

The concern about the food supply is one of the challenges that biomass is facing at this moment; but a well support policy is needed to address this issue. It is expected that the success of using lignocellulosic feedstock can be the answer for this concern. If successful, other countries can follow this process, initiated by United States. In addition, short rotation crops can help in addressing the food concern. We also observed that, biomass can provide more jobs in rural areas and in biorefineries when compared to other conventional energy sources.

The use of modern biomass in developing countries is still weak and the necessity to promote this energy source is crucial to help them overcome dependency of foreign energy. International agencies are engaged to assist these countries to build regulations and to promote the right use of modern biomass.

Further, we agree with Biomass Coordinating Council (BCC) on need of integrated approach to effectively implement sustainable biomass production. Government, universities and local communities must coordinate their resources and knowledge; particularly needed in developing countries. Many OECD and non-OECD countries are promoting biomass by having a secure and well-done policy that not only will boost biomass, but also protect the society and environment.

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