Biomass Energy Source, Review study

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***Abstract* - Contain of this paper describes the possible applications of renewable energy sources to replace fossil fuel combustion as the prime energy sources in various countries and discusses problems associated with biomass combustion in boiler power systems. Here, the term biomass includes organic matter produced as a result of photosynthesis as well as municipal, industrial and animal waste material. Brief summaries of the basic concepts involved in the combustion of biomass fuels are presented.**

***Keywords* - Biomass energy, Renewable, Gasification, resources.**

I. INTRODUCTION

Today Biomass, as a renewable energy foundation, is biological material from living, or recently living organisms. As an energy source, biomass can either be used directly, or converted into other energy products such as Bio fuel. In the first sense, biomass is plant matter used to generate electricity with steam turbines & gasifiers or produce heat, regularly by direct combustion. Examples include forest residues (such as dead trees, undergrowth and tree stumps), yard clippings, wood chips and even municipal solid waste. In the second sense, biomass includes plant or animal matter that can be converted into fibers or other industrial chemicals, including bio fuels. Industrial biomass can be grown from numerous types of plants, switch grass, hemp, corn, poplar, willow, sorghum, sugarcane, and a variety of tree species, ranging from eucalyptus to oil palm.

1. Biomass Sources

Biomass is carbon, hydrogen and oxygen based. Biomass energy is resulting from five distinct energy sources: garbage, wood, waste, landfill gases, and alcohol fuels. Wood energy is derived both from direct use of harvested wood as a fuel and from wood waste streams. The largest source of energy from wood is pulping liquor or “black liquor,” a waste creation from processes of the pulp, paper and paperboard industry. Waste energy is the second-largest source of biomass energy. The main contributors of waste energy are municipal solid waste (MSW), manufacturing waste, and landfill gas. Biomass alcohol fuel, or ethanol, is derived primarily from sugarcane and corn. It can be used directly as a fuel or as an preservative to gasoline.

Biomass is a renewable resource and estimated to be extra across the country. It has been identified as a potential source for power generation. Biomass is derived from the by-products of various resources like agricultural crops such as paddy, corn and sugarcane, wood waste and forest residues. It is estimated that Karnataka has a biomass based power generation potential of 1000 MW and till date close to power projects totaling to 90 MW have been commissioned. Biomass can be transformed to other usable forms of energy like methane gas or transportation fuels like ethanol and biodiesel. Rotting garbage, and agricultural and human waste, release methane gas also called "landfill gas" or "biogas." Crops like corn and sugar cane can be fermented to produce the transportation fuel, ethanol. Biodiesel, another transportation fuel, can be produced from left-over food products like vegetable oils and animal fats. Also, Biomass to liquids (BTLs) and cellulosic ethanol are still under research.

The biomass used for electricity production ranges by region. Forest by-products, such as wood residues, are trendy in the United States. Agricultural waste is common in Mauritius (sugar cane residue) and Southeast Asia (rice husks). Animal husbandry residues, such as poultry litter, are Popular in the U.K.

2. Technical feasibility of Biomass (including rice husk)

Rice husk is a proven fuel for power generation. It is used in dissimilar parts of the country like Maharashtra, Andhra Pradesh, and Tamil Nadu. While it is not one of the best biomass as far as combustion individuality are concerned, its availability as a processed fuel makes it a good choice. It has reasonably good calorific value of 3040 kCal /kg. It is important to note that the calorific value of husk deteriorates if stocked for a longer period. The high ash content of rice husks and the characteristics of the ash inflict restrictions on the design of the combustion systems. For example, the ash removal system must be able to remove the ash without affecting the combustion characteristics of the furnace. The temperatures must be controlled such that the ash melting temperature of approximately 1440°C is not exceeded and care must be taken that the entrenched ash does not erode components of the boiler tubes and heat exchangers. For power production using rice husks, water tube boilers are the most common choice. The combustion chamber is normally of rectangular cross section. The walls of the chamber are formed either by tubes welded to each other or with the interstitial space overflowing with refractory. The chamber is closed at the base. The type of closure depends on the type of boiler but there is always a means of extracting ash from the base. Taking into account the pooling cost of biomass, these power plants use other locally available agro fuels (whose cost is lower than rice husk) along with rice husk to minimize the operating costs. Apart from the boiler, the rest of the other tools of a combustion based biomass power project is similar to any coal based power project.

3. Biomass Types

Distinguish the various types of biomass in different ways but one simple method is to define four main types, namely; Aquatic plants, Woody plants, herbaceous plants/grasses, Manures. Within this classification, herbaceous plants can be further subdivided into those with high- and low-moisture contents. Apart from specific applications or needs, most commercial activity has been directed towards the lower moisture-content types, woody plants and herbaceous species and these will be the types of biomass investigated in this study. Aquatic plants and manures are intrinsically high-moisture materials and as such, are more suited to 'wet' processing techniques. Based chiefly upon the biomass moisture content, the type of biomass selected subsequently dictates the most likely form of energy conversion process. High moisture content biomass, such as the herbaceous plant sugarcane, lends itself to a 'wet/aqueous' conversion process, involving biologically mediated reactions, such as fermentation, while a 'dry' biomass such as wood chips, is more economically suited to gasification, pyrolysis or combustion. Aqueous processing is used when the moisture content of the material is such that the energy requisite for drying would be inordinately large compared to the energy content of the product formed. However, there are other factors which must be taken into consideration in determining the selection of the conversion process, apart from simply moisture content, especially in relation to those forms of biomass which lie midway between the two extremes of 'wet' and 'dry'. Examples of such factors are the ash, alkali and trace component contents, which impact adversely on thermal conversion processes and the cellulose content, which influences biochemical fermentation processes.

4. Biomass Properties

It is the natural properties of the biomass source that determines both the choice of conversion process and any successive processing difficulties that may happen. Equally, the choice of biomass source is partial by the form in which the energy is required and it is the interplay between these two aspects that enables flexibility to be introduced into the use of biomass as an energy source. As indicated above, the categories of biomass considered in this study are woody and herbaceous species; the two types examined by most biomass researchers and technology providers. Dependent on the energy conversion process selected, particular material properties become important during subsequent processing. The main material properties of interest, during subsequent processing as an energy source, relate to:

- i) Moisture content (intrinsic and extrinsic),
- ii) Calorific value,
- iii) Proportions of fixed carbon and volatiles,
- iv) Ash/residue content,
- v) Alkali metal content,
- vi) Cellulose/lignin ratio.

For dry biomass conversion processes, the first five properties are of interest, while for wet biomass conversion processes, the first and last properties are of prime concern. The quantification of these materials properties for the various categories of biomass is discussed in the following section.

II. MATERIALS AND METHODS

A flame biomass has three major valuable effects on the economy and environment. First, using biomass as a fuel significantly reduces the amount of waste that must otherwise be placed in landfills. Instead of land filling waste sawdust, bark, chips and municipal trash, using these materials as a fuel can decrease the volume of waste from one hundred percent to about three percent, depending on the type of material converted to a fuel. This helps motivate the Economy of the region.

A. What are the green impacts?

The term "biomass" encompasses diverse fuels derived from timber, agriculture and food processing wastes or from fuel crops that are specifically grown or reserved for electricity generation. Biomass fuel can also include sewage sludge and animal manure. Some biomass fuels are derived from trees. Given the capacity of trees to regenerate, these fuels are considered renewable. Burning crop residues, sewage or manure all wastes that are continually generated by society to generate electricity may offer environmental benefits in the form of preserving precious landfill space OR may be grown and harvested In ways that cause environmental harm.

At present, most biomass power plants burn lumber, agricultural or construction/destruction wood wastes. Direct Combustion power plants burn the biomass fuel directly in boilers that supply steam for the same kind of steam-electric generators used to burn fossil fuels. With biomass gasification, biomass is converted into a gas - methane - that can then fuel steam generators, combustion turbines, combined cycle technologies or fuel cells. The primary benefit of biomass gasification, compared to direct combustion, is that extracted gasses can be used in a Variety of power plant configurations. Because biomass technologies use combustion processes to produce electricity, they can generate electricity at any time, unlike wind and most solar technologies, which only produce when the wind is blowing or sun is shining. Biomass power plants currently represent about 11,000 MW - the Second largest amount of renewable energy in the nation.

Whether combusting directly or engaged in gasification, biomass resources do generate air emissions. These emissions vary depending upon the accurate fuel and technology used. If wood is the primary biomass resource, very little SO_2 comes out of the stack. NOx emissions vary significantly among combustion services depending on their design and controls. Some biomass power plants show a relatively high NOx release rate per kilowatt hour generated if compared To other combustion technology. This high NOx rate, an effect of the high nitrogen content of many biomass fuels, is one of the Top air quality concerns associated with biomass. Carbon monoxide (CO) is also emitted sometimes at lives higher than those for coal plants. Biomass plants also release carbon dioxide (CO_2), the primary greenhouse gas. However, the cycle of growing, processing and burning biomass recycles CO_2 from the atmosphere. If this cycle is continuous, there is little or no net gain in atmospheric CO_2. Given that short rotation woody crops (i.e., fast growing woody plant types) can be planted, matured and harvested in shorter periods of time than natural growth forests, the managed production of biomass fuels may recycle CO_2 in one-third less time than natural processes. Biomass power plants also divert wood waste from landfills, which reduces the productions and atmospheric release of methane, another potent greenhouse gas. Another air quality concern associated with biomass plants is particulates. These emissions can be readily controlled through conventional technologies. No biomass facilities have installed advanced particulate emission controls. Still, most particulate emissions are relatively large in size. Their impacts upon human health remain unclear. The collection of biomass fuels can have significant environmental impacts. Harvesting timber and growing agricultural products for fuel requires large volumes to be collected, transported, processed and stored. Biomass fuels may be obtained from supplies of clean, uncontaminated wood that otherwise would be land filled or from sustainable harvests. In both of these fuel collection examples, the net environmental plusses of biomass are significant when compared to fossil fuel collection alternatives. On the other hand, the collection, processing and combustion of biomass fuels may cause environmental problems if, for example, the fuel source contains toxic contaminants, agricultural waste handling pollutes local water resources, or burning biomass deprives local ecosystems of nutrients that forest or agricultural waste may otherwise provide.
The first "conventional" solar still plant was built in 1872 by the Swedish engineer Charles Wilson in the mining community of Las Salinas in what is now northern Chile (Region II). This still was a large basin-type still used for supplying fresh water using brackish feed water to a nitrate mining community. The plant used wooden bays which had blackened bottoms using logwood dye and alum. The total area of the distillation plant was 4,700 square meters. On a typical summer day this plant produced 4.9 kg of distilled water per square meter of still surface, or more than 23,000 liters per day. Solar water Distillation system also called "Solar Still". Solar Still can effectively purify seawater & even raw sewage. Solar Stills can effectively removing Salts/minerals {Na, Ca, As, Fe, Mn} Bacteria { E.coli, Cholera, Botulinus}, Parasites , Heavy Metals.
Basic principal of working of solar still is "Solar energy heats water, evaporates it and condenses as clouds to return to earth as rainwater".

- **Advantages**
- ➢ Biomass used as a fuel reduces need for fossil fuels for the production of heat, steam, and electricity for residential, industrial and agricultural use.
- ➢ Biomass is always available and can be produced as a renewable resource.
- ➢ Biomass fuel from farming wastes maybe a secondary product that adds value to agricultural crop.
- ➢ Mounting Biomass crops produce oxygen and use up carbon dioxide.
- ➢ The use of waste materials reduce landfill disposal and makes more space for everything else.
- ➢ Carbon Dioxide which is released when Biomass fuel is burned is taken in by plants. Less money spent on foreign oil.
- **Disadvantages**
- ➢ Agricultural wastes will not be accessible if the basic crop is no longer grown.
- ➢ Additional work is needed in areas such as harvesting methods.
- ➢ Land used for energy crops maybe in demand for other purposes, such as faming, conservation, housing, resort or agricultural use.
- ➢ Some Biomass change projects are from animal wastes and are relatively small and therefore are limited.
- ➢ Research is needed to reduce the costs of production of Biomass based fuels.
- ➢ Is in some cases is a major cause of pollution.

III. INDUSTRIAL OPTIONS

A. Gasification

There are two main industrial options to generate electricity by using rice husk & other biomass as fuel. They are

- **Combustion**
- **Gasification**

Combustion route is one of the oldest established technologies for power generation. Biomass combustion based power projects are similar to coal fired plants. The plant consists mainly of a boiler, steam turbine, alternator, fuel handling, ash handling etc. The only difference between a coal fired and biomass fired plant is the design of boiler. In the process, biomass is fired and the heat energy is used to generate steam in the boiler. The steam turns the turbine which in turn rotates the alternator thereby producing electricity. The range of these biomass fired plants varies between 1 MW to as high as 50 MW. There are many suppliers such as Thermax, Triveni engineering, BHEL, etc who provide services for Biomass power plants. Gasification is process to convert biomass into gaseous fuel, which is termed as producer gas. The process is based on pyrolysis of biomass which results in the flammable gas. This gas is used to generate electricity by feeding it into internal combustion gas engines. The technology for the rice husk is available but not very well proven. The other limitation with the technology is the capacity of power projects. The maximum ability for these projects goes up to 500 kW. Experience with grid inter-phasing is also limited. Therefore the possible options for biomass based power projects in MW scale is the combustion route.

Gasification is a more than century old technology, which flourished before and during the Second World War. The technology disappeared soon after the Second World War, when liquid fuel (petroleum based) became easily available. During the 20th century, the gasification technology roused intermittent and variable interest among the researchers. However, today with rising prices of fossil fuel and increasing environmental concern, this technology has regained interest and has been developed as a more modern and sophisticated technology. Gasification is primarily a thermo-chemical conversion of organic materials at elevated temperature with partial oxidation. In gasification, the energy in biomass or any other organic matter is converted to combustible gases (mixture of CO, CH4 and H2), with char, water, and condensable as minor products. At first, in the first step called pyrolysis, the organic matter is decomposed by heat into gaseous and liquid volatile materials and char (which is mainly a nonvolatile material, containing high carbon content). In the second step, the hot char reacts with the gases (mainly CO2 and H2O), leading to product gases namely, CO, H2 and CH4 (Dasappa et. al., 2004). The producer gas leaves the reactor with pollutants and therefore, requires cleaning to satisfy requirements for engines. Mixed with air, the cleaned producer gas can be used in gas turbines (in large scale plants), gas engines, gasoline or diesel engines.

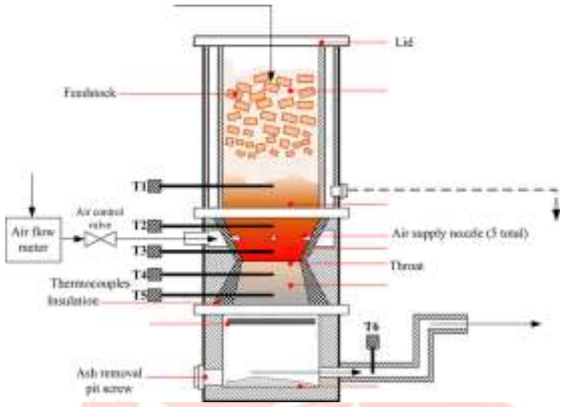

Figure 1. Gasifier design and various reaction zones

The conversion of the biomass to syngas takes place in the downdraft gasifier. There are four distinct processes in the gasifier as the gases make their way through the gasifier: drying of feedstock, pyrolysis, combustion, and reduction. The Imbert design of the gasifier allows the throat to reach temperatures higher than 800°C which enables tar cracking and the production of syngas with the formation of the least amount of char and particulates. There are three major parts of the gasifier, which are described below. As shown in Fig. 1, the first part that is located on the top of the gasifier consists of the condensate drain and a lid. The drying and pyrolysis of the feedstock occur in this section since there is available heat supplied by the flue gas rising from the combustion zone below. The second section consists of the throat region with the air intake valve, air nozzles and the grate. Initially, fresh charcoal is filled up in this section to start combustion. The throat region is designed to achieve the necessary temperature for the combustion and the cracking of tar at the reduction zone. The five air nozzles supply the air for combustion, and the air intake valve is used to control the rate of airflow into the gasifier. The last part is the place where the char and dust settle at the end of the reaction, allowing only the syngas to flow out of the gasifier. The grate filters the ash and dust produced during combustion and allows them to pass and settle at the bottom of the gasifier. Also shown in Fig. 3 are six thermocouples and an air flow meter that were used to measure the temperature distributions in the gasifier and the air flow rate, respectively. A detailed certification and study on the gasifier operating characteristics and performance are given in the previous publication of Balu et al.

B. Technical Performance of Biomass power plants

A majority of biomass power plants (6 – 7.5 MW capacity) has installed boiler of rated capacity of 30 ± 3 TPH water tube type travelling grate bi-drum boiler and 6.5 MW Impulse reacting turbine. The designed steam temperature from the boilers is 480 ± 15 °C. Steam is generated at 65 kg/cm2 (g), 465°C and is fed to turbine. The steam is exhausted at 0.1ata from the turbines and is fed to the surface condenser. Biomass such as rice husk, coconut waste, coconut coir, bengal gram dust, maize waste, palm fiber, wood chips, and saw mill dust are the main fuels. The average fuel consumption is around 225 – 250 MT per day. The boiler is with an in-built economizer, air pre-heater and wet scrubbing venture system. The operation of the boiler is centrally controlled with DCS system. The produced steam is passed through an expansion cum condensing turbine. Other auxiliary equipment are connected to support the operations. The power generated is exported to the grid. A brief detail of the typical biomass based power plant is provided in table.

C. Biomass price

During the study, the cost of biomass fuels was collated from power plants, rice millers and agents. The type of biomass and its current price in different States are given in table 6.2.

Table 6.2 Type of Biomass and its current price in different states

STATE	Karnataka	Andra Pradesh	Tamil Nadu	Maharashtra
Rice Husk	2200-2800	1400-2900	2000-2700	
Maize/Com	2400	1500		2400-2600
Coffee Husk	3000			
Wood Chips	1500		2600-2700	
Juliflora	<1000	<1300	1600	
Chili Powder	1400	1600		
Palm Oil		<600		
Agro Waste			<1200	<1600

D. Biomass Gasification Technologies

Based on the design of gasifiers and the type of fuels used, there exists different kinds of gasifiers. Figure 2 shows three principal types of gasifiers: fixed bed systems, fluidized bed systems and entrained flow systems. All these processes can be operated at ambient or improved pressure and serve the purpose of thermo-chemical conversion of solid biomass.

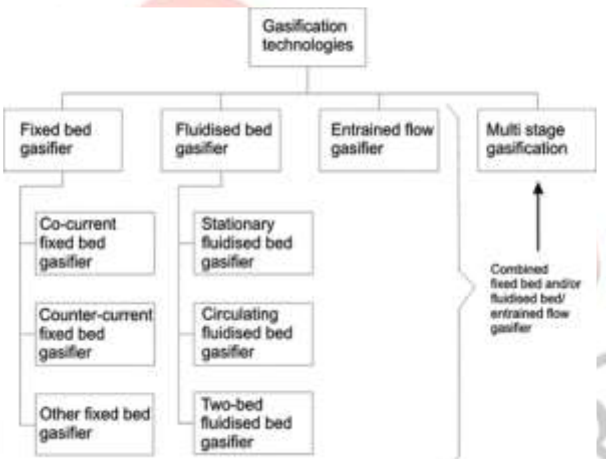

Figure 2. Overview of the different gasification technologies
(Source: BIOS, 2010)

Five major types of classification are fixed-bed updraft, fixed-bed downdraft, fixed-bed crossdraft, bubbling fluidized bed, and circulating fluidized bed gasifiers, which are demonstrated in Figure 3. Isolation is based on the means of supporting the biomass in the reactor vessel, the direction of flow of both the biomass and oxidant, and the way heat is supplied to the reactor (Ciferno and Marano, 2002). Fixed bed gasifiers are typically simpler, less expensive, and produce lower heat content - producer gas. Fluidized bed gasifiers are more complicated, more expensive, and produce a gas with a higher heating value. The product gas from biomass gasification can be used to generate electricity or heat or both heat and electricity using a combined heat and power (CHP) system called integrated gasification combined cycle (IGCC or BIGCC, Biomass-fired IGCC). Several demonstration and commercial CHP plants have been developed around the world as alternatives to the use of fossil fuel for electricity production.

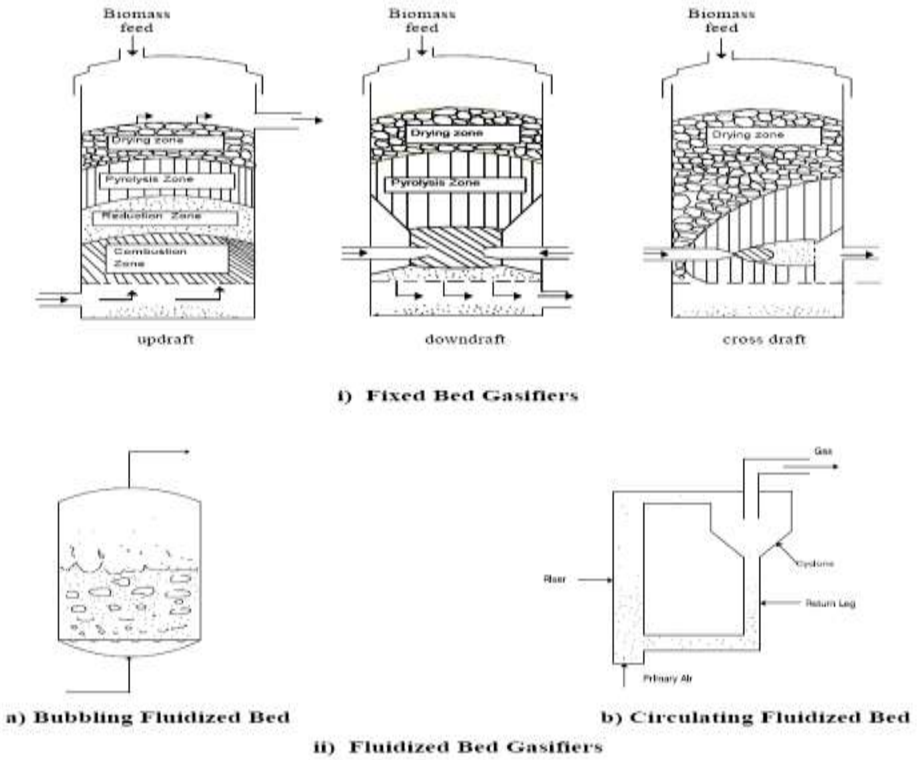

Figure 3. Fixed and fluidized bed gasifiers

IV. CONCLUSIONS

- The use of biomass, as a fixed energy source for the third world, can play a pivotal role in helping the developed world reduce the environmental impact of burning fossil fuels to produce energy but only if major areas of replanting are auctioned immediately.

- Biomass is an accepted form of renewable energy and is seen as a means of helping to decrease global warming, by displacing the use of fossil fuels: up to 10% of the UK's electricity needs is targeted to be generated from renewable forms of energy by 2010.

- From the four main types of biomass, woody plants and herbaceous plants and grasses are the main types of interest for producing energy, with notice focused on the C4 plant species.

- The stored chemical energy in plants is contained in the cellulose, hemicelluloses and lignin components of the plant, the proportions varying with the type of plant.

- Globally biomass based power generation has been familiar as a technically and commercially viable source of power generation. The thrust on technology development and commercialization of technology has led to development of the biomass power generation market. Ensuring availability of biomass and reducing the biomass price volatility among biomass power projects is vital to achieve sustainability. At the same time, it is also important to have attractive buyback duty for renewable energy such as biomass for which a strong regulatory mechanism should be in place. Biomass is a perennial source of energy, unlike solar and wind which are cyclic. The best buyback tariffs will encourage power producers to go in for technology up gradation (like FBC boiler of higher pressure) from time to time leading to increased returns and sustainability.

V. REFERANCES

[1] Reference: http://seminarprojects.com/Thread-biomass-fuelled-power-plants.
[2] Study on the sustainability of Biomass based power generation in Karnataka Demirbas A. Recent advances in biomass Conversion technologies. Energy Edu Sci Technol 2000;6:19–40.
[3] Kalogirou SA. Solar thermal collectors and applications. Prog Energy Combust Sci 2004;30:231–95.
[4] Sayigh AAW. Renewable energy: global progress and examples. Renew Energy 2001, WREN; 2001 p. 15–7.
[5] Johanson TB, Kelly H, Reddy AKN, Williams RH. Renewable fuels and electricity for a growing world economy. In: Johanson TB, Kelly H, Reddy AKN, Williams RH, editors. Renewable energy sources for fuels and electricity. Washington, DC: Island Press; 1993. p. 1–71.

[6] UNDP. World energy assessment 2000 energy and the challenge of sustainability. New York: UNDP; 2000 (ISBN 9211261260). A. Demirbas / Progress in Energy and Combustion Science 190 31 (2005) 171–192
[7] Edinger R, Kaul S. Humankind's detour toward sustainability: past, present, and future of renewable energies and electric power generation. Renew Sustain Energy Rev 2000;4: 295–313.
[8] Nakicenovic N, Gru¨bler A, McDonald A, editors. Global energy perspectives. Cambridge, UK: Cambridge University Press; 1998.
[9] Fridleifsson IB. Geothermal energy for the benefit of the people. Renew Sustain Energy Rev 2001;5:299–312.
[10] Tewfik SR. Biomass utilization facilities and biomass processing technologies. Energy Edu Sci Technol 2004;14: 1–19.
[11] Demirbas A. Biomass resources for energy and chemical industry. Energy Edu Sci Technol 2000;5:21–45. Demirbas A. Global energy sources, energy usage and future developments. Energy Sources 2004;26:191–204.
[12] Demirbas A. Sustainable cofiring of biomass with coal. Energy Convers Manage 2003;44:1465–79. I.M. Arbon, Worldwide use of biomass in power generation and combined heat and power schemes, J. Power Energy 216 (2002) 41– 57.
[13] J.M. Beer, Combustion technology developments in power generation in response to environmental challenges, Progr. Energy Combust. Sci. 26 (2000) 301–327.
[14] F. Evrendilek, C. Ertekin, Assessing the potential of renewable energy sources in Turkey, Renewable Energy 28 (2003) 2303–2315.
[15] Matsumoto H, Takahasi S. Improvement of thermal efficiency for combined cycle power plant during load following operation. IEEE Trans on Energy Conversion 1999;14(3):787–94.
[16] Roy S. Optimal efficiency as a design criterion for closed loop combined cycle industrial cogeneration. IEEE Trans on Energy Conversion 2001;16(2):155–64.