



## Role of Biomass in the Mitigation of Energy Crises in Pakistan

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**Abstract**— The main driving force to run any country is the energy department, as we know that the worlds natural energy reservoirs are depleting day by day so for the energy security of our upcoming generation and for our survival and also for the protection of our environment we have to move towards the biomass utilization especially for the developing countries like Pakistan. We have to improve our technology and gain the knowledge about the current energy system for the efficient use of naturally available biomass resources. Now a day some steps have been taken and some technologies are under the improvement to shift the dependency from non-renewable resources to the renewable resources. This report gives the literature review of the potential of biomass based energy in Pakistan based on the present situation and future perspectives. This report also highlights the natural and local biomass resources and also discuss the probable biomass conversion techniques to convert such natural resources to bioenergy. The potential impact of bioenergy on different sectors like household and industrial sector. Importance of bioenergy over fossil fuel for Pakistan economy and also the challenges to bioenergy production from biomass and will suggest the optimum solution for them.

**Keywords**— Renewable Energy; Biomass; Wind Energy, Hydropower, Salient Features, Agriculture residue, biofuels.

### I. INTRODUCTION

The energy dependency of the world is upon the fossil fuels and the consumption of the fossil fuels increases day by day [1], due to which the natural reservoirs of the non-renewable fossil fuels are diminishing day by day and also due to the use of non-renewable resources our environment and future energy security is in risk. Now a day's different kinds of technologies are under the process to convert our dependency from non-renewable resources to the renewable resources, and minimizing the usage of fossil fuel due to which the emission of greenhouse gases [2] also reduce and our environment will

be safe. Bio energy is not only the energy which just replace the goods based upon the petroleum but it can also provide the extra amount of energy. The basic utilities and our economy of the industries are directly affected by the crises of energy in way of electricity and gas [3]. One of the main reason of energy crises in Pakistan is the cost of the fossil fuels because our local industries and the native consumers use furnace oil and natural gas to produce electricity [4]. So to counter these issues in Pakistan and other developing countries, biomass is measured as a probable source. It is easily available in large amount inside the country. All the renewable energy resources are attractive because they have low environmental effects and is the best solution for the energy crises in developing and developed countries. The developed countries like European Union (EU) is producing nearly 71 % of energy from the renewable resources [5, 6].

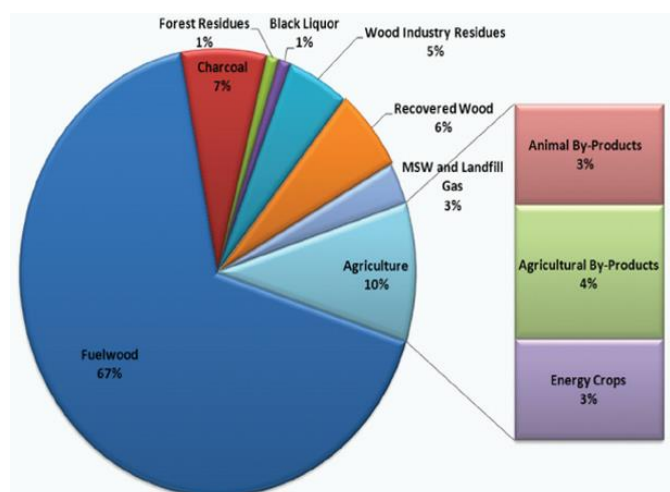


Figure 1 Global biomass distribution as primary resource

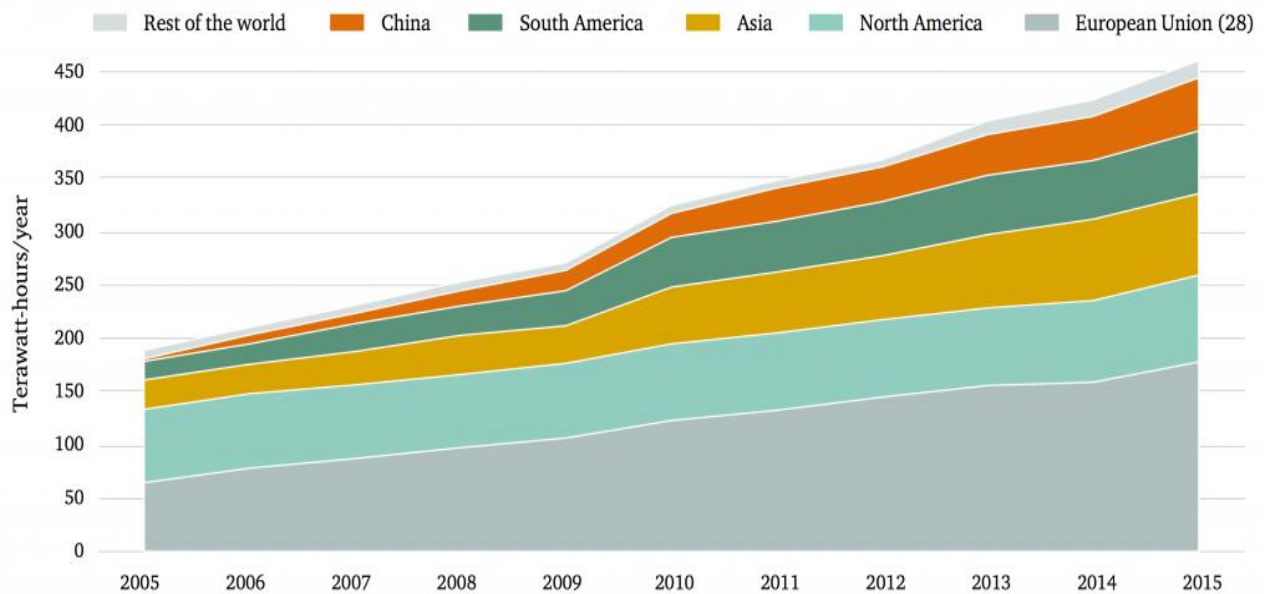


Figure 2 Regional biomass-based electricity production

Among the all renewable resources biomass is the easily available resource and play an important role in full filling the energy demand of the whole world in different sectors like building and transportation and electricity. In the global energy mix the biomass is considered is to be largest energy source because it represents 14 % of the total 18 % renewable energy [7]. Currently 10 % (50 EJ) is the representation of biomass in the total energy supply and added 370 TWh production of electricity in year 2012 [8]. One of the different thing in using of biomass is that the by conversion of the biomass the final product differs expressively based on different areas, i.e. Numerous liquid fuels in Americas, charcoal and the wood fuel for the domestic heating and also use as fuel in small scale industries in Asia and Africa, and use in producing power and for heating purpose in Europe. Those countries which have large amount of biomass resources we clearly see the large share of bio energy in their total energy mix. Fig 1 shows the amount of different biomass resources as world major energy supply. According to the survey of IEA department, there is a large potential in biofuels nearly about 27 % of the whole world transportation requirements of fuel in year 2050 that shows the biofuels have large potential and can easily replace the petroleum based fuels in the future. The share of electricity

production from biomass in the total electricity production in world is 1.5 %. Production of electricity from biomass in different areas from 2005 to 2015 [9] is shown in Fig 2.

The waste materials are using as an input in the energy system for the production of renewable energy in the different developed countries. However, some of the developing countries like Pakistan are still behind to acquire the right method and good use of biomass as an alternate renewable energy resource. Presently the contribution of the renewable energy resources in which biomass, hydro power, wind and solar is about 18 % of the total energy consume in the world [10]. In Pakistan there is critical situation of energy crises due to which our country goes towards the antagonistic social and extended duration of financial problems [11-13]. However, they are now paying attention to use the available natural resources, like solar energy, biomass, wind energy and the potential of hydro-power to overcome the energy crises and demands of the country. The ratio of the use of energy from different energy resources e.g. gas, oil, coal, nuclear from the year 2010-2016 is shown in Fig 3 [14].

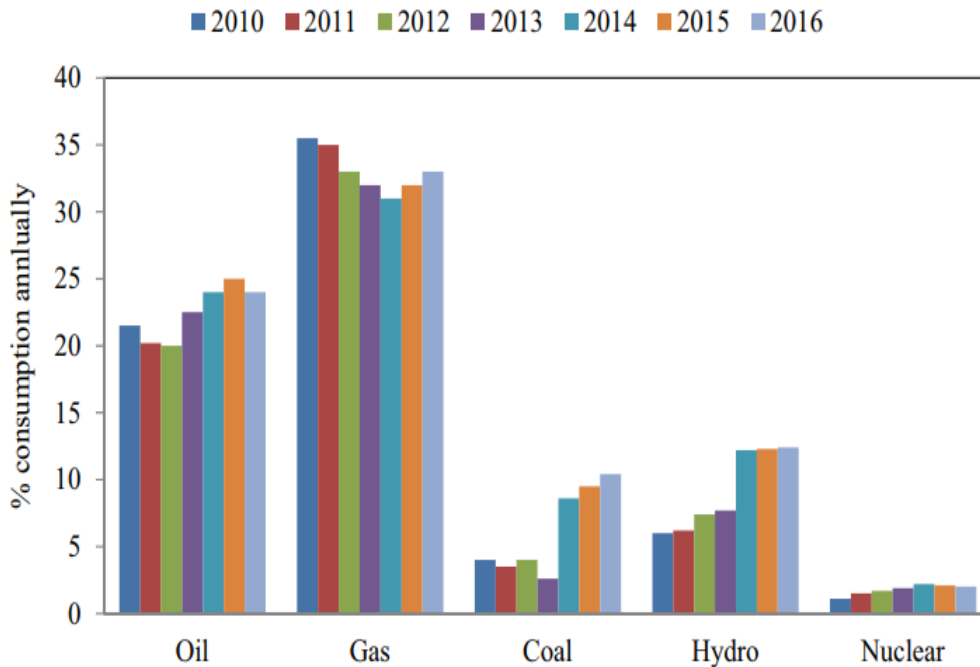


Figure 3 consumption of energy from various resources in pakistan

As the population of Pakistan increases day by day so the consumption of energy also increases in Pakistan. In the beginning Pakistan use the natural available resources like natural gas and big dams for the generation of hydro power but after that when the demand of energy increases Pakistan starts to import the oil to run the industries [15] and to overcome the energy crises in Pakistan, but still there is an energy deficiency in Pakistan. So Pakistan have to move towards the alternative energy resources to minimize the dependency on the imported oil, LPG which is shown in fig 3. The economy of the 60 % of the total population of Pakistan is concern with the agriculture and also about 62 % of the total population of Pakistan is living in the villages in the rural areas and they depend on the use of biomass for their daily purposes like cooking and for heating [13, 16-22]. Wood and animal waste are the two major sources of biomass for the need of energy in the villages of Pakistan. In the developing countries biofuels like ethanol and biodiesel and also other different biomass resources are used for the transportation and for the electricity generation. In the villages of pakistan they have very limited access to the fossil fuels and also other old energy resource like hydro power etc. so they are almost dependent on the traditional methods for using the wood, animal waste, and waste from agriculture for their fuels. In future the role of renewable energy is very important for fulfilling the energy demands of Pakistan [23]. New technologies are very necessary for Pakistan to convert the available resources of biomass which then play an important role in the completion of the energy demands of Pakistan.

## II. NATURAL BIOMASS RESOURCES

The remaining of the wood, crops and the waste of animals have solar energy stored in them by the photosynthesis process. Biomass is used by the peoples in the form of wood for heating purpose and also for cooking. Like the other countries biomass also play a crucial role in the village's economy because it is the replacement of fossil fuel as a primary source of energy. Biomass is present in different kinds like solid, liquid or in gas form and is the 4th major source of energy and supplies nearly about the 10 % of the whole world energy supply. The comparison between the generation of electricity from biomass in Pakistan and total energy generation from biomass in the globe of the year 2015 [24] is shown in Fig 4. The components of the biomass is cellulose, hemicellulose and lignin which are used for the generation of energy. We see from the figure that Pakistan is mostly dependent on the natural Resources like natural gas, oil and the petroleum based products due to which our economy is decreasing day by day so we have to move towards the alternative resources like Renewable resources such as Solar energy, wind energy and biomass energy.

Due to the ignorance and absence of the policies for the good utilization of biomass, a large amount of the remaining's of the crops is burnt instead of their usage for the production of electricity or some other kind of energy. There are different sources of the generation of biomass in Pakistan like remaining's of the forest, wastes from the industries, municipal solid waste and different crops. Different resources of biomass (Fig 5) are listed below

- Wastes from the food processing
- Forest and the woodlands
- Residues from forestry

- Wastes from the industries like black liquor from paper industry
- Waste from the sugar cane industry like bagasse
- Animal dung
- Municipal solid waste (MSW)

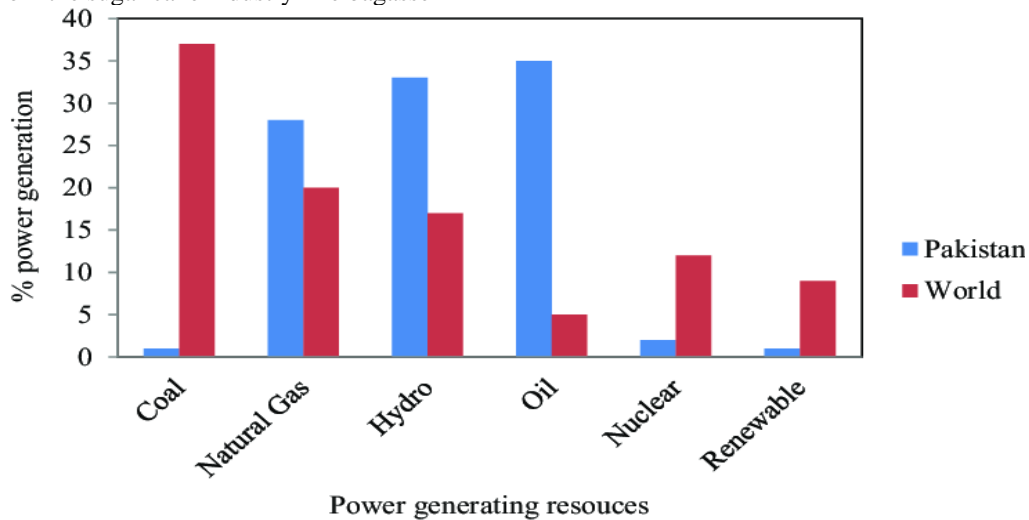


Figure 4 Pakistan and global fuel mix for power generation

In this report I enlighten only such resources of biomass which are present in large amount for the production of bioenergy. Some of the good resources of biomass, and how they are presently consuming and some of the processes of the conversion of biomass are present in the Fig 6. We see in the table that in our country some of the biomass resources like wheat straw, bagasse animal dung or poultry manure and also the solid wastes from the houses are present in very large amount so if we use the good and effective conversion techniques instead of using these resources as a traditional method like just for heating purpose and for cooking purpose we can easily fulfill our energy requirements and can minimized the energy crises in Pakistan.



Figure 5 Different Resources of Biomass

By the conversion of biomass, we can obtain a variety of fuels like solid, liquid and gas with the help of using some of the techniques in which some physical and chemical processes are involved. The main purpose is to convert a raw material which is easily available into valuable fuel. Biomass is the one of the largest available renewable resource and is on the 4th position provides almost 35 % of the energy especially in the

developing countries. Biomass is the source which available for a long time as long as people are living in the world and it is

also eco-friendly because in the growing stages it absorbs carbon dioxide and when during its conversion into bioenergy it emits carbon dioxide. Thus in this way carbon dioxide is recycled and due to which it does not take part in the greenhouse effect.

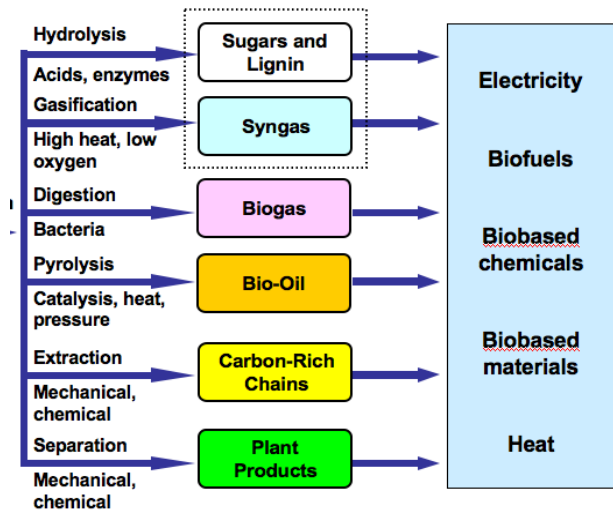


Figure 6 processes of conversion of biomass

1) Municipal solid waste:

Pakistan is one of those countries in which the environmental issues are on large scale because of the municipal waste because we have no proper method to treat this waste due to which country are facing some of the hazardous health issues. Municipal solid waste consists of the many materials like organic matters and also some of inorganic matters which have to pass through the several processes to

convert them into the or to use them for the production of energy. Conferring to survey in Pakistan, if we take the calorific value of these solid waste 6.89 MJ/Kg annually, then by using this municipal waste we can produce power near about 13,900 GWh annually [25]. Pakistan have some of the big cities like Karachi, Islamabad, Multan, Lahore in which a large amount of industries is present and they are producing a large amount of municipal waste and this waste can be efficiently convert into the energy. In municipal waste the wastes from the industries as well as waste from the house hold areas both are include. But in case of Pakistan this tremendous energy source has been wasting because of the lack of awareness and also lack of good technology use for the conversion of this municipal waste in to the energy so these waste are causing different kinds of diseases because there is no proper collection of these wastes.

#### 2) Wastes from animal:

In the developing countries like Pakistan people use the animal dung as an energy source for heating and cooking purpose. Wastes from the animal can be directly converted in to biogas which is then use as energy source and these wastes contains the organic materials and normally people called these waste a manure. In Pakistan the amount of the different kinds of animals are very high some animals are used for milk some are used for transport etc. so according to the survey the animal dung produce per year is 368,434,650 metric tons [26]. In some areas of Pakistan small plants are installed which convert the animal dung into the biogas which is then used in small industries and use in household purposes. In the big cities of Pakistan there are proper chain of Dairy forms and they are producing a huge amount of animal dung which is use in the agriculture land as fertilizer to increase the production of their crops and to reduce the cost which is spend on buying the fertilizer.

#### 3) Agriculture land waste:

Pakistan is agricultural country and most of the people rely on agriculture in the rural areas and also more than half of the population of Pakistan is living in the rural areas of Pakistan so they produce a tons of agriculture land farms residue which are the basic resource for the biomass. In different kinds of agriculture farms there are many types of by products like Wheat straw, straw from rice, bagasse and cotton sticks etc. [27] which are main sources of biomass and can be converted into energy. According to the survey of World Bank the total land covered by the agriculture farms is 26,280,000 hectares. A large amount of the remaining's of the corps are used by the local peoples for their daily needs like cooking etc.

Pakistan is on the 4th position in the list of producing large amount of sugar from sugarcane countries, so they can produce a huge amount of cane trash and producing a large amount of bagasse in the season of reaping during the preparation of sugar. The total cultivated sugarcane in the year 2010 and 2011 is nearly about 63,920,000 metric tons and during the preparation of sugar the by-product or trash generated from this is nearly 5,752,800 metric tons from which we can generate 9475 GWh in the year as bioenergy. According to the constitution of

Pakistan the sugar mills can generate their own electricity by using bagasse to fulfill their own electricity needs and can install a plant up to a capacity of 2000MW.

There is also another biomass resource rather than a trash or bagasse which is called cotton sticks which are obtain from the crops of cotton ad have a good potential to convert into the energy. If we want to fulfill the requirements of local and international textile industries, we have to cultivate about 11 % of the total cultivated land for producing cotton. In year 2011 we residue which are collected from cotton crops is nearly 1,474,693 metric tons [28].

#### 4) Wood residue from forest:

In the old ages people are dependent on the wood and they use wood for their survival as a cooking and for heating purposes. People goes into the forests and collect the small sticks and then stock them in their homes for burning and cooking purpose. In Pakistan the people from the northern areas are still dependent on these forests for their cooking and heating. The residue from the forests includes small trees, branches, and the wood left after cutting. In Pakistan the land covered by forests is 5.2 % of the total land available which is equal to the 4.224 million ha's area [29].

The remaining of the forests are environmental friendly and can give us a huge amount of bioenergy which covers near about 80 % of the total energy use in Pakistan from biomass [30].

### III. IMPACT OF BIOENERGY ON DIFFERENT SECTORS

#### a) Impact on household:

Around 62 % of the total population of Pakistan is living in the villages, and these peoples are dependent on the natural available resources like wood, animal waste, residue from the different crops for their cooking and for purpose of heating [31]. There is good impact of biogas in the villages and also in the big cities because it is use as a resourceful fuel for cooking, as well as the reaming's of the animal waste e.g. dung has also the potential to produce 12 million m<sup>3</sup>/day of biogas with help of which almost 28 million people of villages [32] are getting benefit for their daily use. Other than a private sector, there are almost 4137 small biogas plants are installed by the Directorate General of New and Renewable Resources (DGNRR) under the super vision of Ministry of Petroleum in the whole country. These small plants have a good potential that they can produce 3000 and 5000 Ft<sup>3</sup> of biogas which is use for lightening and heating purpose. Due to the energy crises and low availability of other energy resources about 76 % of the people in Pakistan are rely on the biomass. The consumption of biomass energy in the year 2010 was 954.56 PJ, and the consumed energy by the household sector was 711.75 PJ (76 %).

#### a) Impacts on industrial sector:

In Pakistan most of the industries are running on the fossil fuels or on petroleum based products which is very expensive and also have environmental impacts and also the reservoirs of the fossil fuels are depleting so now they are focusing towards the alternative energy like biomass to fulfill their energy needs.

In the total energy intake, the amount fixed for our industrial sector is 23 % (209.34PJ) [33]. Among all countries Pakistan is on the 10th position for using the biomass resources for their industrial sector (Table 1). As we see in the Table 3 Brazil is on the top of the list of using biomass for their industrial sector and their share in the whole world is 18 %.

Table 1: countries using bioenergy in industrial

No.	Country	Primary Solid Biomass (PJ)	Industrial use of Biomass (PJ)	Global Share
1	Brazil	1317	1317	18
2	India	1195	1195	16
3	United States	1063	1171	16
4	Nigeria	379	393	5
5	Canada	287	287	4
6	Thailand	283	283	4
7	Indonesia	272	272	4
8	Congo	185	185	3
9	Sweden	169	169	2
10	Pakistan	135	135	2
11	Finland	111	112	2
12	Australia	195	105	1
13	Other Countries	1752	1790	23
14	World	7220	7366	100

The main source for the production of energy from biomass is bagasse which are using by many of the industries for the generation of their electricity and this bagasse is easily available from the sugar cane residues. The major portion of the bagasse nearly about 70 % is use as a fuel for the extraction and condensation steam turbines (CEST) in the sugar industries and remaining portion of bagasse is use in the other different industries for the generation of heat and power (CPH) [34]. Also the residues from the agricultural land like cotton sticks etc. contributes efficiently and produce 85.5PJ energy for different kinds of industries. But most of the agriculture residues are used directly by the people for their heating purpose [35].

b) Advantages of biomass over the fossil fuel for the economy of Pakistan:

The environmental issues are increasing day by day due to the installation of new technology in the industries and due to the development of industries. Now a day the sources of electricity or energy in most of the industries are petroleum based product and these products are also use in the transportation sector. There is huge amount of organic compounds present in these petroleum based products so when they burnt the emission of organic compounds (VOC) is done which very harmful for the environment and cause the greenhouse effect. So we need solution for these problems to save our environment and for our survival [36]. So by considering all these aspects renewable energy resources is the most effective and sustainable solution for the environmental issues and the for the energy crises. The attention of the peoples is diverting towards the bioenergy now a day. There are many

advantages of using bioenergy for the environment which is as follow [37];

- Biomass can be used for producing different by products like ethanol
- Reduce the emission of harmful gasses
- Provide Employment opportunities and economic growth
- Easily available and cheap
- Minimize the dependency on fossil fuels
- Sustainable energy
- Reduce landfills

#### IV. METHODS OF BIOMASS CONVERSION

The conversion of biomass can be done effectively into the different kinds of products with the help of many methods and different technologies like by applying some of the thermal technologies which includes anaerobic digestion, pyrolysis etc. shown in Table 1. This conversion of biomass is also helpful to get rid of the waste material and convert it into the valuable products. From biomass we can generate electricity and some other valuable products by applying Fischer-tropsch reaction [38]. Municipal solid waste is declared as impending resource for the generation of energy. Other than that the conversion of biomass into valuable products is one of the potential way for managing the solid wastes and to protect the environment.

##### A. 5.1 Thermal Technologies:

In thermal technologies the feed in the process is biomass which can be converted into different fuels including solid, liquid and gases fuels by simply heating the feedstock at different temperatures. During this heating process the decomposition of biomass occurs then in result bioenergy can be produced from which we can overcome our energy crises.

##### a) Pyrolysis

It is the conversion technique of biomass into bioenergy which includes the heating of the biomass at higher temperature providing inert atmosphere. The pyrolytic properties of the biomass can be determined by their chemical conformation like lignin cellulose etc. A chain of reactions can be done on the biomass to get different kinds of products. The variety of the product depend upon the operating conditions of the reaction. When a pyrolysis of cellulose is done below 300 C it will decrease the generation of water molecules, molecular weight, and also decreases the production of carbon mono, char and carbon dioxide. When the reaction occurs in between 300oC to 500oC the anhydrous glucose will convert into tarry pyrolylate with the help of DE polymerization [39]. At very high temperature the anhydrous sugar will convert into the gases which are light in weight and volatile by passing through a series of different reactions like fission, dehydration, and disproportionation reactions. In the developing countries like countries in Asia the basic raw material for the pyrolysis is agriculture residue and different organic waste.

From biomass we can produce biogas, liquid biofuels and some other solid product by passing our feedstock under the thermal decomposition in the absence of air at very high

temperature of 500-800°C [40]. The quantity of the product depends on the temperature of the reaction. At low temperature we can get the solid products or liquid biofuels and at higher temperature the product will be biogas. According to the literature study the main product of the biomass is biofuels which is in between 40-75 % of the total product obtain from the biomass.

#### b) Combustion

In this technique the feed (biomass) are heated up at very high temperature 800-1000 °C due to which our biomass convert into the flue gases which are then further use for the production of steam and then this steam is used for the generation of electricity with the help of turbines [41]. The combustion process of biomass is not only the combustion occurs in the old days, but it includes the multifaceted combustion and it is very difficult to control and manage the combustion of biomass because in biomass we have different kinds of solid waste and there are many phases reaction occurs during combustion and these complexity is studied properly recently and is using for designing the efficient, controlled and proper combustion systems.

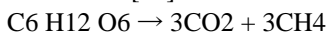
#### c) Gasification

Biomass can be converted into gaseous form with the help of process known as gasification. During this process incomplete combustion of biomass occurs with the help of thermal decomposition and then biomass will convert into the mixture of combustible gases which includes methane, hydrogen, carbon monoxide, carbon dioxide, nitrogen and some water vapors [42]. In result of gasification the product amount is very low and the produced gas is use on the laboratory scale for different chemical reactions and also use for household engines.

Gasification and the pyrolysis are the same processes but the only difference is that gasification occurs on high temperature for the controlled gas production. The process of gasification of biomass is newly introduced to increase the efficiency of the process and also to minimize the cost of input by using gas turbine technology [43]. The efficiency achieved by the combined-cycle gas turbine is nearly about 50 % until now. The waste gases produce during this process are reprocessed and use for the production of steam which is further use in the steam turbines.

### B. Biochemical technologies

Biomass is composed of different kinds of organic matters which are disintegrated by using microorganism in the inert media or in the presence of oxygen for the production of biogas. Whenever microorganism reacts with organic matters it will easily break the structure of organic matter and then convert it into products like biofuels or biogas from simple chemical conversion [44].



In recent days a lot of research has been done on the residue of the forest and agriculture and also on the animal dung to convert it into the potential biofuels like biogas etc.

#### a) Fermentation

In the fermentation process our raw material is sugar. In this process we simply done the hydrolysis process with the help of different microorganisms mostly we use bacteria to convert our raw material (sugar) into the ethanol. In the developed countries this process of producing ethanol has been done on very large scale in the different industries to produce very large amount of ethanol. The main raw material in this process is sugar and starch crops, worldwide 60-70 % material used for the production of bio-ethanol is corn starch.

#### b) Trans esterification

The production of biodiesel is done by the catalytic Trans esterification of the bio-oil. The major raw materials use for the production of biodiesel on the industrial scale are soya bean, mustard, hemp, sunflower, animal fat [45]. The catalyst use in this process are acid, base or some kind of enzyme which is immobile on the substrate and help in the speed of the reaction.

#### c) Anaerobic digestion

Anaerobic digestion is the process in which we can produce biogas by doing microbial activity on the biomass in the absence of oxygen. This process is done on both the industrial level and the household level to convert our raw material (biomass) into the valuable biogas which is the mixture of different gases like methane, hydrogen, carbon dioxide and some amount of other gases [46]. A simple digester convert biomass into the biogas with the help of microorganisms and then this biogas can be use directly for the heating or cooking purpose on domestic level or can be used in gas engines on the industrial level.

### V. IMPORTANCE OF BIOFUELS

We are living in such kind of world in which for the development of any country the most important factor and parameter is the energy. The world population is increasing day by day due to which large amount of industries have been installed to meet the demands of growing population due to which the demand of the energy is exceed from the production. The gap between demand and supply of the energy will not be fulfill by just dependent on the fossil fuels, so therefore we have to move towards some new energy resources to fulfill our energy demands and to overcome this energy gap between demand and supply.

Pakistan is also being affected by this crises of energy because natural reservoirs of the fossil fuels are draining and energy demand of the country is increasing with the increase in population, so it is necessary to go towards some other resources of the energy. A lot of work has been done on the production of bioenergy from the biomass in developed countries to overcome their energy crises and also this bioenergy has some special properties [47].

- Cheap raw material and its availability
- Help in the rural economy
- Reduce the carbon dioxide emission
- Protection of the land

Table 2: Energy supply from biomass in different countries

No.	Country	TPES Biomass (EJ)	TPES per Capita (GJ)	TPES per GDP (MJ/s)	Share of Biomass in PES (%)
1	India	8.41	6.79	5.88	23.50
2	USA	4.12	12.40	0.28	35.51
3	Brazil	4.07	16.89	2.99	28.30
4	Indonesia	2.39	9.23	5.33	25.44
5	Pakistan	1.27	6.97	8.29	5.58
6	Germany	2.37	16.55	4.38	25.57
7	Thailand	0.94	14.88	4.41	18.42
8	China	9.39	6.81	5.05	17.99
9	World	57.7	8.27	1.10	10.20

Table 3: Comparison of production and potential of biomass in Asian countries.

No	Countries	Biomass production Mt Yr-1	Biomass energy potential (PJ)
1	Bangladesh	54 – 61	1344.9
2	China	182.5 – 210.5	8899.8
3	India	62 – 310	8764
4	Sri Lanka	2.0 – 9.9	141.8
5	Thailand	11.6 – 106.6	821.4
6	Philippine	3.7 – 20.4	968.7
7	Pakistan	0.23 – 0.31	0.806

Like other developed countries in the world some of the Asian countries and also Pakistan are now paying attention to the production of energy from biomass and also doing some advance research in this field (Table 3). Other energy resources only provide or fulfill the energy requirement but in case of biomass it provide energy and also help in the management of the waste from the industries and the household sector to clean our environment. To keep clean and safe our environment the waste from the industries etc. have to be manage efficiently because due to these waste material many of the diseases could be spread [48].

The production of bioenergy by using biomass do not give us only energy but it can also enhance the economy of the country and also different industries in the developing countries. The production of bioenergy from biomass can also enhance and support the economy of the agriculture.

a) Biogas

The biomass collects from different resources have organic matters and by anaerobic digestion with the help of bacteria these organic matters decomposes and convert into biogas. The components present in biogas are methane (majority) carbon dioxide and some other gases. Biogas produce during anaerobic digestion can be used for heating and cooking purpose. Biogas also be produced naturally in rice paddies, and in the remaining of oceans and lakes by anaerobic digestion. This gas can also be produced in the remaining or dung from the animal when placed in moisture atmosphere. In case Pakistan the rural areas have a very large potential of biomass which comes from the

residue from the crops and forest and from the animal manure and this can be convert into biogas by installing family size plants in rural areas of Pakistan. Also some of the plants are installed in different kind of industries through which they fulfill their energy demands.

According to the survey the installed biogas plants in the whole country is 5357 which have the potential of production of biogas about 12-16 million m<sup>3</sup> /day and this huge amount of biogas can fulfill the cooking and heating demands in the rural areas of Pakistan [49].

b) Transport Fuel

As we know that the industrial sector is dependent on the bioenergy and also the transportation sector is mainly dependent on the energy which comes from different type of liquid fuels which comes from the fossil fuels and in Pakistan the main consumer of the liquid fuels is the transport sector. The biofuels use for the transportation are normally liquid fuels which are extracted from different types of plants and also from the residue of crops which are pass through some steps and then convert into valuable biofuels. There are different kinds of biofuels which are preparing in the world like bioethanol, biodiesel, gasoline and butanol etc. But in the developing countries like Pakistan the main biofuels are biodiesel and bioethanol which can replace the other fossil fuels.

c) Biodiesel

The waste oil which comes from the houses and also the oil collected from different kinds of plants are processed and then convert it into the liquid fuel mainly composed of fatty acid alkyl ester which is called biodiesel. The oil for the production of biodiesel are mainly collected from the corn, canola, sunflower, peanut etc. We can also produce biodiesel from the used cooking oil and from fats

Pakistan is an agricultural country and we are mainly dependent upon the agriculture and also we have 70 % of agricultural land in total available land so we have a huge potential of producing biodiesel but cultivating such kinds of plants which give us oil and then we convert this oil into biodiesel. Therefore, it is necessary to promote such type of technology in Pakistan, which help us to overcome our energy crises and also help us in our economic growth. AEDB made a policy for the use of biodiesel as an alternative energy resource, in which the main objective is to minimize the dependency on the fossil fuel which is imported, also discourse the raw material demand for the production of biodiesel, and also to encourage the people for the pollution-free environment. On 14th Feb 2008, Economic Coordination Committee (ECC) made a strategy for the use of biodiesel as an alternative energy resource, here are some pf the points of this strategy [50].

- i. AEDB has the responsibility to facilitate the biodiesel plants according to the National Biodiesel Program
- ii. Biodiesel will be introduced gradually and mix biodiesel with the petroleum fuel to increase the use of biodiesel and to attain part of biodiesel which is 5 % by volume of the

total diesel consume in Pakistan by the year 2015 and this share will be 10 % by the year 2025.

iii. The quality and standard of the biodiesel will be maintained by Ministry of Petroleum & National Resources and have some standards for B-100 and can blend up to B-20.

iv. Biodiesel (B-100) are to be purchased by Oil Marketing Companies from the producers and then blend this biodiesel (B-5) in petroleum based fuel and then sale this fuel at their sale point.

During the esterification process the oil from the plants and animal fats are reacted in the presence of catalyst and alcohol and produce biodiesel which is then use as a replacement of petroleum based oil for the transportation purpose. The advantages of biodiesel over the petroleum based fuels in the transportation sector is as follows

- Environmental friendly
- Instead of petroleum based fuels biodiesel can be used in any type of diesel engines
- Biodiesel can also be used as a mixture when a small proportion of it is blend into the petroleum based fuels.
- It is nontoxic, and there is no contents of Sulphur and lead

d) Bioethanol

In the fermentation process the waste and residue collected from different resources are reacted in the presence of bacteria or yeast to convert the waste into bioethanol which can replace gasoline and can be used for internal combustion engine. There is a lot of potential available in biomass like municipal waste and residue from the corps which can be used for the production of bioethanol. According to the survey there are different methods which are being introduced for the production of bioethanol worldwide, and the best fuel for the combustion engine is bioethanol. Presently the major source of the bioethanol production is sugar industry in which raw material (sugarcane, starch based corps) are converted onto bioethanol.

## VI. CHALLENGES FOR THE PRODUCTION OF BIOENERGY FROM BIOMASS AND THEIR SOLUTIONS

The availability of biomass in Pakistan is very wide and there is much difficulties in harvesting and collection of these biomass resources like corps residue and wood from forest etc. so we have to planned our crop rotation efficiently due to which we can avoid the cutting of our forests (rain forests). There is a lack of good, efficient and proper equipment's for the biomass conversion so we have to develop such kind of culture which is new and more efficient and also develop the bio refineries. Another problem in case of biomass is that the availability of biomass is variable and its quantity vary season wise so we have to develop a system which is eco-friendly in which there is no extra deletion of forest and agriculture residue (due to the excessive removal of forest our eco-system will be disturbed and also irreversible degradation will occur). If we control our excessive cutting it will help our eco-system (if we harvest our agriculture residue, then it will decrease the emission from the decomposition. If there is no extra removal of forest residue it will prevent the natural fire the forest and also the insect's life

which is dependent on the forest will be safe). There is also a lot of CO<sub>2</sub> emission and biomass can act as carbon absorber it there is a culture of forestry [51].

The biomass resources are very wide but the energy densities of such resources are quite low so we have to maintain standards and suitability in case of biomass. Biomass resource can give us energy in all forms like solid, liquid and gaseous form. Another problem in case of biomass is the transportation of biomass to the plants their storage and their handling. So we have to develop our regulations about land use and labor due to which a lot of development will be done in the rural areas of Pakistan.

## VII. DEVELOPMENT OF BIOENERGY IN PAKISTAN

In the coming future bioenergy is one of the best alternative resource to overcome the energy crises. If we want to get benefit from this huge potential some challenges and issue which are mention above have to be resolved. By considering all the challenges if we want to use efficiently this potential resource we have to take some steps and pay extra attention towards this resource.

1) 8.1 Development in Technology

A separate department and centers of bio-energy are to be made which will promote the technology related to bio-energy in all educational sectors and also made some of the pilot plants of technology related to bio-energy for the display in museum [52]. We see that in our country we are focusing only some specific projects due to which there is misunderstanding and communication gap between different departments which are responsible for the development in energy and its commercialization. Some technical educational institute are being made in which we promote the alternative renewable energy resources and also understand the conversion technique of these alternative resources. After that efficient and trained people which are related to the field of science and technology of these alternative resources are need to be participate in making the good policy for these resources.

2) 8.2 Consciousness in different areas

We need to give the information to the people living in rural and urban areas about the importance and utilization of biomass energy and to highlight the efficient use of biomass for energy. It is the main step for making the program of bioenergy use successful. Some organization have been made which aware the people about the importance of bio-energy and also use media to give necessary information about the use of bio-energy with the help of trained and skillful people. The people which are related to the agriculture are to be encourage for the use of biomass energy technologies for their agriculture needs.

3) 8.3 Research and development

We have to focus on the development and research of the biomass technology so we can efficiently convert our biomass resources into the bio-energy and to make the biomass technology cheap so the people living in rural areas can easily buy this technology. The educational and research institutes

have to play very important role in this area and include the renewable energy course and also add some new technologies related to the biomass in different degree programs. The potential of biomass is considered to be important issue in both the private and public sector.

### VIII. STRATEGIES FOR THE PROMOTION OF BIOMASS

Other than the traditional resources of biomass for the bio-energy, we have to find some new resources of biomass to overcome the difference between demand and supply of the energy. There is huge amount of biomass resources present in the Pakistan which are efficiently convert into the bio-energy. Recently model (long range energy alternative planning system LEAP) has been proposed which is used for the identification of the use and production of those biomass resources which are non-woody like crops and animal waste in Pakistan and its importance as renewable resource in the future, whereas the biomass collected from bagasse increases up to 152.2 trillion and have the maximum part as compare to the other crops shown in the Table 4 [53]. Some of the biomass resources available other than conventional biomass resources in Pakistan are discussed below.

#### a) Waste from the city

Solid waste producing from the different cities of Pakistan is nearly about 55,000 t on the daily Basis, and if such huge amount of solid waste is collected properly then this will be used for the production of energy on very large scale [54]. Normally we burn our solid waste in an open environment due to this emission of harmful gases is done and due to these gases different types of diseases will occur. If these solid waste are burnt in a good way, then the heat generate from this burning can be used for the generation of electricity. With the help of proper handling and management of the solid waste a huge amount of electricity and heat can be generated.

#### b) Waste from poultry

There is a huge network of poultry forms/industry in Pakistan. A large amount of waste from the poultry forms which include waste from broiler chicken and the chicken in houses is produced daily. If we pay an attention to this biomass resource, we can generate a huge amount of energy from this resource [55]. According to the survey the amount of chicken in house and the broiler chicken in the year 2003-2004 is nearly about 15.2 million and 527 million respectively in which the share of KPK, Punjab, Sindh and Baluchistan are 6.4%, 67%, 23 %, 3.6% [56]. It is estimated that the amount of chicken waste is collected from a poultry farm of 3000 chicken in Pakistan is 15 t daily. If this huge amount of waste is processed properly then it has the potential to generate 40 MW electricity daily.

#### c) 9.3 Animal waste

According to the statistics given by the livestock department and Federal Bureau of Statistics (FBS) of Pakistan the amount of animal in Pakistan are nearly 46.8 million in which different kinds of animals are present like cows, bulls, sheep's, buffaloes and this huge amount of animals produce 700 million of kg manure on daily basis. So if we estimate

Table 1: shows the increase of biomass other than woody biomass and increase in animal growth.

Category	No	Type of Biomass	2009	2012	2030
Insignificant crops (million tons)	1	Bajraa	471	588.87	2275
	2	Maize	295	370.88	1433.2
	3	Barley	83	102.6	396
	4	Dry chili	19.8	23.4	90.8
		Total	866.8	1085.9	4196.7
significant crops (trillion tons)	5	Rice	6.8	7.6	12.9
	6	Cotton	3	3.2	5.4
	7	Wheat	23.8	26.8	51.5
	8	Bagasse	49.5	53.2	82.7
		Total	83.2	90.7	152.3
Animal Manure (millions)	9	Buffalo	36.8	46.4	185.8
	10	Cattle	34.3	43.3	172.8
	11	Sheep	27.9	31	59.7
	12	Camel	1	1.2	2.2
		Total	159.8	188.7	548.7

Then we can produce 17.6 million m3 of biogas by the fermentation process and also produced 50 million of kg

fertilizer as a remaining's from this process which can be used for agriculture purposes. Presently biogas is produced on a

small scale in some rural areas but if government can pay attention to this then we can produce a huge amount of biogas from this single source [57].

### IX. FUTURE SUGGESTIONS

In case of Pakistan the good and the best alternative for the traditional energy resources is biomass. The scientist is now concentrating more on the bio-energy from the biomass because of its easy availability for the generation of energy. With the help of other countries, the Gov. of Pakistan are making some new policies for bio-energy and there are also some projects for the generation of bio-energy are under the process in private and government sectors and also in some universities which are shown in the Table 5. Some of the policies and projects related to biomass are as follows

- The policy made by Pakistan for the addition of Renewable and sustainable energy (RSE) for the generation of energy also made the AEDB department so it can contribute nearly about 5 % from the renewable energy resources. The department of AEDB is now a days working on the production of biogas near Karachi in the Landhi cattle colony which have the huge potential of biomass to produce nearly 30 MW electricity and this project is funded by New Zealand.
- The agreement letter is given for the project of power plant having capacity of 12 MW in which the raw material is agriculture residue in Jhang and also a power plant of capacity of 9 MW is to be installed in Sindh by Pak Ethanol Pvt.

- In the near future the huge amount of small biogas plants nearly about 5000 plants are to be installed by the PCRET in different areas of the country
- Government of Pakistan invested a huge amount of money to import 1400 small plants of biogas.
- USPCAS-EN is working on the project “The availability of Biomass resources” which is funded by International Finance group a subsidiary of World Bank group.

Table 5: Organization and Universities working on Biomass

No	Government institute	Private institute	Universities
1	Directorate of Renewable energy (Ministry of petroleum and National resources)	REAP	NED university of engineering and tech.
2	Alternate energy development board (AEDB)	Engineering resource company	NUST
3	National commission for alternate energy	M.G Engineering Associate	UET Lahore
4	PCSIR	Trans Mark International Pvt.	BZU Multan
5	Pakistan council for renewable energy technologies	East End Engineers	Shaheed Zulfiqar ali Bhutto institute of science and tech
6		Tecnasia International	Comsats institute of info and tech
7		Sky green Engineering	Agriculture uni of Faisalabad
8		Engrotech	University of Balochistan

### CONCUSION

In case of developing countries biomass is one of the most efficient and best alternative source of other fossil fuel and can fulfill the demands of the country. Because of this huge potential of biomass available in the country Pakistan has to put extra effort on the Bio-energy to overcome the energy crises. This article highlights some of the potential biomass resources in Pakistan and also discuss some of the conversion techniques of biomass into bio-energy and also availability of these resources. Considering this huge potential of biomass Government of Pakistan has taken some technical steps to convert biomass into bio-energy. But private and government

institution have to take some emergency steps to utilize these resource to overcome energy crises.

There is also discussion in this article about some rural areas of Pakistan where there is a huge potential of biomass resources both natural and agriculture based. It is also necessary to highlight some thermal and bio-chemical techniques for these biomass resources to convert them into fuels like char, biodiesel, synthesis gas, and then these fuels are further converted into methane, hydrogen etc. These fuels are then use for the heating and cooking purposes in different industries and in houses and also we can convert them into transport fuel. This article have also information about the future development and

future importance of these biomass resources which can be used to minimize the energy crises in developing countries in the world.

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