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Biomass energy source in developing countries

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Abstract
Biomass is an important source of energy in developing countries. In some developing countries, energy from biomass such as wood and agricultural residues represents about 70% of total energy consumption per year. Main applications are in the domestic sector and small-scale industries, but also increasingly in modern systems for combined heat and power generation. Managed properly, biomass energy can be sustainable, environmentally and economically sound. Moreover, biomass energy creates substantial local employment. However, constraints to optimal use as an energy source are still to be resolved. Main issues are legal and institutional barriers, as well as lack of information and technology transfer. Furthermore, common misconceptions about biomass energy have to be redressed. It should be emphasized that the larger part of woody biomass fuels come from non-forest land; fuelwood use is not the root cause of deforestation; biomass energy is more than a traditional commodity; and biomass energy will not phase out in the foreseeable future. On the other hand, biomass is the major source of energy in rural Turkey. Biomass is used to meet a variety of energy needs, including generating electricity, heating homes, fueling vehicles and providing process heat for industrial facilities. Biomass potential includes wood and animal and plant wastes. The total biomass energy potential of Turkey is about 32 Mtoe. The amount of usable biomass potential of Turkey is about 17 Mtoe.

Keywords: Biomass energy; fuelwood; developing countries; sustainable development

1. Introduction

Energy is considered a crucial component of the physical capital needed to ensure sustainable livelihoods, but is often overlooked in humanitarian response interventions in acute emergencies and protracted crises [1]. Energy is needed to cook, process and preserve food, conserve vaccines for human and animal disease prevention, and irrigate crops. Its presence is vital to numerous purposes essential to the immediate needs of affected people, speeding up recovery and building resilience to future shock events. In acute emergencies and protracted crises, the provision of sustainably sourced cooking fuel coupled with appropriate, efficient and clean cooking technologies, can function as a life-saving intervention [2]. Fuel-related interventions are crucial from a food security and an environmental perspective. Regardless of whether food is provided in the form of rations or produced locally, there is a need for a safe, stable and sustainable supply of energy for cooking and heating [3].

About 2.3 billion people in developing countries rely on biomass fuels (e.g. fuelwood and charcoal) to meet their energy needs for cooking food as given in Table 1 [1]. So, fuelwood plays a vital role in ensuring the food security of millions of people and its consumption must be better understood in order to address resource shortages and forest decline. However, the supply and use of fuelwood are often embedded in complex systems that include external factors of a non-forestry nature, which influence the capacity to provide forestry-based solutions. Natural resources including fuelwood must therefore be carefully managed and monitored to meet current demands and ensure sustainability [3, 4].

Environmental impacts resulting from the unsustainable extraction, collection and/or use of woody biomass fuels can be long-lasting and cause damage [4]. Sustainable natural resource management can reduce these impacts and ensure a sustainable fuel supply in tandem with reforestation. Fuelwood can be supplied through a variety of tree and forest systems, such as mixed forest plantations, or through integrated food energy systems that produce both food and energy, such as agro-forestry

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systems [5]. Interventions on the demand side are also necessary to ensure a significant reduction in the unsustainable exploitation of forest resources, decreased expenditure on fuel, and reduced exposure to risk for collectors of fuelwood and other challenges faced by crisis-affected households [7]. Table 2 shows the fuelwood supply and consumption for some developing countries.

Biomass materials are used since millennia for meeting myriad human needs including energy. Main sources of biomass energy are trees, crops and animal waste. Until the middle of 19th century, biomass dominated the global energy supply with a 7% share. Among the biomass energy sources, wood fuels are the most prominent. With rapid increase in fossil fuel use, the share of biomass in total energy declined steadily through substitution by coal in the nineteenth century and later by refined oil and gas during the twentieth century. The present study gives an overview about biomass energy in some developing countries with Turkey. The study showed that there is an important potential for biomass utilization in these five developing countries with Turkey.

Table 1. Number of people relying on biomass for cooking and heating in developing countries (million)

Country/Region	2010	2020	2030
China	701	689	645
Indonesia	152	138	124
Rest of Asia	131	136	145
India	582	597	632
Rest of South Asia	124	165	187
Latin America	92	86	72
Africa	579	806	823
Total Developing Countries	2 361	2 617	2 628

Table 2. Fuelwood supply and consumption for some developing countries in 2010 (PJ)

Country	Fuelwood supply	Fuelwood consumption	Country
Indonesia	1 934	1 920	Indonesia
Malaysia	124	141	Malaysia
Philippines	390	500	Philippines
Thailand	412	540	Thailand
Vietnam	470	470	Vietnam
Bangladesh	410	414	Bangladesh
China	2 720	2 730	China

2. Biomass energy in developing countries

The use of conventional energy like oil, coal and electricity has increased enormously in the last four decades in developing economies [1]. During the 1980s, consumption more than doubled, with an average annual growth rate of 7% [2]. Less spectacular, and somewhat overshadowed by this conventional energy boom, consumption of biomass energy has also increased substantially over the same period. Biomass energy includes fuelwood, charcoal and agriculture residues used as fuel [3,4]. For the five developing countries including Indonesia, Malaysia, Philippines, Thailand and Vietnam where biomass is an important energy source, consumption increased on average 3% per year between 1990 and 2010, due mainly to population growth. Consumption is highest in Indonesia, accounting for more than half of the total consumption because of the large population, while the rate of increase is highest in Malaysia and Vietnam [5].

Despite this growth, the share of biomass energy in total energy consumption has been decreasing for most countries, which often leads to the misconception that it is being substituted by modern energy and is phasing out. In reality, conventional energy is mostly used for new applications such as new industries, transport and household electricity, whereas wood and other biomass continue to dominate in domestic activities such as cooking and in many traditional industries [5].

Only for Thailand, recent and regular national statistics on wood and other biomass energy consumption are available. Comparing these with population data, it appears that there is a strong correlation between population and biomass energy

consumption between 1990 and 2010 (0.99) [5]. By using population forecasts, we can predict an increase of nearly 15% in biomass energy consumption by 2010 over that in 1995. As accurate data on supply sources, both from forest and non-forest areas, are lacking it is difficult to assess if there will be enough supply available to meet future demand [6].

For the other four major biomass-using economies in developing countries, similar or even higher trends of increase in biomass energy consumption are forecast, considering their higher population growth and greater dependence on biomass energy. Of course the above is only a simple modeling exercise, but it highlights the need for more accurate, regular and detailed data on consumption and production of biomass energy and its sources in order to asses trends, to develop forecasts and to formulate appropriate policies [5].

3. Advantage and disadvantage

3.1. Advantages

3.1.1. Economy

Wood and other types of biomass are widely used as fuels in the (private) domestic and industrial sectors, basically because they are cheaper than other fuels. Local availability and reliability of supply add to the economic advantages [4]. Modern applications in both industrialized countries and in South-East Asia have demonstrated that biomass energy can also be competitive for larger-scale industrial applications. For fuel-importing countries, the use of local biomass can save substantial amounts of foreign exchange. The value of fuelwoods currently being used in these five developing country's economies is equivalent to an estimated US$ 24 billion annually [5, 6].

3.1.2. Environment

The sustainable use of biomass energy sources helps to manage the local environment. When wood and other biomass are properly valued by local populations as an important resource base, they are more likely to be protected. Sustainable use of biomass is also beneficial for the global climate, because it is carbon-neutral, whereas substitution by fossil fuels would add to the greenhouse effect. This is the main reason why many industrialized countries have embarked upon policies for increasing the share of biomass in national energy consumption.

3.1.3. Rural income

The use of wood and some other forms of biomass energy generates at least 20 times more local employment within the national economy than any other form of energy, per unit. A large amount of unskilled labor is engaged in growing, harvesting, processing, transporting and trading the fuels, which generates off-farm income for rural populations, either regularly or off-season. Policy makers in the European Union are increasingly coming to recognize the employment benefits for their own countries [5].

3.1.4. Social

In times of hardship, or when harvests are inadequate for subsistence, the opportunity to generate income in fuelwood business provides a safety-net for the people affected. The most important argument for using biomass for energy purposes is that it is a low carbon fuel, which is considered CO2-neutral at the point of combustion as it only releases recently absorbed carbon. It therefore does not contribute to increasing the CO2 content of the atmosphere and to the resulting aggravation of the greenhouse effect. Biomass is an essential part of the renewable portfolio; unlike other sources of renewables, it can provide Base-load power generation and heating, and can also be used in existing thermal plants. Furthermore, biomass can be used as fuel in the automotive and transport sector. We favor the use of sustainable biomass, avoiding potential detrimental effects on the environment and social welfare [4].

3.1.5. Efficiency

The application of biomass energy in modern technologies allows for increased energy efficiency by combined heat and power generation. Applications of cogeneration in decentralized systems based on locally available fuel resources help to further reduce losses in the transmission and distribution of power.

3.1.6. Energy mix

Incorporation of biomass fuels in national energy supply policy improves the energy mix by increasing the diversity of energy sources. This helps to reduce vulnerability to market fluctuations and can improve stabilization of prices.

3.2. Disadvantage

3.2.1. Misconceptions

It is sometimes assumed that biomass energy is a traditional commodity which will phase out in the near future. Some people even believe that fuelwood collection poses a major threat to tropical rainforests. Misconceptions such as these hamper the development of sound energy policies.

3.2.2. Data and planning

Systematic data are still inadequate or unavailable for biomass energy planning and for developing specific energy policies for supply and demand.

3.2.3. Technologies

Technologies for biomass combustion which are at present widely used in ASEAN economies still need to be improved towards best practice. Financial, institutional and legal issues have to be resolved to make the best use of available technologies.

4. Utilization and sources

4.1. Biomass fuels

Biomass fuels consist of both woody and non-woody biomass. The first come from trees and shrubs, the latter from crop residues and other vegetation. Both can be converted into charcoal. In these five developing country's economies, important biomass fuels are wood and residues from coconut, rubber and oil palm trees, as well as sawdust, bagasse and husks and straw from rice plants. They are used in both traditional and modern applications.

4.2. Utilization of biomass fuels

4.2.1. Domestic

The domestic sector is the main user of biomass fuels, primarily for cooking and space heating. The main user groups are farmers and villagers, but daily wage earners, industrial workers and food vendors in cities all use biomass fuels to some extent. Villagers also use biomass fuels to process agricultural products either for preservation or for conversion into tradable commodities. Biomass can be used as a source of energy input for electricity generation, provision of heat and in the transport sector. The biomass itself is derived from three principal sources: forestry, agricultural products and biogenic waste. These areas encompass a wide range of feedstocks, as discussed in later sections, but in general forestry products consist of wood, bark, branches and stumps, agricultural products consist of oil and sugar containing plants, whilst biogenic waste is derived from the agricultural, commercial and household sectors. These sources of biomass exist in three forms: solid (e.g. plants and wood), gaseous (e.g. from biowaste) and liquid (oils from crops or biofuels produced from lignocellulosic matter) [4].

4.2.2. Industrial

Numerous industries in these five developing countries rely on biomass fuels for process heat and drying of the final product. Many are small-scale and based on traditional technology. These industries usually purchase the fuel, but some also collect biomass fuels from free supply sources. The industries include: agricultural and food processing (e.g. like sugar, rubber); metal processing and mineral-based activities (e.g. brick making, lime burning); and forest products and textile industries (e.g. bamboo and cane). Besides these industrial activities, services rely on biomass fuels (e.g. road tarring, soap making, tyre retreading, paper making, fishing net and boat making, food preparation and catering services).

The current situation is not expected to change as long as the supply of biofuels is secure and their price remains competitive with commercial fuels like coal, gas and electricity. The consumption of biomass fuels may even increase with growth in population. Bio-energy-using industrial and other commercial activities are mainly found in rural areas, but also exist in townships and even metropolitan cities. Also, many households in large urban centers use biomass fuels, in particular charcoal. Densified biofuels (briquettes of charcoal fines and loose residues) are becoming more popular in urban centers where different forms of woody biomass fuels have already been accepted as traded commodities. At present, many higher-income rural families, urban households and industrial enterprises are purchasing biomass fuels, especially wood and charcoal, to meet their energy needs [4].

4.2.3. Modern applications

More recently, modern bio-energy has developed through adoption of technologies like cogeneration power plants. Cogeneration is gaining increasing acceptance. Efficient, mature and proven biomass-based energy conversion technologies are available both within and outside these five country region. Cogeneration of heat and power from residues in

forest-based and agroindustries is being increasingly promoted (particularly in Indonesia, Malaysia, the Philippines and Thailand) by the private sector, mostly for own use. Utility companies in Western countries already supply electricity and heat from biomass to national grids and local communities [5].

4.3. Sources of biomass energy

4.3.1. Fuelwood definitions

Biomass is defined as material of biological origin form. Biomass is organic material that is plant or animal based, including but not limited to dedicated energy crops, agricultural crops and trees, food, feed and fibre crop residues, aquatic plants, alga, forestry and wood residues, agricultural waste, processing by-products and other non-fossil organic matter [7].

Biofuels are solid, liquid or gaseous fuel produced directly or indirectly from biomass. Forest fuel (fuelwood) is produced directly from forest wood or plantation wood through mechanical process, the raw material has not previously had another use. Wood fuels are defined as all types of biofuels originating from woody biomass, where the original composition of the wood is preserved and unaltered from its original form [5]. Wood fuels are specified by: a) origin and source; b) major traded forms and properties. Following the definitions of major traded forms of wood fuels are [7]:

Firewood: Cut and split oven-ready fuelwood used in household wood burning appliances like stoves, fireplaces and central heating systems. Firewood usually has a uniform length, typically in the range of 200 mm to 1000 mm (see Figure 1).

Figure 1. Fuelwood (left) and log wood (right)

Log wood: Cut fuelwood in which most of the material has a length of 500 mm or more (see Figure 1).

Wood chips: Chipped woody biomass in the form of pieces with a defined particle size produced by mechanical treatment with sharp tools such as knives.

Wood pellets: Densified biofuel made from pulverised woody biomass with or without additives, usually in cylindrical form, of various lengths but typically 5 to 40 mm, with broken ends (see Figure 2).

Wood briquettes: Densified biofuel made with or without additives in cubiform or cylindrical units, produced by compressing pulverised biomass (see Figure 2).

Figure 2. Wood pelled (left) and wood briquettes (right)

4.3.2. The main sources of fuelwood

Forests are the most important source of wood fuels in southeast Europe. About half of the region's territory is covered by forests and this represents a significant source of wood fuel production [7]. Wood has been used as a source of fuel for millennia and is still used in households around the world. Wood fuel is used mainly in rural areas and less so in urban areas. On the other hand, plantations are usually defined as short rotation energy plantations. They are generally established on agricultural land, by regenerating new stems from stumps or roots, harvested over a 1-5 year cycle. Fast-growing species like poplar, willow, black locust and eucalyptus are commonly used. Short rotation coppice harvested on a 2-3 year cycle is the most common across Europe, with a planting density of between 5 000 and 16 000 plants per ha and a planting design of 0.5 x 3 m. The rotation cycle may vary from 1 to 3 years. A growing interest in coppice with a lower planting density and rotation cycles up to 5-8 years has also been registered. The obtainable assortments in this case are firewood and wood chips [5-7].

4.3.3. Fuelwood utilization

The forest source is one of many sources of fuelwood production. It consists of government-owned and managed natural forests and tree plantations. However, this is not the only or even the main source. The situation in Indonesia, Malaysia, the Philippines and Thailand presents a typical scenario [6]. In these countries, in recent years non-industrial plantations of different types have gained recognition as important sources of fuelwood supply. These non-forest sources, managed and operated mostly by the private sector as informal business enterprises, are gaining prominence in supplying traded fuelwoods to markets [5].

In the countries of South-East Asia, forest sources contribute between 10 and 50% of total national fuelwood supplies, with the balance coming from non-forest sources. The share of non-forest fuelwoods in total household-level consumption in Indonesia is reported to be as high as 93%, and the share in total fuelwood supply in the Philippines and Thailand as 85% and 50% respectively [1, 2, 6].

Forest and non-forest sources produce fuelwood by the felling of trees which have grown naturally, or trees which were raised on single or multi-purpose plantations (i.e. as the main products of dedicated fuelwood plantations or as by-products of non-industrial plantations). Alternatively, woodfuels are obtained as lops and tops from forest harvesting; as dead wood, fallen branches, twigs and dead stumps at site; as by-products of wood-based industries (e.g. waste and scrap wood, sawdust); as surplus non-commercial wood derived from land clearing; or as recovered wood from replacement or demolition of old structures and constructions (e.g. wood from old poles, posts, buildings, scaffolding). The latter are used mostly by the urban poor [4, 5, 7].

4.3.4. Other biomass

Agro residues like rice husk and straw, coconut husk and shells, palm oil kernel shells and fiber, and bagasse are the other main sources of biomass fuels. They are important for both the domestic and the industrial sectors. In Thailand, the energy balance shows that bagasse and rice husk accounted respectively for 8.4% and 1.8% of all energy used in the country in 2010. In Indonesia, residues accounted for 9–11% in 2010, in Malaysia 18–20% in 2010, and in the Philippines about 14% in 2010. These amounts are basically consumed in the industrial sector. Data for the domestic sector are often not available, but evidence from limited surveys indicates that biomass in the form of residues plays an important role, in particular in areas where wood as a source of energy is in short supply [5].

4.4. People involved

In addition to the millions of users of biomass fuels in these five developing countries, numerous actors play specific roles in the supply and distribution of traded biomass fuels from their sources to final users. Fuelwood collection for self-use and for the market can be an important occupation in rural areas. For the better-off it may be part-time off-season work, but for the poor it can very well be a full-time occupation for livelihood. And for yet others it may provide an opportunity for self-employment in fuelwood-related business to earn cash income and supplement household income. Most fuelwood gatherers live in villages close to the forests. They may be poor with very small land holdings, or landless laborers [5].

Estimated employment of fuelwood on the basis of person-days involved in production of one terajoule (TJ) of energy, compared to other commercial fuel alternatives, shows just 10 person-days per TJ for kerosene, compared to 200 to 350 person days for charcoal, depending upon productivity of site, efficiency of producers and the distance to the market. For instance, over 630,000 households were employed in fuelwood-related activities in the Philippines in 2012. It was the main source of income for about 10% of rural households, supplying about 40% of their cash earnings [5].

4.5. Environment

If the supply source is properly managed, fuelwood can contribute positively to both the local and the global environment. Degradation of watershed and catchment areas occurs only when fuelwood is extracted in an unsustainable manner from environmentally sensitive sites. Also, woody biomass fuel is a carbon-neutral energy source, provided the rate of harvest of the wood is equal to the rate of re-growth, so it need not contribute to the greenhouse effect. With present improvements in wood combustion technologies, other emissions like carbon monoxide (CO), polycyclo-aromoatic-hydrocarbons (PACs), nitrous oxides (NOx) and particulate matter can also be significantly reduced [4].

Considering the important contribution from non-forest production sources, it has been concluded that in most areas sustainable production of wood for energy can be viable. The present supply-demand imbalances may not be as serious as has been projected for most countries. It is also observed that, except in some highly populated forest deficit areas, the use of woody biomass fuel by a majority of rural households is not the root cause of deforestation. In the present context of warnings against deforestation and growing concerns about biodiversity and environmental conservation, the role of government-raised plantations as newly emerging additional sources of fuelwood becomes more prominent as far as traded woody biomass fuel is concerned [4-7].

5. Biomass energy in Turkey

Biomass resources, particularly residues from forests, wood processing, agricultural crops and agro-processing sources are utilized in developing countries [4]. These resources are renewable, environmentally friendly in energy production, and sustainable in terms of supply. Some of these residues are already used as raw materials for other products, as fodder and fertilizer, or as household and industrial fuels. However, large portions are still unused and represent potential sources of energy. Energy generation technologies specifically designed to use biomass residues are available and are becoming more and more economical. Countries have yet to make optimum use of the additional power generation potential from their biomass residue resources, which could help them to partially overcome the long-term problem of energy supply. However, in order to make the most of biomass energy, various aspects must be taken into account [3-6]:

There are several factors limiting the potential for large-scale fast-growing fuelwood plantations on a commercial scale: international petroleum fuel prices, remaining subsidies on commercial fuels, large initial investment requirements for fuelwood plantations, long gestation period between planting and harvesting, and conversion and transportation costs. This implies that the development of fuelwood should focus on the by-products of agroforestry and on the use of wood and biomass residues from relevant processing industries at their source [6].

Biomass fuels are mostly used in the household sector, primarily by the rural and urban poor and middle-class people in small towns. These people usually end up paying more for their household energy than their counterparts in larger urban centers. Cost-benefit analyses should incorporate avoided costs. The low income level of the majority of rural fuelwood users can not support high investments in modern biomass-based energy generation. Governments should come in with financial schemes [4-7].

Biomass has a lower calorific value than fossil fuels. Densification (briquetting) of biomass residues increases accessibility but involves a cost, which may be out of reach of those present users who get their biomass fuels free. Detailed study of the local fuel market and careful selection of technology should precede major investments in biomass energy development [5, 7]. On the other hand, prevailing practices of technology transfer do not sufficiently take into account the local conditions under which imported technology has to be operated and managed, the training required for its use, maintenance requirements and capabilities, and backstopping arrangements. Promoters need to consider both hardware and software aspects of technology transfer. Research and development for biomass production and use on a commercial basis has not yet received adequate attention in the region.

The main indigenous energy resources are hydro, mainly in the eastern part of country, and lignite. Turkey has no big oil and gas reserves. Almost all oil and natural gas imported, as is high-quality coal. Turkey also has a large potential for renewable energies and geographic location has several advantages for extensive use of most of the renewable energy sources [8-16]. In recent years,

many attempts have been made to utilize biomass, such as wood, hazelnut shell, agricultural waste residues, waste paper and wheat straw, tea waste and olive husk for energy production. Among the biomass energy sources fuelwood seems to be the most interesting because its share of the total production of Turkey is high at 20% and the techniques for converting it to useful energy are not necessarily sophisticated. Figure 1 shows Turkey's total biomass potential [8, 9].

The consumption of forest biomass compared to total energy has slightly decreased from 22 to 14 % during the last decade because the consumption of liquefied petroleum gases (LPG) is increasing continously [8]. Domestic energy consumption accounts for 27 % of the total energy consumption and about 35 % are biomass-based fuels [9]. Traditional fuels predominate in rural areas; almost all biomass energy is consumed in the household sector from meeting the heating, cleaning and cooking needs of rural people [10, 11]. Total recoverable bio-energy potential of the country for 2013 is estimated to be about 33 Mtoe as shown in Table 2. Table 3 shows present and planned biomass energy production in Turkey.

Table 3. Turkey's annual biomass energy potential in 2013

Biomass	Annual potential (million tons)	Energy value (Mtoe)
Crops	60	20.0
Forest residues	20	5.4
Residues from agro-industry	10	3.0
Residues from wood industry	5	1.6
Animal wastes	6	1.4
Other	9	1.6

Various agricultural residues such as grain dust, wheat straw and hazelnut shell are available in Turkey as the sources of biomass energy [12]. Approximately 3.4 x 107 tons of wheat straw was produces annually in Turkey. The hazelnut shell is a potentially important energy source and the amount produced annually in Turkey is estimated to be about 3.5 x 105 tons [13]. The higher heating value of hazelnut shell is 19.2 MJ/kg and its calorific value is equivalent to about 1.9 x 106 kWh [14]. These agricultural residues can be converted to hydrogen-rich gaseous products by the steam gasification method [15]. Classic biomass is obtained from conventional sources and methods. Modern biomass is obtained in sustainable manner from renewable sources [8-10; 12-26].

Biogas production potential in Turkey was estimated to be around 1.5-2.0 Mtoe. However, since the share of the renewable energy in energy production is so low, the possible contribution of biogas to this share can also be ignored. Preliminary research activities using pilot-scale plants were initiated by the Ministry of Energy and Natural Resources (MENR). These preliminary investigations covered production of biogas only from animal manure. However, these activities were somehow terminated in 1987. Besides, no research activity was encountered on production of biogas from agricultural residues and/or energy crops. There also exists not much data in literature about applications of biogas technology in Turkey as well [7-9; 16-18; 19-27].

Table 4. Present and planned biomass energy production in Turkey

Years	Modern biomass (ktoe)	Classic biomass (ktoe)	Total (ktoe)
2012	2121	5364	7485
2014	2543	5082	7625
2016	2854	4856	7710
2018	3284	4568	7852
2020	3598	4234	7832
2022	3860	3976	7836
2024	4086	3785	7871
2026	4472	3556	8028
2028	4732	3322	8054
2030	4940	3300	8240
Total	39840	53773	93613

Biogas, which is the anaerobic fermentation product of animal dung, has a potential between 2.2 and 3.9

billion m3 per year, corresponding to 1-2 million tons, provided that all dung is used for biogas production [18]. Around 85 % of the total biogas potential is from animal dung, and the remainder is from lanfill gas. Production of biogas from different types of biomass offers a great opportunity to reduce CO2 emissions and therefore to protect the environment. Turkey has theoretically the capability to produce biogas from biomass sources, as long as legislation procedures for production and conversion of biogas have specifically been identified and implemented [16]. Technological and infrastructural constraints, which may particularly be encountered in rural areas, can be overcome by involvement of both state agencies and private sector together [26]. It is also obvious that more research activity should be conducted about applications of biogas technology in Turkey, considering the country specific conditions [20-27].

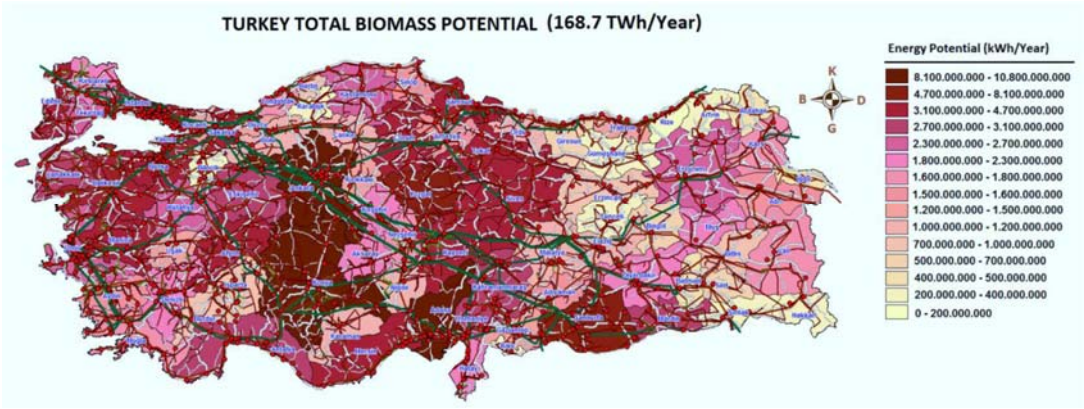

Figure 3. Turkey's total biomass potential

Biomass available for energy can be converted to different types of final energy, e.g. power (electricity) and heat (charcoal); of these, production of electricity appears to be particularly important [4]. In our homes, we burn wood in stoves and fireplaces to cook meals and warm our residences. Wood is the primary heating fuel in 6.0 million homes in rural region of Turkey [8, 9]. Use of biomass is a very sensitive matter because of the potential financial impact in Turkey where forest wastes or wastes from wood-processing industries such as lumber and furniture factories, could be used profitably in local boilers. Agricultural and municipal solid wastes, as energy sources are available economically in Turkey [16].

Direct combustion in Turkey for many years has used fuelwood, animal wastes, agricultural crop residues and logging wastes [17]. These sources are often called non-commercial energy sources, but in Turkey, fuelwood is a tradable commodity, since it is the primary fuel in rural and urban poor districts [30-36]. One alternative for producing electricity from biomass in a gas turbine is direct combustion of biomass as a primary energy source. Biomass is burned directly to produce steam; the steam turns a turbine and the turbine drives a generator, producing electricity [18]. Because of potential ash build-up only certain types of biomass materials are used for direct combustion [19].

6. Conclusions

It is estimated that, biomass and waste accounted for some 10% of global energy demand in 2010. In OECD countries, biomass use is concentrated largely in the pulp and paper sector and to a lesser extent in the residential and transport sectors. In developing countries, biomass is used predominately as a fuel for cooking and heating, but additional uses include brick-making, fish-smoking, food processing and other small industries. Biomass is expected to play a key role in meeting renewable energy objectives in the EU, Japan and the USA. Compared with oil, gas and coal, biomass used for energy does not contribute to global warning. Biomass offers a carbon-neutral source of energy that is renewable on a short time scale, and hence provides an attractive means of climate change mitigation. Most of the growth of biomass use in OECD countries will be due to policies that support its use. Except for the industry sector, where biomass technologies are economic, most of the technologies used in the residential and transport sectors are costly compared with fossil fuel ones. Moreover, energy prices in

most countries do not reflect negative externalities from fossil fuel use. In developing countries, demand for biomass is also expected to rise; some 2.8 billion people are expected to continue to rely on traditional biomass to meet their heating and cooking needs in 2030.

Turkey is an energy importing country and more than half of the energy requirements has been supplied through imports that have caused financial problems. Because of the economical problems in Turkey today, the Turkish energy policy should be concentrated on assurance of energy supply; reliability, domestic sufficiency, in time, in economic terms, and renewability. Therefore as a renewable energy source, biomass (especially fuelwood) seems interesting because its share of the total energy production at 25% is high and the techniques for converting it to useful energy is easy. On the other hand, biomass may, however, see greatly expanded use in response to the environmental problems caused by fossil fuel use in the country. Biomass has been proposed to have a central role to play in future, more sustainable energy scenarios. For this to become a reality several real problems need to be overcome. In Turkey as in other developing countries modernization of biomass energy provision is an urgent necessity for the sake of human health, protection of the environment, and climate change abatement. Given sufficient recognition, resources and research biomass could become the environmentally friendly fuel of the future.

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