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Global energy demand and woody biomass

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Abstract
Globally, by 2050 biomass could provide 3,000 TWh of electricity, or around 7.5% of the world's generation, and could create 1.3 bill tons of CO_2 equivalent emission savings per annum. In addition, biomass could provide 22 EJ of final heat consumption in industry and 24 EJ in the buildings sector by said year. Satisfying the demand will require around 5-7 billion dry tons of biomass by 2050 for electricity and heat production. Turkey's annual biomass potential is about 120 million tons and the total biomass energy potential is about 36 Mtoe. The amount of usable biomass potential of Turkey is approximately 18 Mtoe. Turkey has the potential to produce 4.0 million tons of wood pellet has approximately 780 million dollars of market value by the help of existing woody biomass. Ukraine has the potential to increase renewable energy use tenfold from 87 PJ in 2009 to 870 PJ of the total final renewable energy in 2030. Out of this, 73% is accounted for heat, 20% by electricity generation, and 7 % by transport. Nearly 80% of this total comes from biomass technologies, power generation, and transport fuels. In Ukraine, annual imports of 150-750 TWh of primary energy would be needed to meet the contry's targets. These imports will probably be in the form of pellets for the most part, due to their lower transport costs. The volumes above correspond to between 30 and 150 million tons of pellets for Ukraine.

Keywords: woody biomass, bioenergy, biomass utilization, forest biomass, Turkey, Ukraine.

1. Introduction

The production and trade of bioenergy has increased significantly during the previous years and is projected to increase further during the coming decades. For example, according to the International Energy Agency the world output of biofuels will climb from 0.8 EJ (2005) to 2.3 EJ by 2015 and to 3.9 EJ by 2030 [1]. Concerns have arisen about potential negative impacts of the production of bioenergy, such as the impact on the security of food supply in developing countries and the impact on biodiversity. Large-scale bioenergy production systems are therefore ideally evaluated against sustainability criteria that take into account the social, environmental and economic impacts. Certification systems can be used as a tool to evaluate a given project against sustainability criteria. Various national and supranational initiatives are currently being developed and implemented to develop certification schemes and also several utilities are developing certification systems [2, 3].

Renewable supply globally increased to 18.6% in 2014 - a 0.3% increase over the previous year [4, 5]. The growth is prominent in Asian and African continents which together accounted for half of the renewable energy supply while Europe accounted for 10%. Among the top 10 countries in energy supply, India (25.4%), Brazil (39%) and Indonesia (34.4%) have the highest share of renewables supply [6]. In consumption, renewables share increased to 18.6% and Asia consumes almost half of the renewable energy consumption globally. Again, among the top 10, India, Brazil and Indonesia have the highest share of renewables due to a large presence of biomass and hydropower in their energy system [1-7]. Figure 1 and 2 shows final energy consumption and primary energy supply from renewable energy sources.

Among the end consumption sectors of electricity, heat and transportation, the share of renewables is highest in the electricity sector [1]. The global renewable electricity generation increased to 5 469 TWh accounting for 23% of the global electricity generation. Biomass is the 3rd largest renewable electricity generating source with generation of 493 TWh (Fig. 3). However, solar and wind electricity are the fastest growing sectors with annual growth rates of 45.1% and 25.1%. Derived heat (heat produced in power plants) and Direct Heat (heat directly consumed in end sectors) are dominated by biomass (Fig. 4). The

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renewables share is 7.1% in derived heat and 27.7% in direct heat. In both sectors, biomass contribution is more than 95%. The contribution of renewables such as solar thermal and geothermal is minimal. Heat sector is the single most important future development sector for biomass [1-5].

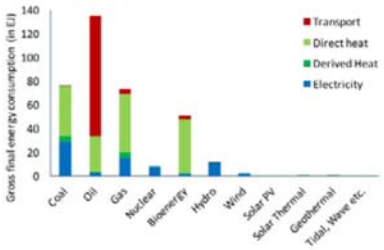

Figure 1. Global final energy consumption of all energy sources in 2014 [5].

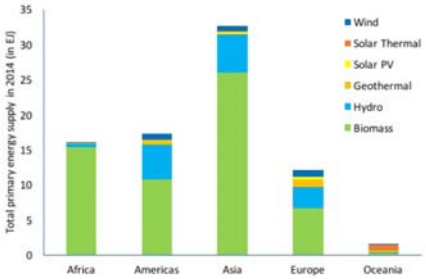

Figure 2. Total primary energy supply of renewables in 2014 (in EJ) [5].

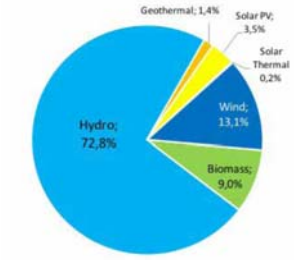

Figure 3. Electricity generation from renewables globally in 2014 [5].

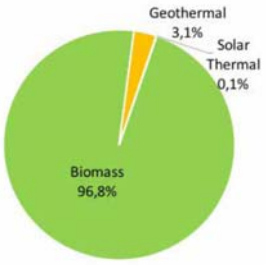

Figure 4. Derived heat generation from renewables in 2014 [5].

The share of renewables in transport sector is quite low. Only 2.8% - of the transport sector is renewable. This is largely due to the use of biofuels and they are growing at a faster rate than electrification. The total supply of biomass in 2014 was 59.2 EJ accounting for 10.3% of the global energy supply. The growth is at 2.3% annually. The forestry sector is key for biomass development. Fuelwood accounts for 67% of the biomass feedstock share followed by 7% from charcoal, 6% from recovered wood and 5% from wood industry residues. The forestry sector as a whole accounts for 87% of the supply of biomass [5-7].

As a globally, agriculture sector contributes 10% to biomass supply via the use of animal byproducts, agricultural byproducts and energy crops [2]. The

third sector of waste to energy accounts for the remaining 3% with energy generated from Municipal Solid Waste (MSW) and landfill gas. Bioenergy development requires land. The total land area is 13 billion ha - 37.6% in agriculture sector and 30% in the forestry sector. Since 2000, the arable land for temporary crops has increased by 0.09% while the area set aside for permanent crops and meadows increased to 1.28%. More than half of the global agricultural area is in Europe.

Primary forestry area decreased while planted forests has seen an annual growth of 1.9% to reach 290 million ha. In agricultural sector, comparing yields of major crops across all continents, Africa has the lowest average yields. Agricultural residues have significant potential to increase bioenergy supply from the agriculture sector. Theoretical estimate show a high potential of 123 EJ [2, 5, 14]. On the other hand, there is an increasing tendency all around the world to use the renewable energy sources instead of fossil fuels with a view to mitigate climate change, supply renewable energy, adapt to climate change and for other reasons [1]. Enhancement of biodiversity, competitiveness for forest products, sustainability, development of appropriate policies should be met to use the forest based woody biomass for bioenergy as a renewable source [2]. The woody bio mass is a main component of the forest biomass, a significant potential as a primary energy source in the world, that has been used in various forms ranging from industrial raw material to energy wood through modern and traditional ways [3]. Woody biomass from forestry is defined as all of the aboveground and underground biomass of trees, including all by-products and residues [8-13].

Woody biomass can be generated directly from harvest operations related to the commercial forest management, forest restoration and fuel reduction activities [13]. The natural gross potential of biomass energy (including agricultural, forestry and other products) was calculated as 120–130 Million tons of oil equivalent (Mtoe)/year while it was assumed that the net potential was 70 Mtoe/year, the technical potential was 30 Mtoe/year, and the economic potential was 20 Mtoe/year in Turkey [13, 14]. According to the data obtained from the Ministry of Energy and Natural Resources (MENR), the total available biomass potential was roughly 7.0 Mtoe per year [20-22]. Furthermore, the total woody biomass was 1 660 million tons only in the productive forest area and 162 tons per hectare according to the statistical data of FAO [14]. The total recoverable bioenergy potential from agricultural residues, forestry wastes and wood processing residues was estimated to be 17 Mtoe in 2000. The total biomass production was anticipated to be 12.6 Mtoe in 2020 [14-23].

According to an IEA report, Ukraine has the potential to increase renewable energy use tenfold from 87 PJ in 2009 to 870 PJ of the total final renewable energy in 2030 [1]. Out of this, 73% is accounted for heat, 20% by electricity generation, and 7 % by transport. Nearly 80% of this total comes from biomass technologies including heating buildings and industrial plants (particularly district heating), power generation, and transport fuels. On the other hand, Ukraine can contribute to the EU renewable targets, as imports of biomass to Europe will be needed. Even if the “aggressive supply mobilization” scenario in Europe were to fully materialize, annual imports of 150-750 TWh of primary energy would be needed to meet the EU targets. These imports will probably be in the form of pellets for the most part, due to their lower transport costs. The volumes above correspond to between 30 and 150 million tons of pellets, or the output from 50 to 300 large-scale pellet mills [1, 3, 5].

Turkey is energy poor for fossil fuels but has enough renewable energy sources. It is estimated that Turkey has 6 784 ktoe renewable energy in 2018 and biomass has about 50% of this amount as shown in Table 1. For this reason, utilization of biomass energy has gained importance as an energy source in Turkey [13, 20, 21]. The present study discussed the potential and utilization of the woody biomass globally, in Turkey with Ukraine. The results show that biomass has the potential to be a key player among the renewable options in both countries [16-19].

Table 1.Estimated energy from renewables in Turkey (ktoe).

Renewables	2018	2020	2022
Geothermal	420	452	474
Solar	718	746	778
Woody biomass	3 550	3 550	3 550
Heat Pump	2 096	2 234	2 370
TOTAL	6 784	6 982	7 172

ktoe: kilo tons of oil equivalent

2. Woody biomass in Turkey

Turkey's biomass energy is flourishing and amazing opportunities for the development and commercial implementation of energy crops. Energy imports in Turkey are 75% of its energy needs and energy demand in the country is forecast to double by 2020. Supporting sustainable energy investments is therefore a key element of several banks and investors in Turkey. The demand for energy and particularly for electricity is growing rapidly. The proceeds of the facility are used to finance energy efficiency and small-scale renewable energy investments, including geothermal, solar, biomass and biogas, implemented by Turkish businesses and households, helping them to cut their carbon footprint by reducing energy wastage. Some local companies have developed enough an evaluation of resources and define the map we have included here shows a total national potential of 170 TWh/year [14, 15, 20, 21].

Turkey has a great potential, but energy crops sometimes will be required to minimize biomass collection and supply chain risks to bio-based industries. Current cumulative installed biomass capacity in the country of 130 MWe is insignificant, but a number of fully permitted and ready to build projects will promptly increase in 2014. On the other hand, Turkish biomass market has a good chance of reaching several hundred MWe cumulative installed capacity in the next four years. The report provides a complete picture of the market situation, dynamics, current issues and future prospects [21, 22].

The largest portion of this product is used in rural areas for heating and cooking in a primitive way. Turkey has about 21,7 million ha of forest area. A similar share is occupied by pastures and grasslands. Turkey has about 21,7 million hectares of forest area. A similar share is occupied by pastures and grasslands. 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 continuously. LPG is not expensive; it is easy to transport and ignite, and in addition it is a clean fuel [13, 15].

The annual biomass energy potential of Turkey has been estimated to be 32 Mtoe and the total biomass consumption in Turkey was 7.6 Mtoe/year for 2014 (Table 3). Electricity selling price regulations that are generated with the usage of the renewable energy sources such as hydropower, wind, geothermal, biomass and solar. In 2014, electrical production from biomass, primarily wood, had a net impact of $4.7, billion and biomass electrical-generating capacity will have grown to approximately 36 GW in 2014 [20-23].

One alternative for 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. Because of potential ash build-up, only certain types of biomass materials are used for direct combustion. Direct combustion usually involves reducing the biomass into fine pieces for fueling a close-coupled turbine system. Table 2 shows Turkey's annual biomass energy potential. Table 3 also shows present and planned biomass energy in Turkey [20, 21].

Table 2.Turkey's annual biomass energy potential in 2014.

	Annual potential	**Energy value**
Biomass	(million tons)	(Mtoe)
Crops	60	14.1
Forest residues	20	5.1
Residues from agro-industry	10	3.0
Residues from wood industry	5	1.2
Animal wastes	6	1.4
Other	9	1.2
Total	110	26.1

Biomass has the potential to be a key player among the renewable energy options in Turkey, aiming to a reduction in the short term and substitution in the long term of fossil fuels dependence (Tables 1-3 and Figs. 5-7). According to the energy need of the country it was identified that bioenergy options that supply heating and cooking as well as electricity would have a prime interest. The results of this assessment indicate that there exists a high potential to supply the renewable energy targets based on the available biomass in Turkey, using efficient technologies and specific profitable production conditions [15].

Table 3. Present and planned biomass energy production in Turkey.

	Modern biomass	Classic biomass	Total
Years	(ktoe)	(ktoe)	(ktoe)
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

Figure 5. Turkey's biomass amount (ton) [15].

Figure 6. Turkey's total biomass potential map [15].

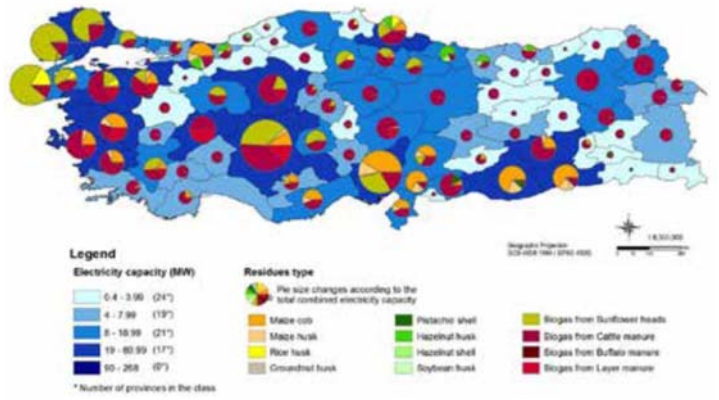

Figure 7. Electricity capacity generation (MW) from crop residues in Turkey [15].

3. Woody biomass in Ukraine

There is a stable trend of public and commercial consumers replacing gas boilers with biomass installations. During the 2014/2015 heating season, about 450 MWh of biomass boilers were installed in the public sector alone. At present, wood biomass (like wood chips, firewood, and pellets) is the most commonly used type of biomass for heat generation. Nevertheless, a number of schools and other public buildings in rural areas, as well as agro-companies, resort to straw (both as bales and pellets) for the same purpose. In our opinion, looking forward, the number of boilers running on straw and other agro-waste (like maize stalks, maize cobs, and sunflower stalks) will increase considerably while the rise in the number of wood-fired boilers will be comparatively limited [1, 2, 3, 4, 5].

Another promising option for heat is the use of energy crops (like willow, poplar). This is due to the structure of available biomass resources in Ukraine, the main constituents of which are agricultural residues and energy crops with a comparatively small volume of wood biomass. It is believe that the development of the market for biomass as a fuel will be accompanied by increasing biomass prices, although this trend is not as pronounced as that of natural gas and other fossil fuels. With the further development of the biofuels market and the entry of a large number of competing suppliers, biomass prices will probably stabilize at a market-driven level [1, 5, 14].

The key barriers to implementing biomass-to-energy projects identified in the survey are for the most part correct. However, this should be supplemented by another important impediment, i.e. the still subsidized price of natural gas for district heating. The drivers mentioned in the survey are desirable for accelerating biomass-to-energy projects but do not exist now. Among the available drivers we can point to the following: the increasing price of natural gas in the commercial sector and for those that own individual homes, availability of the feed-in tariff for renewable power that can enable introduction of biomass CHP plants, and availability of the stimulus tariff for heat produced “not from natural gas” for public sector consumers. In the near future, we expect that a similar stimulus tariff will be introduced for heat generated “not from natural gas” covering the general public heated through DH systems and also that a simplified procedure will be in place for allocation of land for construction of renewable energy installations [1, 5, 14].

The most common pellet business in Ukraine is producing wood pellets. All the surveyed pellet producers manufacture wood pellets. Additionally, three companies produce pellets from sunflower husk. Other kinds of pellets produced in Ukraine include cereal straw pellets, corn stalk pellets, and sunflower stalk and head pellets. Each of them was mentioned by one company only. More than half of those surveyed (54%) are focused solely on pellet production. The rest combine it with other activities, the most common of which is wood processing [1, 2, 5]. Figure 8 and 9 shows woody biomass potential and utilization in Ukraine.

Figure 8. Map of Wood Residue for Ukraine [14].

Wood waste is the main raw material for pellet production, as it is used by 95% of the surveyed pellet producers, with its share reaching 87% in the total volume of raw materials. The use of agricultural waste is rare, with sunflower husk being mentioned most frequently. Raw materials are mainly supplied by external vendors, 88% of the total being procured from them, while the remaining 12% are obtained from producers' own enterprises. In most of the cases, the pellet producer cooperates with 2 to 5 vendors on a regular basis. Frequent changes of suppliers are usually avoided [1, 2, 5, 14].

Figure 9. Potential Boiler Replacement Sites Using Woody Biomass for Ukraine [14].

4. Conclusions

Biomass can become a reliable and renewable local energy source to replace conventional fossil fuels in local industries and to reduce reliance on overloaded electricity grids. In this perspective, many medium-to-large agricultural, wood processing, or food processing industries in developing countries and emerging economies are well placed to benefit from the successful development of biomass-to-energy. Biomass-to-energy is a sustainable solution that can reduce greenhouse-gas emissions to the atmosphere, assuming the use of secondary and tertiary biomass to substitute the use of fossil fuels. Agricultural and forest-based industries in developing and emerging economies generate a substantial amount of biomass residue and waste that could, in principle, be used for energy production.

Both Turkey and Ukraine has rich biomass potential. Limited sources of petroleum-based fuel made the subject of producing quality energy and productive usage of it an important point for Turkey. Among the renewable energy sources, woody biomass seems to be the interesting because its share of the total energy production of Turkey is high, at about 10 % and the techniques for converting it to useful energy are not necessarily sophisticated.

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