

## Biomass Energy Potential In Northern Cyprus

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### Abstract

Northern Cyprus is a small developing state with total area of 3,355 km<sup>2</sup>. It has no fossil fuel resources and it is completely energy importing region. Although Northern Cyprus enjoys the abundance of solar energy, the utilization of solar energy didn't go further of hot water generation. Besides the solar energy, biomass is another available renewable energy source in the form of agricultural residues, municipal organic solid wastes and forestry residues. The main agricultural products in Northern Cyprus are cereal, citrus and olive respectively. All these products have residues in the form of cereal straw, solid olive oil residue and citrus peel. Beside all, in last 3-4 years, the potential of growing new agricultural products has been investigated in Northern Cyprus and observed that, the climate and other agricultural land properties of Northern Cyprus is suitable for pomegranate production as well. Investments for pomegranate production and extracting its juice have been done. Northern Cyprus is not an industrialized country and most of wastes are in the form of domestic organic wastes, that still contains energy as biomass. Forestry residues have also contributed the biomass resources of Northern Cyprus since most of trees in forests are producing pine straw. This work investigates the type and amount of biomass resources in Northern Cyprus for different energy production purposes.

*Keywords:* Northern Cyprus, renewable energy, biomass, agricultural residues

### Introduction:

Northern Cyprus is an Eastern Mediterranean region, with total area of 3,355 km<sup>2</sup> at the south of Turkey. It has no fossil fuel resources and it is completely energy importing region. Although Northern Cyprus has no fossil fuel resources, it enjoys the abundance of solar energy but the utilization of solar energy didn't further of hot water generation due to several reasons. Besides the solar energy, biomass is another renewable energy resource in Northern Cyprus. The utilization of biomass, in the form of wood, is popular from ancient times for cooking and heating purposes. Nowadays, recognized environmental impacts of fossil fuels, due to the emission of greenhouse gases increase the reputation of biomass and all other renewable energy resources. Formally, biomass is defined as "All non-fossil-based living organisms and organic materials that have intrinsic chemical energy content" [1]. Biomass sources include plant and animal residues which are classified three general groups as woody, non-woody and animal wastes [2]. Compared to other renewable energy resources biomass is one step ahead due to being locally available in the form of plant and animal residues in most region of the world. It should be stated that, plant residues include the agricultural residues with its merit that, within the conversion of biomass to energy, the emission of CO<sub>2</sub> is equal to CO<sub>2</sub> conversion during photosynthesis reaction of plant and no additional CO<sub>2</sub> is emitted to atmosphere. It is also stated that, "if biomass remains unused, even more potent greenhouse gas, methane (CH<sub>4</sub>), is emitted during the natural decomposition"[3].

Besides the plant and animal residues, organic municipal solid wastes are sources of biomass. As mentioned above, if organic municipal solid wastes are left to natural degradation they emit methane and contribute to

global climate change. Using organic municipal solid wastes as biomass resource provides the solid waste management in region as well.

Although biomass seems locally available and clean energy resource; disadvantages can be listed as; having low calorific value, low bulk density, high moisture content and etc.. It is possible to overcome some of these problems with biomass upgrading processes. Biomass upgrading processes or technologies aim to utilize biomass much more efficiently. These treatments are classified in three groups as [4]; Physical processes, Bio-chemical Processes and Thermal Processes. As shown in Figure 1. combustion, gasification, pyrolysis and liquefaction are thermo-chemical processes. Anaerobic digestion and fermentation are biological processes and esterification is physical treatment.

The end-products of each process are different and could be solid, liquid or gas. Processes such as gasification and pyrolysis converts raw biomass to more valuable energy carriers such as charcoal, bio-oil and biogas [4]. The anaerobic digestion and fermentation convert biomass to bio-gas, compost and ethanol [4]. All types of upgrading processes and technologies aims to; convert biomass to more valuable energy carriers that can also be transported from one region to another and can be stored for longer time periods. The selection of upgrading process based on desired end product and the profitability of process depends on the type and amount of biomass. The main aim of this paper is investigating types and amount of biomass resources in the form of agricultural residues, solid municipal wastes, animal sludge and forestry residues in Northern Cyprus to be a reference for future work that will investigate the most profitable biomass upgrading process in region.

## 2. Land Use Distribution and Agricultural Structure of Northern Cyprus:

The total area of Northern Cyprus is 3,355 km<sup>2</sup>. The land use distribution and the distribution of area under cultivation are shown in Figure 1 and Figure 2 respectively. As shown in Figure 1, more than half of the total land in Northern Cyprus is used for agriculture and 19,50% is covered with forests. The agricultural products of Northern Cyprus can be listed as; Cereal, Fodder Legumes, Legumes, Melon, Industrial Plants, Fruit, Vineyards and Citrus yard. The main agricultural products in Northern Cyprus are cereal with 67,75 % and the second main product is citrus yard with 6,12 %. The agricultural structure of Northern Cyprus has been changed in last 10 years and potential of growing new agricultural products has been investigated. It is observed that the agricultural structure of region is suitable for olive and pomegranate. The olive and pomegranate production raised and gained importance in last 3-4 years. The types and amounts of Northern Cyprus' agricultural products and residues will be presented in detail in section 3.

## 3. Agricultural Residues of Northern Cyprus

As mentioned above the agricultural products of Northern Cyprus include cereal, citrus, olive and pomegranate. The cereal which is the main product of Northern Cyprus have residue as cereal straw. Most of citrus produced in country is exported to Turkey and small amount is squeezed in several citrus juice extracting factories in Northern Cyprus. Citrus peel is the residue after squeezing process. Olive is a promising agricultural product in Northern Cyprus. The 80% of olive produced in Northern Cyprus is used for olive oil extracting and solid olive oil residue is produced after extracting process. The new and alternative agricultural product in country is the pomegranate. It is aimed to produce pomegranate juice which have residue as pomegranate peel. The annual production rates of these agricultural products and their residues are given coming sections.

### 3.1 Cereal Production in Northern Cyprus:

Cereal production occupies %67,75 of the agricultural land of Northern Cyprus. Figure 3, shows the annual total cereal production between 1979-2009 in the region [5]. The average annual cereal grain production is approximately 108,477 tons between 1979-2009. Cereal yield strongly depends on climate and Northern Cyprus has typical Mediterranean climate. As shown in Figure 4, for some years the cereal production reaches to 200,000 tones where for some others decreases less than 50,000 tones. Average annual straw production in region is around 106,000 tons between 1987 and 2005[5].

### 3.2 Citrus Production in Northern Cyprus:

The citrus production of Northern Cyprus includes lemon, grapefruit, orange, and tangerine and occupies 6.12% of the total land. The total annual production rate of citrus yard (lemon, grapefruit, orange and tangerine) between 1975-2009 is given in Figure 5 [6]. Produced citrus (lemon, grapefruit, orange and tangerine) mainly exported to Turkey and small amount is consumed in the country. The annual average of the citrus consumed in Northern Cyprus is approximately 19,305 tons according to statistics between 1983-2003 [6]. The citrus juice is produced by existing factories in the region and some portion of these residues are used for animal feeding where rest goes to landfills and left for natural degradation by emitting methane gas.

### 3.3 Olive Production in Northern Cyprus

As a Mediterranean basin region, Northern Cyprus' olive oil production has significantly increased in last 3-4 years. It is estimated that 600,000 olive trees exist in Northern Cyprus. The 80% of produced olive in N. Cyprus is used for olive oil production. The solid residues of olive milling, obeys the definition of biomass with its high energy content. The annual olive production rate in Northern Cyprus can be seen from Figure 6 [7]. The average annual olive production in Northern Cyprus is 2900 tons between 1987-2003. According to unofficial statistics; it is estimated that 930 tones of solid olive oil residue is produced annually.

### 3.3 Pomegranate Production:

Pomegranate is a new and alternative agricultural product in Northern Cyprus. The pomegranate growing is encouraged by government and several grants have been supplied to investors. It is planned to export both pomegranate and pomegranate juice to Turkey and other countries. Pomegranate producers have been stated that the total area of pomegranate gardens was 300 acres in 2008 and it is increased to 450-500 acres at the end of 2010[8]. Since pomegranate production is new in Northern Cyprus, no statistical data is available yet. Investment for a pomegranate juice extracting juice has been done and planned to operate on 2012. Pomegranate peel remains from the extraction of pomegranate juice and can be used as biomass resource.

## 4. Forestry Residues:

The 19.50% of the total land in Northern Cyprus is covered with forests and these forests are composed of Calabrian pine (*pinus brutia*), Aleppo pine (*pinus halepensis*), Cypress tree (*Cupressus Sempervirens*) and Stone pine (*pinus pinea*). The most abundant trees are Calabrian pine (*pinus brutia*) and the cypress tree (*Cupressus Sempervirens*). All these trees are producing pine straw and pine cone that can be used as biomass resource. Literature states that, 20% of the pine straw fall throughout the year occurs from January to July and 80 % of needle fall occurs from August to December [9, 10, and 11]. The total annual average pine straw yield varies between 3,000 and 4,000 kg ha<sup>-1</sup> [9, 10, and 11]. It should be stated that repeated removal of pine straw may negatively affect the growth and the yield of the tree and fertilization is necessary if pine straw is being harvested. In literature, it is recommended to rank forests 2 to 4 times during the rotation [11]. It is observed that, monthly (August 2007- July 2008) pine straw fall patterns of the pine forests in Northern Cyprus obeys similar patterns presented in [11] and the annual average yield is estimated to be 3100 kg ha<sup>-1</sup>. Besides the pine straw and pine cone, wild grass, fennel, ordinary cane bushes and etc grow densely in winter season and degrade during summer in unused lands and forests. All these plants can be harvested and could be used as biomass resource in Northern Cyprus.

## 5. Municipal Solid Wastes:

All types of solid wastes are stored in open-landfills in Northern Cyprus. The number of open-landfills is around 100. Northern Cyprus is not an industrialized region and most of wastes are domestic organic solid wastes. Storing organic solid wastes in open landfills has so many disadvantages such as; emission of methane (CH<sub>4</sub>), bad odor, pollution of underground water resources and etc. Organic solid wastes still contains useful chemical energy that can be converted to other forms (electricity, heat, biogas) by biomass upgrading processes. It is important to know the type and mass of solid wastes in order to select the most profitable biomass upgrading system. Although, the government had several attempts to determine the type and amount of solid wastes, no net result is obtained yet. However, it is estimated that; 107,000 tonnes of municipal solid waste is produced in Northern Cyprus [12].

#### 6. Animal Sludge:

Animal husbandry in Northern Cyprus includes cattle, sheep and goat. The average number of castles in region is 35,058 between 1996-2005 and the average number of sheep and goats in Northern Cyprus is 270,146 [13]. The animal manure production in Northern Cyprus can be seen from Figure 7 and Figure 8. Animal sludge can be used to produce energy via biological biomass upgrading processes and biogas is produced as energy carrier. Besides the cattle, sheep and goat, there exist poultry farms in Northern Cyprus. The official statistics states that; the average number of poultries between 1995-2004 is 3541135 and their manure can be used as biomass as well.

#### Conclusion:

The contribution of fossil fuel combustion on global climate change, acid rain and environmental pollution are well-known facts of this century. All these impacts, of fossil fuels; increased the reputation of renewable energy resources in order to control the emission of hazardous gases which some are called green-house gases. Biomass is a renewable energy resource with advantage of being locally available in different forms such as; plant (agricultural residues), animal residues and municipal solid wastes. This work investigated the amount and type of biomass resources in Northern Cyprus. For that purpose the land-use distribution and agricultural structure of Northern Cyprus are inspected and shown that; the agricultural products of region have residues that could be used as biomass resources. These residues includes cereal straw, olive oil residue, citrus peel and pomegranate peel. Besides the agricultural residues, animal sludge and forestry residues (pine straw and pine cone) in Northern Cyprus are sources of biomass. Northern Cyprus is not an industrialized region and most of solid wastes are domestic organic solid wastes that contain energy. These wastes are stored in open landfills and bring environmental problems such as emission of methane (CH<sub>4</sub>). Amounts of all these agricultural, municipal and animal energy containing residues are given in detail within the content of the work and shown that considerable amount of biomass exists in Northern Cyprus. Necessary forecasting and profitability analysis must be done for the selection of upgrading system and biomass should be utilized for energy production immediately. One of the problems associated with the biomass utilization is transportation difficulties from one place to another due to its low bulk density. If it is considered that; Northern Cyprus does not have wide range of transportation infrastructure, transportation will not be a big concern and biomass will take its place as, new, clean and renewable energy resource in Northern Cyprus.

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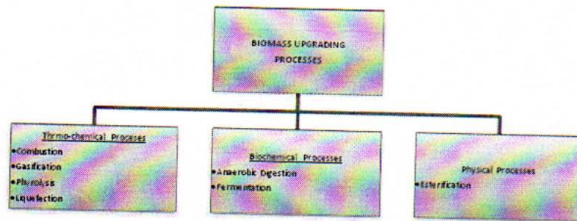


Figure 1: Biomass Upgrading Processes

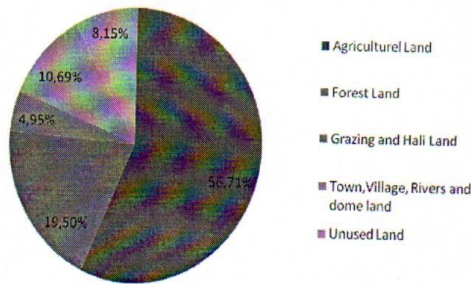


Figure 2: Land use distribution in Northern Cyprus[5].

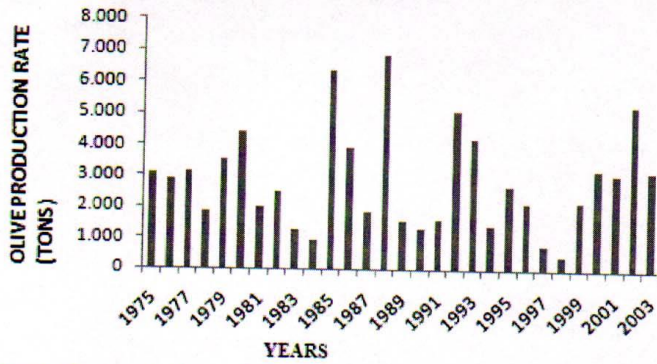


Figure 6: The annual olive production rate of Northern Cyprus between 1975-2003[7].

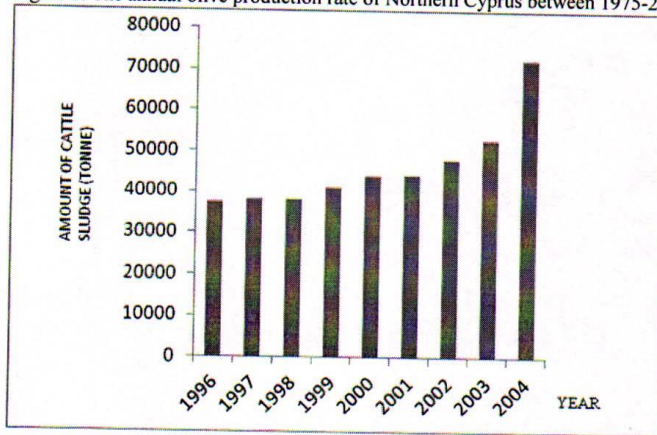


Figure 7: Annual cattle manure production rate [13]

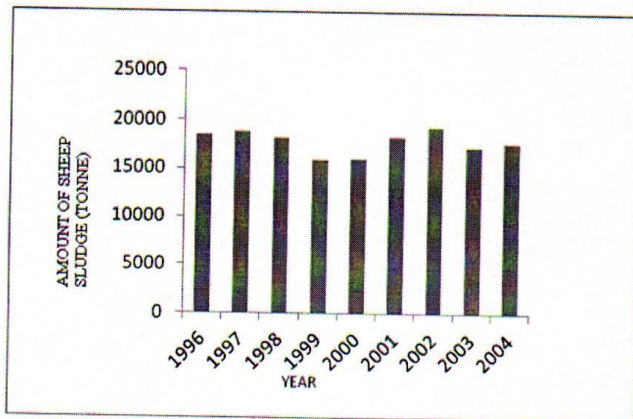


Figure 8: Annual sheep/goat manure production rate. [13]

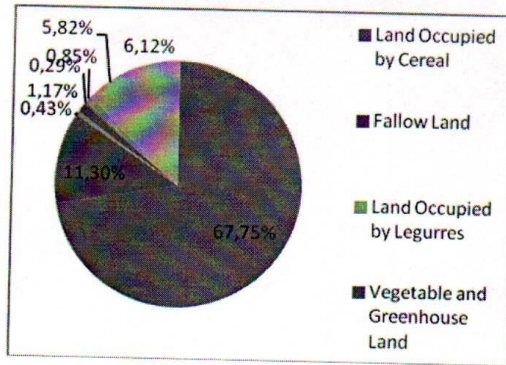


Figure 3: Distribution of area under cultivation [5].

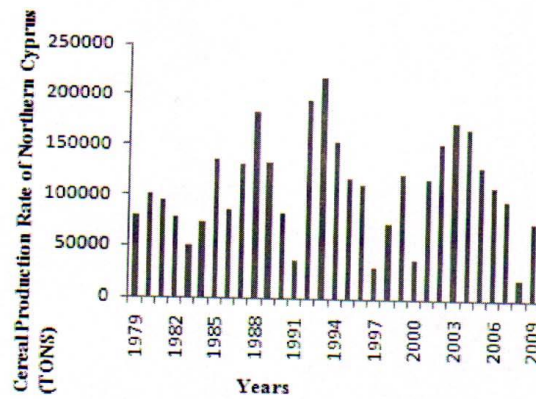


Figure 4: Annual cereal production of Northern Cyprus between 1979-2009 .

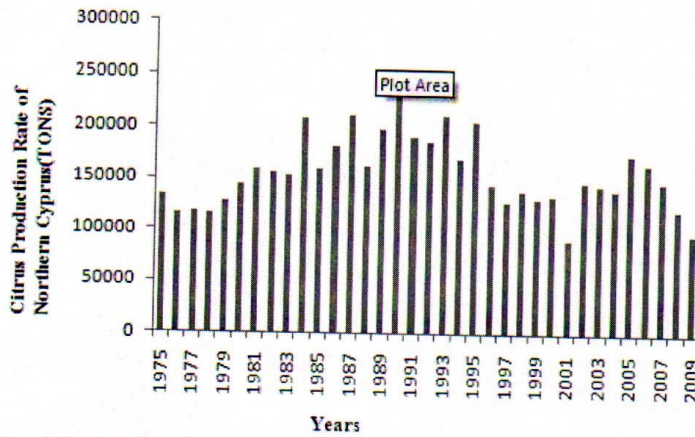


Figure 5: Annual citrus (lemon, grapefruit, orange and tangerine) production between 1975-2009[6].