

Biomass Potential As Power Generation Sources: A Case Study In Kerman-Iran

Hüseyin Gökçekuş, Youssef Kassem, Shaghayegh Ostovar Ravari

Abstract: The use of renewable energy sources has improved around the world in recent decades. One of the most popular sources of renewable energy is biomass. Energy production from biomass is highly dependent on the resources available in the area and can bring many benefits depending on the type of resources. In this paper, the agricultural residues and animal wastes in Kerman, Iran are shown, then three different countries (Turkey, India, and China) have selected and controlled the benefits of using biomass in these countries with the same resources that are available in Kerman. The benefits of establishing a biomass energy production plants in Kerman-Iran are illustrated which can be environmental, social, economic, technological, and political benefits.

Keywords: Biomass, Biomass Resources, Agricultural Residues, Animal Waste, Iran, Kerman.

1. INTRODUCTION

Environmental issues have expanded as a result of human activities and have become increasingly important around the world in recent decades. Therefore, in recent years, all sectors of human societies such as populations, industries, governments, and organizations have considered impacts of their activities on the environment and have sought to reduce the negative effects on the environment and resources. Many industries and human activities depend on fossil fuels around the world. However, the use of fossil fuels has been one of the main causes of environmental problems over the past decades. Today, different types of renewable energy are used for a variety of purposes to reduce fossil fuel consumption, emit carbon dioxide, and slow down climate change. Biomass is a renewable energy source that can be used around the world. Biomass resources are organic matter derived from plants, animals, or humans. In many countries, biomass is used in traditional ways and is burned directly to providing heat. However, there are many modern methods that can be used to convert biomass into liquid biofuels or biogas that can be used for a variety of activities.

China is one of the countries that has used biomass in traditional ways since ancient times and has modernized the biomass energy production technology in recent decades. China plans to expand its use of renewable energy to reduce its fossil fuel consumption by 600 Mtec (Mtce is the abbreviation of million tons of coal equivalents) by the end of 2020 [1]. "China's long term development plan of renewable energy" aims to improve biomass energy production capacity by 30 million kW by the end of 2020, and biomass energy production is projected to be the main type of renewable energy in this country by 2025 [2]. The project has had positive impacts on energy structure and energy saving in China. According to their plan, carbon dioxide emissions will be reduced by about 1,200 Mt by the end of 2020 [1]. The

development of biomass renewable energy has also had other effects, including improving rural economic development, raising the level of modernization, improving some public facilities [1], increasing annual income for rural farmers, and creating new jobs [3]. Turkey is another country that intends to develop the use of biomass resources for renewable energy production in the long run. Biomass will be the third renewable electricity generation capacity in Turkey after wind and hydropower. Electricity generation from biomass in 2009 was about 10 gigawatts and plans to reach 50 gigawatts by 2030. This progress has many benefits for Turkey. At this level of capacity, the economic benefits are estimated at \$ 6.4 billion in personal and corporate income and the creation of 250,000 new jobs [4]. India is a developing country that produces about 47% of its total energy from the biomass and is growing at an annual rate of 2%. The use of biomass in India significantly reduces air pollution by about 60% [5]. The Ministry of New and Renewable Energy (MNRE) reported that 73,000 MW of energy will be generated using biomass by 2032 [6]. Biomass energy production reduces carbon dioxide emissions by about 249 million tons and has significant environmental impacts [5]. The aim of this study is to evaluate the local and national benefits of using biomass as a renewable energy source in Kerman, Iran. Biomass energy power plants in Iran are located in Mashhad with a nominal capacity of 650 kW, Isfahan with a capacity of 1 MW, Saveh with a capacity of 600 kW, Shiraz with a capacity of 1060 kW and Tehran with a capacity of 5 MW [21]. Kerman is one of the largest provinces in Iran and has a high potential for biomass energy production and the establishment of various biomass power plants in this region will be very efficient. [7]. The main agricultural products of this province are pistachios and wheat. More than 22,920 tons of pistachios were harvested on 212,000 hectares and about 167,290 tons of wheat were harvested on 35,980 hectares of land in Kerman in 2018 [23]. According to researchers, about 42% and 31% of all pistachios and wheat are wasted annually, respectively. These wastes can be used as the main source of biomass for the production of renewable energy in Kerman [7]. In this study, the local and national benefits of biomass energy production, the establishment of biomass energy production plants, and the use of this type of renewable energy source in this region are investigated. For this purpose, three other countries that have the same resources for biomass production have been selected and the benefits of energy production from biomass in those countries have been studied and compared with the selected region.

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2 STUDY AREA

The selected area for this study is Kerman-Iran. Kerman is the largest province in Iran, located in the center of southeastern of Iran between 53° and 26' to 59° 29' east longitude and 25° 55' north latitude to 32°. In Kerman, the summers are hot, arid, and clear and the winters are very cold, dry, and mostly clear. In general, the weather conditions in Kerman province are a dry situation in the north and northwest, warm and humid in the south and southeast, and cold and mountainous in the southwest and center [14]. Climate diversity as a result of the province's geographical variability creates good opportunities for the production of various agricultural products. Waste from these agricultural activities can be a major source of biomass. Figure 1 shows the position of this province in Iran.

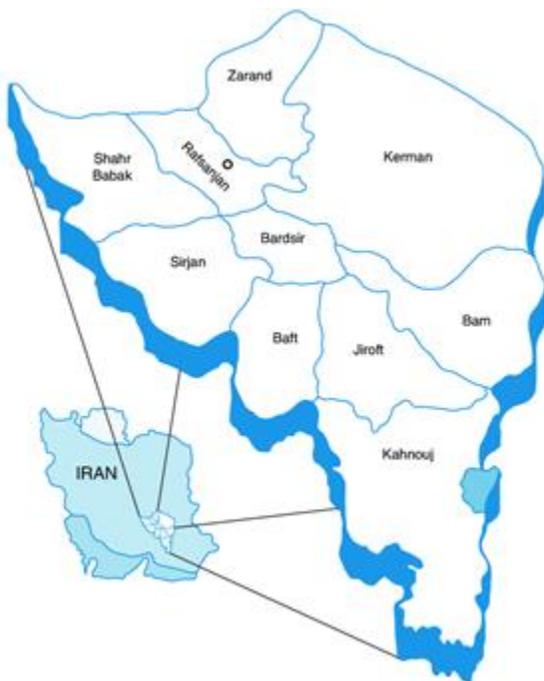


Figure 1 Kerman location in Iran

3 BIOMASS RESOURCES

3.1 Biomass sources in the world

There are several sources of biomass in the world. These resources are categorized in different ways. One of the most accepted categories of biomass resources is based on the origination of the biomass resources. In this type of

classification, all resources are classified into two different groups that are "productive biomass" and "unused biomass". The first group includes terrestrial products (such as carbohydrates, starch, cellulose, and hydrocarbons) and aquatic products (such as water hyacinth and microorganisms). The second category of classification includes waste from agricultural, forestry, and fisheries (such as agriculture, animal husbandry, forestry, and fisheries) and waste (such as municipal waste, industrial organic waste,

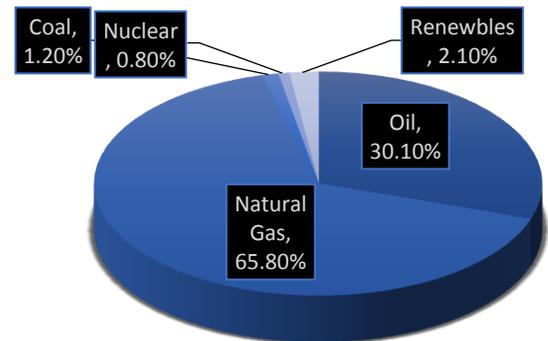


Figure 2 The energy mix in Iran (BP, 2018)

garbage, and sewage sludge). Table 1 shows these categories and examples of each type. In each region, some types of these resources are available in different forms, but the second group is usually more popular as a source of biomass [15].

3.2 Biomass sources in Iran

According to BP, [25] the energy mix in Iran by the end of 2018 is mostly based on natural gas and oil, and renewable energy has a very small share. Figure 2 shows the energy composition in Iran. The small share of renewable energy in the energy mix of Iran shows the importance of considering the advantages of using and expanding the use of renewable energy sources to reduce dependence on fossil fuels such as natural gas and oil. The use of renewable energy can reduce greenhouse gases and carbon emissions, reduce the use of fossil fuels, increase national energy security, increase rural development, and provide sustainable fuel for the future [16]. Although the share of renewable energy in Iran is very small, according to the renewable energy organization of Iran (SUNA), wind, solar, small hydroelectric and biomass are the main renewable energy types which are used in Iran. Figure 3 shows the share of each type of renewable energy source in Iran according to the SUNA report in 2018. [19].

Table 1 Biomass resources categories according to their origination (Long, Wang 2013.)

Categories		Representative materials	
Productive biomass	Terrestrial	Carbohydrate	Sugar cane, corn, sweet sorghum
		Starch	Maize, cassava, sweet potato
		Cellulose	Tropical grasses, poplar, sycamore
	Aquatic	Hydrocarbon	Eucalyptus, green coral
		Grease	Oil palm, rapeseed, sunflower
		Freshwater	Water hyacinth
Unused biomass	Residues from Agriculture Forestry Fisheries	Ocean	Large kelp
		Microorganism	Green algae, photosynthetic bacteria
		Agriculture	Wheat bran, straw
		Animal Husbandry	Vegetable residues, processing residues
	Waste	Forestry	Animal manure
			Farm residues
			Secondary forest
			Woodland remnants
	Fisheries	Crippled material in plants	
	Municipal Waste	Jettisoned and dead fish	
	Garbage	Municipal and pulp sludge	
		Family garbage, feces	

There are four main groups of biomass resources in Iran:

- Agricultural, horticultural, and forestry wastes

The rural economy, as well as macroeconomic performance, are largely dependent on agriculture in Iran. Since Iran has various regions with weather diversity, different agricultural and horticultural crops can be produced in Iran [17]. In 2018 more than 81.2 million tons of crops were produced in 11 million hectares and also more than 20.53 million tons of horticultural products were produced in 2.9 million hectares in Iran [23]. The agricultural wastes are usually burnt or used as fertilizer [16]. According to SUNA, on average, about 30 percent of agricultural crops and horticultural production in Iran are lost as waste which can be converted into biomass for energy production. These agricultural wastes are mainly dispersed in the northern provinces, which include Gilan, Mazandaran, Golestan, and South provinces, which include

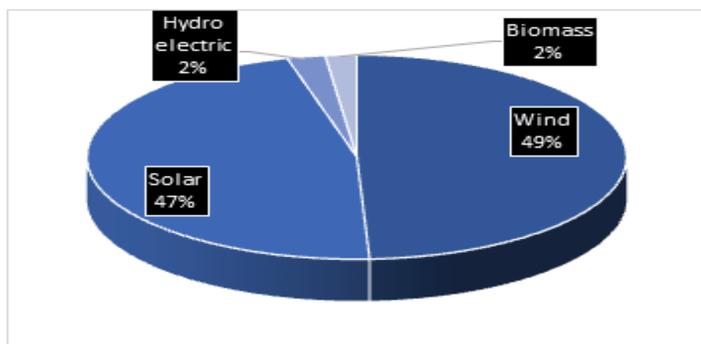


Figure 1 Renewable energy share in Iran (SUNA, 2018)

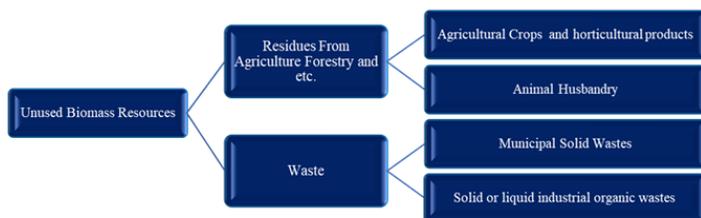


Figure 2 Biomass resources categories according to their origination in Kerman

Kerman, Fars, and Khuzestan [24].

- Municipal solid waste (MSW)

The amount of solid waste depends on the consumption pattern in each area. Solid wastes are the main sources of pollution in and around cities and can cause many diseases [19]. Municipal solid waste contains about 75% organic waste in Iran. Each person produces an average of 0.8 kg of waste per day in Iran [18]. In Iran, municipal solid wastes are usually dumped in landfills and some parts of them are composted and recycled [19]. Solid waste is a good potential for biogas production. According to researches, 15 kg of solid waste can produce 1 m³ of biogas. Therefore, municipal solid waste is one of the main sources of biomass in Iran [18].

- Animal wastes

Animal husbandry is one of the industries related to the human nourishment supply chain and it usually developed by increasing the population. Animal husbandry has increased in Iran during the last decades as a result of increasing the population. Animal wastes are one of the rich sources of organic matter that can be used as sources of biomass in Iran [19]. The main animals are sheep, goat, cow, buffalo, chicken, and camel. The amount of biogas produced from animal waste depends on the feed, weight, and solids in the waste [20].

- Solid or liquid industrial organic wastes

Food and wood industrial wastes can be used as sources for producing biogas. The quantity of biogas production is related to the contaminants of the wastes, type of industry, wastewater refinery process, and quantity of wastewater [18].

3.3 Biomass sources in Kerman

Figure 4 shows the main biomass energy resources that are available in Kerman-Iran according to the SUNA. In this study, only the benefits of using agricultural crop wastes and animal wastes are considered and explained.

4 AGRICULTURAL CROPS IN KERMAN-IRAN

The agricultural crops of Kerman can be classified into two different groups. The first group is containing agronomical products. The main agronomical products are wheat, potato, onion, tomato, and cumin. In 2018 about 168,420 tons of wheat, 288,750 tons of potato, 295,000 tons of onion, and 461,570 tons of tomato were produced in Kerman [23]. However, about 31% of wheat, 27% of potatoes, 16% of onions, and 11% of tomatoes are wasted annually. These

wastes can be used directly as biomass for energy production [21]. The second group is horticultural products and the main ones are pistachio, date, apple, and citrus such as orange and lemon. Iran is the world's largest producer of pistachios, according to the Food and Agriculture Organization (FAO). Kerman province produces more than 67% of Iran's total pistachios. Pistachios have a soft shell and a hard shell, both of which are used as a source of biomass. In addition, pistachio trees need pruning, which can also be used as a source of biomass. In addition, Kerman is one of the four provinces in Iran that produces dates [7]. In 2018 about 22,920 tons pistachio, 30,000 tons apple, 170,000 tons date, and 112,000 tons orange were produced in Kerman [23]. However, about 42% of pistachios, 28% of apples, 24% of dates, and 30% of oranges are waste annually [21]. Residues from agriculture and horticulture are not used and can be used as raw material for biomass energy. In addition, it should be noted that in many rural areas a large number of agricultural residues are burned on the farm to re-clean the agricultural land for planting crops, which has many environmental issues. However, residues can be used effectively as biomass resources.

5 DOMESTIC ANIMAL FARMS

There are many domestic animal farms in Kerman. As mentioned earlier, animal waste is an efficient and available resource for biomass energy production. There are several small farms in Kerman that usually use the conventional feeding method, which is natural feeding and usually for sheep and goats. Large and medium-sized farms are commonly used to produce cattle, including dairy cows and beef cattle, and also chickens for egg or meat production. In 2018, there were about 1,226,300 sheep, 1,278,600 goats, 130,000 cows and 8,200 camels in Kerman [23]. The dead animals of the large and medium-sized farms are useless and they are buried. However, these wastes can be good sources for producing biomass energy. The manure of the animals is another good source of biomass for energy production. In order to find the benefits of using agricultural and animal waste as biomass resources, three different countries (Turkey, China, and India) that have the same agricultural waste and animals as Kerman have been selected. Examining the benefits of using biomass in these countries helps to identify the short-term and long-term benefits of using these resources to generate renewable energy in Kerman.

6 BENEFITS OF USING BIOMASS AS A RENEWABLE ENERGY SOURCE

For demonstrating the benefits of using biomass in Kerman, three countries that include China, Turkey, and India are selected. These countries are developing countries like Iran. These countries have planned to increase energy production by biomass in recent decades and they have plans to expand energy production from biomass in the coming years. In addition, these countries have the same agricultural and animal wastes resources of biomass energy production as Kerman. Therefore, they are efficient options for examining the benefits that are achieved by developing the use of biomass and showing the benefits of using biomass in Kerman.

• China:

China's energy consumption has more than doubled over the past decade and is among the world's top energy consumers, according to the US Energy Information Administration [22]. By

increasing energy consumption in China, this country plans to expand its use of renewable energy to reduce its fossil fuel consumption by 600 Mtec (Mtec is the abbreviation of million tons of coal equivalents) by the end of 2020 [1]. "China's long term development plan of renewable energy" aims to improve biomass energy production capacity by 30 million kW by the end of 2020, and biomass energy production is projected to be the main type of renewable energy in this country by 2025 [2]. There are various sources of biomass in China. Animal waste and agriculture residue are the main sources used for biomass. Using crop residues to produce biofuels in China can reduce air pollution instead of burning them as a common method. [3]. In addition, the use of biomass has had a positive effect on energy structure and energy saving in China. According to their plan, carbon dioxide emissions will be reduced by about 1,200 Mt by the end of 2020 [1] and with the increasing use of biomass, sulfur dioxide emissions have decreased, which has many environmental benefits [2]. The use of renewable energy has affected 10 million people living in power shortages and about 100 million rural residents in China. The development of biomass renewable energy has also had other effects, including improving rural economic development, raising the level of modernization, improving some public facilities [1]. The use of agricultural residues and other biomass feedstocks could increase annual income between \$ 18 billion and \$ 23 billion for rural farmers in China and promote rural economic development. In addition, it caused to create 40 million new jobs [3].

• Turkey:

Turkey is one of the countries that has needed more energy over the past two decades due to its young and growing population, growing economy, and rapid rate of urbanization. Under these conditions, biomass was used for different purposes, such as producing electricity, heating, refueling vehicles, and generating energy for industry [9]. Wind, hydroelectric, and biomass are the main sources of renewable energy in Turkey, respectively. Electricity generation from biomass in 2009 was about 10 GW, and there are plans to increase biomass energy production to 50 GW by 2030. At this level of capacity, biomass energy production has economic benefits such as bringing \$ 6.4 billion in personal and corporate income and creating more than 250,000 new jobs [4]. It should be noted that many biomass power plants have been built in rural poor areas, which reduces the rate of migration from rural to urban areas and reduces urbanization issues. Therefore, it can be argued that biomass energy production has helped revitalize rural communities by creating new jobs [10]. Turkey has different sources of biomass energy production. The agricultural potential of Turkey is rich. The three main agricultural products of Turkey are wheat, barley, and corn, respectively [4]. Various agricultural residues such as wheat straw and hazelnut shells, animal wastes, and municipal solid wastes are used as biomass in Turkey [9]. In addition, pistachios are another Turkish product, and about 13,000 tons of pistachios shells are produced that are used as biomass annually [11]. In addition, using biomass have some environmental effect. One of the most important environmental benefits of using biomass is reducing carbon dioxide and other greenhouse gas emissions, which play an important role in reducing greenhouse effects [9]. Less carbon dioxide emissions from biomass than fossil fuels have led Turkey to pursue its GHG reduction targets [13]. In addition, energy production from biomass can reduce thermal and noise

pollution [10]. Biomass energy balances the carbon dioxide by the photosynthesis process in the atmosphere [11] and can lead to zero carbon dioxide emissions during the short life cycle [12]. Biomass wastes contain less sulfur and nitrogen than fossil fuels, thus reducing environmental pollution and reducing health risks [11]. In addition, reducing the volume of waste sent to landfills and reducing dependence on oil and coal are other benefits of using biomass [9]. Storing or disposing of many biomass residues such as agricultural waste, animal waste, and municipal solid waste causes anaerobic fermentation and methane production [12]. Biomass in Turkey is economically usable [9] because it has a lot of resources [11]. Fossil fuels are affected by political instability, trade disputes, sanctions, and other disruptions [10]. Thus, reducing dependence on non-renewable energy reduces the impact of energy price instability on the economy and economic security and national energy [4].

- **India:**

India's economic and industrial growth is one of the highest in the world in recent years [5]. Energy demand is also growing due to the rapid growth of industries. The major sources of energy in India are oil and coal [6]. India produces 151.3 GW of energy from coal, natural gas, and oil, 30.49 GW by hydro-power, 27.54 GW from renewable energy, and 4.78 GW from nuclear energy annually [6]. There are several renewable energy sources in India, with wind energy accounting for the largest share at 52.20%, small power plants at 20.98%, biomass at 18.63%, and other renewable resources at about 8% [6]. There are 638,000 villages in India and about 69% of its population still lives in rural areas [6]. In addition, India has 200 cities and 8 metropolitan cities. As mentioned earlier, the country is heavily dependent on coal and oil for energy production [5]. In recent decades, the trend of biomass energy consumption has been significantly increasing. This is mostly due to increased demand in rural and urban areas and the lack of alternative fuels [8]. The total biomass energy production capacity by the end of 2015 was 17,500 MW in India and the Ministry of New and Renewable Energy (MNRE) expects to produce 7,300 MW of energy by 2032 using biomass [6]. There are various sources of biomass in India, including municipal solid wastes, forestry residues, animal and agricultural wastes. The main crops in India are rice, wheat, cotton, and sugarcane which produce important residues that can be used as biomass [5]. One of the most important benefits of biomass energy production in India is that biomass resources are locally available all over the county, and biomass technology is easily applicable in rural areas. This option has helped India prepare the energy for distanced rural areas in recent decades [5]. In addition, the demand for clean energy resources became more popular due to the growth of pollution and energy demand. Biogas is environmentally friendly and profitable due to lower greenhouse gas emissions. The use of biomass reduces carbon dioxide emissions by about 249 million tons per year and has significant environmental impacts [5]. Compared to other renewable energy sources such as solar and wind, energy production from biomass resources has an economic advantage in production costs and is thus an attractive alternative in India [5]. Investigating these three countries shows that in general, the benefits of using biomass can be classified into environmental, social, economic, technological, and political benefits. The obvious and widely known benefits of using biomass renewable energy sources include environmental

benefits such as reducing air and soil pollutions, carbon dioxide emission, fossil fuel usage and can lead to zero carbon dioxide emissions during the short life cycle by the photosynthesis process. In addition, biomass renewable energy sources contain less sulfur and nitrogen, which can improve air quality. Reducing heat and noise pollution and the amount of waste sent to landfills are other environmental benefits of using biomass. Renewable energy sectors provide a large number of jobs and also prepare healthier job conditions for employees in their sectors compared to fossil fuel sectors. Renewable energy is resilience and some types of renewable energy can generate energy without any complex infrastructure, therefore, they can provide the necessary energy in emergency situations or during severe weather events. In addition, renewable energy sources can provide electricity for small rural areas and distant villages more easily than ever before. In addition, the use of biomass has positive effects on energy structure and can be used economically because biomass resources are locally available and are not affected by political instability, trade disputes, and sanctions, therefore, it prepares price stability and energy security. The use of biomass improves rural economic development and raises the level of modernization. It can be argued that biomass energy production has helped revitalize rural communities, reducing the rate of migration from rural to urban areas, and reducing urbanization issues.

7 CONCLUSION

A large number of agricultural residues as well as animal wastes in Kerman show that this region has a high potential in establishing biomass power generation plants. The use of biomass for energy production in Kerman not only has many environmental benefits such as reducing air and soil pollution, carbon dioxide emission, sulfur and nitrogen emission, and reducing the amount of waste sent to landfills, but also has some social and economic advantages such as creating new jobs, preparing healthier job conditions, and providing the energy for distant rural areas, improving the economy of the rural areas that can reduce the rate of urbanization and the dependency on the fossil fuels.

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