Possibility of Using Olive Pomace as a Source for Renewing Energy for Generating Electricity in Libya

- **Engineer Hamza Abubeker Falifla**

- Faculty of Medical Technology, Almergib University
hamza_flfa@yahoo.com

Abstract

This paper addresses the possibility o using olive pomace as clean, cheap and renewable as a reliable energy source by which it is able to contribute to total energy. Due to the exceptional circumstances o the country in 2011 and the sabotage and disruption o projects of the General Electricity Company and the Executive Authority of Renewable Energies, which put the general network in difficult and critical situation that led to a large deficit in meeting the demand for electric power, therefore tending to cut the electric power off, for long time – intervals. However, it is necessary to work hard to restart the station and think about ways to reduce depence on fossil fuels.

Considering that Libya is a famous country for olive cultivation and production, and according to the annual statistics, olive pomace is available in large quantities of thousands of tons annually, especially for that the cost of this raw material does not exceed 0.1 LD/ kg plus the costs of transport and handing which is very cheap when compared to the cheapest heavy oils used in thermal plants.

On the other hand, if we look at what the world is exposed to today due to environmental pollution and global risks of climate change and global warming due to the heavy use of oil and fuel; and on the contrary, the production of biofuels - theoretically - means to germinate a tree that absorbs CO_2 from air and water H_2O from soil, as well as to use sunrays to convert these elements into either sugars or starches from which biofuels can be produced.

In this paper, samples of olives produced in Libya in successive 29, from 1990 until 2018, were taken. Mathematical equations were applied and programmed by the MATLAB program. It was deduced that electric power can be produced at 9.48 MW as an average for the annual production, 175 thousand ton which covers the third of consumed power for lighting.

Keywords- Olives pomace; biomass; Renewable energies; Potential energy; Energy produced.

▪ **Engineer Hamza, Abubeker Falifla**

INTRODUCTION

1.1 General context

Since the beginning of industrial revolution, atmospheric concentration of greenhouse gases has increased significantly. This phenomenon is mainly because of the human activities that include the massive use of fossil fuels and deforestation. Unfortunately, it's evident today that over the past three decades, the global climate change has a very bad impact on several physical and biological systems. Therefore, any project that aims to reduce the emission of greenhouse gases can prevent or delay many expected future damages on our planet [1].

Nowadays, biomass has become one of the most important renewable and sustainable sources of energy. Because of the carbon dioxide emissions that harm the ozone layer, and therefore intensify the risk and the consequences of greenhouse gases, it is highly encouraged to use biomass as a source of power since it is fast developed and it is the best way to convert Olive residues and waste to energy.

In Libya, olive cultivation was one of the sources that experienced a massive revolution after proving the economic feasibility of this precious tree. With the growing areas planted with olive trees, interest in extracting oil increased, which led to an increase in the number of oil mills contemporarily. Currently, there are about 120 olive oil mills that use different technologies.

The olive tree is a perennial tree for it is found in some mountainous areas that date back thousands of years and still give an economic crop [2]. Others are extinct and new growths have emerged. However, the modern growths are between 40 to 60 years, they are in the economic feasible interval of their ages, especially those that receive a continuous care in their cultivation area. It is estimated that there are about 865 million olive trees in the world and the vast majority of these trees are found in the Mediterranean countries. Since the olive tree in Libya was considered a basic element for the continuation of life on earth in the pre-oil period and until the early 1960s, olive oil was an important agricultural commodity for export. According to recent statistics, it was found that the number of olive trees in Libya is about 11.3 millions of different ages among which are eight million are productive. The average production of olives is about 175 thousand tons per year [2].

Figure No. 1, shows olive residues, or so-called "peat", after being squeezed into special machines to obtain olive oil is one of the sources that can be used as a good alternative source of energy in several forms [1], but it is still used in a primitive way as farmers sell it as wither animal feed or organic fertilizer for farms.

Olive pomace is the solid by-product obtained from the extraction of olive oil. It consists of pieces of skin, pulp, stone, and olive kernel (or pit)[3], pit (42%–54%), skin (10%–11%) and pulp (21%–33%), and has an oil content of 5%–8% depending on extraction technology. Some olive oil mills economically recovered that oil with solvent to produce "crude pomace oil," which is dark-green, and preferred for soap making or industrial purposes, but never called "olive oil" according to the International Olive Oil Council rules in Madrid, Spain.[4] Figure 1: shows the Classic process of olive oil extraction

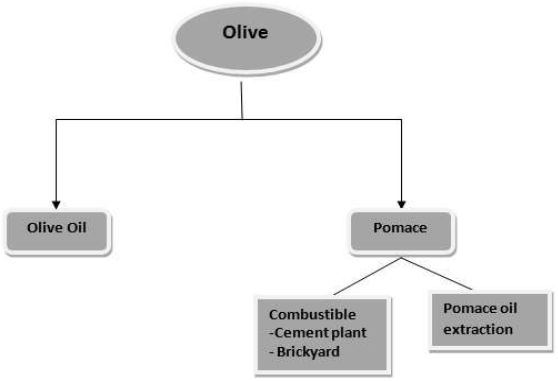

Fig. 1: Classic process of olive oil extraction[1]

1.2 Problem statement and historical setting

Despite the great challenges facing the absolute dependence on fossil fuels, it is one of the easiest sources of energy available at present, because the main reason is the great obstacles that face the new and renewable energies, especially in developing societies where traditional fuels are highly available and there is no future vision to the reality of energy while continuing depleting the available stock of fossil fuels. Renewable energies are reliable sources of energy in the future, especially in Libya as a result of the development of its technologies and the growth of global markets and the inevitable depletion of fossil sources of energy, the growing fear of the dangers of nuclear energy and increasing voices calling for the reduction of emissions on the planet [11]

That's why, replacing this source of energy by another biomass that is more available and less harmful in our country is an interesting alternative, and might be the best way to reduce the environmental effect of the massive use of wood and prevent deforestation that is one of the biggest environmental issues and that has negative effects on the global warming since it increases the amount of carbon dioxide in the atmosphere.

1.3 Project objectives

In Libya, there are many sources of energy that have not been used sufficiently as in other parts of the world, so that they have been kept inactive and not used. At the same time, some Libyan officials attributed this inactivity to the lack of allocating sources of funding for its production or the lack of experts and possibly limiting in some legal legislations made by the government which had a negative impact on not using these sources.

The Olive pomace is one of that renewable energy which can be produced on yearly basis and in large amount as a byproduct of olive oil industry, making the potential of its use as a source of energy by direct combustion that is highly feasible.

The use of olive pomace as a source of energy for electricity generation will solve a part of the increasing demand on energy problem in Libya; it is largely used in Mediterranean countries like Spain, Italy, and Greece, where Andalusia region in Spain has established several power plants that are fueled by this byproduct.

The main objective of the present study is to investigate and evaluate the potential and utilization of a biomass in the country.

The following points constitute the main goals of this paper:

- Collecting the information concerning annual Olive Production and Olive Pomace .
- Using the previous information based on the average production o f the last six years in the Libya and substitutes it with mathematical equations and calculating it through the MATLAB program to estimation energy in MW which will cover a portion o the electric energy consumed in lighting.
- By using Olive Pomace as renewable energy to potential power that will aim to reduce activities that include the massive use of fossil fuels then, reduce the emission of greenhouse gases can prevent or delay many expected future damages on our planet.

2. Olive Pomace in Libya

Libya is the one of the countries producing olive oil and the olive pomace, where the annual average quantity of olive pomace is reached 49.87 thousand ton as will it shown in the Figure No. 3 when explained the power calculations. So the olive pomace is a byproduct of manufacturing process (olive oil production process) and is considered as an important biomass fuel that can be used in boilers for many fields looks like in the saunas[5].

It is true that this biomass is used to be underestimated and is not used before, but the Libyan people became recently aware of its benefits. Indeed, many researches claimed that olive pomace is a good agricultural residue that might be easily commercialized to satisfy the needs of many industries and networks that aim to generate energy without harming the environment. Despite the underuse of olive pomace, a lot of Local Libyan companies export it annually into boundary countries to extracting olive another time and using as byproduct of manufacturing process.

Olive pomace is a renewable fuel source that can be used instead of fuel, gas and wood in many fields like cement plants and brickyard, domestic heating, heating in hammams and bakeries, industrial central heating system, etc. It is in fact an environmental friendly sustainable alternative of fossil fuels. Its calorific value as shown in Table No. 1 is equal 20 Mj/kg [6] and it is more than the other biomass like wood; it is therefore a good combustible and has an affordable price: approximately 0.10 LD/ kg.

Table 1: Calorific value Comparison

Type	Wood	Olive pomace	Ethanol	Coal	Crude	Diesel
calorific	10	20	28	31	41	46

Mainly, the harvesting period of olives in Libya lasts from October to January with a peak period in November and December. During the extraction of olive oil, the olives harvested are pressed and the olive oil is extracted after passing by a crushing unit; and the olive pomace obtained is very wet; its moisture content varies between 40 to 70 % depending on the efficiency of the machines used in the extraction process[7]. In order to make it useful as biomass fuel energy, it should be dried so that the moisture content would be minimized to a percentage range of 8 to 15 %. The remaining solid by product which is olive pomace or olive cake has a dark color and is a mixture of pulp, olive skin, crushed olive pits (kernels or stones), and few waste waters and pomace oil residue[2].

3. Future Forecast for Electricity Demand

Table 2 shows the summaries of the latest studies conducted by the General Electricity Company and the Executive Authority for Renewable Energies in Libya showed that the demand for electricity is increasing, whether due to natural growth of demand or due to the entry of strategic projects into service and the expansion of existing projects. Besides, the factor of the development of economic growth has witnessed clear progress on the standard of living and increasing income allowing the expansion of electricity usage in all fields. Therefore, the annual growth rate of the maximum load is expected to be about 8% [8].

The long-term annual maximum load projections of the electrical system are carried out in the long run by examining the relationships between the consumption of the electric power of different sectors as well as and GDP and population data, as well as the use of annual rates of increase. Table No. 2 shows the expected maximum annual loads of the public network up to 2030[9].

Table 2: Expected annual maximum loads of the general network up to 2030

Year	2001	2005	2010	2015	2020	2030
Max. Load MJ	2,880	4,299	6,027	8,419	13,433	17,847

4. Eelectricity Crisis in Libya and the Role of Renewable Energies

As shown in Figure No. 2,which shows the daily sample load at middle of each month in the 2019, where it is clear that the total power consumption in the every month is greater than total power generating. Because the general electrical network suffered a lot of exceptional and difficult conditions during the past years, represented in the serious damages in the generating stations, transferring stations and the main transmission lines as well as the distribution networks and other electrical installations. In addition, many production projects have been discontinued as a result of security companies and armed clashes which put the general network in a difficult and critical situation that led to a large deficit in meeting the demand for electric power, and therefore resort to power cuts for long periods of up to eight hours a day. So according to that it is become necessary to think about renewable energy to compensate the miss of power [10].

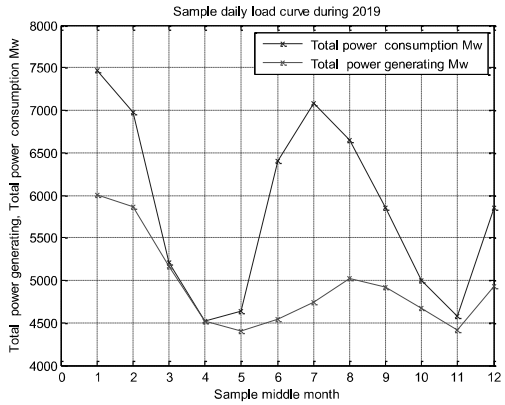

Fig. 2: sample daily load curve during 2019

5. Renewable Energies

Hydroelectricity, wind and wave power, solar and geothermal energy and combustible renewable and renewable waste (landfill gas, waste incineration, solid biomass and liquid biofuels) are the constituents of renewable energy.

The rapid growth of renewable power generation continued in 2018, with an increase of 14%. In volume terms, the largest increase was in China, accounting by almost 50% of the total increase at a global level explained that, the consumption grew by 14% in 2018, providing 9% of the world's electricity.

The OECD remains the main source of renewable power generation (59% of world total) in 2018. Nevertheless, non-OECD growth is larger and accounts for almost 2/3 of the total increase in renewable energy for some individual countries renewable now contribute a significant share of power. Countries where renewable contribute more than 20% of the power generated include Germany, Spain, UK, Italy, Portugal, Denmark, Finland, Ireland and New Zealand.

Direct dependence on fossil fuels as a major source of energy has great future implications. Specialists and officials at the Saudi International Conference on Water and Energy in 2013 held in Jeddah affirmed the existence of major challenges facing the production of water and energy in the Arab world for the high cost of production, and the unsustainability of natural resources of water and fossil fuels, as well as the growing per capita consumption, in addition to the pollution of the surrounding environment, which is one of the most serious problems caused by conventional plants as a result of burning fossil fuels, that could reach the upper atmosphere, i.e. ozone, which causes the problems of global warming. For example, in Libya, since 2013, the burnings of petroleum fuels have caused the emission of carbon oxides by more than 60% and about 40% of natural gas. The emission of carbon dioxide in 2014 was about 50 mega tones [11].

In this context, in addition to Libya's enjoyment of renewable energy sources and the geographic location close to the energy markets, Libya's interest in developing and using its renewable energy sources was established by the establishment of several institutions working in this field, led by the Ministry of Electricity and Renewable Energies. Future plans for the use of renewable energy sources in Libya, namely solar and wind energy, which are supposed to contribute 3% of the total electricity produced in 2015, 7% of the total electricity produced in 2020, and 10% of the total electric energy produced in 2025[12].

6. Calorific Values and Energy Calculations

Caloric value of olive pomace depends on many factors [13], the pressing method utilized; due to the fact that different pressing methods (traditional, dual, and triple phase extraction methods are the main three extraction methods) leave different amounts of residual oil in the pomace, which contribute to the Caloric values, it is also affected by the ratio of pulp and pits in the olive cake samples [4] and by the moisture content of the samples.

Table 3. shows the quantity of olive being used for oil extraction and the corresponding resulting pomace quantity for nine years. It also shows the Calorific Values and Energy Calculations

Table 3: Olive, pomace production and power.

Year	Olive production *1000 / (Ton)	Oil production * 1000 / (Ton)	Pomace's Mass * 1000 / (Ton)	Potential Energy MJ	Potential Energy Mwh	Potential Energy out put Mwh	Power Mw
2010	150.0	142.5	42.75	855	237500	71250	8.133
2011	155.0	147.25	44.17	883.5	245416	73625	8.40
2012	186.6	177.27	53.18	1063.36	29550	88635	10.11
2013	168.0	159.6	47.88	957.6	266000	79800	9.10
2014	168.8	160.36	48.10	962.16	267266	80180	9.15
2015	169.0	160.55	48.16	963.3	267583	80275	9.16
2016	168.8	160.36	48.10	962.16	267266	80180	9.15
2017	188.8	179.17	53.75	1075.02	298616	89585	10.22
2018	189.6	180.12	54.03	1088	300200	90060	10.28

Since calorific value is affected by the ratio of pulp and pits in the olive cake samples, reproducibility of the results varies between +/- 850 kJ/kg [13]. However, the average value of measurements performed in triplicate was taken. Although the pulp fraction contributes more to the total calorific value than the pits (pulp 22.183 MJ/kg[15] and pits 19.56 MJ/k g)[14], the partition of pulp and pit was not considered in that experiment.

The oil content in the dried samples was extracted using the Soxhlet method with distilled hexane for 3 hr Measured calorific values varied between 21.129 and 22.02 MJ/k g.

The experimental results obtained in [4]. Make a very reasonable reference for estimating the energy content of a certain amount of olive pomace, for instance, a value of 20 MJ/kg will be used here for the energy content estimation.

The total potential energy stored in olive pomace can be calculated based on the average production o f the last six years in the Libya [16].

$$Averge\ olive\ production = 175{,}000\ Ton$$
$$Used\ Olive\ production = 0.95\ X\ 175{,}000 = 166{,}250\ Ton$$
$$Pomace'sMass = 0.3\ X\ Used\ Olive\ production$$
$$Pomace'sMass = 0.3\ X\ 166{,}250$$
$$Pomace'sMass = 49{,}875\ Ton$$
$$Energy\ (KJ) = Mass\ (Kg)\ X\ Calorific\ value\ (KJ/Kg)$$

$$X\ \frac{20\ \text{MJ}}{\text{kg}}\quad \text{potential energy} = \frac{49{,}975*1{,}000{,}000\ kg}{1}$$
$$= 997{,}750000\ MJ$$
$$X\ \frac{1\ \text{Mwh}}{3600\ \text{MJ}}\quad \text{potential energy} = \frac{997{,}750000\ \text{MJ}}{1}$$
$$= 277{,}083.33\ Mwh$$

This amount of stored energy can vary depending on the fuel final status; as mentioned before, this estimated value corresponds to dried and de-oiled fuel. Increasing the moisture content of olive pomace can significantly decrease the heat output, since a fraction of the heat will be lost in vaporizing the moisture; consequently drying must be as less agglomerated as possible. In the Libya, most of the mills use sun drying method to dry the pomace [13].

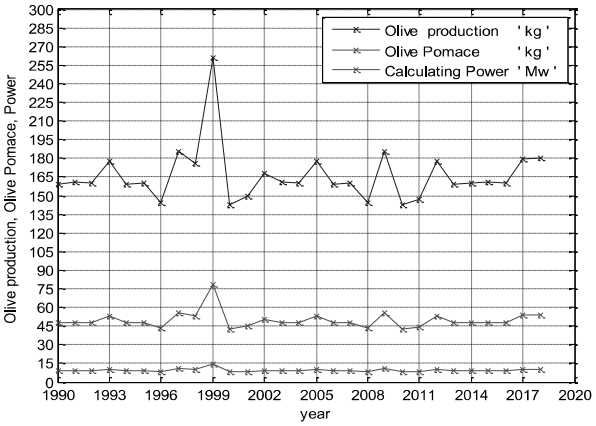

Fig. 3: Olive Production, Olive Pomace and Calculating power

As shown in Figure No. 3,which shows the Production, Olive Pomace and Calculating power.

Moreover, to insure a maximum burning efficiency, the fuel must be as less agglomerated as possible; in the Libya, olive pomace is supplied in two forms, powder or pellets. Clearly, powder form is the best form to be used for this application but still the particle sizes are relatively big; consequently more crushing must take place for better performance.

For electrical application, the technology used for obtaining electricity is the Rankine vapor cycle, with generation or co-generation (heat electricity) electrical plants (steam conventional cycles).Normally , the efficiency of Rankine cycle depend s on the working fluid and operating temperatures that are usually limited to the creep temperature of turbine materials. However in real life, application for biomass power plants efficiency ranges between 15% and 45% are recorded, and an efficiency of 30% will be used here as a best estimation.

$$\text{Potential energy output} = 277083.33\ (Mwh)X\ 30\ \%$$

$$\text{Potential energy output} = 83{,}125.33\ Mwh$$

which if compared to the electricity consumed in the Libya in 2010 (12844 GWh), this amount is equivalent to 0.48% of the total energy demand.

Such energy can be produced by a power plant operating with a capacity of 9.48 MW, working full load in one year

$$X \quad \frac{1\ year}{8760\ h} \text{ working full load } = \frac{83125\ Wh}{1}$$

working full load in one year = 9.48MW

DISCUTION

Due to the increasing demand on energy in the Libya, strategies for alternative and economic options were planned for the future. General Electric Company and the Executive Authority for Renewable Energies sector included introducing legislations on increasing the contribution of the new and renewable energy up to 3% of the energy mix in 2015 and 7% in 2020, and 10% in 2025[12].

To increase the share of renewable energy to the total energy mix, the plan for bio- energy sector is to utilize bio- mass to generate electricity with a capacity of 20–30 MW[12], by investing in the biogas sector .

The estimated potential output by direct combust ion of olive pomace based on the Rankine cycle technology (9.48 MW) is as much as 23%–36% of this planned capacity (20–30 MW) and can increase the total planned capacity to be 27 to 37 MW, for instance.

Based on the data obtained from the study carried out by the General Electricity Company in the field of renewable energies, where its data was used as an input to the program predicted to predict the product of renewable energies such as solar energy and wind energy shows that the energy obtained from the olive pomace is 17% of total renewable energies for the year 2015 and 8% of total renewable energies for the year 2025.

Environmentally, using olive pomace as an energy source instead of fossil fuels reduces the damage that may be done to the climate through the combustion of fossil fuel. The use of biomass does not increase atmospheric levels of carbon dioxide, as shown in Figure No.4 to explain the GHG emissions (gCO2eq/MJ)[17] in the different methods renewable generation energies.

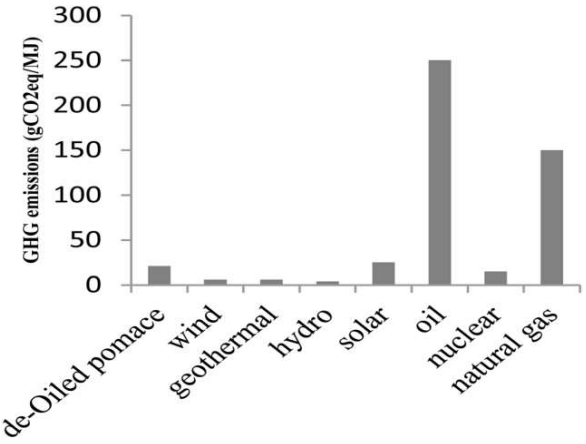

Fig. 4: GHG emissions (gCO2eq/MJ).

A primary greenhouse gas, because of the life-cycles of plants and trees, since carbon dioxide emitted by thermal plants fuelled with biomass is the same as that absorbed by plants or trees to produce an Equal amount of biomass.

In the biomass energy cycle, the carbon dioxide is in balance [18]; the use of biomass can also decrease the amount of methane, another greenhouse gas, which is emitted from decaying organic matter. Olive pomace is a renewable, CO2 neutral, fuel, making it a valuable technology in efforts to reduce CO2 emissions in order to curb global warning and climate change [8]. Ashes resulting from burning olive pomace could be used as amendment in agriculture because of its high nitrogen and phosphorus content, as a biofertilizer, and as a biofilter for toxic metal removal [19].

8. Conclusion and Recommendations

Some people used Olive oil production byproducts as a source of energy for space heating as a result of increasing oil prices, But in this study we estimation energy in MW of Olive pomace production for electricity generation that, will be contribute to the total renewable energy strategy set by the government for the next decade; It was deduced that electric power can be produced at 9.48 MW as an average for the annual production, 175 thousand ton of Olive pomace which covers the third of consumed power for lighting and will contribute about 23%–36% of the planned capacity for bio-energy resources to generate electricity in the Libya for the next decade.

The creation of supply olive-pomace-to-energy chains could be the optimal solution for olive pomace management in the Libya. Logistics and raw material transportation in the supply chain will be related to the location of the power plant. For optimal performance and better economic benefits, the best location for the power plant must be in a place where the highest concentration of this raw material is available; for instance, the cities of the western part of the Libya are relatively closer to each other, compared to the southern and northern part of the country, and the fact that 95% of the mills and production lines are found in the western part of the country also makes the northern part the “first best estimation” for the location of a power plant fueled by olive pomace, and it will also contribute to the total CO2 emissions reduction by increasing the total cultivated area in the Libya and decrease the dependency on petroleum products to meet the demand, in the Libya.

To availability of real potential of biomass in Libya, It should be national action plan in the field of biomass has become necessary in order to:

1. Increase the efficient use of energy derived from arboriculture and olive pomace,
2. Preserve and protect our national resources against the irrational use inside the country and its exportation to outside the country,
3. Establish incentives laws to encourage private production of green electricity from biomass.

- Building Private Biomass Power Plants.
- Using developed and efficient conversion technologies
- Working with international cooperation and partnership (technology transfer).

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