Renewable and Sustainable Energy Reviews 52 (2015) 209–216

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Management of olive solid waste in Lebanon: From mill to stove

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ARTICLE INFO

Article history:
Received 5 January 2015
Received in revised form
14 May 2015
Accepted 21 July 2015
Available online 11 August 2015

Keywords:
Biomass
Olive solid waste
Renewable energy
Sustainability
Waste management
Lebanon

ABSTRACT

Finding new clean sources to match the fast overgrow of energy consumption and its expected environmental pollution has become an inevitable need [1]. The solution will mainly be to increasingly befriend renewable energy sources. Narrowing the circle towards a more local setting, this study focuses on biomass olive solid waste as source of renewable energy in Lebanon.

The paper presents an overview at oleiculture in Lebanon: geographical distribution, olives' production, mills distribution and types, olive solid wastes produced, and their energy potential. Effectively, the energy potential of the yearly produced 79,000 t of olive solid wastes is around 380 GJ per year. In addition to the benefits coming from using this waste as an energy source, economic, environmental and social benefits are evaluated. The ultimate purpose hence becomes seeing the sustainability of this product. A primary planning is also taken on the treatment of this waste.

Contents

1. Introduction

In a word where global energy consumption will have increased up to 50% 20 years from now, finding new sources to match that fast overgrow has become an inevitable need [1]. The solution will mainly be to increasingly befriend renewable energy sources. Narrowing the circle towards a more local setting, it is known that the usage of these types of sources is underwhelming in Lebanon: apart from a modest amount of hydropower and traditional energy (wood), which combined represent less than 2% of total energy consumption, all energy in Lebanon is derived from imported petroleum products and some coal solely consumed by two cement factories [2]. Many types of renewable energy represents a serious potential in the country of cedars considerably hydro, solar, wind and biomass which are locally feasible [3]. The solar energy is becoming widely used, particularly in solar water heaters. As for the hydro power, Lebanon has about between 5 and 12% of its electricity production coming from hydro power plants, only recently. This percentage is relatively low compared to the past few decades, and it can be elevated by building the dams

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http://dx.doi.org/10.1016/j.rser.2015.07.094
1364-0321/

already studied, which can increase the total hydropower capacity from 281.1 MW to about 531.1 MW [4]. When it comes to the wind energy, the Ministry of Energy believes that the development of this kind of energy can play a crucial role in reaching the set goal of 12% of renewable energy by 2020 in Lebanon [5].

Conversely, biomass energy is one of the most important energy sources used in the world. It is, in fact, the third largest primary source of energy in the world after coal and oil. More than 10% of final globally consumed energy resources comes from biomass, giving it such importance. Biomass sources vary from wood, wood's waste, agricultural waste, animals' waste, to municipal and industrial solid waste, energy crops and even aquatic waste. This type of energy is a renewable low-carbonated fuel. Its production and use also bring additional environmental and social benefits.

Various studies were carried out regarding the energy potential of the biomass sources. According to Rosúaa [6], energetic needs for domestic heating homes in Spain can be covered up to 20.2% from biomass mainly from olive and fruit trees and pruning vines. While Abu-Ashur [7] estimates the animal and olive wastes in Jordan potential as a supplementary energy source representing about 2% of the total primary energy consumption. Moreover, García-Maraver [8] evaluated the potential of biomass from olive grove residual in Andalusia region to generate electricity in addition to thermal energy and biofuels for transportation. Spinelli [9] developed a simple model for predicting harvesting productivity and cost of olive tree pruning residue for energy biomass based on a total area of 69 ha producing over 190 t of wood fuel in Italy. Similarly, residual biomass obtained from different varieties of olive trees from Mediterranean groves was quantified by Velazquez-Marti [10]. Also, Romero-García has identified co-products and residues from cultivation and olive oil production [11], and proposed a biorefinery scheme based for ethanol production. Furthermore, Rodriguez [12] identified olive stone valuable bioactive compounds and its main use as fuel for combustion to generate electric energy or thermal heat for commercial and residential building space heating [13,14], since olive stone has a competitive calorific value of 19.2 MJ/kg [15]. Also, this biomass has almost no environmental impact due to its low nitrogen and sulfur content [16] and therefore low emissions of NO_x and SO_2. Moreover, this olive waste valorized as biomass based energy will help solve the major environmental problem of olive mills waste [17–19].

The previous cited studies were concentrated in Mediterranean countries where Olive trees are natives to the flora of the land. However, olive oil's consumption has healthy benefits, which contributed into the spread of this cultivation worldwide in more than 40 countries: its production has reached 2.67 million tons in 2013 [11]. In Australia for the past two decades, the olive industry has been growing at an annual rate of 9%. In parallel to this growth, biomass energy potential and sustainable management of olive oil industry waste is progressing [20].

Correctly managed, biomass can be a sustainable fuel that can deliver a significant reduction in net carbon emissions. In particular, the emissions from the combustion of olive waste are low compared with fossil fuels and depend on the contents of the olive waste [21,22].

For these reasons, this study will focus on this sector of biomass and more specifically on olive's solid waste coming from the olives oil mills, as a renewable energy source especially that Lebanon is elite in oleiculture: it is ranked 16th in the world which is relatively good given its area of 10,452 km^2.

This study aims at giving an overview at oleiculture in Lebanon: geographical distribution, olives' production, mills' distribution and types, pomace produced (which means olive solid waste), so that the potential energy recovered from the olive waste can be calculated. The goal is not solely to studyolive waste from an energetic point of view; it is also discussing the benefits coming from using this waste as an energy source from economic, environmental and social viewpoints. The ultimate purpose hence becomes seeing the sustainability of this product. In addition, a primary planning will be taken on the treatment management of this waste. Knowing that a complete planning would consider all the parameters affecting the olive waste final product properties in the different phases of the production from collection, storage, drying, processing and distribution [23–25]. The main parameters are the moisture content, density and calorific value [26] (Fig. 1).

2. Overview of olive production in Lebanon

Oleiculture in Lebanon has a major importance: more than 23% of the total cultivated area is planted with olive trees. Geographically, these trees are unequally distributed across different provinces; mostly concentrated in the surroundings of Koura, Zgharta and Akkar in North Lebanon, in South Lebanon, the trees are usually found in Sour and Marjayon, without forgetting the Chouf area located in Mount Lebanon. The majority of the olives' groves is situated in either North or South Lebanon: 39% in the north, 40% in the south, 15% in Mount Lebanon and only 6% in the Bekaa Valley. Fig. 2 shows a more detailed distribution of the olives' groves and gives the cultivated areas of each province [27].

The olives' cultivation areas are sustaining a growth rate of 3% annually. As shown in Fig. 2, the total area occupied by olive trees has been constantly increasing throughout Lebanon: from 27,000 ha in 1961 to 58,000 ha in 2013 [28]. This constant and progressive growth over the years states that the olive sector is a very safe one for investing. It has very few risk factors, and any investment will probably be profitable (Fig. 3).

The same applies to olives production in the last 50 years: from 65,000 t in 1961 to 97,000 in 2013.

The ministry of Agriculture estimates that nearly 70% of the total olive production is processed into olive oil. The pomace is a product of the olives' pressing. But before venturing into the quantity of pomace obtained, it is of a high degree of importance to take a look at the mills' distribution amongst the different provinces and their types.

Fig. 1. Samples of olive waste pellets for different moisture contents 24.4%, 26.7% and 23.2% respectively [26].