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Possibilities of Creating Zero CO_2 Emissions Olive Pomace Plants Due to Energy Use in Crete, Greece

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Abstract

Olive pomace plants process olive paste, a waste product of olive mills which produces crude olive kernel oil and olive kernel wood. Olive kernel wood has very good burning characteristics, high heat content, low cost and it is used as a renewable solid fuel replacing liquid fuel and heating oil. Part of the produced olive kernel wood is consumed inside the factory for heat generation and the rest is sold to heat consumers. It has been estimated that a typical olive pomace plant located in Crete, Greece consumes 42.86% of the produced olive kernel wood for its own heat generation, while the remaining 57.14% is sold to various heat consumers. 99.1% of the energy used in these plants is consumed for heating and the rest, 0.9%, for lighting and the operation of various electric devices. Olive pomace plants utilize a renewable solid fuel, which is carbon neutral, for the production of thermal energy. Therefore their CO_2 emissions regarding energy utilization are due to electricity use. Installation of solar-PV panels in the plant could generate annually all the electricity needed for its operation. The current legal framework in Greece through net-metering allows the offsetting of grid electricity consumed in factories with PV electricity. The required capital cost of a solar-PV system installed in a typical olive pomace plant located in Crete, Greece in order to offset the grid electricity consumed annually has been estimated at 185,832€, the payback period of 5.33 years and the net present value at 555,671€. Since the plant could utilize only solid biomass for heat generation and could offset the grid electricity consumption with solar electricity, its total CO_2 emissions due to energy use would be zero contributing positively to climate stabilization.

Keywords

Solid Biomass, CO_2 Emissions Savings, Crete-Greece, Olive Pomace Plant, Photovoltaics

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1. Introduction

1.1. CO_2 Emissions Due to Energy Use in Industry

Decreasing energy use and greenhouse gas emissions in various sectors including industry are of paramount importance today in order to cope with climate change. Although reducing CO_2 emissions in industry is not so easy as it is in the building sector, various measures and actions have been proposed and implemented so far. The reduction of industrial energy use and CO_2 emissions with the use of advanced materials and technologies has been reported by Gielen *et al*. [1]. The authors mentioned that nearly one third of the world's energy consumption and 36% of its CO_2 emissions are attributable to manufacturing industries. According to them approximately an 18% - 26% reduction in emissions can be achieved based on existing technologies while further improvement can be achieved with the use of advanced materials and processes. Similar results have been reported by the International Energy Agency [2]. They concluded that the manufacturing industry can improve its energy efficiency by 18% - 26% while reducing its CO_2 emissions by 19% - 32% based on proven technology. A report on reducing CO_2 emissions from heavy industry with a review of technologies and considerations for policy makers has been published by Imperial College London, Grantham Institute for Climate Change [3]. The report proposes the following measures for reduction of the emissions.

1) Maximization of energy efficiency potential by replacing older, inefficient processes with best practice technologies.

2) Change in the fossil fuels used with low carbon energy sources.

3) Acceleration of the research leading to CO_2 capture and storage.

4) Alteration of product design and waste protocols to facilitate reuse and recycling.

The long term US industrial energy use and CO_2 emissions have been reported by Wise *et al*. [4]. The authors studied the energy technologies and fuel choices over a 100-year period and the response of the industrial sector to climate policies. They found that electrification is an important response to climate policy although there are services where there are practical and economic limits to electrification. The ability to switch to a low-carbon fuel and the use of biomass for the co-generation of heat and power may also play a key role in reducing carbon emissions under a policy constraint.

The creation of zero CO_2 emissions buildings due to energy use has been reported by Vourdoubas [5]. The author described residential buildings in Crete, Greece which could cover all their energy needs with various renewable energy sources zeroing the use of fossil fuels and their CO_2 emissions. This could be achieved with the use of solar thermal energy, solar-PV, solid biomass and low enthalpy geothermal energy with heat pumps. The assessment of the impact of a carbon tax in energy demand and in energy related CO_2 emissions in Greek manufacturing has been studied by Floros *et al*. [6]. The authors reported that the Greek manufacturing industry is electricity intensive and the share of electricity in total energy consumption in the sector of food products and beverages is 55.19%. Using mathematical models they found that reduction of direct and indirect CO_2 emissions can be achieved if a carbon tax is imposed as a policy instrument, but a relative high carbon tax may have significant adverse economic effects in the Greek industry. The path to a low carbon economy with reference to the Masdar example has been presented by Nader [7]. He reported the Masdar initiative in Abu Dhabi for the creation of a low carbon future. Masdar city is a carbon neutral, zero waste urban development which uses various existing renewable energy technologies in order to achieve a sustainable future with zero CO_2 emissions. CO_2 emissions requirements for global temperature stabilization for the next several centuries using an earth system model have been studied by Matthews *et al*. [8]. The authors concluded that stable global temperature within the next several centuries can be achieved only if CO_2 emissions are reduced to nearly zero. Installation of solar photovoltaics in buildings and in factories to offset the consumed grid electricity has been allowed since the end of 2014 in Greece. A review of solar energy use in industry has been presented by Mekhilef *et al*. [9]. The authors reported that buildings of integrated grid-connected PV systems are growing in developed countries. Solar electricity is applied also in the telecommunications industry, in poultry plants and in the desalination industry. CO_2 emissions per capita in Greece and in various other countries according to the World Bank are presented in **Table 1**, World Bank, [10]. Greek emissions are high compared with other Mediterranean countries.

There is consensus among researchers that reduction of CO_2 emissions in industry can be achieved with the use of low carbon fuels including solar energy and biomass. The necessity to reach in a zero carbon economy has been pointed out and solar electricity applications in various industrial sectors have been reported.

Table 1. CO_2 emissions in Greece and in various other countries (2011).

Country	CO_2 emissions per capita (tons/capita, 2011)
USA	17.0
Russian federation	12.6
China	6.7
Australia	16.5
Germany	8.9
France	5.2
Italy	6.7
Spain	5.8
Turkey	4.4
Cyprus	6.7
Malta	6.0
Slovenia	7.5
Greece	7.6

1.2. Olive Pomace Plants

Production of olive pomace oil has been reported by Sanchez Moral *et al*. [11]. The authors investigated the evolution and the changes in this sector over the last 100 years searching for a role in the new strategy of the olive oil industry in the beginning of the 21st century. Treatment technologies of liquid and solid wastes from two phase olive mills have been presented by Borja *et al*. [12]. The authors reported that in the last 10 years, 90% of the Spanish olive oil factories are using the two phase technology. The management of olive mill wastes in Greece has been presented by Chartzoulakis [13]. Pomace from two and three phase olive mills has been used in Greece for the production of pomace wood and pomace pellets both used for direct heating while gasification plants for electricity generation are expected to be created in the future. Analysis of olive grove residual biomass potential for electric and thermal energy generation in Andalusia, Spain has been presented by Garcia-Maraver *et al*. [14]. The authors mentioned that biomass contributes significantly to Andalusian energy infrastructure. The generation of agricultural and industrial residues from the olive sector produced in Andalusia is an important source of different types of residual biomass that are suitable for generation of thermal and electric energy since they reduce the negative environmental effects of emissions from fossil fuels. The use of agricultural and animal byproducts and residues for decentralized energy production has been studied by Skoulou *et al*. [15]. The authors presented the available quantities of various biomass resources in Greece and described the traditional and new thermochemical technologies which could be used for energy generation. They concluded that there is a large potential for the exploitation of the existing biomass resources for energy generation in Greece.

The profitability of solar-PV investments in accordance to net-metring initiative has been presented by Tselepis [16], who estimated for such industrial investments pay-back periods of less than 8 years and attractive IRR at 17%. Steam economy and co-generation in cane sugar factories have been reported by Ogden *et al*. [17]. The authors reported that most cane sugar factories have been designed to be energy self-efficient using bagasse for heat and power generation. They investigated the energy improvement of those plants with the use of bagasse-fired cogeneration systems which offer much higher electricity generation than the existing conventional systems. Energy production from sugarcane bagasse in Brazil through different technological routes has been reported by Dantas *et al*. [18]. The authors found that approximately 98% of the energy needs of sugarcane processing mills are provided by the burning of bagasse in co-generation plants which deliver the thermal, mechanical and electric energy required for the production of ethanol and sugar. They also reported that recently the sugarcane processing plants generate surplus electricity for sale in the national grid. The production and use of olive kernel wood, produced in olive pomace plants in Crete, have been presented by Vourdoubas *et al.* [19]. The potential of using olive pomace for electricity generation in Jordan has been presented by Alketan, [20]. The author believes that the increased energy demand in Jordan can be supplied by renewable energies and olive pomace could be an excellent source for that. A thermo-economic assessment to investigate the economic profitability of a small scale CHP plant using gasified olive pomace as fuel in Italy has been implemented by Borelo *et al*. [21]. The authors assumed that the co-generated electricity could be sold according to the current feed-in tariffs and they discussed the advantages and the bottlenecks of such co-generation schemes. A life cycle analysis of a plant producing energy from the de-oiled pomace and waste wood as fuel has been implemented by Intini *et al*. [22]. The LCA shows the important environmental advantages of biomass utilization in terms of greenhouse gas emissions reduction. Energy-economic life cycle assessment and greenhouse gas emission analysis of olive oil production in Iran has been reported by Rajaeifar *et al*. [23]. The authors studied GHG emissions considering four main stages of agricultural olive production, olive transportation, olive oil extraction and its oil transportation to the customers centers. The agricultural production stage ranked the first in GHG emissions with a share of 93.81% for total GHG emissions. An environmental impact assessment of olive pomace oil biodiesel production and consumption has been presented by Rajaeifar *et al*. [24]. The authors found that olive pomace oil biodiesl could be a good alternative to petroleum diesel having environmental advantages. They also stated that the production of olive pomace oil biodiesel is economically attractive.

Currently there are no reports of Greek food industry plants which are energy self-efficient. Reports on the operation of sugar cane factories in Brazil prove that they are not using external energy sources. According to findings the Greek food industry consumes more electricity than heat. At the same time there are no reports proving that Greek food industry tries to reduce CO_2 emissions due to energy use. Installation of solar-PV systems has not been achieved yet although the legal framework exists and its economic viability has been proved. Studies or commercial processes utilizing olive pomace for power generation or for co-generation of heat and power in Greece have not been reported although existing studies in Italy and Jordan have suggested their profitability and attractiveness.

The aims of the current work are a) to estimate the CO_2 emissions due to thermal and electric energy consumption of a typical olive pomace plant in Crete-Greece, b) to investigate the possibility of installing solar-PV systems in the plant in order to become energy self-efficient regarding the thermal and electric energy consumed and to zero its CO_2 emissions due to electric and thermal energy use and c) to assess the profitability of this solar-PV investment.

2. Materials and Methods

The methodology used included the following steps. Firstly an energy analysis of the plant regarding fuels and electricity consumption was implemented, together with an estimation of the CO_2 emissions due to energy use. Secondly the energy content and the CO_2 emission savings of the olive kernel wood sold as a renewable fuel to various heat consumers were estimated. Thirdly a proposal for a solar-PV system sized to cover all the annual electricity requirements of the plant was made. Finally the capital cost of the proposed solar-PV system was estimated and an economic assessment of the investment was implemented.

The present work contributes to our existing knowledge regarding the energy balance of various plants and their impact to climate change due to emissions of greenhouse gases. It focuses on the operation of olive pomace plants in Crete, proving that their carbon footprint due to thermal and electric energy use is negative due to two factors: first because they mainly utilize for heat production a renewable solid fuel produced in situ and secondly because they sell large quantities of the produced renewable fuel to external heat consumers. It also suggests that their sustainability could be increased and they could become energy self-efficient if a profitable solar-PV system were installed generating annually all the electricity required in the plant.

2.1. Olive Kernel Oil Producing Plants

Olive pomace plants (olive kernel oil producing plants) process the olive mill paste in order to extract the residual olive oil from the remaining components. Over the last 20 - 25 years the olive oil industry has undergone significant changes regarding the technology used. Initially the prevailing technology in olive mills was based on the removal of olive oil after pressing the olives. Pomace from olives pressing contains 25% - 30% moisture. Later, another technology based on the three phase continuous centrifugation process dominated in olive mills producing higher amounts of liquid wastes compared with the previous technology. This three phase continuous centrifugation process produces an oily phase, an aqueous phase and a solid phase with approx 50% water content. Nowadays the three phase continuous centrifugation process has been replaced with the two phase centrifugation process which produces an oily phase and a solid phase with higher moisture content (65% - 75%) without producing highly polluted liquid wastes, overcoming the difficult problem of environmental pollution from liquid wastes. However the pomace produced with high moisture content presents many difficulties in its transportation, handling and drying.

The solid byproduct in the two phase continuous centrifugation process contains residual oil, water and organic matter. Its further processing in the olive kernel oil producing plants results in the evaporation of the water contained and the production of olive kernel oil and olive kernel wood. The latter is a solid with low moisture content approximately 12% p.w., high calorific value, approximately 4000 - 4500 Kcal/kg, and very good burning characteristics. Olive kernel wood is currently used in Crete for heat generation in various buildings, in industry and in greenhouses. Since olive pomace plants consume energy during their operation mainly in the form of heat rather than electricity, they utilize large amounts of the olive kernel wood produced in the plant as a solid fuel instead of fuel oil.

The solid with high moisture content produced in the two phase olive mills is transported to the olive kernel oil producing plants where it is undergoes processing for water evaporation and the removal of the kernel oil. Initially the water contained is evaporated in rotated cylindrical dryers and afterwards the oil is extracted with the use of organic solvents. Heat is needed in various processes in the plant. It is needed for drying of the high moisture in the olive cake, for steam production, for the extraction of the oil from the dried cake and for the distillation of the kernel oil-solvent solution in order to separate and reuse the solvent. The crude olive kernel oil produced undergoes further processing in order to become edible. Its processing includes neutralization to reduce its acidity, decolourization with filtering to change the colour and finally deodourization in order to remove the undesirable odours. The main advantage of the two phase continuous centrifugation process compared with the previously used three phase centrifugation process is the operation of the olive mills without producing the highly polluted liquid wastes which have very high BOD_5 and COD values. Pollution with olive mill liquid wastes is currently a difficult and practically unsolvable technological problem which is eliminated with the modification of the three phase olive mills to two phase plants. The growth of tourism in Crete which is incompatible with environmental pollution increases the pressures on family-size olive mills in order to use more environmentally friendly processes. However the solid byproduct produced with the new process has a higher water content which must be removed with evaporation in the olive kernel oil processing plants. This fact requires the modification of the drying process in the olive pomace plants with changes in the capacity of the dryers and the burners. In recent years the majority of olive mills in Crete have modified their processes in order to avoid the production of highly polluted liquid wastes. Crete has currently 539 olive mills which correspond to 23% of the total Greek olive mills and 9 olive pomace industries which correspond to 29% of the total Greek olive pomace industries. The average olive kernel wood production in Crete is approximately 110,000 tons/year. Part of the produced olive kernel wood in olive pomace plants could be used for power generation or co-generation of heat and power, transforming them to plants producing olive pomace oil, olive kernel wood and electricity sold to the grid.

2.2. Energy Balance in a Typical Olive Kernel Oil Producing Plant

The olive kernel wood produced in an olive pomace plant in Crete is presented in **Figure 1**.

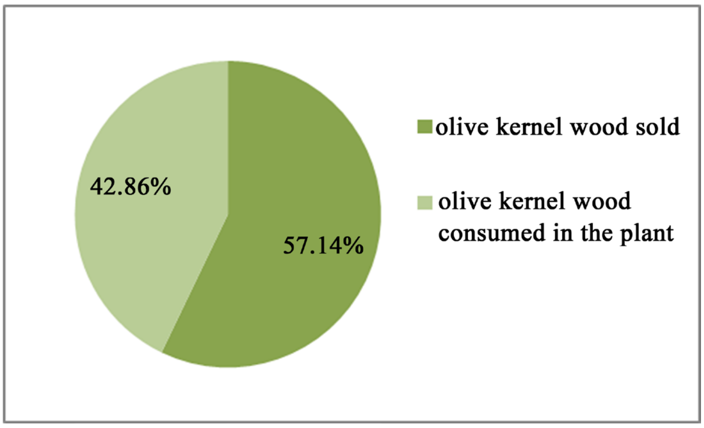

Figure 1. Olive kernel wood production and utilization in an olive pomace plant in Crete.

Olive pomace plants mainly consume heat and small amounts of electricity during their operation. They also consume energy during their operation for the transportation of the feedstock in the plant and the produced goods in the market. Energy has been also consumed in the plant during its construction, maintenance and it will be consumed during its future demolition. Therefore there are "indirect" CO_2 emissions apart from those due to thermal and electric energy use.

The thermal and electric energy consumption in a typical olive pomace plant in Crete is presented in **Figure 2**.

As shown in **Figure 2** electricity consumption in these plants is very low compared with heat consumption, corresponding to only to 0.9% of the total. Heat is generated by burning part of the olive kernel wood produced in the plant while the rest is sold to various heat consumers in order to be used as a renewable solid fuel. As can be seen from **Figure 1** the majority of olive kernel wood produced is sold as a fuel, compared with the amount consumed inside the plant. Therefore these plants are not using fossil fuels for covering their heating needs since the cheap olive kernel wood with its excellent burning characteristics is available in situ. Its current low price, 0.08 - 0.09 €/kg, compared with the prices of fossil fuels increases its attractiveness as a renewable fuel alternative to fuel oil. Olive pomace plants cover all their thermal energy requirements with solid biomass, which is carbon neutral assuming that olive trees in the region recreate the consumed biomass with photosynthesis. Therefore their CO_2 emissions are only due to electricity consumption and they are low as it is presented in **Table 2**. Electricity is generated in Crete from fossil fuels (fuel oil and heating oil), 86%, and renewable energy sources (mainly wind and solar-PV energy), at 14%. It is assumed that the carbon footprint of electricity in Crete is 0.75 kg CO_2/KWh, Vourdoubas [25]. The use of solid biomass instead of fuel oil in these plants results in significant CO_2 emission savings. Assuming that 2.5 kg of olive kernel wood corresponds to 1 kg of fuel oil it is concluded that the consumption of 5133 tons/year olive kernel wood in a typical olive pomace plant in Crete corresponds to the consumption of 2053.2 tons/year of fuel oil. Therefore if fuel oil was used for heat generation instead of olive kernel wood in this plant, its CO_2 emissions would be 6570.24 tons/year. Since olive pomace plants sell solid biomass to various heat consumers, they contribute further to CO_2 emission savings operating as

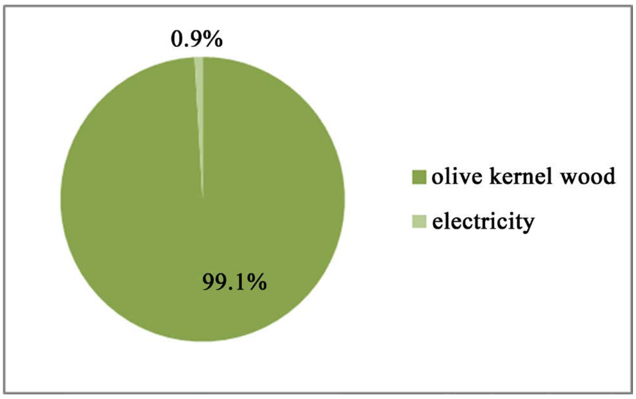

Figure 2. Energy balance in a typical olive pomace plant in Crete.

Table 2. CO_2 emissions in a typical olive pomace plant in Crete, Greece.

CO_2 emissions due to electricity use	174.22 tons/year
CO_2 emissions due to olive kernel wood use	0
Total CO_2 emissions	174.22 tons/year
Fuel oil which could replace the use of olive kernel wood	2053.2 tons/year
CO_2 emissions due to fuel oil use which could be used instead of olive kernel wood	6570.24 tons/year
Total CO_2 emissions in the plant if fuel oil is used instead of olive kernel wood	6744.46 tons/year
CO_2 emission savings due to olive kernel wood sold to heat consumers	9073.92 tons/year
Total CO_2 emissions savings due to the use of olive kernel wood in the plant including the olive kernel wood sold to heat consumers	15,644.16 tons/year
Total CO_2 emissions savings due to the use of olive kernel wood in the plant including the olive kernel wood sold to heat consumers plus the generation of solar electricity in order to offset the grid electricity used	15,818.38 tons/year

plants with negative CO_2 emissions. Olive pomace plants could be transformed to energy self-efficient plants with the installation of a solar-PV system generating annually its required electricity. Investing in solar-PV energy has proved to be profitable in Crete. CO_2 emissions in a typical olive pomace plant in Crete including emissions if fuel oil was used in the plant instead of olive kernel wood are presented in **Table 2**.

- Net heating value of fuel oil 9000 Kcal/kg
- Net heating value of olive kernel wood 3600 Kcal/kg
- CO_2 emissions for fuel oil 3.2 kg CO_2/kg

CO_2 emissions savings due to olive kernel wood consumed in the plant, sold to various heat consumers and due to a solar-PV system generating all the electricity required in a typical olive pomace plant in Crete are presented in **Figure 3**.

3. Results

3.1. Requirements for Zeroing CO_2 Emissions in an Olive Pomace Plant

In order to zero the direct CO_2 emissions due to energy use in a grid-connected olive pomace plant the following two requirements must be fulfilled:

1) All the heat needed must be generated by renewable energy sources.

2) The grid electricity consumed must be offset annually by solar electricity or another renewable energy source.

Since heat is generated by the use of solid biomass in the plant as already mentioned, solar electricity could be generated with the installation of a properly sized solar-PV system. In most olive pomace plants there is available space for the installation of the PV system. Apart from the CO_2 emissions caused from the use of thermal and electric energy more "indirect" CO_2 emissions are created due to the following reasons.

1) Transportation of the olive pomace in the plant and the produced goods in the market.

2) Construction, maintenance and future demolition of the plant.

Furthermore CO_2 emissions due to construction, transport, installation and future demolition of the PV system should be taken into account. The abovementioned "indirect" CO_2 emissions have not been included in the current calculations.

Due to high solar irradiance in Crete, Greece and the economic incentives offered by the government, many solar photovoltaic installations have been realized in the last 5 - 6 years on the island. Currently the net-metering initiative offers the possibility for various electricity consumers including households and enterprises to become power producers, by installing grid connected solar-PV systems on their premises in order to offset the grid electricity consumed annually. Through this initiative an olive pomace plant can install a grid connected solar-

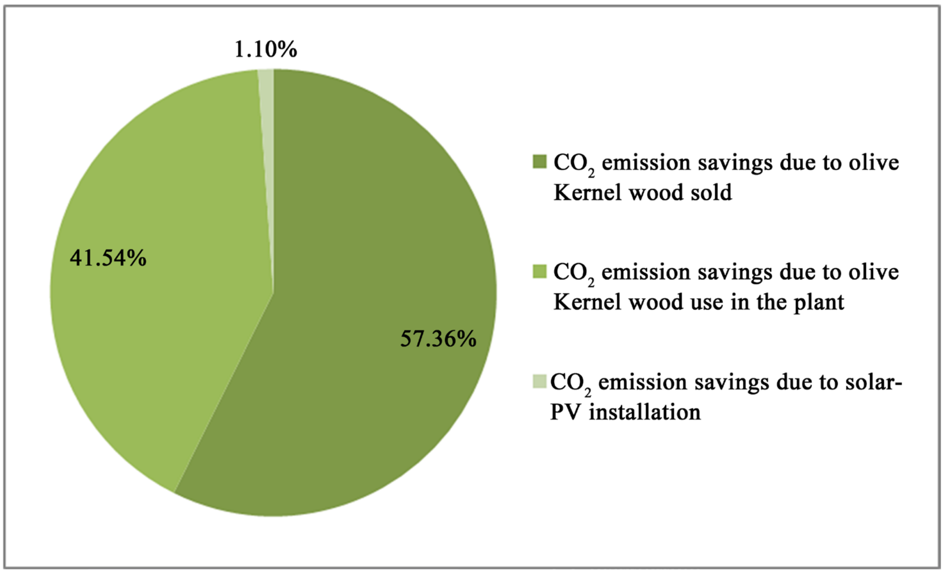

Figure 3. CO_2 emissions savings in a typical olive pomace plant in Crete, Greece.

PV system in a factory generating the same amount of electricity that it consumes annually. In this case the plant can offset the grid electricity used annually with solar electricity. Therefore it could zero its CO_2 emissions due to electricity use: taking into account that it uses only solid biomass for heat generation, the plant could zero its total CO_2 emissions due to energy use becoming a CO_2 neutral plant.

3.2. Sizing and Assessment of a Solar-PV System in the Olive Pomace Plant

The estimation of the required nominal power of the PV system has been made assuming that all the grid electricity in the island has been generated from fossil fuels. However since part of it is generated by renewable energy sources, the solar-PV system has been oversized. The characteristics of a solar-PV installation generating the electricity consumed by the olive pomace plant in Crete are presented in **Table 3**.

The current decrease in the investment cost of solar-PV systems increases their attractiveness in various applications. In order to assess the profitability of the investment of the solar-PV system in an olive pomace plant in Crete with the same characteristics as in **Table 3**, the investment period is considered 20 years, the interest rate 2% and the cost of electricity 0.15 €/KWh. The payback period of the investment is estimated at 5.33 years and the net present value 555,671€ all of which prove that the investment is very attractive. Carbon neutral olive kernel wood produced in the plant is partly sold to various heat consumers replacing fossil fuels. Therefore the operation of the plant assists in the mitigation of the greenhouse effect. The transformation of the olive pomace plants to zero CO_2 emission plants according to the recent legal framework results in the creation of an economic benefit and the improvement of the environmental impacts. The main weaknesses include the economic difficulties due to current economic crisis in Greece and the bureaucratic procedures and delays for the approval of the required licence. The installation of a solar-PV system in the plant will allow its operation to utilize only its own energy resources without being dependent on fossil fuel generated electricity. At the same time the olive pomace plant will zero its direct CO_2 emissions due to energy use and it will increase its sustainability.

4. Discussion and Conclusion

Olive pomace plants require mainly heat and small amounts of electricity for covering their energy needs during their operation. This is unusual in the Greek food industry which utilizes more electricity than heat. They use olive kernel wood, which is produced in the factory, as a solid fuel for heat generation. Since solid biomass used in a typical olive pomace plant in Crete replaces the use of fossil fuels, it results in emissions savings of 6744.46 tons CO_2 per year. At the same time it sells the surplus olive kernel wood produced which is not needed in the plant to various heat consumers obtaining an additional income. The olive kernel wood sold to heat consumers from a typical olive pomace plant in Crete replacing the use of fossil fuels results in emissions savings of 9073.92 tons CO_2 per year. Since the current olive kernel wood price related with its energy content is very attractive compared with the prices of fossil fuels, its demand is high in the local market. Apart from electricity, derived mainly from fuel and heating oil in Crete, those plants do not utilize fossil fuels in their operation. Since the energy content of the olive kernel wood sold to heat consumers is greater than the energy content of the electricity consumed by the plant, olive pomace plants have a negative carbon footprint during their operation, which would become higher in the case where they will generate solar electricity according to the net-metering initiative. The investment of a solar-PV system in the plant in order to offset the grid electricity consumed annually is profitable, resulting in economic and environmental benefits. The investment cost of the solar-PV system is rather low estimated at 185,832€, while its payback period is 5.33 years and its NPV 555,671€ resulting in emissions savings of 174.22 tons CO_2 per year. Therefore the olive pomace plants can be considered as factories which produce an edible oil and an environmentally-friendly renewable biomass fuel while they have a negative contribution to climate change if the solid biomass produced and sold as a renewable fuel is taken into ac-

Table 3. Characteristics of a solar-PV system generating the electricity needed by an olive pomace plant in Crete.

Electricity generation	232,288 KWh/year
Nominal power of the PV installation[1]	154.86 KWp
Capital cost of the PV installation[2]	185,832€
Capital cost per ton/year of CO_2 emission savings	1066.65€

[1]Annual PV electricity generation in Crete, Greece 1500 KWh/KWp; [2]Capital Cost of solar-PV in Crete, Greece 1200 €/KWp.

count. With the use of solid biomass for heat production and solar power for electricity generation they could cover all their energy needs without using fossil fuels and emitting greenhouse gases. An increase in the energy intensity in those plants would result in less energy consumption. Therefore further research is needed for the improvement of the efficiency of the thermal processes in those plants which would reduce the use of olive kernel wood for heat production. An interesting future prospect of olive pomace plants is their utilization of the olive kernel wood produced for co-generation of heat and power. The generated heat could be consumed in various heat demanding processes in the plant. The co-generated electricity could be sold to the grid according to the current feed-in tariffs. Therefore olive pomace plants could be transformed in the future to plants which could produce olive kernel oil, olive kernel wood and, additionally, electricity.

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