Technoeconomic Assessment for the Viable Exploitation of Western Greece' Biomass Residues by an Innovative Pyrolysis-Anaerobic Digestion Processing Plant

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Greece, as an agricultural country, produces large amount of crop residues as well as livestock manure (Lais et al., 2017). The agricultural sector of the country covers almost 70% of its total area (Sagani et al., 2019). According to Aravani et al. (Aravani et al., 2022), the total average annual production of agricultural residues is approximately 10 Mt/y, and the total average annual production of animal manure is approximately 26 Mt/y.

The majority of the European countries use residual biomass as a major source of electricity and thermal energy. However, Greece, a country with high biomass potential, still disposes it uncontrollably in the environment or in landfills, while farmers burn the residual biomass in the fields (Aravani et al., 2021). Vlyssides et al. (Vlyssides et al., 2015) reported that 39% of the annual electrical consumption in Greece could be replaced by electrical energy from agricultural residues and livestock manure.

The utilization of biomass via thermal or biological processes can play a key role to the success of EU's environmental and energy goals (Aravani et al., 2022). The present work is a technoeconomic assessment for the environmentally friendly viable exploitation of biomass residues produced in the Prefectures of Ilia and Achaia (Western Greece Region of Greece) for the generation of energy by an innovative pyrolysis-anaerobic digestion (AD) processing plant. The market for the products will be domestic, addressed mainly to the region of Peloponnese. However, the capacity, the production process and the market are parameters to be designed and optimized.

It is proposed the creation of a central processing unit with capacity of approximately 330,000 t/y in the Industrial Area of Patras (Achaia Prefecture) to which the residues will be transported by trucks. The proposed area offers available lands and necessary infrastructures for the installation of the processing unit. The only suppliers of the installation will be the Prefectures of Ilia and Achaia.

In the present study it is considered that the AD process will be carried out in a continuous stirred tank reactor (CSTR) cylindrical in shape, double-walled and made of stainless steel. The produced biogas will be fed into a cogeneration system that produces electricity (50-55%) and thermal energy (45-50%). The processed biomass will be corn residues and cattle manure.

Concerning the pyrolysis plant, the current study is based on the work of Zabaniotou and Karabelas, (1999) and more specifically on the Evritania (Greece) demonstration plant of biomass. According to market research for the requirements of such unit a custom-made continuous pyrolysis plant is proposed. In particular, a rotary reactor would be a good option for this plant as it shows a more robust design than fluidized bed reactor (in addition to be easier to operate). Herein, the processed residues will be olive tree prunings.

The creation of an industrial unit requires costs for the preparation of studies, for the purchase of a plot of land and its configuration, for the purchase and installation of machinery, equipment etc. The fixed cost of the unit is calculated equal to 11,838,584 €, while the initial working capital is equal to 2,130,945 € (sum=total investment cost equal to 13,969,529 €). Operational cost of a processing unit is defined as the total cost for the production and distribution of its products and usually is calculated per unit of time. The operational cost (Figure 1) of the processing unit is equal to 10,555,729 €/y, while the incomes amount to 14,103,435 €/y. The net profit of the unit is equal to 3,547,706 €/y and the rate of return on initial investment is 25%. Payback period is the time needed to recover the fixed cost from the net profit generated during the operation of the processing unit and is approximately 4 years.

After conducting the main techno-economic study, a sensitivity analysis was carried out to find the influence of some significant factors on the rate of return of initial investment. Specifically, the following parameters were examined: raw material transportation costs, incomes, and capacity.

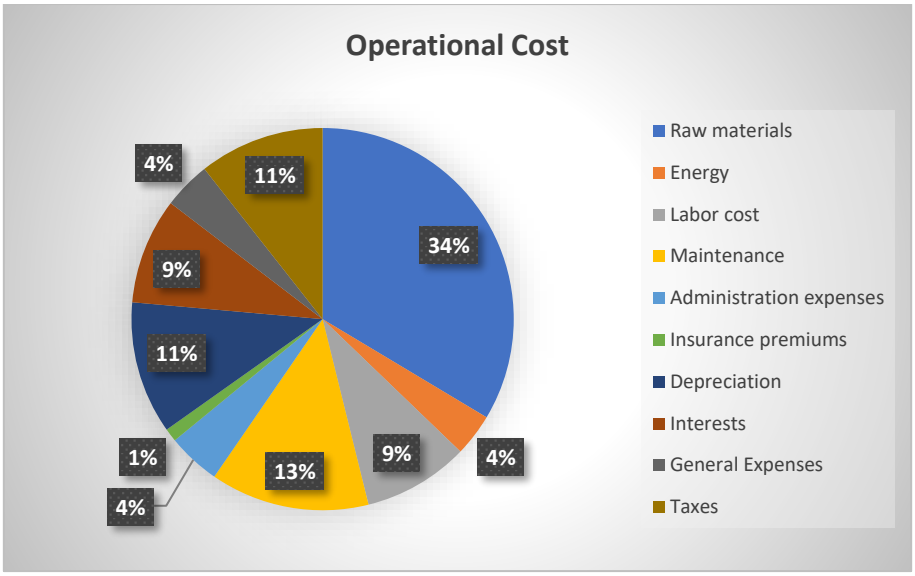

Figure 1: Operational cost of the pyrolysis-AD unit

Concerning the use of biomass for the production of energy, globally bioenergy from biomass is higher through the years. More specifically, in the EU-28, the energy produced from biomass has increased 466 PJ (13%) this decade, principally driven by a rapid extension in the power and heating industries sector. According to the International Energy Agency, by 2050: biofuels could provide up to 27% of total transport fuel worldwide; biomass could provide 7.5% of total electricity generation; and heat from bioenergy could provide, respectively, 15 and 24% of the final energy consumption for the industry and building sectors.

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