Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 113 (2017) 28 – 34

Energy Procedia

International Scientific Conference "Environmental and Climate Technologies", CONECT 2016, 12–14 October 2016, Riga, Latvia

Optimization methodology for complete use of bio-resources

Anna Kubule*, Tatjana Komisarova, Dagnija Blumberga

Institute of Energy Systems and Environment, Riga Technical University, Azenes iela 12/1, Riga, LV–1048, Latvia

Abstract

Every type of bio-resource has its specific and multi-tier applications. To promote resource efficiency and complete use of bio-resources the simplistic and environmentally less valuable options must be replaced with technological solutions that contribute to the development of high added value products, while ensuring environmental sustainability. This paper proposes a methodology for evaluation of the added value of various bio-resource applications in order to optimize the use of bio-resources. The optimization target function is determination of net present value depending on product price and its growth, economic feasibility, product sustainability, specific water and energy consumption, operation and maintenance parameters. The methodology incorporates a system of equations that describe the product value and the required investments at each level of applications. Simultaneously, the impact of bio-resource application and the developed product on climate change is evaluated. The developed methodology is approbated for identification of technological opportunities of Japanese quince (*Chaenomeles Japonica*) by-product valorization. Comparison of four alternative scenarios proves the applicability of the optimization method and determines that the highest net present value and the lowest CO_2 emissions would be for a case of Japanese quince seed oil extraction at the facility of existing food processing company.

Peer-review under responsibility of the scientific committee of the International Scientific Conference "Environmental and Climate Technologies".

Keywords: by-product valorization; bioeconomy; Japanese quince

* Corresponding author. Tel.: + 371 26357568.
E-mail address: anna.kubule@rtu.lv

Peer-review under responsibility of the scientific committee of the International Scientific Conference "Environmental and Climate Technologies".
doi:10.1016/j.egypro.2017.04.009

1. Introduction

The improvement of resource efficiency is one of the European Union's development targets that are included in the "Europe 2020" strategy [1]. To improve resource efficiency while simultaneously ensuring the growth of economy, new approaches and business models need to be developed for bio-resource use [2]. Bio-resources are renewable stock resources (e.g. fisheries, forests) or renewable flow resources (e.g. solar, wind or wave energy) [3]. The bioeconomy approach which focuses on valorization of local bio-resources and bio-resource technologies is one of the promising strategies for improving resource efficiency.

The by-products and co-products of agriculture and industrial production, especially from the food processing industry, are very heterogeneous. Depending on the type and quality of the bio-resource, various technologies may be applied to obtain products with different added value. The advantages of bio-resource valorization are commonly expressed by the additional economic income. Kwan et al. [4] performed a techno-economic analysis for a food waste valorization and determined the most feasible from two potential scenarios. A literature review by Negro et al. [5] strives to determine the optimal technique for valorization of citrus waste, while also accounting for energy sustainability criterion. For valorization of woody biomass, Aksoy et al. [6] implemented supply chain optimization amended by economic analysis to identify which of the assessed alternatives are economically feasible, while also considering the optimum facility location. Nevertheless, Lopes et al. [7] stress the necessity to also evaluate the environmental impact of bio-resource valorization, particularly the potential negative impact in comparison with other treatment approaches. Similarly, Beloborodko & Rosa [8] emphasize the necessity for integrated economic and environmental evaluation of industry by-product valorization alternatives.

The EU Waste management directive [9] prescribes the priority order for waste prevention and management. This waste hierarchy consists of prevention, preparing for re-use, recycling, recovery and disposal. Waste prevention is the most desirable option, whereas waste disposal is the most undesirable solution and should only be applied if there are no possibilities for material or energy recovery. Similar to the waste management hierarchy, the hierarchy of bio-resource application includes multi-tier solutions, some of which are more environmentally valuable or lead to higher added value. The most simple, but environmentally less valuable option, is considering bio-resource by-products as waste and depositing them in landfills. Another option is to use bio-resources as fuel source for energy production, e.g., for direct combustion or biogas production. Nevertheless, this solution focuses on production of a low added value products. Therefore, there is a need to develop new technologies that contribute to development of high added value products. Due to the heterogeneity of the pathways for bio-resource application, an optimization methodology is necessary for selection of the most feasible application.

This paper proposes a methodology for evaluation of the added value of various applications of bio-resources in order to optimize the use of bio resources. The developed methodology is approbated for identification of technological opportunities for valorization of Japanese quince by-products.

2. Materials and methods

The target function of the proposed methodology is the net present value (NPV). The NPV accounts for the difference between the present value of the initial and future investments and return, i.e., savings or earnings (see Eq. (1)). The NPV of each alternative bio-resource application depends on various factors: product price and its change, economic feasibility, product sustainability, specific water and energy consumption, operation and maintenance parameters. The optimization process is aimed at maximizing the NPV value based on a set of these selected variables. Depending on changes of the independent factors, the designed scenarios may be exposed to unaccounted variation. Sensitivity analysis is applied to account for the impact of significant change of the main input variables.

$$NPV = \sum_{y=1}^{n} \frac{B_y}{(1+r)^y} - I_0 \qquad (1)$$

where

B	annual savings or earnings (net), €/year;
r	real interest rate;
n	economic life time, years;
I_0	initial investment costs, €.