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A comparative life cycle assessment of energy recovery from end-of-life tires and selected solid waste

Vaida Malijonyte[a,b]*, Elina Dace[a], Francesco Romagnoli[a], Irina Kliopova[b], Martins Gedrovics[a]

[a]*Institute of Energy Systems and Environment, Riga Technical University, Azenes iela 12/1, Riga, LV–1048, Latvia*
[b]*Institute of Environmental Engineering, Kaunas University of Technology, Donelaičio g.20, Kaunas, LT–44239, Lithuania*

Abstract

End-of-life (EoL) tires are a non-degradable waste, which is generated annually in large amounts all over the world. Due to the high carbon content, EoL tires have a large energetic potential, which currently is not fully used. Moreover, municipal solid waste (MSW) and sewage sludge have a significant growing potential for energy recovery. The aim of the study it is to assess the environmental impact and potential benefits generated during the gate-to-gate life cycle of preparation of the end-of life tires and solid recovered fuels from selected waste for energy recovery. The paper presents the impact assessment results of fuel preparation for energy recovery from waste derived fuels according to three selected fuels' scenarios: (a) shredded EoL tires, (b) solid recovered fuel produced from MSW, and (c) solid recovered fuel produced from pre-composted sewage sludge combined with biomass residues.

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Keywords: end-of-life tires; life cycle assessment; solid recovered fuel; wastewater sludge; municipal solid waste

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1. Introduction

End-of-life (EoL) tires are a non-degradable waste, which is generated annually in large amounts all over the world [1]. EoL tires' management systems differ in each country, depending on the development of a country's waste management infrastructure, implementation of innovative technologies and other impacts [2, 3]. As Europe

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* Corresponding author: Tel.: +370-628-65642
E-mail address: vaida.malijo@gmail.com

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has stepped forward and banned the landfilling of EoL tires, new pathways for management of EoL tires have to be explored [4].

Looking from the perspective of the waste management hierarchy [5], energy recovery is next-to-last waste management method, after landfilling, which allows us to use waste energetic potential to minimize landfilling. For many years already EoL tires have been incinerated in dedicated incinerating plants or cement kilns [6]. The high calorific value of tire rubber makes it an attractive fuel for energy recovery.

Municipal solid waste (MSW) is another material, which represents a growing potential for energy recovery [7–9]. Due to the requirement to pre-treat waste prior to landfilling, many countries have installed mechanical waste sorting facilities, where refuse derived fuel (RDF) or solid recovered fuel (SRF) can be generated when recyclable materials and biodegradable waste are separated from the disposable waste flow. Calorific value of this fuel depends on MSW composition, hence varies by country, region and selected waste management technologies [7].

With the increasing demand for renewable energy, various types of biomass waste are increasingly assessed for energy production [10]. Sewage sludge is also a material that can be used for SRF production [11]. Sludge is generated in growing amounts, as new modern waste water treatment plants are being opened, especially in the Baltic States' region. The typical use of processed sewage sludge is composting and land reclamation [12], but these processes cannot be done on a frequent basis because of various organic pollutions and chemical elements, incl. heavy metals, found in the sewage sludge. Therefore, not all generated sludge is suitable for application on land [13]. Meanwhile, disposal in landfills is limited as it would generate greenhouse gas emissions [4, 14]. Thus, other solutions for utilization of sludge are being analyzed. One of such possibilities is to use the energetic potential of the sludge, by mixing sewage sludge with different bio-waste and producing SRF [15].

The aim of this study it is to assess the environmental impact and potential benefits generated during the gate-to-gate life cycle of preparation of the EoL tires and SRF from selected waste for energy recovery. For LCA, three energy recovery scenarios were developed using the following fuels: (a) shredded waste tires, (b) SRF produced from MSW, and (c) SRF produced from the separate fraction of pre-composted sewage sludge and biomass residues.

2. Methodology

Environmental impact is evaluated by using the Life Cycle Assessment (LCA) methodology, which is widely applied for evaluation of end-of-life tire management methods. It is performed according to standard regulations ISO 14044 [16] and using ILCD Handbook [17]. Moreover, the waste management hierarchy combined with life cycle perspective that systematically evaluates environmental impacts, is reported by RECO Baltic 21 Tech [18] to be a requirement in studies assessing waste management systems.

For conducting the comparative LCA, the *SimaPro 8* software was used, as it allows modeling and analysis of various life cycles in a systematic and transparent way, as well as to measure the environmental impact of processes across selected life cycle stages and identify the hotspots in all aspects of the chain [19].

2.1. Definition of goal and scope

The comparative LCA study aims to evaluate the environmental impact of different energy recovery scenarios from waste fuels. For energy recovery, three different fuel scenarios were selected: (a) use of shredded waste tires, (b) use of SRF produced from MSW in a mechanical-biological treatment (MBT) plant, and (c) use of SRF produced from the separate fraction of pre-composted materials (sewage sludge and biomass residues).

2.2. Functional unit

In our LCA study, the functional unit is selected to be 1 GJ of fuel input for incineration. Fuel input is considered a consistent indicator, used for comparing various fuels and calculating emissions, as it is not related to any specific incineration plant. The amount of recovered energy in a specific plant can be estimated according to the fuel input data. Recovered energy amount is crucial when evaluating incineration possibilities, as it is the main product of the process. Thus, the LCA results of our study provide a comparison of generated environmental impact of the selected scenarios with equal fuel input.