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Abstract

Innovative Integrated Biorefinery in Waste Management as an Important Factor for Sustainable and Resilient Cities Development †

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A key area of the smart city is the free flow of energy within the urban fabric. The use of intelligent solutions and systemic management in the field of energy management means that municipal economic facilities can not only fully meet their own energy needs but are also able to supply other urban facilities. It is important to implement integrated systems in which waste management technologies with different characteristics enable the production of bioenergy and other value-added products while maintaining environmental neutrality.

In the light of known knowledge and based on the authors' own research over many years, it is possible to design and implement an integrated biorefinery system in which wastewater and waste are treated as resources that are utilized in an industrial symbiosis. Against the background of the current development of innovative bioenergy technologies, this creates new, sustainable opportunities for the development of urban agglomerations in terms of green growth.

The aim of the work is to develop a functional concept and to present the energy and environmental balance of an integrated bioenergy system based on the utilization of wastewater and municipal waste as well as selected industrial waste.

The technological assumptions are based on modern solutions of an integrated biorefinery in which processes for the production of gaseous (biogas, biomethane, biohydrogen, biohythane), liquid (bioethanol, biooil, biodiesel), and solid (RDF, sewage sludge, microalgae biomass) fuels are functionally linked. Important elements affecting the improvement of economic efficiency are the use of energy and technology efficient pre-treatment technologies, including the authors' original solution based on the use of an innovative method of biomethane production based on a closed loop of biogas enrichment and carbon dioxide cycle (TeCH4BiogasUp).

This concept directly supports the implementation of several Sustainable Development Goals (SDGs), particularly SDG 6 (Clean Water and Sanitation) through innovative wastewater treatment, SDG 7 (Affordable and Clean Energy) by promoting decentralized bioenergy production, SDG 11 (Sustainable Cities and Communities) via urban industrial symbiosis, and SDG 13 (Climate Action) through reduced greenhouse gas emissions and improved carbon circularity. The proposed system contributes to the transformation of urban metabolism towards climate-resilient, resource-efficient cities.

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