Applications of the 3T Method as an efficiency tool for Waste-to-Energy facilities and numerical comparisons with the R1 Formula

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Abstract

The term "energy from waste" refers to technologies that utilize waste streams for energy production. However, for the energy production by means of thermal treatment of non-hazardous waste it is usually the term "waste-to-energy" that is commonly used. The Waste Framework Directive 2008/98/EU separates the waste management strategies into Recovery Operations and Disposal Operations (ANNEXES I and II respectively). Waste-to-energy technologies that use waste as fuel for energy generation are considered Recovery Operations, i.e. R 1. When the scope is the destruction/ reduction of the waste before landfilling, the waste-to-energy technologies are considered Disposal Operations, i.e. D 10. This issue has been of high importance because each waste-to-energy facility can potentially fall into both categories according to the assessment tool that sets the bar. In order to address this issue European Commission integrated the R1 formula in the second revision of the Waste Framework Directive of 2008 and improved it in the Directive 2015/1127/EU that entered into force from July 31st, 2016.

It should be stated for the record that the R1 formula has been a very helpful tool for assessing waste-to-energy plants and has set the general framework. The problems with the use of

the R1 formula start from the fact the formula is not thermodynamically consistent since it is self-proclaimed to be more a “utilization efficiency” formula rather than a pure energy efficiency. In addition, modern technologies that treat thermally municipal solid waste are polygeneration facilities because they produce several output streams. Such typical cases are the waste gasification facilities that produce several streams in addition to CHP production like char or sometimes even reformed fuels like methanol. Also, waste-to-energy facilities are effectively metal recovery units. These parameters are not taken into consideration by the R1 formula. Vakalis et al. (2017) addressed this issue by introducing the 3T method, which calculates the overall efficiency of waste-to-energy plants by taking into consideration also the quality of the produced materials except from the CHP production. Thus, different waste-to-energy technologies, like combustion or gasification, can now be directly compared. On a second level, the 3T method aims to set a common framework for waste management strategies. A first possible step can be the assessment of other facilities like biorefineries and compare them with waste-to-energy plants.

This study will present the numerical results from the analysis of waste-to-energy plants both with the R1 formula and with the 3T method and will compare the accuracy of each approach. It has to be stated that the methods do not have a same value system and the final efficiencies that they calculate are not comparable. For the case of the R1 formula, the facilities that attain values over 0.65 (or 0.6 for older plants) achieve the R1 status. It is usually the case, that high cogeneration plants can achieve values that are significantly higher than that. On the other hand, conventional waste-to-energy plants achieve values of 0.2 – 0.25 with the 3T method. The comparison of the methods becomes very interesting for the case of gasification or pyrolysis plants where the R1 formula is not able to take into consideration of the final products except the CHP, like char or bio-oil.

Keywords **Waste-to-Energy**, **Energy Efficiency**, **Thermodynamics**, **Policy**, **Polygeneration**

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