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Waste to energy: waste incinerated and CO_2 behind in the case of WTE plant in Lithuania

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Abstract. Incineration of municipal waste for electricity and heat recovery allows reducing the amount of waste in landfills, however the question arises whether this energy recovery method is superior in terms of CO_2 emissions compared to traditional energy production methods. Though there are examples of such comparisons in the other countries, Lithuanian case is underestimated. Therefore, this study aims to analyse the amount and structure of waste incinerated in one of the WTE plants in Lithuania as well as and related CO_2 emissions, compared to the use of traditional fuel sources for energy production and landfilling. The study employs data from WTE plant on waste volumes and structure as well as national emission factors for different types of energy and fuels. Selected WTE plant incinerated 256 thousand tons of waste annually during 2018-2024 period. Majority of waste incinerated is local municipal waste. Depending on the waste volumes and structure of waste incinerated WTE plant produced some 2600 – 2860 TJ of energy. Correspondingly, CO_2 emissions fluctuate around 291 CO_2t/PJ. However, comparing emissions per energy unit only in the energy production stage, WTE appears to be not the most efficient CO_2 approach to produce energy. Hence, the whole life approach is needed to make comprehensive comparison between different fuel types regarding CO_2 emissions as well other benefits should be considered.

Keywords: Waste to energy, municipal waste, CO2 emissions, WTE plant

1. Introduction

Incineration of municipal waste has become one of the most popular ways to manage municipal waste: incinerators typically have efficiencies ranging from 20 to 40% and can produce around 7 MW of energy per year from 100000 t of waste (De Greef et al., 2018; Gupta, & Nguyen, 2022). In Europe, the WTE sector provides up to 8% of electricity and up to 15% of heat demand (Cole-Hunter et al., 2020). In addition, waste to energy (WTE) technologies reduce the amount of waste sent to the landfills and the dependence on fossil fuels (Saini & Saini, 2021). However, there is still much discussion about the benefits and drawbacks of such installations in the context of the circular economy and environmental pollution. Research shows that waste incineration produces different CO_2 emissions in different countries. For example, in China, waste incineration produces 9,41 CO_2 (kg /t municipal waste), while in France it produces a significantly higher amount of 401,7 CO_2 (kg/t municipal waste). As about 76% of France's electricity comes from nuclear power, it is assumed that the waste incinerated is mainly used to generate heat. However, municipal waste has a low calorific value, which means that larger volumes need to be burned, which in turn leads to higher CO_2 emissions (Van Fan et al., 2019).

Thought there are examples of such comparisons in the other countries, Lithuanian case is underestimated. Therefore, this study analyses the efficiency of a selected waste incineration plant operating in Lithuania, focusing on one of the main greenhouse gases (GHG's) – CO_2.

Fuel	Net caloric value GJ/	CO_2 emission factor t/TJ
Heavy fuel oil	39.77	78.4
Liquefied petroleum gas	45.84	66.81
Firewood	16.88	101.34
Municipal waste	11.2	111.65

2. Methods

The study uses data on the amount of waste incinerated at the selected facility for the period 2018-2024. Enterprise managing waste incineration plant shared the data on the volume and type of waste incinerated as well as the origin of the waste.

To compare CO_2 emissions while producing the same amount of energy from different resources, national emissions factors by Lithuanian environmental protection agency were used (Table1). On the same approach energy produced was estimated. To compare WTE emissions to the emissions of landfilling of the same amount of waste is based on the study of Mickevičiūtė (2015), revealing methane emissions from one of the landfills in Lithuania.

It should be acknowledged that only energy production stage, but not the whole lifecycle of different origin energy is considered in the analysis.

Table 1. National net calorific values and pollutants emission factors of fuels (According Environmental protection agency of Lithuania, 2024)

3. Results

In general waste incineration volumes in Lithuania is increasing. In 2011 more that 75% of waste was landfilled compared to that of 7.8% in 2023. There were no possibilities for WTE in 2011 but in 2023 some 40% of municipal waste was managed in WTE plants in Lithuania. In total three WTE plant are operating within the country.

Selected waste incineration plant processes about 256 thousand tons of waste per year for energy and heat recovery on average. Most of the waste incinerated is municipal waste. Depending on the year municipal waste incinerated ranged from 87% to 93% of the total waste stream incinerated. The remaining 13-7% is made up of industrial renewable waste (textile fibres, pharmaceuticals, packaging, fractions not otherwise specified) and biofuels (firewood, sawdust, tree bark). Correspondingly, industrial waste ranged from 2 to 6%, and biofuels from 3 to 6%. Waste incinerated is dominated by the local waste, only some 3-20% is imported. In general import of unsorted waste is not allowed in Lithuania.

Over 2018 – 2024 period energy produced from the waste fluctuated from 2.3 to 2.6 PJ. To produce the same amount of energy approximately 65 t of heavy fuel oil, 57 t of liquefied petroleum gas and 175 t of firewood will be required per year, while approximately 250 thousand t of municipal waste were used for that. Production of 2.6 PJ generated 249790.2 t CO_2 in 2024. Though per tonne CO_2 emissions are the lowest in the case of WTE, waste is characteristic with lower caloric value (Table 1) and in overall terms generates more CO_2 compared to the energy produced from other fuels (Fig. 1). Despite that, compared to the waste disposal in landfill, WTE produces times less GHG in CO_2 eq.

4. Conclusions

Though WTE still generates GHG, it significantly superior landfilling not only due to the lower emission, but also avoided land uptake, minimized environmental risks. Comparing WTE regarding the other fuel types analyzed, it should be acknowledged that only CO_2 and only one stage of life cycle (production of energy) was considered.

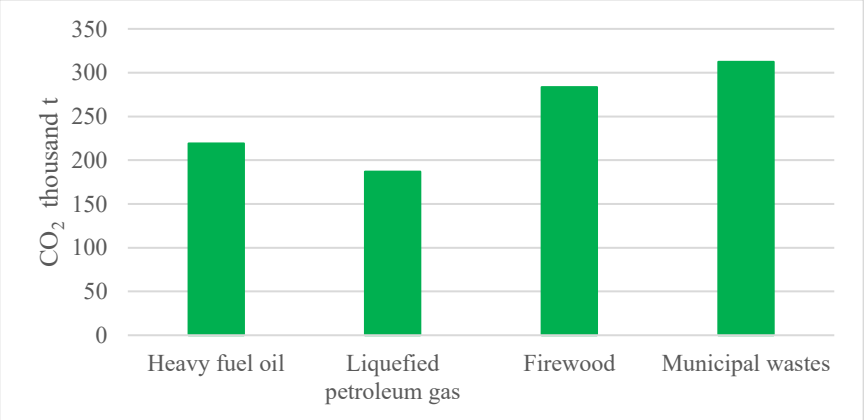

Figure 1. CO_2 generated to produce the same amount of energy from different fuels in the case of selected WTE plant (authors' estimations)

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