GHG EMISSION MITIGATION POTENTIALS IN TURKEY'S WASTE SECTOR USING A BOTTOM-UP ENERGY MODEL

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Overview

Annual generation of municipal solid waste (MSW), mainly from households but including similar wastes from such sources as commerce, offices and public institutions in Turkey has reached to 32.2 million tonnes in 2018. Turkey is still highly dependent on landfilling in waste management. About, 67.2% of the collected MSW was sent to sanitary or managed landfills, whereas 20.2 % ended up in municipality dumpsites or unmanaged landfills in 2018. Remarkably, MSW sent to recovery facilities has reached a portion of about 12.3 % in 2018 including biological and material recovery.

There are mature technologies to mitigate GHG emissions from waste. These technologies include landfilling with landfill gas recovery (reduces CH_4 emissions), post-consumer recycling (avoids waste generation), composting of selected waste fractions (avoids GHG generation), and processes that reduce GHG generation compared to landfilling (thermal processes including incineration and industrial co-combustion, MBT with landfilling of residuals, and anaerobic digestion). Currently all of these technologies available in Turkey with private sector investments in the last decade. The number of sanitary landfills had reached 88 in 2018.

In Turkey, YEKDEM provides the sales of electricity to the National Grid with a feed-in guarantee of 13.3$/kWh. Plants that using landfill gas as fuel for power generation receive the feed-in tariffs for the first 10 years of operation. The electricity production on landfills has reached more than 250 MW installed capacity and 1.9 million MWh annual production capacity including other biological recovery for energy facilities.

The annual capacity for biological treatment of waste is at a low level of 1.5 million tonnes. There exist 8 biological waste recovery facilities (6 composting, 2 biomethanisation) for source-segregated municipal waste; 6 mechanical and biological treatment (MBT) facilities (1 composting, 4 biomethanisation, 1 bio drying) for mixed municipal waste. There is only one coincineration plant for mixed municipal waste that only processing industrial waste as thermal treatment. In addition to positive developments in waste management, there are still more than 800 dumpsites that receive 29% of the municipal waste.

This study discusses GHG emission mitigation potentials in Turkey's waste sector. First, the baseline scenario constructed based on the most-widely used bottom-up energy model called TIMES. Then the GHG mitigation actions selected as utilization of methane by LFG to energy facilities and biological recovery facilities, and increasing materials recycling rate and analyzed separately for the emission reduction potentials and cost evaluations. Additionally, the average emission mitigation costs of the actions with respect to different levels of the policies/options are going to be estimated through scenarios as well.

Methods

Bottom-up models evaluate on a detailed representation of technological options and technical changes in the energy system. Paths from the extraction of resources to final use are introduced and the connections represented as energy flows and the technologies include technical and economic parameters.

The TIMES as a bottom-up model generator aims to find the minimum cost energy system with balanced energy supply and demand by the linear programming approach based on user-defined constraints and the deployment of the best available technologies in the modelled sector. To model the waste sector of Turkey, a TIMES database has been developed which covers the period 2015 through 2050 with five-year increments.

The projection of municipal solid waste (MSW) for the years between 2015 and 2050 have obtained based on population projection and expert opinion on the generation rate of waste per capita. Total MSW was differentiated as MSW from the mixed collection and source-separated municipal high-quality waste.

Reference scenario is developed with minor limitations and assumptions such as closure of old dumpsites and disusing them after 2023; end of YEKDEM after 2020 (plus 10 years' payment period) and sale of electricity with a market price afterward; constant source-separated collection of MSW until 2050 with the same rate of the base year 2015 and using all captured methane in electricity generation.

In the real world, waste is pushed out and collected by municipalities to processed in a facility. In other words, waste is not a demanded commodity. On the other hand, TIMES model is triggered by the demand and works as a pulling system. In order to adopt the real case into the TIMES structure, a synthetic 'processed waste demand' was generated to guarantee each waste unit is necessarily processed in a waste treatment facility such as incineration, sanitary landfill, composting etc. Thereby, the model needs unprocessed waste to satisfy the 'processed waste demand' and pulls the waste.

Results

In the reference scenario, sanitary landfill which is the lowest cost option comparing to the biological recovery and thermal treatment options have an increasing trend. Electricity production from collected gas from landfills is also in increasing trend although YEKDEM ends in 2020. The established landfill gas to energy facilities tend to continue operation, and even more, facilities join the system, however, with a reduced rate of increase. The reason behind this result is the closing old dumpsites in the 2023 assumption in the baseline. Otherwise, electricity production would not be feasible compared to the low cost of dumpsites, and it is expected to see a decreasing trend in electricity production. In the baseline scenario, no thermal treatment is observed until 2050. Mechanical biological treatment is also limited to already established facilities.

The reference scenario results show that CO_2e emissions reported to UNFCCC are expected to increase by 46% in 2050. CO_2 emissions from landfills are not included in calculations as they are assumed as biogenic according to IPCC guidelines. In addition, CO_2 emissions from gas combustion and flaring are not reported to UNFCCC under the waste sector. This study only includes solid waste-based emissions and does not involve wastewater-based emissions. The increasing trend in landfill gas to electricity production also leads to an increasing amount of methane capturing from landfills.

The effects of material or energy recycling are not credited to the "Waste" sector in the GHG inventories reported to the UNFCCC but are included in the "Energy" or "Industrial Processes" sectors for methodological reasons. For instance, scrap recycling is included in the industry sector under "Metal Production: Iron and Steel Production" using an emission factor for steel production in an electric arc furnace where most of the scrap is used. The resulting emissions are lower than those from other steel production methods where the primary material is used. The saved emissions due to the recycling process and the reduced emissions from substituting the extraction of iron ore and production processes are not stated separately in the GHG inventory and thus hide the contributions of the waste sector to these GHG reductions. Net GHG emissions from recycling in the baseline scenario, except for plastics recycling materials contributes to efforts in GHG emission reduction. In the baseline scenario, around 2.5 Mt CO2 emissions being avoided by recycling annually. Similar to CO2 emissions from waste-based gas combustion, recycling emissions are not reported to the UNFCCC.

In the methane utilization action, there are two different options: biomethanisation and LFG to energy generation landfills. The results show that biomethanisation takes over the market and biogas generation increase tremendously by years. Maximizing recycling action assumes the extraction of all recyclables from mixed municipal waste. Source separated recyclable collection stays in a fixed amount same as baseline and methane utilization scenarios. However, the mechanical separation of recyclables is maximized.

Methane utilization action has higher GHG emission mitigation potential then maximizing recycling action with about 40% lower GHG emission level comparing to baseline. In methane utilization scenario, avoided emissions from recycling reaches 7 Mt CO2e whereas avoided emissions are around 9 Mt CO2e in maximizing recycling scenario. The total system cost of maximizing recycling action is higher than 2 times of reference scenario cost and 10% higher than the methane utilization action in 2050. The average cost of mitigation is 5 times lower in the methane utilization action.

Conclusions

Two GHG mitigation actions are evaluated in this study. As a result of the quantitative comparison, methane utilization action can be concluded as the most feasible action with a significantly higher potential to emission mitigation and also has lower average mitigation cost.