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EVALUATION OF ENERGY POTENTIAL FOR MUNICIPAL SOLID WASTE IN TURKEY



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Outline

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Introduction

- ▶ MSW, which is the final result of our vital activities simply known as garbage, is an extremely important issue for sustainable development.
- ▶ Incinerating the MSW to produce energy means that less waste is buried in a landfill. However, this will cause air pollution and release of chemicals and materials into the air.
- ▶ A good solid waste management is not only a takeaway model of solid wastes but also an economic resource to produce energy.
- ▶ Turkey is an energy importing country. Since this import reaches up to 70% of its energy needs, Turkey obliges to evaluate new energy sources such as renewables.
- ▶ About one-third of the total MSW is still not being disposed of properly.
- ▶ There are currently about 25 MSW plants in Turkey with an installed power capacity of 170 MW_e. In most of the provinces of the country, there is lack of MSW plant, but new facilities are in a phase of construction or being planned [1].

▶ [1] Electricity Market Regulatory Authority.
<http://lisans.epdk.org.tr/epvysweb/faces/pages/lisans/elektrikUretim/elektrikUretimOzetSorgula.xhtml>

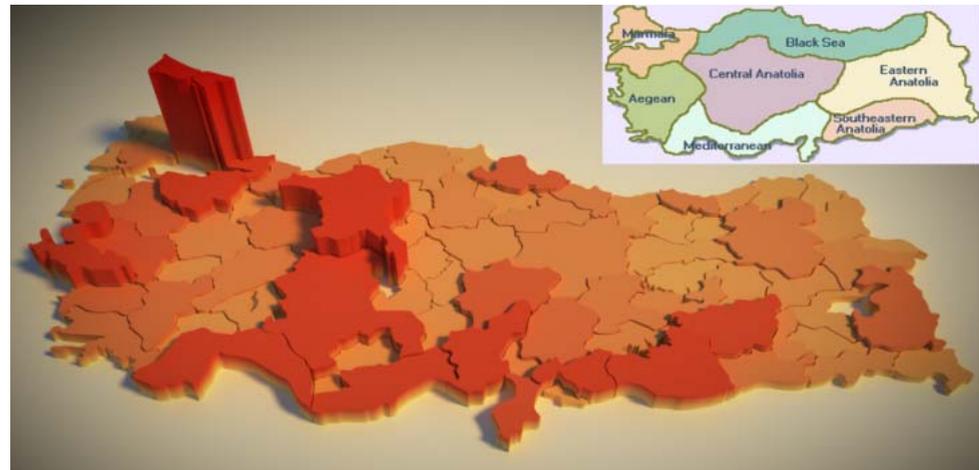
Purpose

- ▶ The aim and distinctive of this study is to not only consider LFG production but also to quantify the energy production by using the MSW potential both in Turkey and its geographical regions.
- ▶ Energy recovery through LFG is projected from 2012 to 2023 to analyze how many portions of the energy deficit of the country can be met in terms of landfilling.



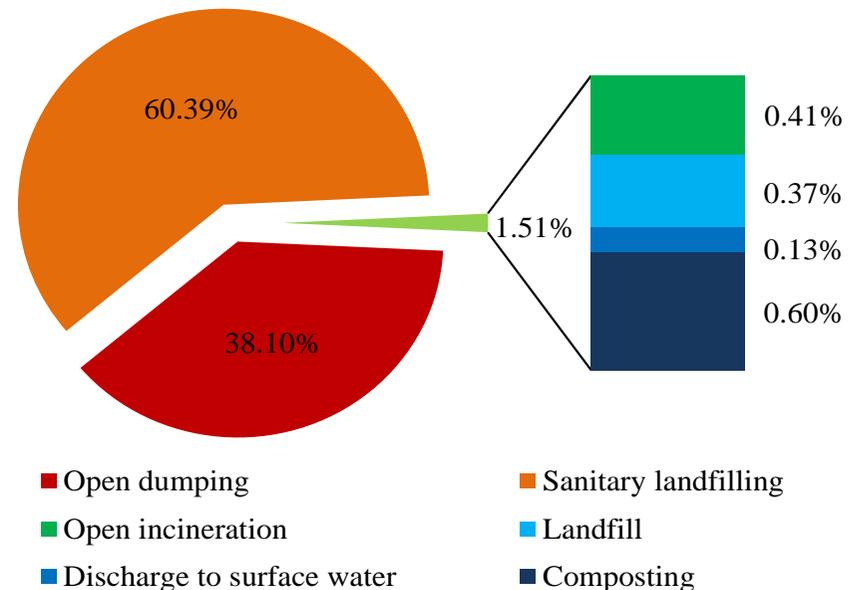
Methods

- ▶ MSW data collected by Ministry of Environment and Urbanization of Turkey
- ▶ Data for the year 2012 statistically made by the Turkstat [2] for each province
- ▶ 81 provinces under seven geographical regions
- ▶ Total population around 76 million by the end of 2012



MSW management in Turkey

- ▶ 25,642,290 tons of MSW (except industrial waste)
- ▶ Waste generation per capita is about 1.12 kg/day
- ▶ The number of landfills increased about 4.5 times relative to that of one decade ago



MSW characteristics in Turkey

- ▶ Waste characterization defined in the report of Solid Waste Master Plan in 2006 [3]
- ▶ Turkey's historical waste composition stays nearly constant in recent years
- ▶ More than 50% of the MSW can be considered biodegradable.

Waste composition	Weight in %
Kitchen waste	34
Paper	11
Glass	6
Cardboard	5
Plastics	2
Metals	1
Other combustibles	22
Other non-combustibles	19

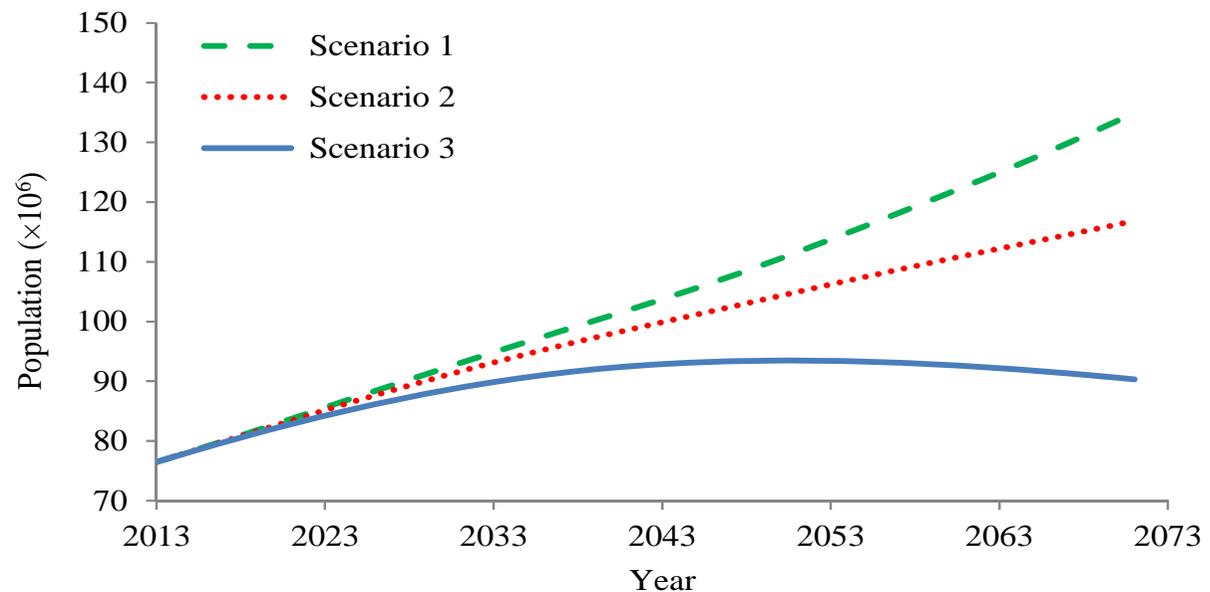
Demography & MSW generation

- ▶ MSW acceptance of the landfill between 2012-2023.
- ▶ Direct relationship between MSW generation and population growth
- ▶ The Malthusian theory of growth population



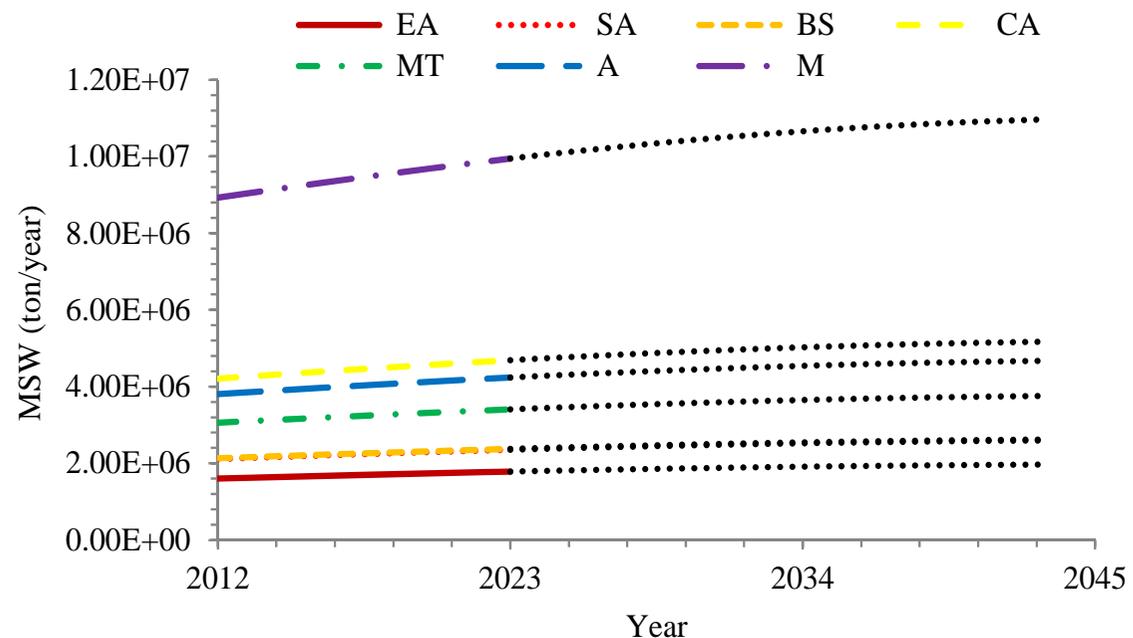
Demography & MSW generation

- ▶ Scenario 1, the total fertility rate increases to 3.0 in 2050, then remains stable to 2073
- ▶ Scenario 2, the total fertility rate increases to 2.11 in 2020 and to 2.50 in 2050 gradually, and then remains stable between the years 2050 and 2073.
- ▶ Scenario 3, the total fertility rate decreases in its natural flow and reached to its lowest value 1.65 in 2050, and then increases after this year and reached the value 1.85 in 2073.



MSW projections in the regions

- ▶ Accurate prediction of the MSW generation is challenging in developing countries
- ▶ Waste generation per capita stays nearly fixed in recent years as mentioned



Landfill gas emission model

▶ LandGEM model [4]

- ▶ Costless
- ▶ Not need to measure the LFG collected
- ▶ Revealing data on LFG production during storage on site and after shutdown

$$Q_{CH_4} = \sum_{i=1}^n \sum_{j=0.1}^1 kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

- ▶ 50% CH₄ and 50% CO₂
with an additional constituent
of NMOC

Region	Landfill type	k year ⁻¹	L ₀ m ³ /ton
EA	Arid area	0.02	100
SA	Arid area	0.02	100
BS	Conventional	0.04	100
CA	Arid area	0.02	100
MT	Conventional	0.04	100
A	Conventional	0.04	100
M	Conventional	0.04	100

▶ [4] U.S. Environmental Protection Agency. <http://www.epa.gov>

Energy recovery from LFG

- ▶ The technical potential of the energy recovery can be estimated in case of burning CH_4 produced.
- ▶ Electricity from the potential can be produced using a WTE plant [5]

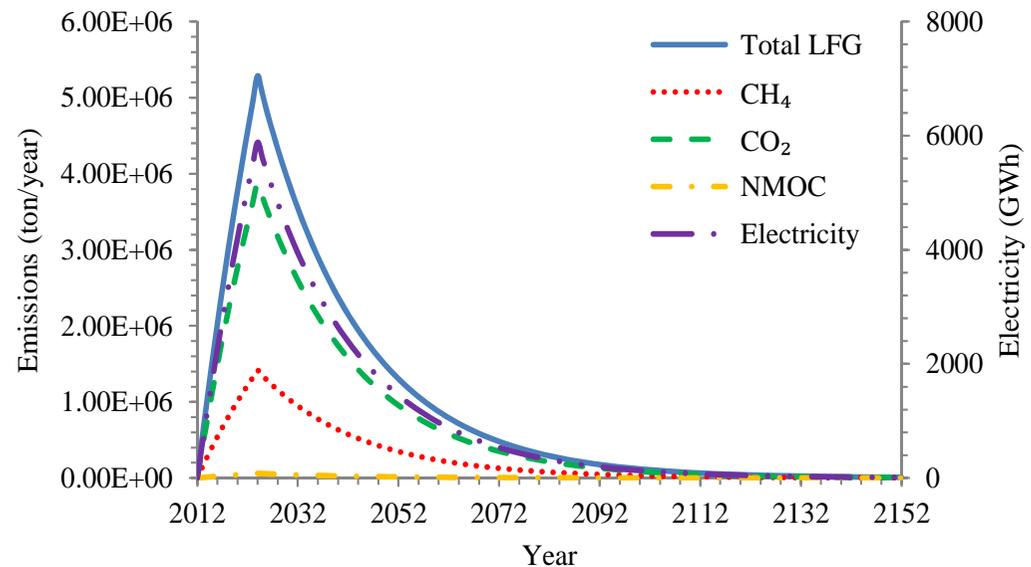
$$\text{Power} = Q_{\text{CH}_4} \text{LHV}_{\text{CH}_4} \eta_e$$

where is the lower heating value of CH_4 being equal to 50 MJ/kg, and η is the conversion efficiency of WTE plant considered to be 30%.

▶ [5] Bidart, C.,Fröhling, M.,Schultmann, F. Municipal solid waste and production of substitute natural gas and electricity as energy alternatives. Appl. Therm. Eng. 51, 1107–1115(2013)

Results

- ▶ The annual electricity consumption of Turkey in 2012 was around 205,632 GWh and forecasted to be 534,317 GWh in 2023 [6].
- ▶ As the whole MSW is converted into LFG how many portions of the energy deficit of the country can be met?



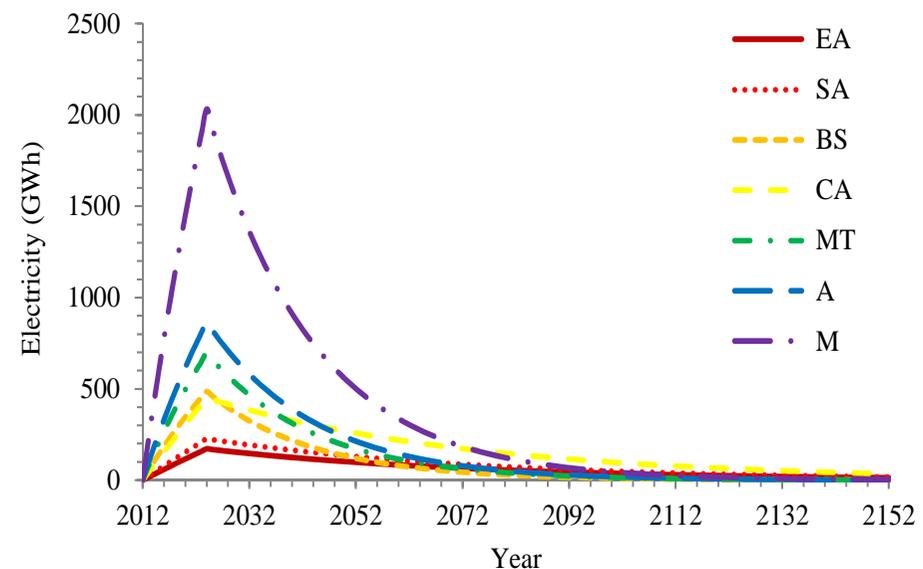
- ▶ [6] Melikoglu, M.: Vision 2023: Assessing the feasibility of electricity and biogas production from municipal solid waste in Turkey. Renew. Sust. Energ. Rev. 19, 52–63 (2013)

Results

- ▶ It is estimated that about 0.3% of the electricity consumption can be compensated by LFG collection at the end of 2013. This ratio increases to 1.02% according the projection of electricity consumption in 2023.
- ▶ The peak value of CO₂ emission reaches to 3.87 mtons which correspond to a small part of the total CO₂ emission (355.5 mtons in 2012 [2]) of Turkey.

Results

- ▶ The Marmara region has the highest potential due to its population density.
 - ▶ 30% of the population lives there where is the most industrialized region of Turkey.
 - ▶ The Marmara region has currently a total installed capacity of around 63-MW. Its capacity in 2023 according to the projections is 100 MW.
 - ▶ The EA, SA, BS and especially Marmara region in landfilling construction could reach 560 MW in 2023.



Conclusions

- ▶ MSW distribution in Turkey's geographical regions based on the 2012 data were provided.
- ▶ LFG potential of the regions was analyzed using LandGEM tool.
- ▶ It is estimated that about 1.02 % of the electricity consumption can be compensated by LFG collection at the end of 2023 according the projections.
- ▶ It is figured out that landfills would much serve as waste repositories rather than meeting the energy deficit of the country.
- ▶ Nonetheless, the number of landfills should be increased especially in the provinces where the population growth is high and there is no landfill.



Thank you
for your kind attention

