Carbon in global waste and wastewater flows - its potential as energy source under alternative future waste management regimes

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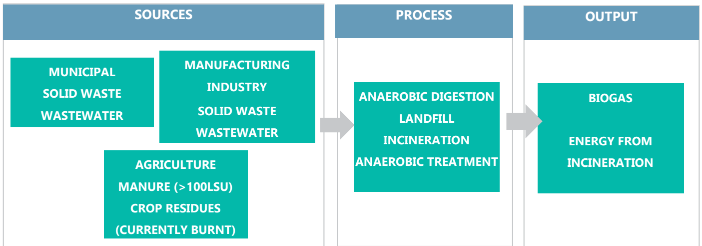
1. Outline

What? Assess the availability of organic materials for energy generation under current waste and wastewater management and future policy initiatives to reduce the impacts of waste and wastewater on human health and the environment.

Why? The availability of sufficient organic materials for energy generation is key to a successful future decarbonization of the global energy system. Conversion of the carbon content in waste and wastewater into energy offers a potential source of energy that can simultaneously reduce air pollution and greenhouse gas emissions associated with current waste management.

How? Estimating the carbon content in global waste and wastewater and simulating the associated future carbon flows for a range of different waste and wastewater management regimes. We identify current and future carbon flows for 174 countries/regions, allowing for a wide range of alternative technological solutions for handling and treating municipal and industrial waste and wastewater.



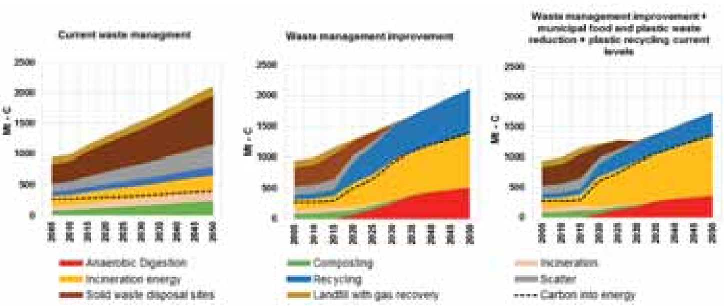
Defining maximum technically and environmentally feasible recovery of energy from the waste stream

Presented estimates assume a maximum technically feasible phase-in of waste management (following the the EU's waste management hierarchy) and wastewater treatment technologies that generates energy while reducing greenhouse gases, air pollution and water contamination (Cost are not considered in the analysis).

1. Phase-out of waste going to landfills, being dumped or openly burnt.
2. By 2050, 100% of food waste treated in anaerobic digesters with biogas recovery for energy generation.
3. 90% of municipal paper and textile waste recycled by 2030 – 80% of municipal plastic and wood waste recycled by 2030. 100% incineration of industrial solid waste by 2030.
4. A maximum municipal food waste rate reduction of 50% by the year 2030 based on Lipinski et al. 2013 and based on the target adopted by the United Nations Assembly in 2015 of halving per capita food waste at the retail and consumer level as a part of the 2030 Sustainable Development Goals .
5. A maximum municipal plastic waste rate reduction of 50% by the year 2030 as a part of the 2030 Sustainable Development Goals . Current recycling plastic rates maintained at present levels in order to reduce the supply of recycled plastic reflecting the current market situation.
6. 100% of urban wastewater treated by 2030. Increase anaerobic wastewater treatment with energy generation to 100% by 2050.

2. Findings

Total carbon content in solid waste

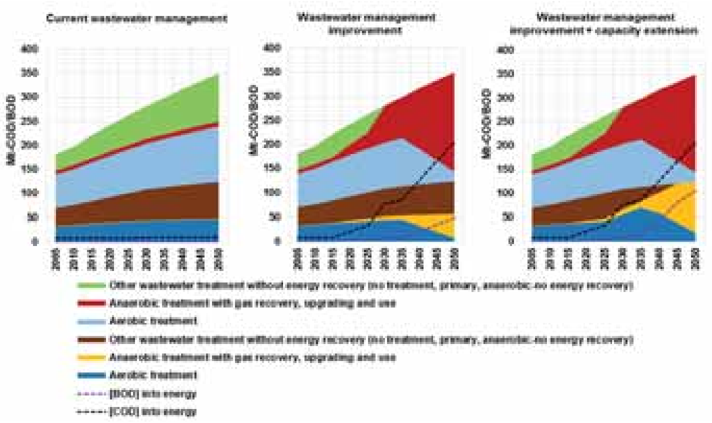


Current waste management: **59%** of carbon in waste currently lost (dumped, scattered and burnt). **18%** of carbon in waste is recycled/composted. **23%** of carbon in waste converted to energy. **35%** of carbon comes from industrial waste and **65%** from municipal solid waste. **403 Mt-C** into energy by 2050.

Waste management improvement: Following the waste management hierarchy - **66%** of carbon in waste used as energy by 2050. **34%** of carbon recycled. **1388 Mt-C** into energy by 2050.

Waste management improvement + municipal food and plastic waste reduction policy + plastic recycling current levels: **78%** of carbon in waste used as energy by 2050. **22%** recycled. **21%** reduction of carbon available for energy generation. **42%** of carbon comes from industrial waste and **58%** from municipal solid waste. **1355 Mt-C** into energy by 2050.

COD and BOD content in wastewater

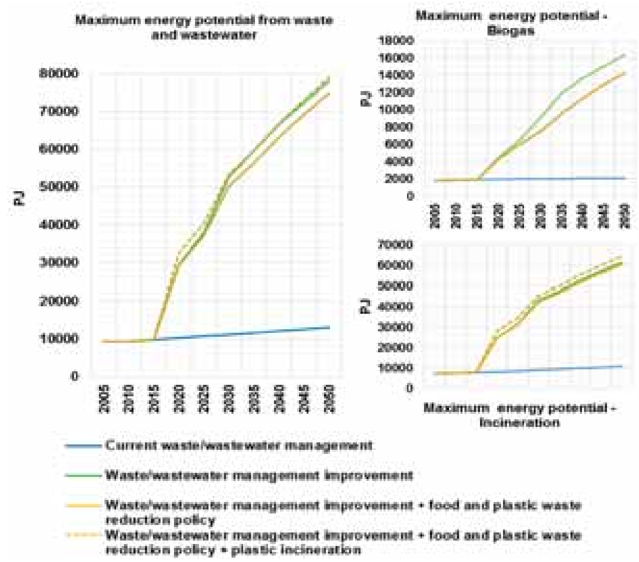


Current wastewater treatment: **57%** of BOD in wastewater and **38%** of COD is currently lost (untreated/primary treatment) **42%** of BOD and **56%** of COD is going to aerobic treatment and **1%** of BOD and **6%** of COD is going to anaerobic treatment with energy recovery. **1 Mt-BOD** and **10 Mt-COD** into energy by 2050.

Wastewater treatment improvement: Purpose energy generation- **39%** of BOD and **91%** of COD going to anaerobic treatment with energy recovery and used by 2050. **48 Mt-BOD** and **205 Mt-COD** into energy by 2050.

Wastewater treatment improvement + treatment capacity extension: Purpose energy generation plus an increase on collection and treatment rates of urban wastewater. **85%** of BOD and **91%** of COD going to anaerobic treatment with energy recovery and used by 2050. **105 Mt-BOD** and **205 Mt-COD** into energy by 2050.

Maximum energy potential from waste – wastewater (before conversion electricity/heat)



With an improvement of waste and wastewater management energy generated would be around 6 times higher compared to the current management by 2050.

Technological improvement: Increase biogas generation 8 times in 2050 compared to current management. Policy of 50% food waste reduction by 2030 would reduce biogas generation by 12% in 2050 compared to the improvement of waste management alone.

Technological improvement: Increase energy from incineration 6 times in 2050 compared to current management. Policy of 50% plastic waste reduction by 2030 would reduce energy generation by 2% in 2050 compared to the improvement of waste management alone. Plastic incineration would increase energy by 7% in 2050 when recycling rates are kept at current levels.

Reduction on total global energy when implementing the policies on municipal food and plastic waste reduction would be around 5% by 2050. However, if recycling plastic rates are kept at current levels and plastic is sent to incineration instead, energy would increase around 6% by 2050.

80% of energy from waste comes from incineration and 20% from anaerobic digestion/treatment of waste and wastewater.

The IEA (WEO 2016) projects a total energy primary demand of 796228 PJ by 2050 in the reference scenario. With the improvement of waste and wastewater management (+ food and plastic reduction policies) the contribution to the total energy demand would increase from 2% (in the current scenario) to 10% by 2050.

3. Highlights:

Governments ought to move towards improved waste and wastewater management systems for health and environmental reasons. The choice of treatment pathway has to take into account the prevailing benefits, constraints and complexities of each nation/region/city.

Policies targeting a reduction in municipal food and plastic waste generation would not significantly affect energy generation from solid waste.

One of the advantages of anaerobic wastewater treatment over the other treatment methods is the generation of biogas which can be recovered and used as energy and the reduction of sludge production.

An increase on the share of energy from waste/wastewater is observed when management systems are improved and the carbon available is used as energy. The management of waste/wastewater focusing on energy generation is a good alternative as sustainable energy solution supporting the development of a low-carbon energy system.

What is next?

Cost – benefit analysis is important in order to identify the potential economic barriers associated with the adoption (or not) of a certain technology.

Evaluation of biogas and energy from incineration utilization following different pathways.

References

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