



Reasons for very low recycling rate of plastics in U.S. and means for increasing material or energy recovery from plastics.

Jawad A. Bhatti (Adviser: Prof. Themelis)
Earth & Environmental Engineering, Columbia University



The Problem :

Excessive landfilling of plastic wastes

250 million tons of material solid waste was generated in 2008. 12% of that was plastic.

Figure 5. Total MSW Generation (by Material), 2006
251 Million Tons (Before Recycling)

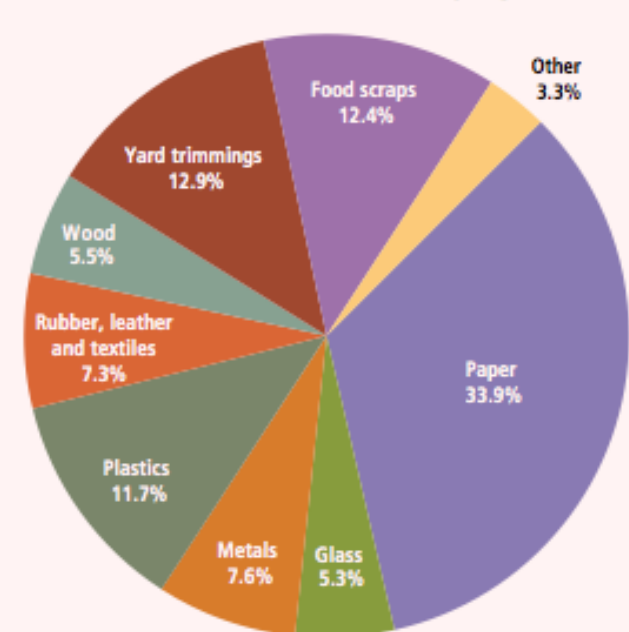
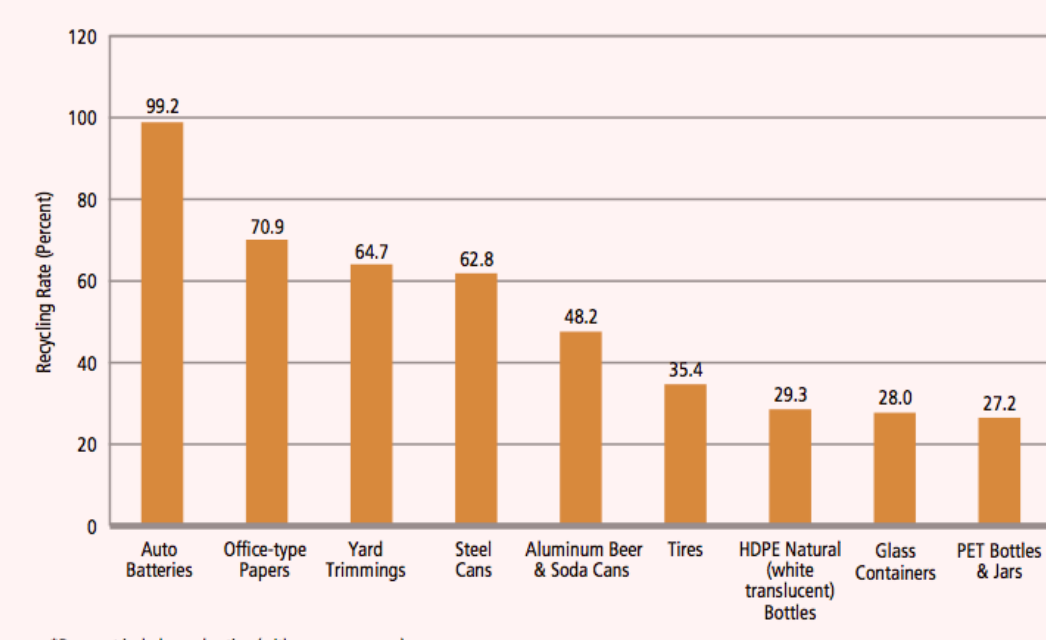


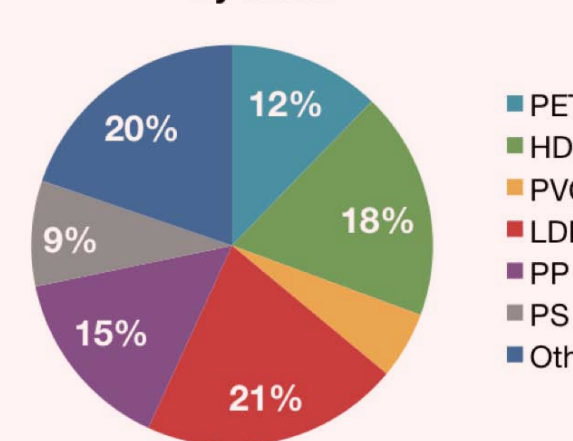
Figure 3. Recycling Rates of Selected Products, 2008*



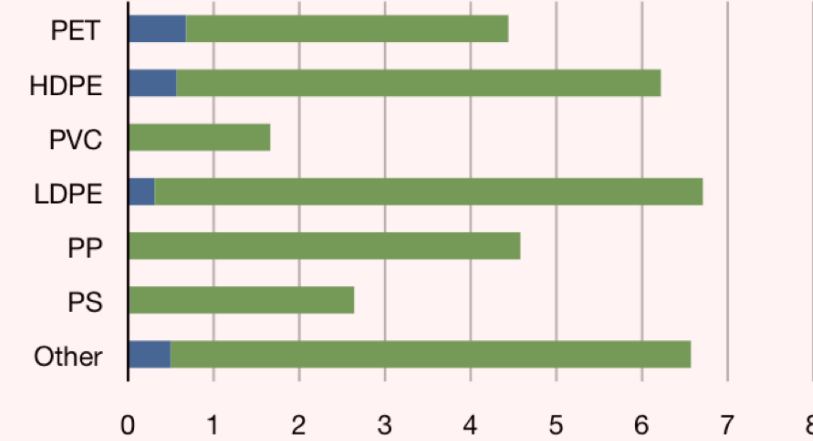
*Does not include combustion (with energy recovery).

Some resins fared better than others; PET plastic soft drink bottles were recycled at a 27% rate, and HDPE milk & water bottles were recycled at a 29% rate. However, of the overall 30 million tons of plastic waste generated, only about 2 million tons were recovered -- a paltry 7.1%.

Breakdown of Plastic Wastes in MSW, by Resin



Recycling Rates by Resin



Municipal Solid Waste Generation, Recycling, and Disposal in the United States Detailed Tables and Figures for 2008, Environmental Protection Agency

Potential solutions :

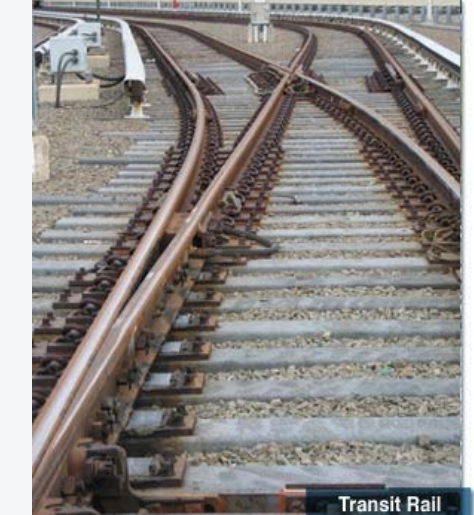
Improving collection & separation

Recycling begins with proper collection & separation of individual resins. Curbside collection schemes should be expanded to accept more than just PET & HDPE jugs & bottles, as most municipalities currently do.

Laws such as the *New York State Plastic Bag Reduction, Reuse, & Recycling Act* (2008) and the NYS "Bigger Better Bottle Law" (2009) are successful examples of using legislation to improve recycling rates.

Improving materials recycling

As materials recycling is the most efficient use of resources, "close the loop" on plastics that allow it, e.g. PET bottles, and find new products and target markets for plastics more difficult to close the loop e.g. plastic bags.



Left: TriMax Structural Lumber – made from 70% recycled HDPE and 30% Fiber Fill
Center : EcoSheet Plastic Plywood Alternative – made from waste electrical equipment
Right : TieTek composite railroad ties – made from 85% recycled HDPE.

Chemical Recycling

As plastics are made from petroleum, waste plastics are a good candidate to be converted into synthetic liquid & gaseous fuels. The energy required to pyrolyze plastics can be less than 5% of the embedded energy.

Goncalves, Cecilia K. et al. "Emissions from Premixed Combustion of Polystyrene." *Energy & Fuels* 22 (2008) pp354-362.



Left: Plas2Fuel's batch process to convert plastic wastes to synthetic crude oil. 8 lbs of plastic yields 1 gallon of synthetic crude.
Right: Envion has a less efficient solution but claims its synthetic crude will cost just \$10/barrell

About plastics

Plastics are synthetic materials formed from petroleum feedstocks. Production of plastics consumes 8% of the world's annual oil production – 4% as feedstock and 4% during manufacture.

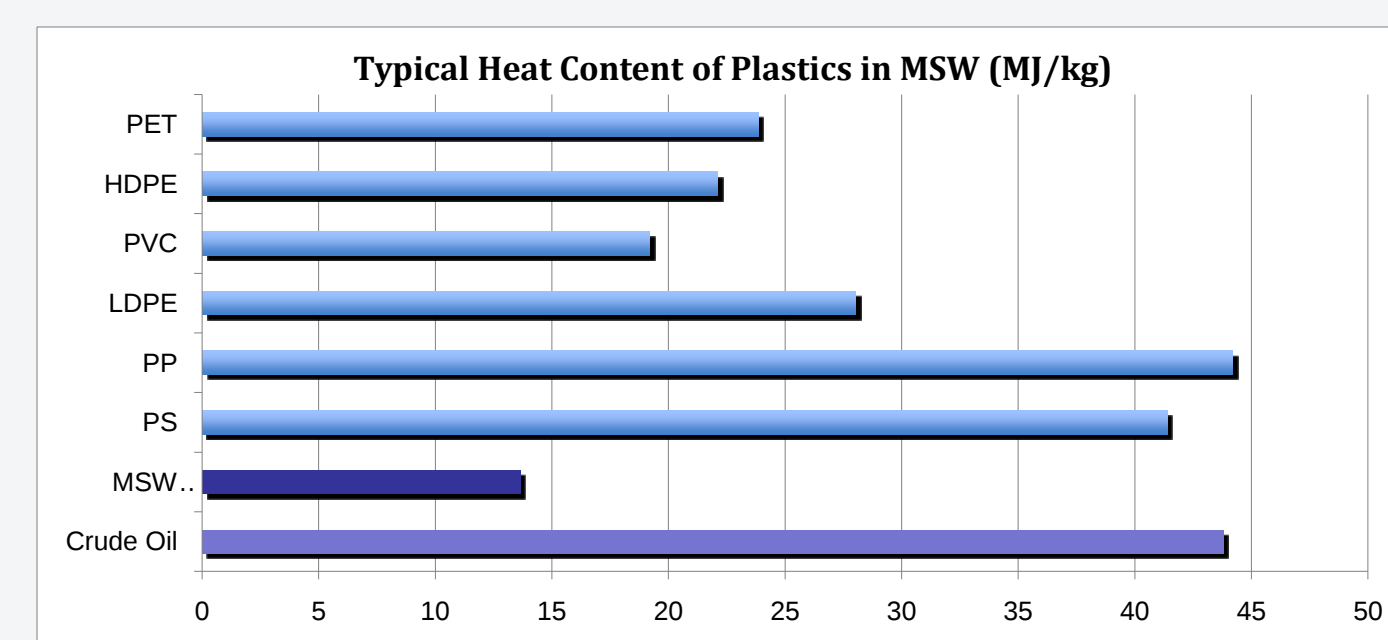
Recycling No.	Symbol	Abbreviation	Polymer Name	Uses once recycled
1		PETE or PET	Polyethylene terephthalate	Polyester fibres, thermoformed sheet, strapping, and soft drink bottles. (See also: Recycling of PET Bottles)
2		HDPE	High density polyethylene	Bottles, grocery bags, recycling bins, agricultural pipe, base cups, car stops, playground equipment, and plastic lumber.
3		PVC or V	Polyvinyl chloride	Pipe, fencing, and non-food bottles.
4		LDPE	Low density polyethylene	Plastic bags, various containers, dispensing bottles, wash bottles, tubing, and various molded laboratory equipment.
5		PP	Polypropylene	Auto parts, industrial fibers, and food containers.
6		PS	Polystyrene	Desk accessories, cafeteria trays, toys, video cassettes and cases, and insulation board and other expanded polystyrene products (e.g., Styrofoam).
7		OTHER	Other plastics, including acrylic, acrylonitrile butadiene styrene, fiberglass, nylon, polycarbonate, and polylactic acid.	

In 1988, the Society of Plastic Industries developed Resin Identification Codes. While all these plastic types are technically recyclable, generally only PETE/PET and HDPE are widely recycled due to economic reasons.

http://en.wikipedia.org/wiki/Resin_identification_code

Combustion & WTE

The heat content of plastics is well above the MSW average, on par with crude oil. Additionally, combustion offers a 90-99% volume reduction.



EIA – Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy

Low quantities of contaminants allow for clean burning, with the complete destruction of dioxins at temperatures above 900 degC.



Left : Eco-Clean Burners – GR-Tech Boiler (Plastic-fueled burner)
Right : Atlas Certified Fuels – PlastoFuel formed from agricultural film waste for use in GR-Tech boiler