

Environmental Business Council of New England, Inc.

Plastics recycling: what happens after collection



**EBCNE Webinar on Solid Waste Management:
Big Battles in the World of Recycling**

23 September 2021

CommonWealth
Resource Management Corporation

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Big Battles in the World of Recycling

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Appeared in the Boston Globe on 8 August 2021.
Used by permission of the cartoonist.
Thank you Alex!

There's a lot more to recycling than collection!














- 1. What are plastics?**
- 2. What is plastics recycling? When we collect plastics, what can we do with them?**
- 3. What are pyrolysis and gasification? Are they recycling?**

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Plastics #1 - #7: the popular view

 PET	 PE-HD	 PVC	 PE-LD	 PP	 PS	 O
Polyethylene terephthalate	Polyethylene (high density)	Polyvinyl chloride	Polyethylene (low density)	Polypropylene	Polystyrene	Bisphenol A and others
PET is commonly used in commercially sold water bottles, soft drink bottles, sports drink bottles, and condiment bottles.	HDPE is commonly used in milk and juice bottles, detergent bottles, shampoo bottles, grocery bags, and cereal box liners.	PVC can be flexible or rigid, and is used for plumbing pipes, clear food packaging, shrink wrap, plastic children's toys, tablecloths, vinyl flooring, children's play mats, and blister packs (such as for medicines).	LDPE is used for dry cleaning bags, bread bags, newspaper bags, produce bags, and garbage bags, as well as "paper" milk cartons and hot/cold beverage cups.	PP is used to make yogurt containers, deli food containers, furniture, luggage and winter clothing insulation.	PS, also popularly known as Styrofoam, is used for cups, plates, take-out containers, supermarket meat trays, and packing peanuts.	Any plastic item not made from the above six plastics is lumped together as a #7 plastic. Things like CD's baby bottles and headlight lens
						

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Plastics: an elemental view.
How many molecules are there in a
bowling ball? In a tire?



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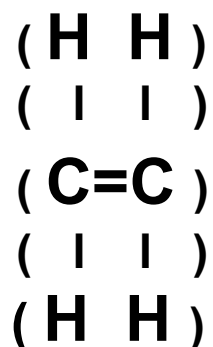
Plastics: an organic chemist's view

Atoms

Carbon (C)
Hydrogen (H)

Oxygen (O)
Chlorine (Cl)

Monomer



Example shown is ethylene monomer – C₂H₄

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Plastics: an organic chemist's view

Atoms

Carbon (C)

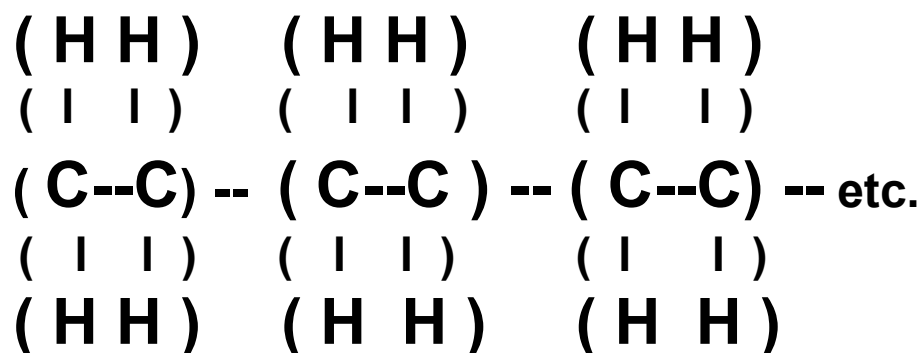
Oxygen (O)

Hydrogen (H)

Chlorine (Cl)

Polymers

(many monomers)



*Example shown is **polyethylene** polymer – $(\text{C}_2\text{H}_4)_n$*

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Plastics #1-#7: an engineer's view

Type	Monomer	Melt/freeze T	Properties
#1 PET	$C_{10}H_8O_4$	500 deg F	Strong but heat-sensitive
#2 HDPE	C_2H_4	270 deg F	Strong, light and stable
#3 PVC	C_2H_3Cl	212+ deg F	Rigid, can be flexible with additives, very heat-sensitive
#4 LDPE	C_2H_4	230 deg F	Thin/flexible version of HDPE
#5 PP	C_3H_6	320 deg F	Strong and stable
#6 PS	C_8H_8	800 deg F	Heat resistant; concerns with additive leaching
#7 Misc.	Many !	Wide range	Wide range of properties

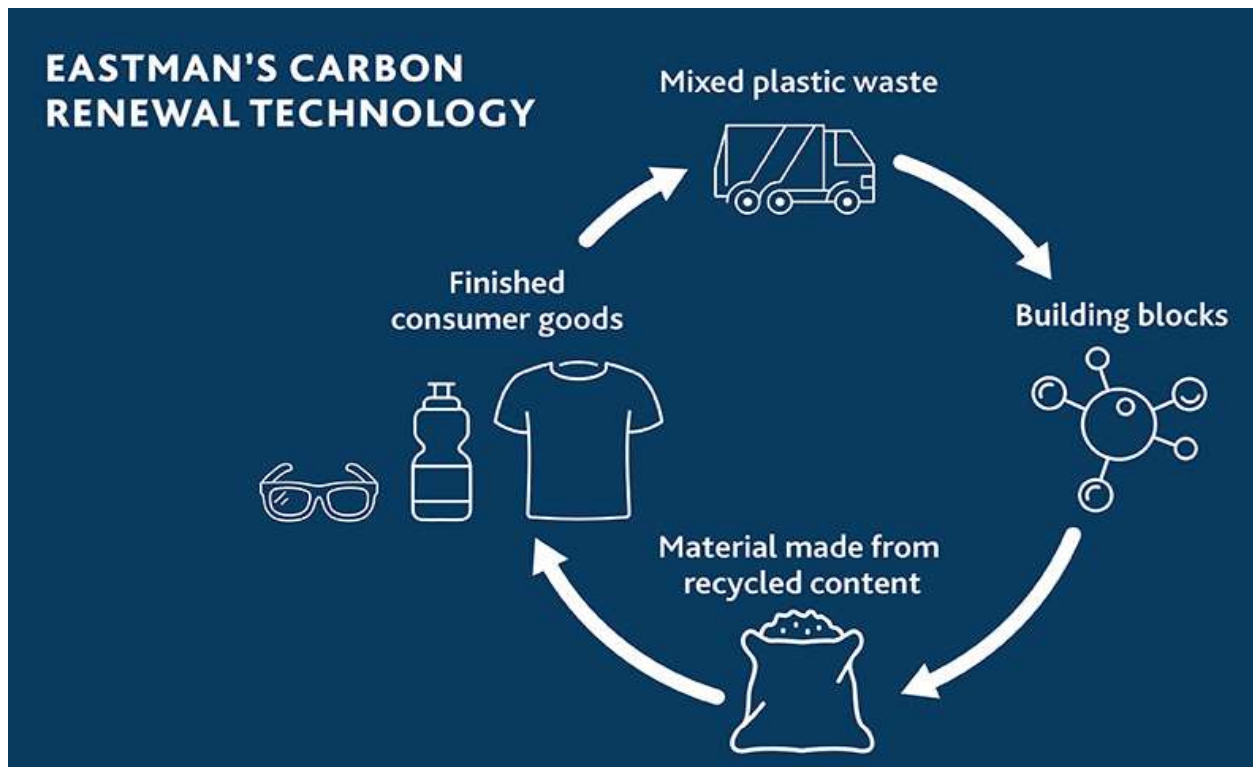
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What are the methods for plastics recycling?

- **Mechanical recycling** (shred soda bottles for carpet filler – no change to the monomers)
- **Thermal recycling** (sort, clean, heat, soften/melt, compress/pelletize, mold/stretch and harden/freeze – minimal changes to the monomers)
- **Molecular, chemical or solvent recycling** (pyrolysis and other processes to change the monomers through unlimited cycles)

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Plastics monomer recycling



- *Infinite cycling*
- *Flexibility*
- *Capex and scale*
- *Energy and resources*

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Post-consumer plastics recycling: US markets

Local options

- Traders/processors – supply chain
- End-users – small-scale extrusion and molding products
- In New England, plastics waste supply exceeds demand

Regional facilities – large wasteshed areas

- Fayetteville, NC (Clear Path) – 140,000 tpy PET
- Troy, AL (KW Plastics) – 500,000 tpy HDPE/PP
- Winchester, VA (Trex) – LDPE/HDPE film

Exports

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Post-consumer plastic global markets, 2017-2021

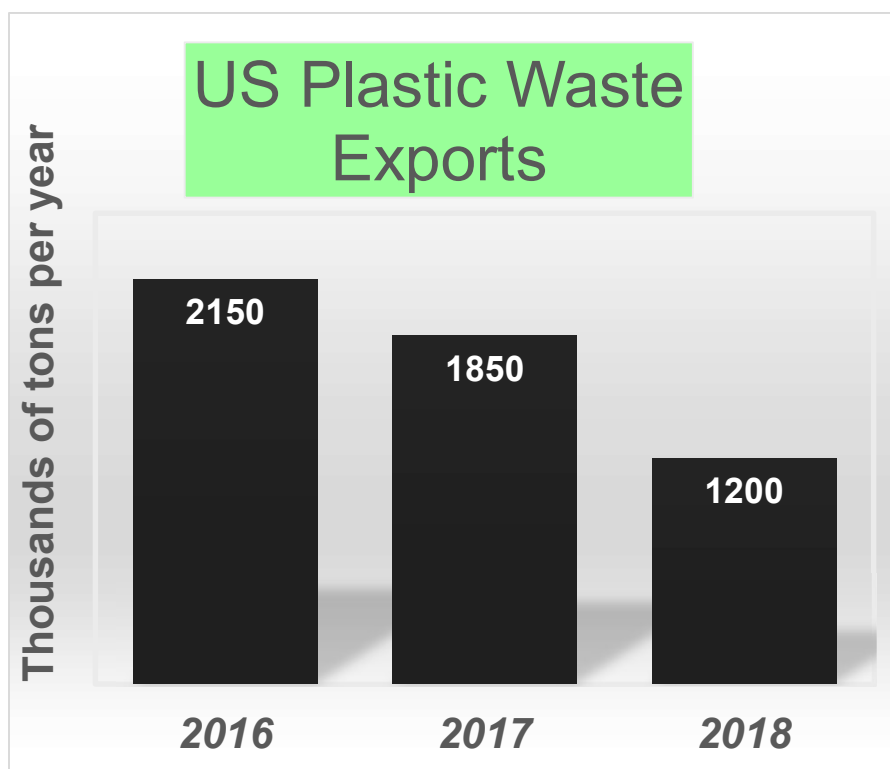
2013	China's " Green Fence " limits all scrap contamination, including plastics
2018	China's " National Sword " bans mixed plastic waste imports, limits contamination to 0.5%
2018	Other Asian countries limit imports Chinese plastics companies enter US market
2019	MRFs stockpile plastics, reduce collection China and US announce tariff increases
2020	Pandemic reduces economic activity
2021	Big freeze in Texas disrupts resin production
Ongoing	Concerns with ocean waste, climate change

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Plastics recycling: export markets, 2017-2018

China bans mixed plastic imports on January 1, 2018

limits contamination to 0.5% as of March 1, 2018

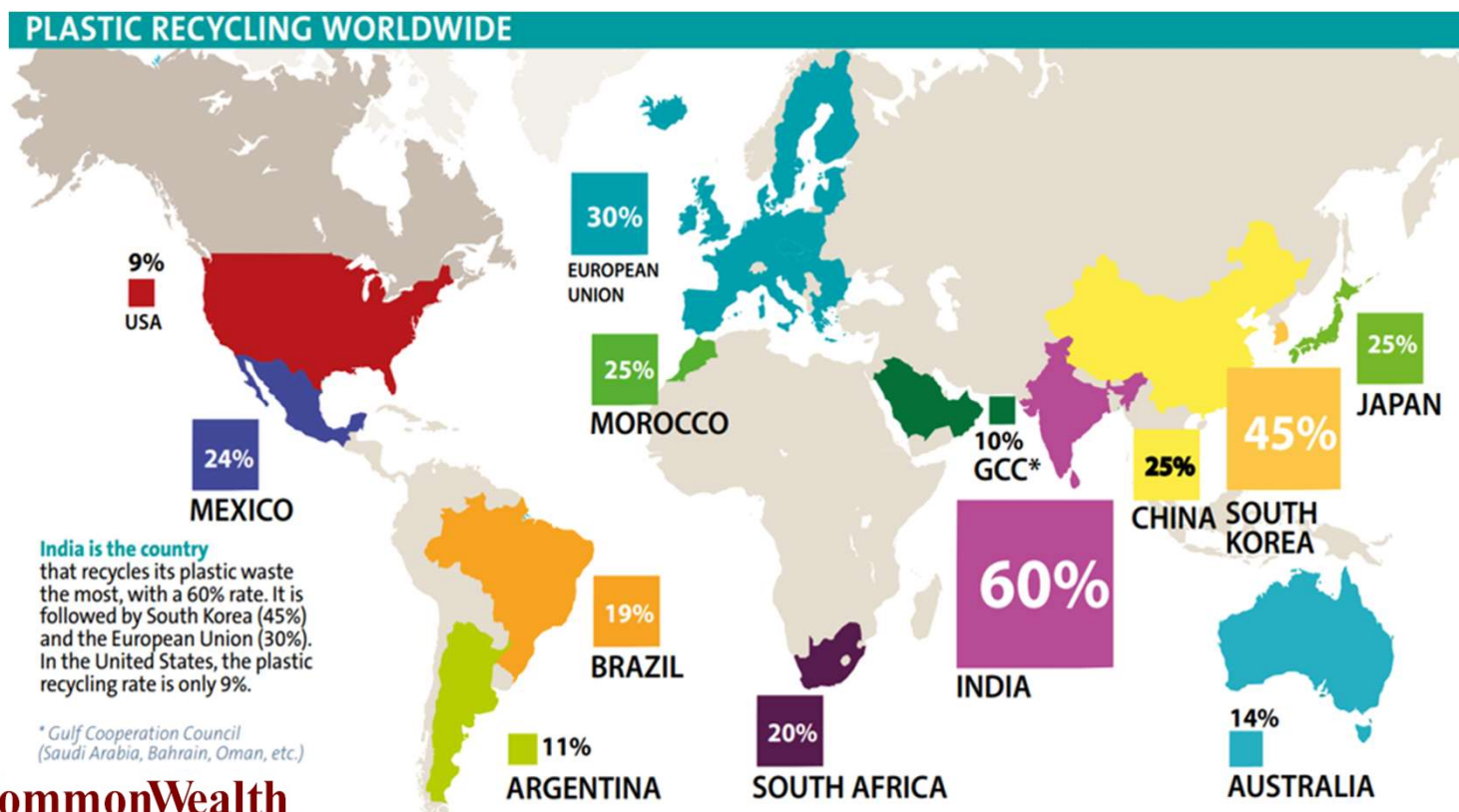


	2017	2018
China	611	60
Hong Kong	407	132
Vietnam	148	84
India	148	144
Malaysia	130	228
Mexico	56	48
Indonesia	37	36
Taiwan	37	60
Thailand	37	120
Other	93	132
	1850	1200

Data in thousands of tons per year

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Plastics recycling around the world



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New restrictions on waste exports in trade

- Control trading of overly-contaminated scrap
- Reduce impacts on oceans

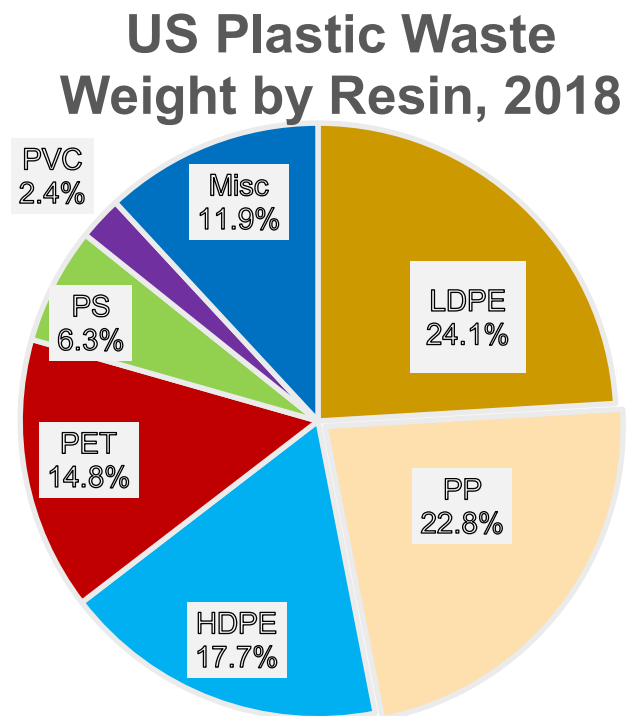
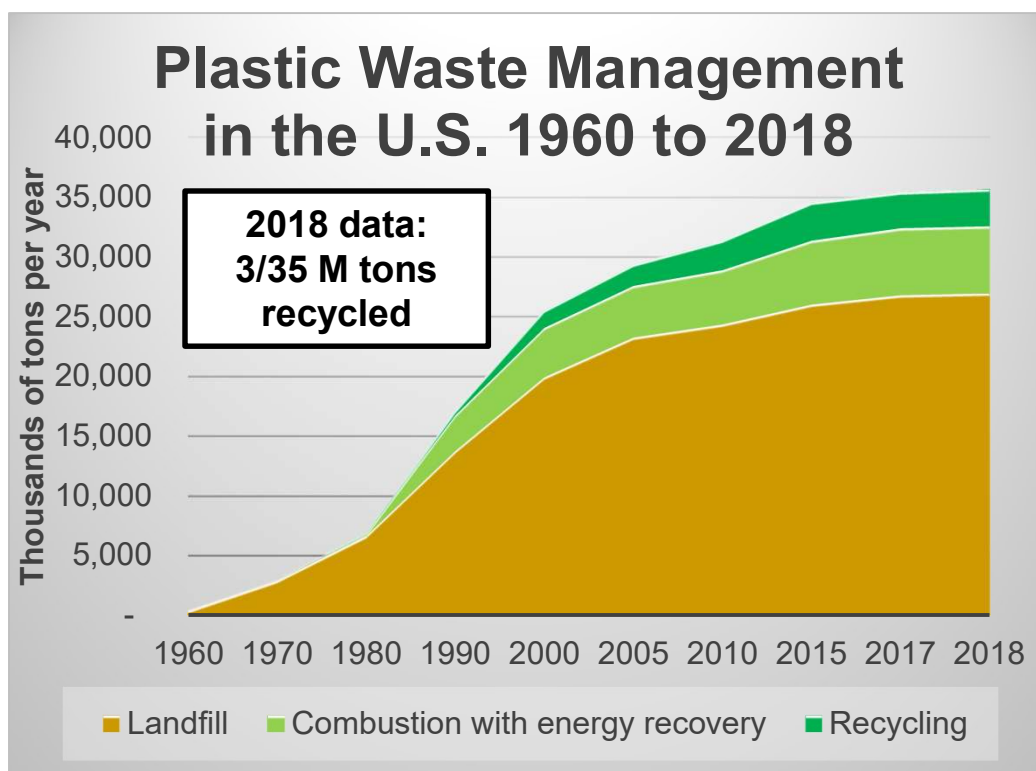
Basel Convention, 2021

- Plastic waste exports require notice and consent
- 187 countries sign; the US has not yet signed
- US waste plastic exports are now limited to
 - Pre-sorted clean uncontaminated materials; or
 - Bilateral agreements with notice and consent
(Canada, Mexico, OECD)

**Circular Economy Resolutions for UN Conference on
the Environment, Nairobi, Kenya 2022**

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Plastic waste: US tons and resins



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In crisis there is opportunity!



- **Crisis:** imbalance of waste plastic supply/demand
- **Public sector response:** reduce plastics waste
- **Industry response:** add plastics recycling capacity
 - Increased interest in ESG investments
 - New corporate carbon footprint reduction goals
 - Domestic sources improve supply chains
 - Recycled resins depend less on oil markets

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Evolving hierarchy for plastics recycling

- A. Reduce plastics waste**
- B. Return plastic waste to commerce**
- C. Avoid/reduce fossil fuel use/emissions**
- D. Dispose of the irreducible minimum**

Evaluation criteria

- Energy use and emissions from processing**
- Energy use and emissions from transport**
- Carbon footprint over the use/recovery life-cycle**

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**Reduce
plastics waste.
Minimize
energy use and
emissions from
transport**



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U.S. Plastics Pact Unveils National Strategy to Achieve 2025 Circular Economy Goals. June 15th, 2021

1. Eliminate problematic or unnecessary packaging.
2. Make all plastic packaging reusable, recyclable, or compostable.
3. Recycle or compost 50% of plastic packaging.
4. Achieve average for plastic packaging of 30% recycled or responsibly-sourced bio-based content

<https://usplasticspact.org/>

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New large-scale plastics recycling facilities

PureCycle (Proctor & Gamble): replace PET/HDPE with PP

- 50,000 tpy new capacity, Ironton, OH by 2022
- 500,000 tpy new capacity by 2025

Envision Plastics:

- Diversion of ocean-bound plastics to produce resins
- Production of food-grade post-consumer HDPE at former MRF in Reidsville, NC

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New large-scale plastics recycling facilities

Eastman Renew: carbon renewal technology

- Allows full recycling of C-H monomers, 1-2 and 4-7
- Can recycle infinite times with no loss of quality
- 100,000 tpy new capacity, Kingsport, TN, by 2022

Brightmark: pyrolysis/gasification of 1s through 7s

- 100,000 tpy new capacity, Ashley, IN, in start-up
- 400,000 tpy new capacity in Macon, GA by 2025

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Pyrolysis process: decompose polymers to gases and monomers with

- **Controlled heat and pressure**
- **No oxygen (prevent burning)**
- **Catalysts**
- **Distillation and post-processing**

Products include

- Plastic monomers
- Liquid fuels (synthetic diesel, jet fuel, heating oil)
- Biochar and solid residues

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Other pyrolysis/gasification processes

Alternative feedstocks

- **Biosolids (carbohydrates) with PFAS destruction**
- **Mixed plastics and products (hydrocarbons) pre-processed to a physical spec**

Other products

- **Electricity (steam turbines and IC engines)**
- **Renewable pipeline gas**

Small-scale skid-mounted facilities

- **Reduce energy for transport**

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Waste plastics to diesel by pyrolysis, Jiangsu Province, Republic of China

1. Feedstock pre-processing



2. Conversion in a reactor vessel with mixing, heat and a catalyst

All photos by G Aronson

3. Product distillation and refinement



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**Small-scale pyrolysis/gasification facility
development in the Northeast:**

- 1. Sustane Technologies, Chester, NS – in start-up**
- 2. Warwick, RI – pre-construction development**
- 3. Aries CleanTech, Taunton MA – in MEPA
permitting process**
- 4. Trashology: pilot test facility, Concord, MA**
- 5. Nantucket RFEI process – planning and
procurement process**

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MassDEP guidance on pyrolysis/gasification

Letter to City of Taunton, July 2019

Technology	Status of 1990 permit moratorium
New MSW combustion capacity	Applies
Use syngas from pyrolysis or gasification to make electricity	Limited to 350,000 tpy MSW statewide capacity
Transportation liquid fuels (synthetic diesel, jet fuel)	Exempt
Other fuels that might be combusted (synthetic home heating oil, pipeline natural gas)	Not addressed yet

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MassDEP guidance on pyrolysis/gasification

Letter on Aries CleanTech project in Taunton, July 2019

Projects will require upfront recycling programs with measurable and enforceable performance standards

- Implies that source separation/recycling is preferred to pyrolysis
- Standards will depend on technology
- No precedents yet

Where should local pyrolysis/gasification be in the hierarchy ?

- Monomer cycling vs. fuel/energy production
- Net carbon footprint of local vs. remote recycling?
- Fate of exported material not known with certainty

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De-carbonization vs. de-fossilization

- Mass. de-carbonization roadmaps have a continuing role for synthesized liquid fuels
- Cost, quantities and sources are "major uncertainties requiring further in-depth study"
- Pyrolysis/gasification of plastics could fill role as an alternative to bad-politics biomass

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Summary

- Consider monomers
- Export limits led to supply/demand imbalance
- New actions to address waste plastics
 - Public action to reduce waste plastic supply
 - Private action to add recycling capacity
- Emerging pyrolysis technology regionally and locally for monomer recycling, liquid fuels and electricity

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Thank you for listening.
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George Aronson, Principal
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