RUTGERS
THE STATE UNIVERSITY
OF NEW JERSEY

PLASTIC WASTE AS A FEEDSTOCK FOR CIRCULAR CARBON ECONOMY

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The EcoComplex "Clean Energy Innovation Center"

Impacts of MICROPLASTICS in the Urban Environment
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New Brunswick, NJ

The EcoComplex:

- The EcoComplex is a clean energy innovation center at Rutgers University that harnesses research and education resources towards the development and commercialization of innovative clean energy, agricultural, and environmental and technologies.

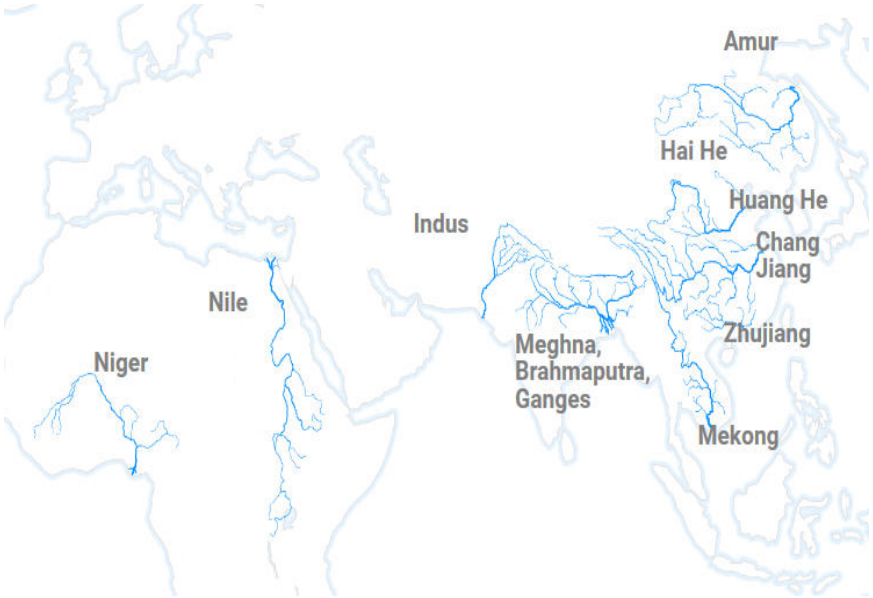
- The Center also serves as a business incubator and houses 5 start-up clean technology companies.

member incubatenergy network

nbia INTERNATIONAL BUSINESS INNOVATION ASSOCIATION SOFT LANDINGS

NEW JERSEY BIN BUSINESS INCUBATION NETWORK

Why is Plastic Waste Drawing More Attention?



10 rivers carry more than 90% of the plastic waste that ends up in the oceans*

Chang Jiang (Yangtze) river delivers 1.5 million tons of plastic waste into Yellow Sea*

https://www.unenvironment.org/interactive/beat-plastic-pollution/

"Export of Plastic Debris by Rivers into the Sea" by Christian Schmidt, Tobias Krauth, and Stephan Wagner, published in Environmental Science & Technology (2017)

US MSW Generation, 2015*

Waste Material	Weight Generated	Weight Recycled	Weight Composted	Weight Incinerated for Energy	Weight Landfilled	% Recycling	% Composting	% Incineration	% Landfilling
Paper	68.05	45.32	-	4.45	18.28	66.6	-	6.5	26.9
Glass	11.47	3.03	-	1.47	6.97	26.4	-	12.8	60.8
Steel	18.17	6.06	-	2.14	9.97	33.3	-	11.8	54.9
Aluminum	3.61	0.67	-	0.50	2.44	18.5	-	13.9	67.6
Other Metals	2.22	1.50	-	0.06	0.66	67.6	-	2.7	29.7
Total Metals	24.00	8.23	-	2.70	13.07	34.3	-	11.2	54.5
Plastics	34.50	3.14	-	5.35	26.01	9.1	-	15.5	75.4
Rubber, Leather	8.48	1.51	-	2.49	4.48	17.8	-	29.4	52.8
Textiles	16.03	2.45	-	3.05	10.53	15.3	-	19.00	65.7
Wood	16.30	2.66	-	2.58	11.06	16.3	-	15.8	67.9
Other Materials	5.16	1.43	-	0.69	3.04	27.7	-	13.4	58.9
Total Materials	**183.90**	**67.77**	-	**22.78**	**93.44**	**36.8**	-	**12.4**	**50.8**
Food	39.73	-	2.10	7.38	30.25	-	5.3	18.6	76.1
Yard Waste	34.72	-	21.29	2.63	10.80	-	61.3	7.6	31.1
Inorganic Waste	3.99	-	-	0.78	3.21	-	-	19.5	80.5
Total Other Waste	78.44	-	23.39	10.79	44.26	-	29.8	13.8	56.4
Total MSW	**262.43**	**67.77**	**23.39**	**33.57**	**137.76**	**25.8**	**8.9**	**12.8**	**52.5**

*USEPA, (2018). "Advancing Sustainable Materials Management: (2015) Fact Sheet-Assessing Trends in Material Generation, Recycling, Composting, Combustion with Energy Recovery and Landfilling in the United States

US MSW Generation, 2015*

Waste Material	Weight Generated	Weight Recycled	Weight Incinerated For Energy	Weight Landfilled	% Recycled	% Incinerated	% Landfilled
Plastics	34.50	3.14	5.35	26.01	9.1	15.5	75.4

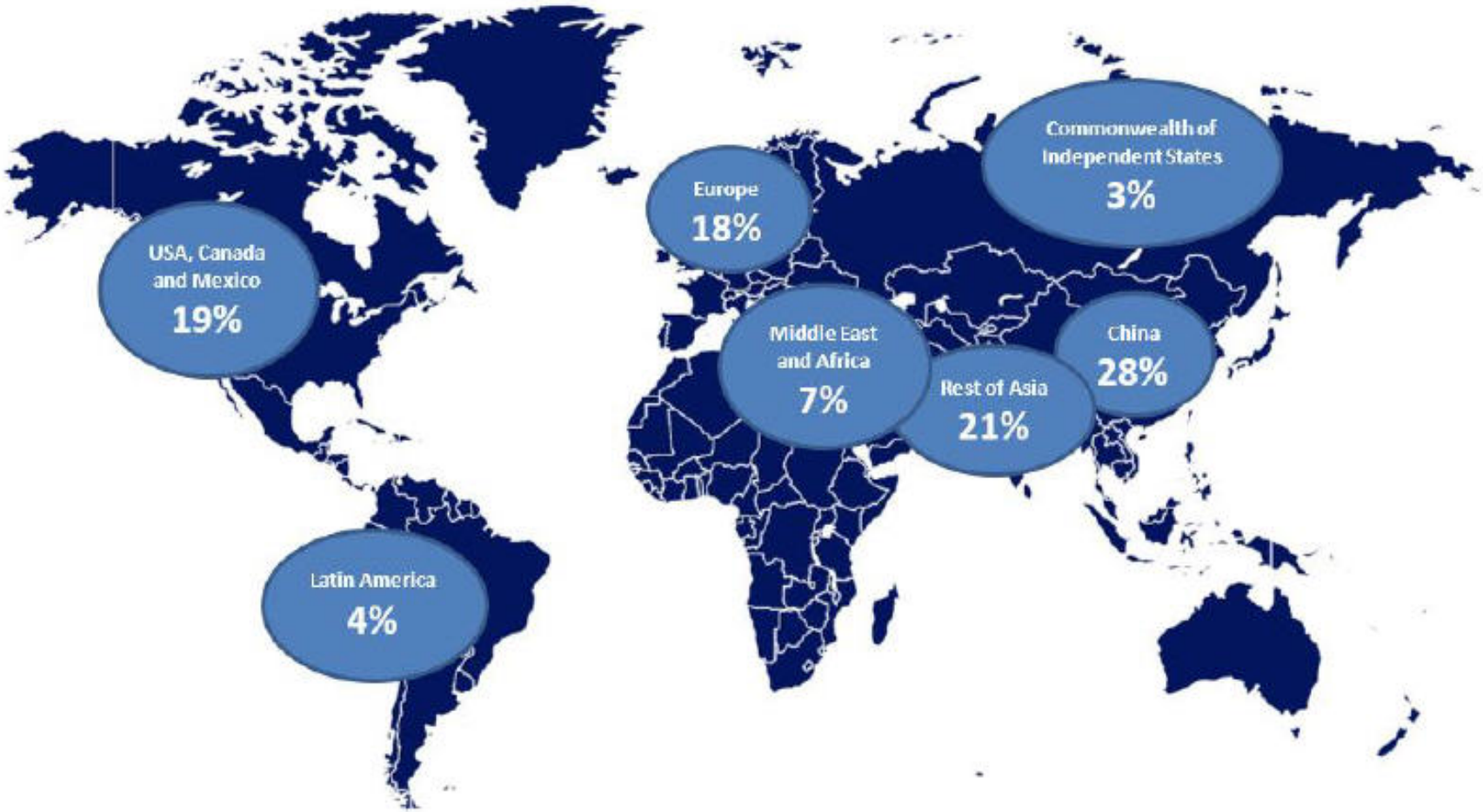
These numbers do not include leakage to the natural environment!!

*USEPA, (2018). "Advancing Sustainable Materials Management: (2015) Fact Sheet- Assessing Trends in Material Generation, Recycling, Composting, Combustion with Energy Recovery and Landfilling in the United States

Plastic Waste

- Fossil- based plastics have significant role in our lives
- At least 10-15 items either full or partially made out of plastics . i.e. medical devices, phones, efficient food storage and better cars
- Low-cost production

Global Plastic Production*



*http://www.stapgef.org/sites/default/files/documents/PLASTICS%20formatted%20for%20posting.pdf

Plastic Waste

- Global plastics production reached to 381M tons in 2015 with total volume of plastics ever produced 34B tons.
- Yearly production is expected to double by 2035 and quadruple by 2050.
- 15M tons of plastics waste traded in 2016 globally with China being the top importer and US the largest exporter.
- 2018 January China cancelled its global imports unless its completely uncontaminated.
- Single stream recycling increased the quantity of the recycled materials but reduced the quality.

Environmental Footprint of Plastics:

- Production is highly dependent on virgin fossil feedstock (NG and oil)
- Greenhouse gas emissions from plastics were estimated to be 390 million tons of CO_2 in 2012
- It takes approx.. 22 gallons of water to make a lb. of plastic
- Some plastics contain toxic chemical additives including persistent organic pollutants (POP) that may be linked to cancer, mental, reproductive and developmental diseases.
- Land degradation and water contamination and impacts to food systems are extreme
- UN estimated that the natural capital cost of plastics, environmental degradation, climate change and health to be about $75B /year

*http://www.stapgef.org/sites/default/files/documents/PLASTICS%20formatted%20for%20posting.pdf

NJ & Plastic Waste

- New Jersey generates approx.. 1,000,000 tons of plastic waste*
  - 28.3 % Incinerated
  - 58.4% landfilled

- Rutgers EcoComplex's Pilot Assessment of Unrecycled plastics in MSW**:

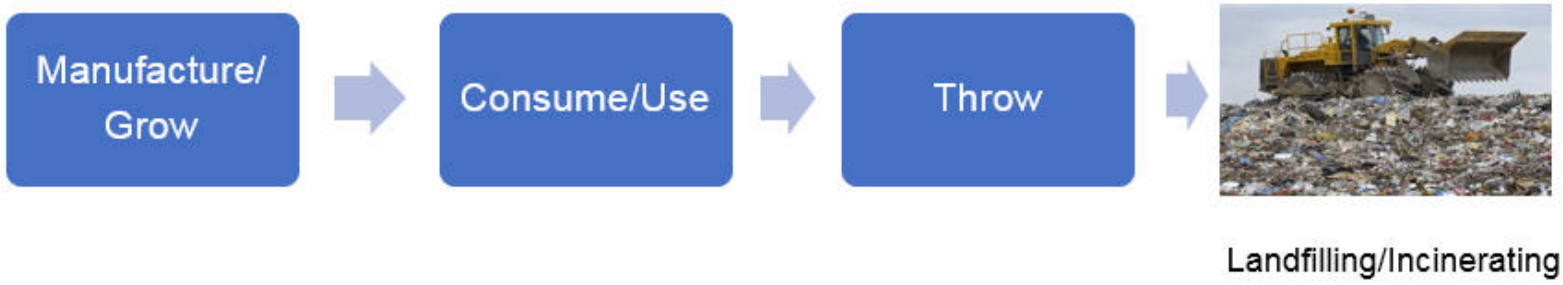
Suburban (weight %)	17.2%
Rural (weight %)	21.8%
Urban (weight %)	17.4%
Estimated Average NRP in a Landfill MSW (%)	18.8%

*Themelis, N.J., and Mussche, C., "2014 Energy and Economic Value of Municipal Solid Waste (MSW), Including Non-Recycled (NRP) Currently Landfilled in the Fifty States.
**Rutgers EcoComplex Study

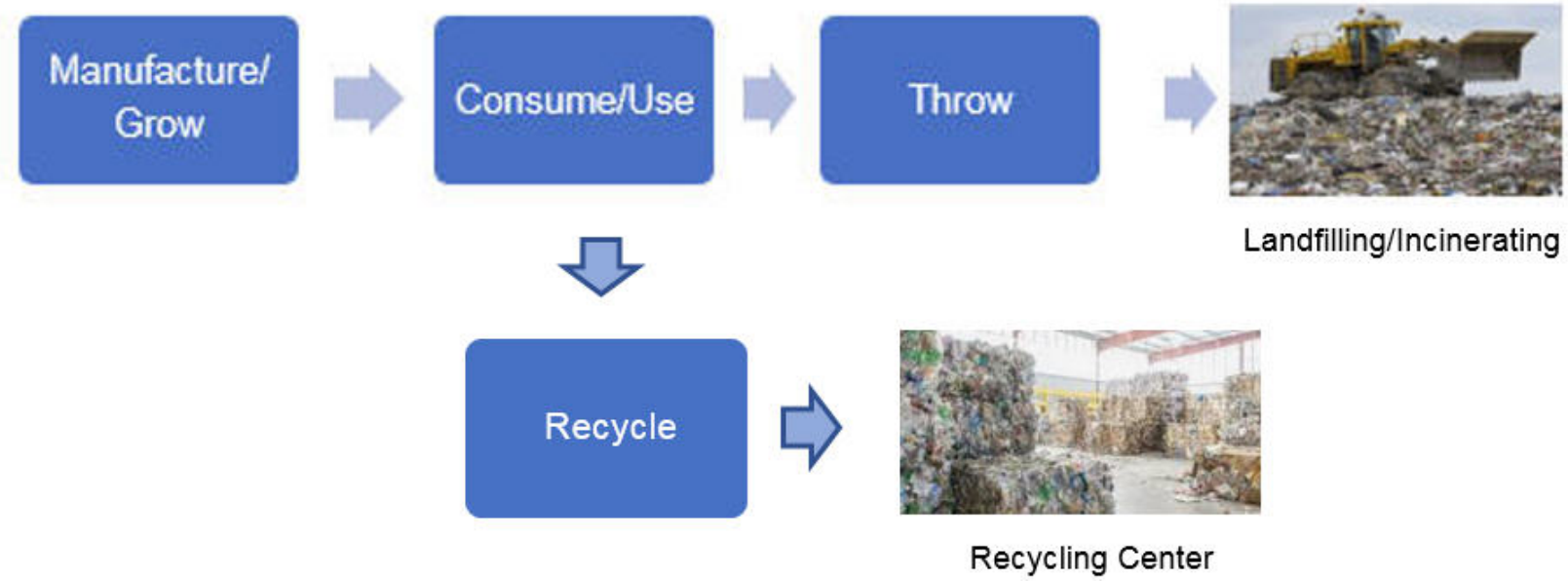
Single Use Plastics

- Plastic packaging and other consumer products made out of plastic that are designed to be used once and thrown away after a brief use.
- Bottles, cups, plastic lids, bags, plates, utensils, straws, stirrers, swabs, food containers, plastic films wraps, and plastic packaging.
- Americans purchase 50 billion water bottles per year – with average of 13 bottles per month per person.
- 100 billion plastic bags and 25 billion “Styrofoam” coffee cups are thrown away by Americans each year - that means 307 bags and 77 cups are thrown away per person.
- Half a billion straws are used and thrown away by Americans every day

Linear Economy Resource Management Approach



Linear Economy Resource Management with Recycling Approach



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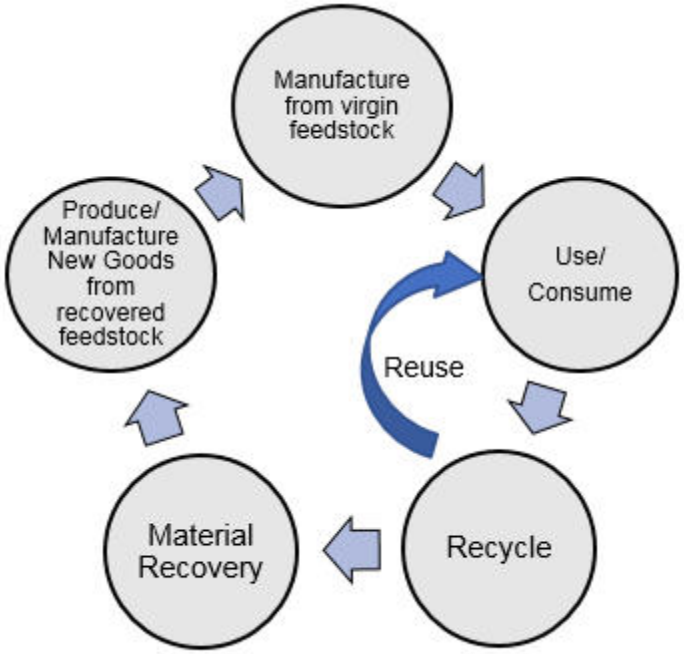
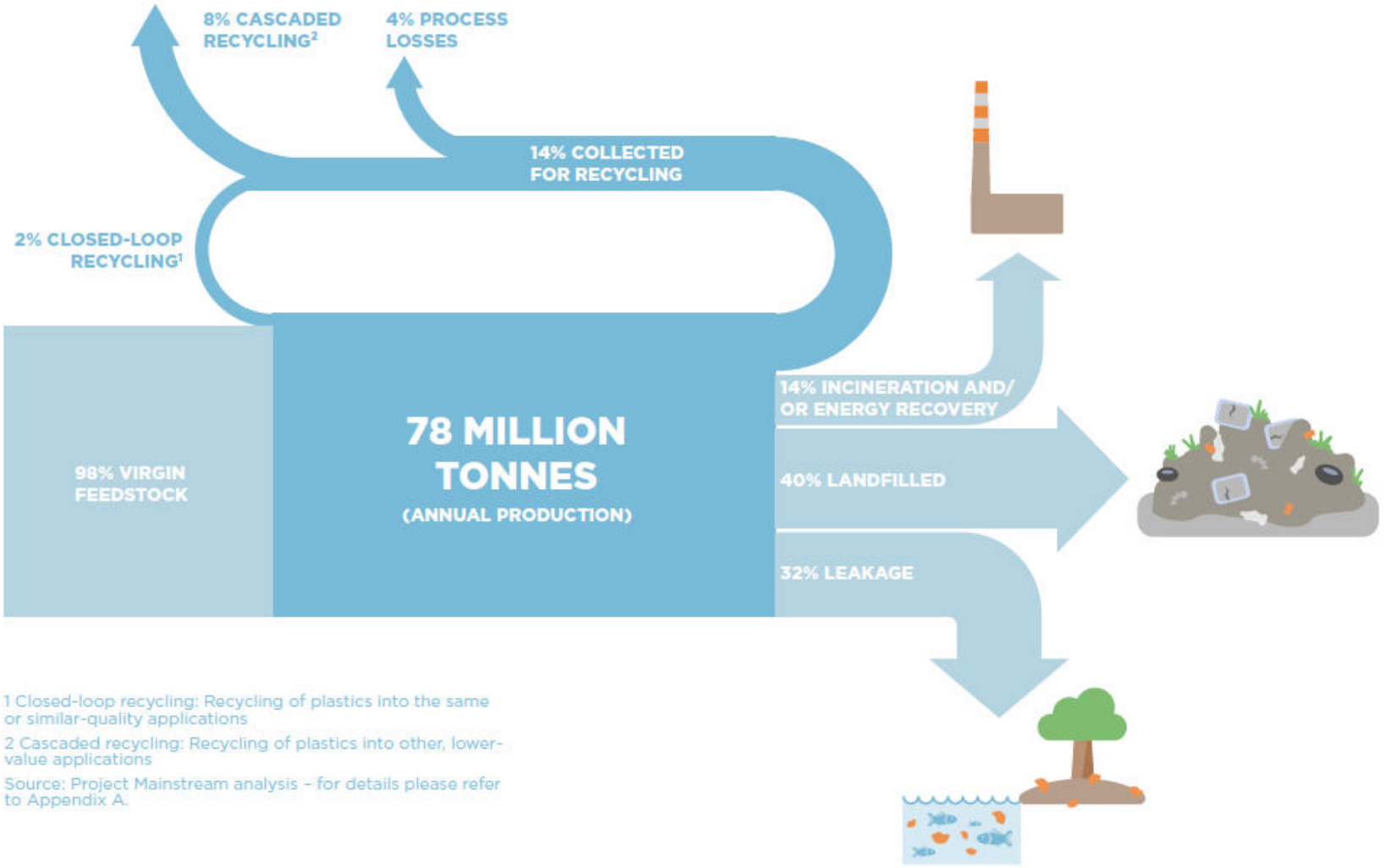
Closing the Loop for Resource Recovery



Current Flow of Plastic Packaging



https://www.ellenmacarthurfoundation.org/our-work/activities/new-plastics-economy/2016-report

We Need to Plan Ahead!

- Identify Barriers for Circular Carbon Approach
  - Cost (up-front investment, risks)
  - Complex international production & consumption supply-chains
  - Lack of understanding & participation (Business, consumer and decision makers)
  - Need for knowledge and capacity for implementation
  - Unfavorable regulations & lack of standards
  - Insufficient monitoring and reporting on plastics
  - Need for innovative technologies, polices and business models
  - Need for education

-http://www.stapgef.org/sites/default/files/documents/PLASTICS%20formatted%20for%20posting.pdf
-Rutgers EcoComplex

We Need to Plan Ahead!

- Short term
  - Engage decision & policy makers
  - Avoid contamination
  - Improved collection and sorting
  - Enable secondary markets
  - Innovative thinking to reduce the leakage of plastics into the natural systems
- Mid- & long-term
  - Innovative thinking in creation of after-use plastics economy
  - Investment on better packaging
  - Policies and Intervention for decoupling plastics production from fossil feedstocks
  - R&D on renewable feedstocks for plastics

Waste Plastics Recycling Options

- Waste plastics can provide building blocks for new plastics
  - Polycarbonates – thermoplastic polymers with good optical clarity, high impact resistance and durability (contains bisphenolA) (automotive ind.)
  - High Impact Polystyrene (HIPS) (contains styrene and butadiene) (toys, packaging, signs)
  - ABS resin (acrylonitrile, butadiene and styrene, construction industry, household appliances)
- Approaches to removes plastics from packaging and products
  - Dissolution/reprecipitation by using high dissolution ability (dichloromethane, toluene, chloroform and acetone at optimized Temp, time, concentrations)
  - Chemical and thermochemical recycling methods to recover monomers or (solvolysis, pyrolysis, gasification)

Achilias, D.S., and Antonakou, E.V., Chemical and Thermochemical Recycling of Polymers from Waste Electrical and Electronic Equipment, http://dx.doi.org/10.5772/59960

Plastics from alternative Feedstocks

- Utilize Carbontech (Captured CO_2 as a feedstock)
- Bio-based sources (oils, starch and cellulose)
- Organic waste (Food waste, sewage sludge)
- Renewable Natural Gas (Biogas from Anaerobic Digestion)

Redesign Plastics

- Multi-usage plastics
- Eliminate toxics from plastics
- Eliminate microplastic releasing plastics design
- Durable healthy plastics

Solutions for Consideration

- Sustainable Business models
- Consumer & Business partnership for urban –industrial symbiosis
- **Education & Outreach**
- Policy
  - Surcharges
  - Taxes, extended producer responsibility
  - Standards for circular design plastics
  - Ban on certain types of plastics
  - Science-based decision making

Thanks

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