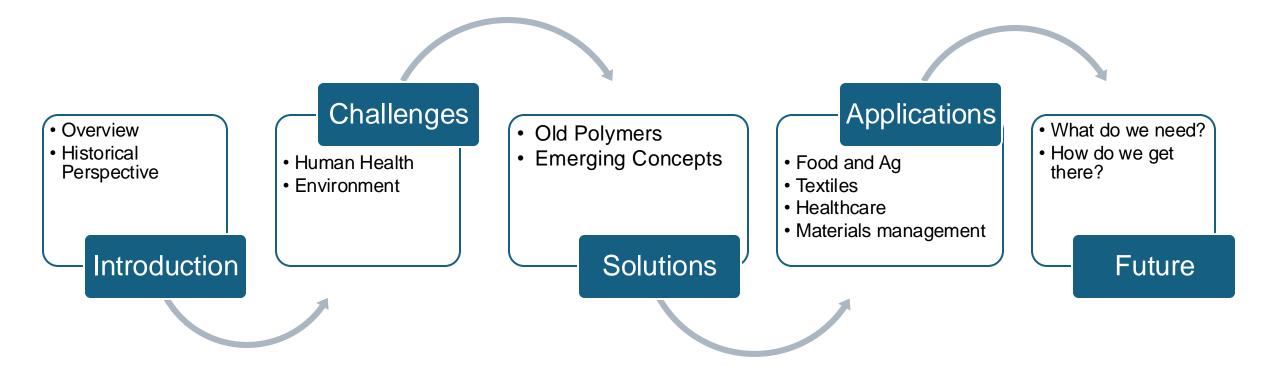
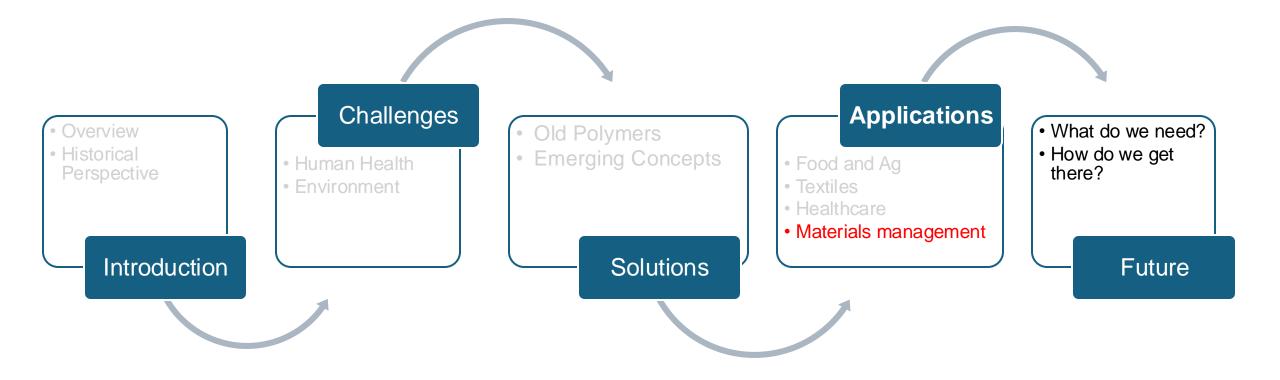
Course Overview







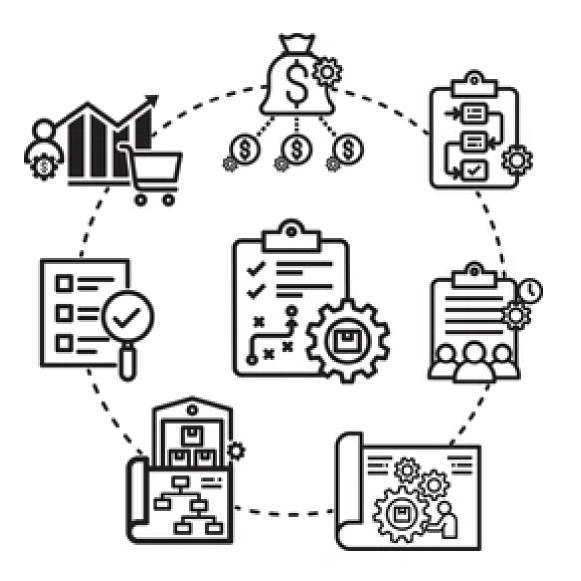
1) Sustainable Materials Management

2) Recycling

- 3) Sustainable production
- 4) Life cycle analysis
- 5) Final assignment



- 1) Solid Waste Policy Models
 - Solid Waste Policy Models in USA
- 2) Sustainable Materials Management
 - ✤ Management Basics
 - Waste materials hierarchy
- 3) Recycling
 - Why so important?
 - Environmental Benefits
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- 4) Sustainable Materials Management Tools
 - Prioritization Tools
 - Additional Tools



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Why me talking about SMM?

B.Sc. Design and Technology of Electronic Devices (2012-2016) Moscow Aviation Institute (National Research University), Moscow, Russia

M.Sc. Design and Technology of Electronic Devices (2016-2018) Moscow Aviation Institute (National Research University), Moscow, Russia

Ph.D Materials, Mechatronics and Systems Engineering (2019-2022) Department of Industrial Engineering, University of Trento, Trento, Italy

Courses:

- Modeling, Development and Management of High Technologies Production Manufacture Technologies and Processes (GMP, ISO 9001, pFMEA).
- Decision Making under Certainty, Risk and Uncertainty.
- Industrial Planning for Production System.









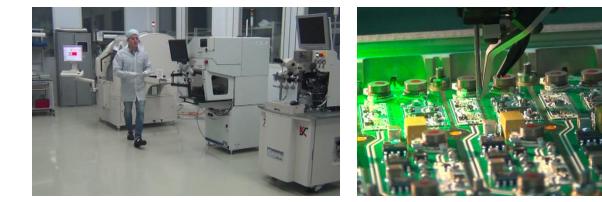
Why me talking about SMM?

Microelectronics Manufacture Engineer (Sep 2016 – Oct 2017)

- Launched two production lines of LTCC micromodules production and microassembly (plasma treatment, dieattachment, wire-bonding and testing).
- Developed manufacture process protocols and industrial plans for LTCC and microassembly production lines.

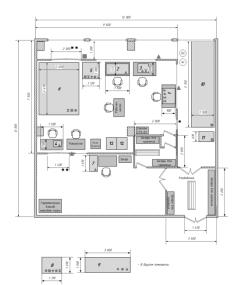
Leader of the Department of Microelectronics Materials (Oct 2017 – Dec 2018)

- Technical support and production consulting.
- Production planning and control.









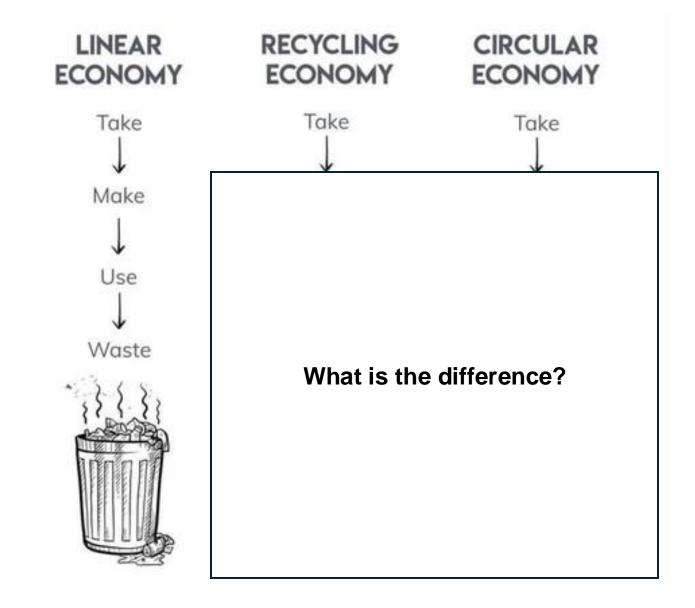


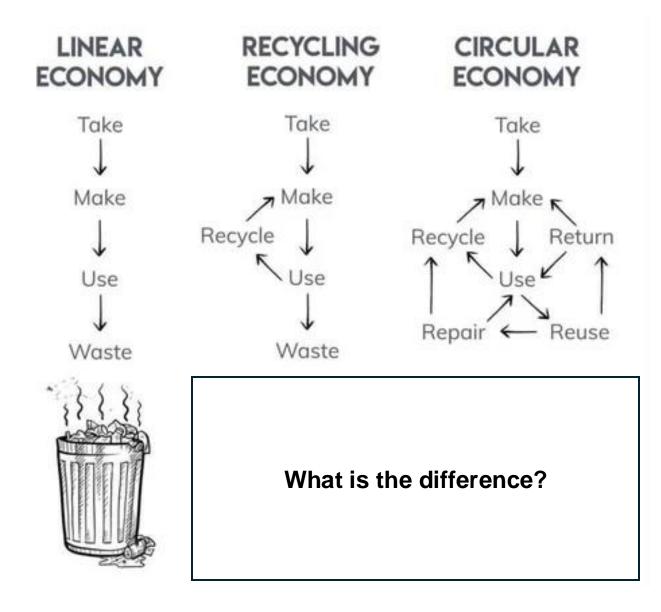
What skills and qualities do you need to have to be successful?

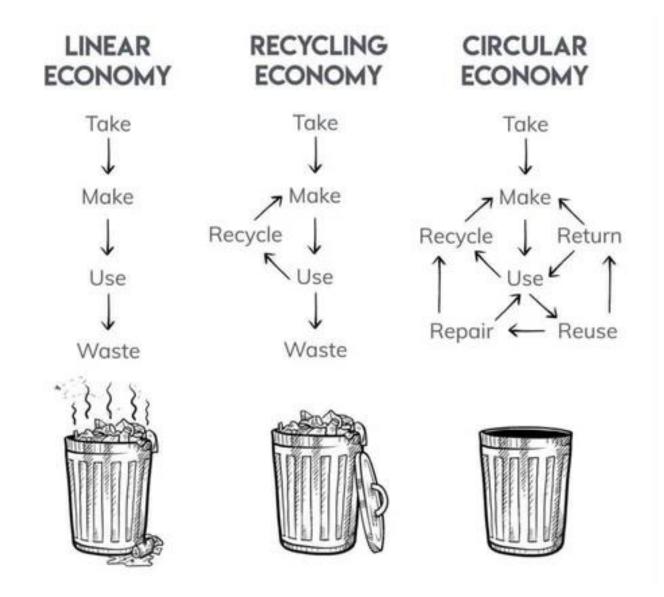
What skills and qualities do you need to have to be successful?

Communicational skills.

Managing skills (your own work, resources and other people).









Sustainable Materials Management -

an approach to serving human needs by using/reusing resources most productively and sustainably throughout their life cycles, generally minimizing the amount of materials involved and all the associated environmental impacts



Material management decisions is based on a material's impact on the environment, society, and the economy throughout its life cycle. **Circular economy** - An industrial economy that is restorative or regenerative by intention and design

No explicitly described hierarchy.

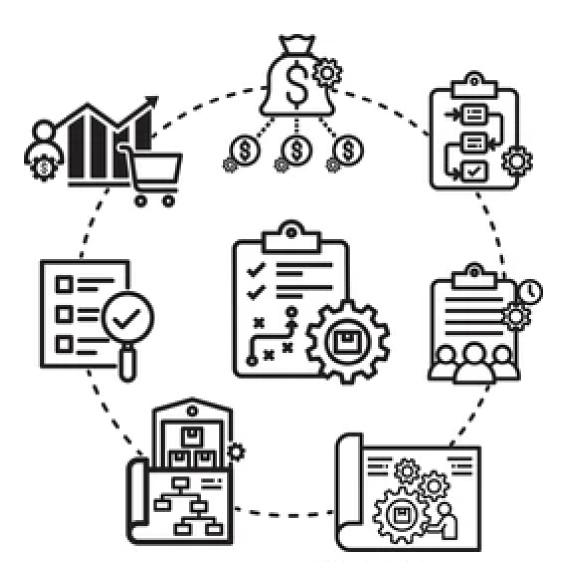


An alternative to the dominant economic linear model of takemake-dispose, where materials and energy flows are designed to be reduced, reused, and recycled. **Zero waste** - Designing and managing products and processes to reduce the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them.



Elimination of waste; end-of-life products or output waste are treated as resources and continually used as inputs, substituting the demand for the extraction of natural resources.

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What is Sustainable Materials Management?

- Use materials in the most **productive** way with an emphasis on using less.
- **Reduce** toxic chemicals and environmental impacts throughout the material life cycle.
- Assure we have **sufficient resources** to meet today's needs and those of the future.

Life Cycle Assessment (LCA) is a technique to make more informed decisions through a better understanding of the human health and environmental impacts of products, processes, and activities. This can include an evaluation of the air, water, land, and energy consequences of a product or process, and possible alternatives.



Most environmentally preferable

Prevent, Rethink, Redesign

Reduce, Conserve, Minimize

Reuse, Repair, Maintain

Remanufacture

Recycle

Material Conversion

Thermal Processing with Energy Recovery

> Residuals Management

> > Regulated Disposal

> > > Unregulated Disposal

Least environmentally prefetble

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Avoid waste, rethink policies and incentives, redesign for waste elimination and ease of reuse and recovery, reduce toxicity

Manufacturing efficiency upgrades, material lightweighting & minimization, sustainable purchasing strategies, sharing, lending, product-as-a-service

Reuse, maintain, repair, refurbish, component salvage

Rebuilding to original specifications using a combination of reused, repaired, and new parts

Traditional recycling (including single stream, dual stream, multi-stream, and curbside collection), chemical recycling, composting, anaerobic digestion

Mixed waste processing, solid fuel production, and other processes that downcycle materials to create secondary products or commodities

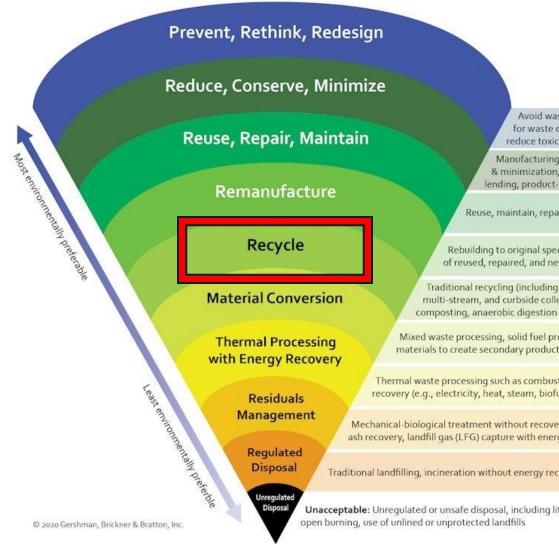
Thermal waste processing such as combustion, gasification, pyrolysis with energy recovery (e.g., electricity, heat, steam, biofuels)

Mechanical-biological treatment without recovery, stabilized landfilling, ash recovery, landfill gas (LFG) capture with energy recovery

Traditional landfilling, incineration without energy recovery

Unacceptable: Unregulated or unsafe disposal, including littering, illegal or open dumping, open burning, use of unlined or unprotected landfills

What is our goal and why?



Avoid waste, rethink policies and incentives, redesign for waste elimination and ease of reuse and recovery, reduce toxicity

Manufacturing efficiency upgrades, material lightweighting & minimization, sustainable purchasing strategies, sharing, lending, product-as-a-service

Reuse, maintain, repair, refurbish, component salvage

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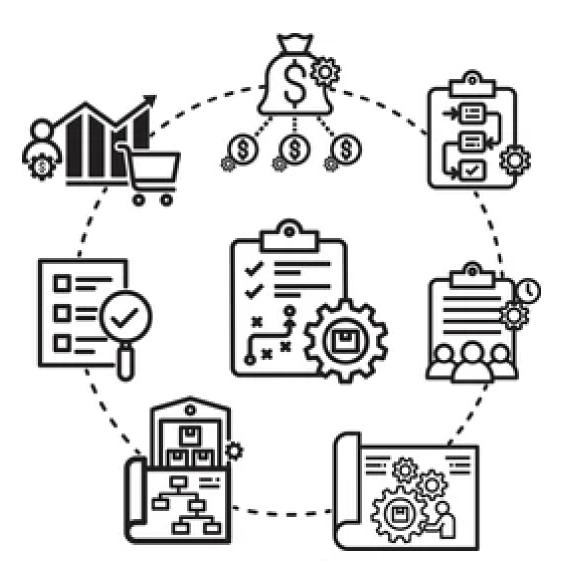
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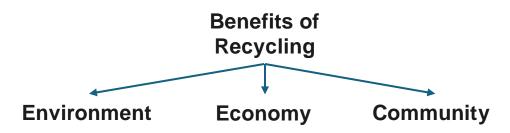
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Why recycling is so important?

Recycling is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products. Products should only be recycled if they cannot be reduced or reused.



TOGETHER, WE CAN MAKE A DIFFERENCE

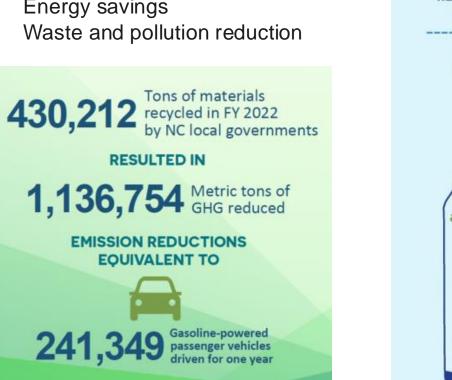
SMALL CHANGES IN BEHAVIOR CAN HAVE A BIG IMPACT ON OUR PLANETY

WHEN YOU THROW SOMETHING AWAY, WHERE DOES IT GO?



Environmental Benefits of Recycling:

- Conserve natural resources
- Climate change
- Energy savings
- Waste and pollution reduction

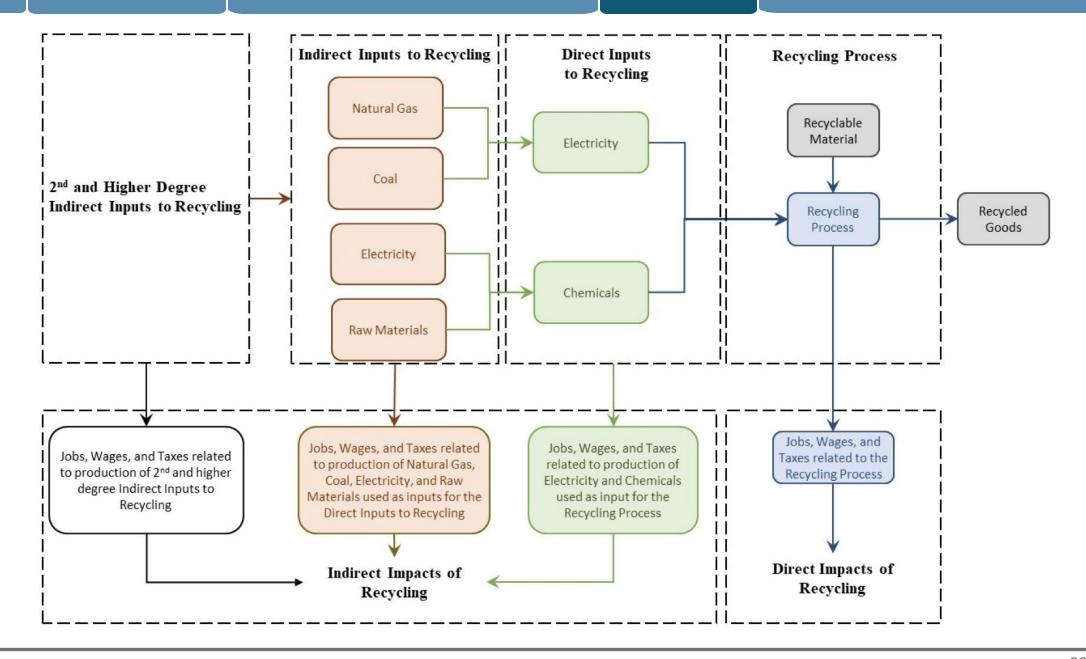


Calculated using the EPA's Waste Reduction Model.



ENERGY SAVED USING RECYCLED VS. RAW MATERIALS





In North Carolina, more than 15,700 people are directly employed by the state's private recycling industry with a total estimated annual payroll of \$759 million. Each step along the recycling process employs local workers. See the impact of plastic bottle recycling in the Carolinas.



Economic Impact	Units	US Total	Total Impacts Approach	
Total Economic Imp	acts			
Employment	# jobs	143,739,789	681,004	
Wages	\$1,000	\$6,568,987,567	\$37,837,425	
Tax Revenue	\$1,000	\$704,394,773	\$5,460,992	
Percent of Total				
Employment			0.47%	
Wages			0.58%	
Tax Revenue			0.78%	
Primary Factors				
Employment	jobs / 1000 s	hort tons	1.17	
Wages	\$ / short ton		\$65.23	
Tax Revenue	\$ / short ton		\$9.42	

Problems with recycling?

Step 1: A material recovery facility decides which products to accept.



Step 2: Consumers buy products, then dispose of waste and recyclables.

Step 3: A logistics company does curbside recyclable collection.













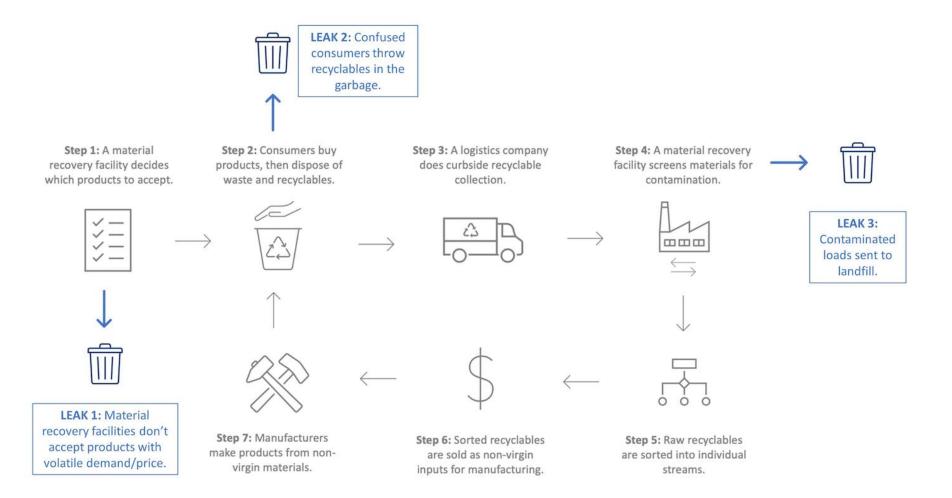
Step 7: Manufacturers make products from nonvirgin materials.

Step 6: Sorted recyclables are sold as non-virgin inputs for manufacturing.

Step 5: Raw recyclables are sorted into individual streams.



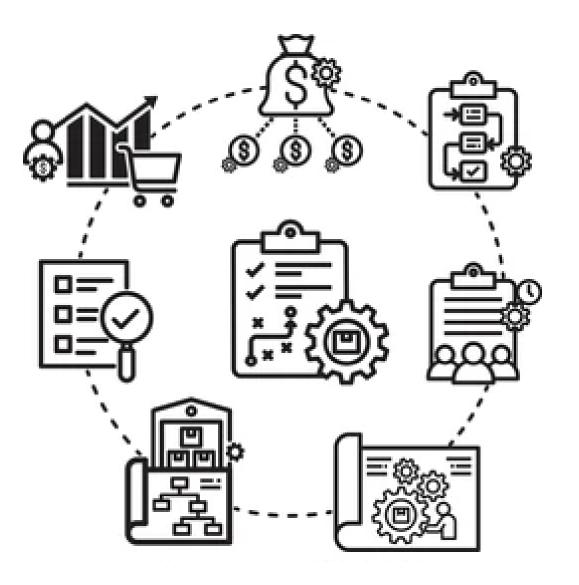
Problems with recycling?



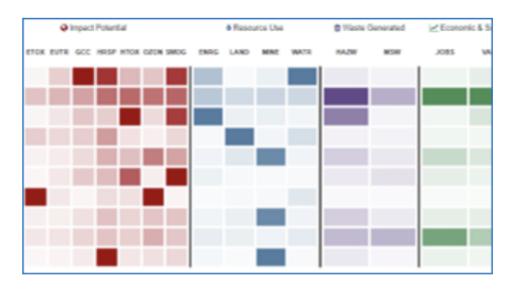
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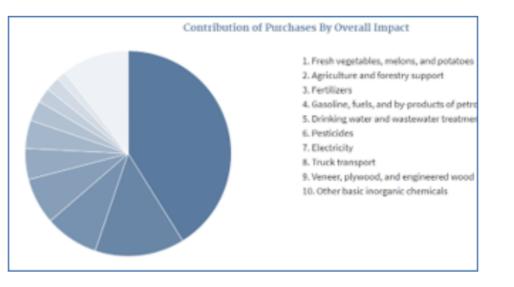
National



Big picture view for anyone with a national focus, such as government, trade associations and NGOs.

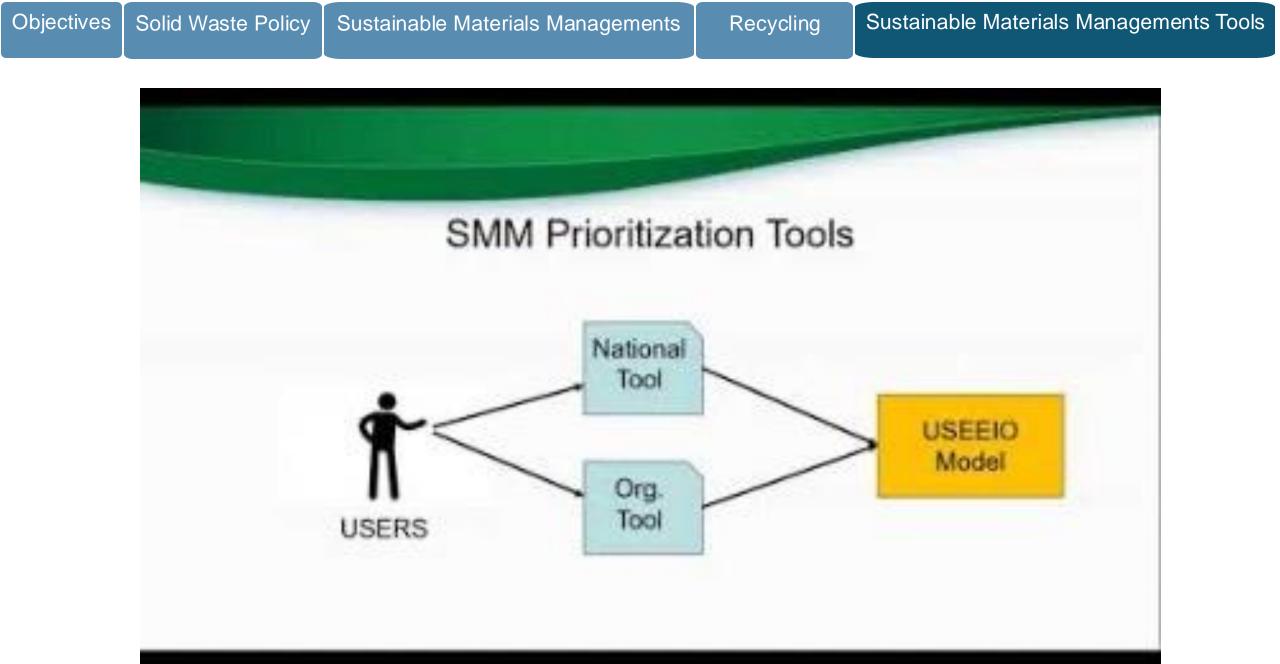
Get Started

Organizational



Quick snapshots for organizations, such as companies, small enterprises and their sustainability/procurement staff.

Get Started



 SMM Prioritization Tools: user interfaces that access, extract and display information from the United States Environmentally-Extended Input-Output (USEEIO) model.

Who are the intended users?

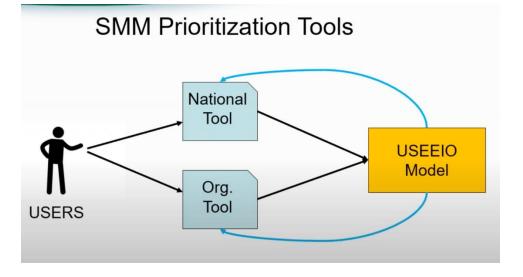
Solid Waste Policy

Objectives

- USEEIO model: fully transparent, reproducible and freely shareable life cycle assessment model that assesses over twenty indicators associated with ~386 categories of goods/services produced or consumed in the US.
- **Provides big-picture** information about potential environmental improvement opportunities in the United States and opportunities for benefits across a range of indicators.

Individuals who are looking for environmental improvement opportunities or developing sustainability strategies, including:

- Individuals who are not in the field of life cycle assessment.
- Organizations who do not have the resources to hire consultants.
- CEOs, procurement and sustainability professionals.
- Government.
- Non-profits.
- Trade associations.
- Academic institutions.



Waste Reduction Model (WARM)

WARM calculates and totals GHG emissions of baseline and alternative waste management practices—source reduction, recycling, anaerobic digestion, combustion, composting and landfilling.

Waste Redu	ction Mod	del (WAF										
			RM)									
cenarios		2 Further Char	racteristics		3 04	eneral information			4 Calculati	on .		
enter data in short tons (1 short ton + 2,0 ine Scenarie: Describe the baseline gene				and a set second second	the second second second second	stands and shall be a						
ative Scenarie: Describe the alternative r					a se your consideray of	por so not said to a	age to the tas					
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h input row will be validated to sum up	correctly. The tons ge	enerated in the bas	seline scenario must	match the tons gen	erated in the alterna	etive scenario.						
w is valid if the sum of tons entered in the I							olumns. For example	, if the Daseline Sce	nario assumes that 10	0 tons of aluminum	ans are landfiled, th	s is the Tons
rerated value. To generate valid results, all	values entered in the Al	ternative Scenarios ci	olumns must add up to	100 tons to equal the	Tons Generated value	e.						
	_						_		100000			
	_		Baseline Scenary							re Scenario		
Material	Tons Recycled	Tons Landfilled	Essetine Scenario Tons Combusted	Tons Composted	Tona Anaerobically Digested	Tons Generated	Tons Source Reduced	Tons Recycled	Atternation Tons Landfiled	Tons Combusted	Tons Composited	Tons Anserobically Digested
Material Compaled Containers			Tons	Tons	Anaerobically		Source		Tons	Tons		Anaerobically
	Recycled	Landfilled	Tons Combusted	Tons Composted	Anaenobically Digested	Generated	Source Reduced	Recycled	Tons Landfilled	Tons Combusted	Composited	Anaerobically Digested
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Compated Containers Magazines/Third-class Mail Newspaper	Recycled 0	Landfilled	Tons Combusted	Tons Composted N/A N/A	Anaenobically Digested N/A	Generated 0 0	Source Reduced 0	Recycled	Tons Landfilled	Tons Combusted	Composited NA NA	Anserobically Digested NA NA
Consigned Containers Magazines/Third-class Mail Newspaper Office Paper	Recycled 0	Landfilled	Tons Combusted	Tons Composted N/A N/A N/A	Anaerobically Digested N/A N/A	Cenerated 0 0 0	Source Reduced 0	Recycled	Tons Landfilled	Tons Combusted	Composited NIA NA NA	Anaerobically Digested N/A N/A N/A
Compated Containers Magazines/Third-class Mail Newspaper Øfice Paper Phonebooks	Recycled 0 0 0 0	Landfiled 0 0 0 0	Tens Combusted	Tons Composited N/A N/A N/A N/A	Anaerobically Digested N/A N/A N/A N/A	Cenerated 0 0 0 0	Source Reduced 0 0	Recycled	Tons Landfilled	Tons Combusted 0 0 0	Composited NA NA NA NA	Anserobically Digested NA NA NA NA NA
Consigned Containers Magazines/Third-Cases Mail Nenspaper Office Paper Pronebooks Tectbooks	Recycled 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Landfiled 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Tens Combusted	Tons Composited NA NA NA NA NA	Anaerobically Digested NA NA NA NA NA	0 0 0 0 0 0 0 0	Source Reduced 0 0 0 0	Recycled	Tons Landfilled	Toms Combusted 0 0 0 0 0	Composted NA NA NA NA NA	Anaerobically Digested NA NA NA NA NA NA
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Tools for Preventing and Diverting Wasted Food

By EPA's wasted food using tools. food service assessment establishments can save money, reduce environmental impacts, support efforts to eliminate hunger, increase tax benefits, and more. EPA provides a variety of wasted food assessment tools to suit a food establishment's unique service circumstances.

EPEAT Benefits Calculators

GEC's interactive environmental benefits calculator allows purchasers to measure and report the environmental benefits gained from purchasing electronic products covered by the EPEAT ecolabel. The benefits calculator also enables purchasers to estimate how they can achieve further environmental reductions by using products longer and responsibly recycling them when taken out of service.

Wasted Food Scale €EPA How to reduce the environmental impacts of wasted food 🖸 DO AVOID Prevent Wasted Food Send Down the Drain, Landfill, or Incinerate Produce, buy, and serve only what is needed with or without energy recovery Anaerobic Digestion Donate Upcycle Apply to the Land Feed Compost Animals Anaerobic Leave Digestion Unharvested with beneficial use of

Number of Units Purchased by EPEAT Level	
Bronze	
Silver	
Gold	
Region of use 0	Select +
Optional Data Entry	
Electricity 0	
Unit energy cost during use (cost/kWh) ()	
Energy cost during use (specify currency) 0	Select \$
Extended Product Use, Donating the Product for Reuse, and Recycling ()	
How long do you plan to use the products on average (in months)?	(22.7 minimum)
How many of the products purchased above do you plan to donate for reuse by another user? 0	
How many of the products purchased above do you plan to recycle at the end of service? 0	
Number of phones disposed of at end of life 0	
Average weight per unit (grams) 0	

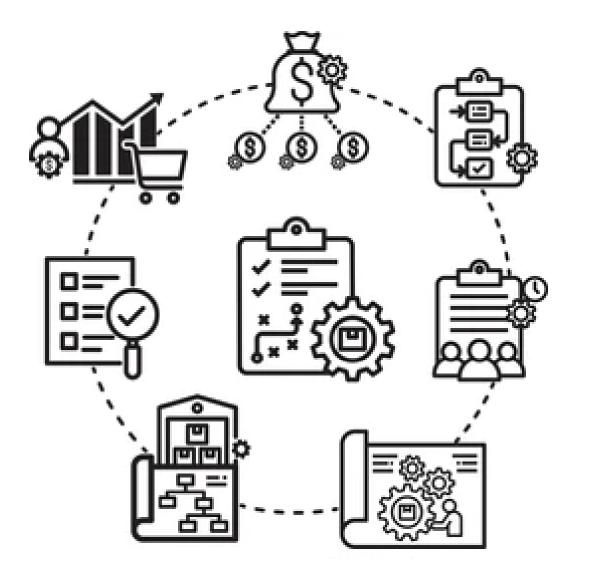
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Comprehensive Procurement Guideline (CPG) Program



The Comprehensive Procurement Guideline (CPG) program is part of EPA's Sustainable Materials Management initiative that promotes a system approach to reducing materials use. A key component of the CPG program is EPA's list of designated products and the accompanying recommendations for recovered content, both post-consumer material content and/or total recovered material content.

Construction Products: Building insulation, Carpet (polyester), Carpet cushion, Cement and concrete, Consolidated and reprocessed latex paint, Floor tiles, Flowable fill, Laminated paperboard, Modular threshold ramps, Nonpressure pipe, Patio blocks, Railroad grade crossing surfaces, Roofing materials, Shower and restroom dividers/partitions, Structural fiberboard, Proposed: Nylon carpet and nylon carpet backing

Landscaping Products: Compost and fertilizer made from recovered organic materials, Garden and soaker hoses,

Hydraulic mulch, Lawn and garden edging, Plastic lumber landscaping timbers and posts

<u>Miscellaneous Products</u>: Awards and plaques, Bike racks, Blasting grit, Industrial drums, Manual-grade strapping, Mats, Pallets, Signage, Sorbents

Nonpaper Office Products: Binders, Clipboards, File folders, Clip portfolios, Presentation folders, Office furniture, Office recycling containers, Office waste receptacles, Plastic desktop accessories, Plastic envelopes, Plastic trash bags, Printer ribbons, Toner cartridges

Paper and Paper Products: Commercial/industrial sanitary tissue products, Miscellaneous papers, Newsprint, Paperboard and packaging products, Printing and writing papers

Park and Recreation Products: Park benches and picnic tables, Plastic fencing, Playground equipment, Playground surfaces, Running tracks

<u>Transportation Products</u>: Channelizers, Delineators, Flexible delineators, Parking stops, Traffic barricades, Traffic cones <u>Vehicular Products</u>: Engine coolants, Rebuilt vehicular parts, Re-refined lubricating oils, Retread tires



Recommended Recovered Materials Content Levels for Building Insulation¹

Product	Material	Postconsumer Content (%)	Total Recovered Materials Content (%)
Rock Wool	Slag		75
Fiberglass	Glass Cullet		20-25
Cellulose Loose-Fill and Spray-On	Postconsumer Paper	75	75
Perlite Composite Board	Postconsumer Paper	23	23

The recommended recovered materials content levels are based on the weight (not volume) of materials in the insulating core only. The heatmap below shows potential areas of significant opportunity for environmental improvement for individual goods and services. Those goods and services (down the left side) are ranked by overall environmental, human health and socioeconomic impacts (across the top) based on the selected analysis settings.



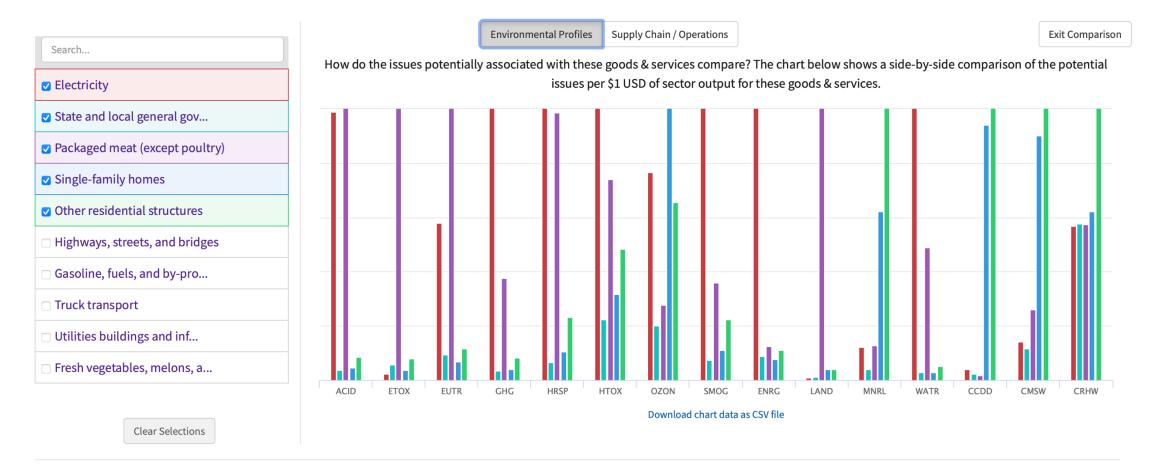
Display 10 -

Comparison Analysis 🗸



What's this?

Compare Goods & Services





Organizational SMM Prioritization Tool

If you have any questions, suggestions or feedback to help make our tools more useful, please use this <u>contact us</u> link.

- <u>Select Good/Service</u>
- Environmental Profile
- Supply Chain/Operations
- Impactful Purchases
- Supply Chain Hotspots
- <u>Summary</u>

What's this?

Select the primary good or service provided by your organization

Enter keywords here to describe your organization

Select an option from a list

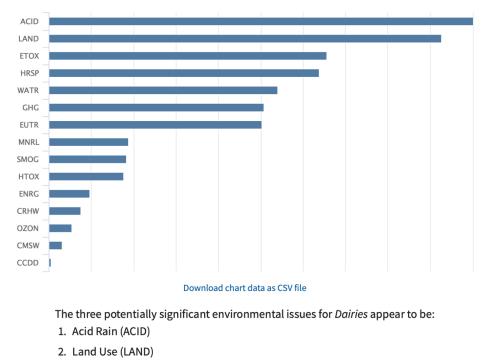
Select the primary good or service provided by your organization

Enter keywords here to describe your organization	
Fresh soybeans, canola, flaxseeds, and other oilseeds	
Fresh wheat, corn, rice, and other grains	
Fresh vegetables, melons, and potatoes	
Fresh fruits and tree nuts	
Greenhouse crops, mushrooms, nurseries, and flowers	
Tobacco, cotton, sugarcane, peanuts, sugar beets, herbs and spices, and other crops	
Cattle ranches and feedlots	
Dairies	
Animal farms and aquaculture ponds (except cattle and poultry)	
Poultry farms	



What are the potentially significant environmental issues associated with *Dairies*?

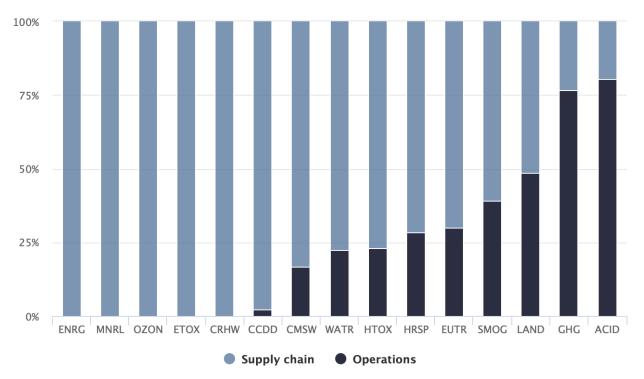
The Environmental Profile below shows the issues potentially associated with *Dairies* from high to low significance. Level of significance is based on a good or service's contribution to the overall issues in the US.



3. Freshwater Aquatic Ecotoxicity (ETOX)

Where are the potential issues originating from for this good or service?

The chart below shows the share of environmental issues associated with operations and the supply chain for this good or service.

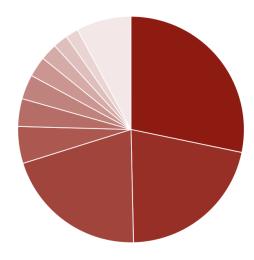


Sustainable Materials Management Prioritization Tools



Contribution of Purchases By Indicator

Acid Rain (ACID)	0



Download chart data as CSV file

1. Other animal food

2. Fresh wheat, corn, rice, and other grains

3. Cattle ranches and feedlots

4. Tobacco, cotton, sugarcane, peanuts, sugar beet...

- 5. Electricity
- 6. Agriculture and forestry support
- 7. Animal farms and aquaculture ponds (except catt...

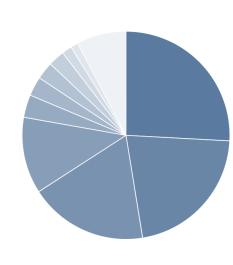
8. Truck transport

9. Water transport (boats, ships, ferries)10. Gasoline, fuels, and by-products of petroleum r...



The charts below show the direct purchases potentially contributing to overall environmental issues (first chart) and each individual issue (second chart). Click on a good or service in the charts or lists to get more information.

Contribution of Purchases By Overall Impact



1. Other animal food

2. Tobacco, cotton, sugarcane, peanuts, sugar beet...

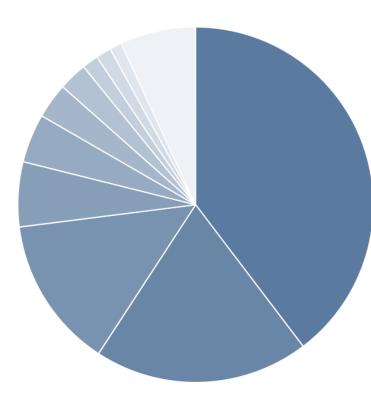
3. Fresh wheat, corn, rice, and other grains

- 4. Cattle ranches and feedlots
- 5. Dimensional stone
- 6. Vegetable oils and by-products
- 7. Agriculture and forestry support
- 8. Gasoline, fuels, and by-products of petroleum r...
- 9. Electricity
- 10. Truck transport

Sustainable Materials Management Prioritization Tools



Dairies, Fresh wheat, corn, rice, and other grains and Tobacco, cotton, sugarcane, peanuts, sugar beets, herbs and spices, and other crops are potentially the most significant hotspots for environmental issues in the supply chain of Dairies:



1. Dairies

2. Fresh wheat, corn, rice, and other grains
 3. Tobacco, cotton, sugarcane, peanuts, sugar beet...

4. Cattle ranches and feedlots

5. Fresh soybeans, canola, flaxseeds, and other oi...

6. Dimensional stone

7. Unrefined oil and gas

8. Agriculture and forestry support

9. Electricity

10. Truck transport