Waste is a Design Flaw

ENGR 1501 FALL 2023 - Week 10

Attendance

Today's Agenda

1. CLASS PROJECT
2. 3D PRINTING: HOW IT WORKS
3. TOOLS FOR 3D PRINTING
4. 3D MODELING WORKSHOP

Course Objectives

- Learn how waste creation is designed into our linear economy
- Understand engineering frameworks for designing “out” waste and designing with waste
- Explore what main components make up electronics and how to work them
- Create a Circular Engineering outline for an E-waste product

Assembly Ideas

Past due

Please list all of your ideas (wild and crazy encouraged!) for builds to create from the components you salvage
(you are able to have some additional pieces but the build should rely primarily on the salvaged pieces)

Pick your top 3 (can prioritize marketability, ease of creation, creativity, etc.)

Assembly Goal and alternative ideas

Due tonight

What is your ideal design from your ideation list?

What else is needed?

Tools/expertise

Drawings!!!/ inspiration

How each component can be used

Due 11/15

For each component you salvaged, what is a possible use?

For components not listed in the assembly, how would you use them?

It's okay to not know for each but the ones unused should be identified and ideas should be given.

Be creative! Leave no trace recycling!

List what components are used in your assembly. For those not listed, give an example of how else they could be used

Assembly Guide and Design

Due 11/22

Steps for how to assemble what you envision

This section is where we can see a lot of variance. The actual creation is not required but I am looking for effort on thinking out the process. Can be drawn, written, several slides, etc. This is the biggest part of the project.

Value Generated and Waste Removed

Due 11/29

What is the marketability of your design?

What value does your assembled product create/save?

What amount of waste did you reduce?

What would someone have learned through your disassembly and assembly?

How are slides going?

- Where are you stuck?
- Would an office hours help?
- What else do you want to learn?

3D Printing/Modeling

Who has experience with 3D modeling?

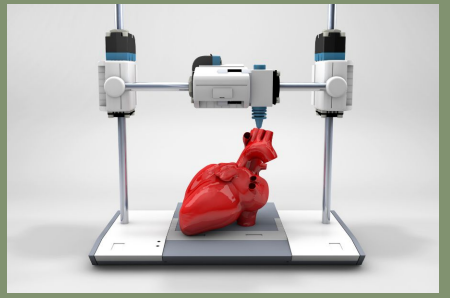
How do you think of 3D Printing?

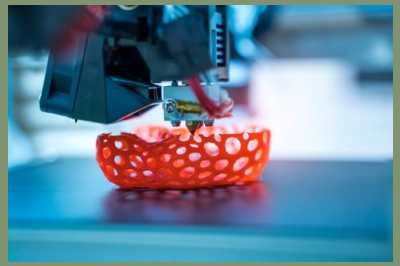
Why would I want to 3D print?

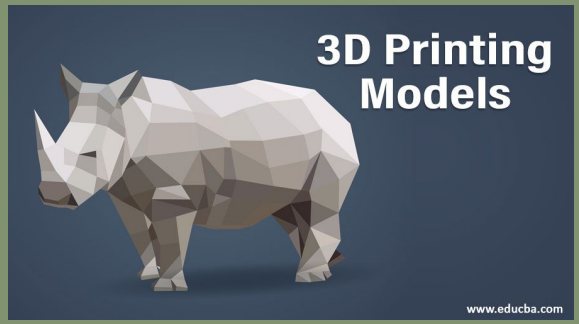
Making a prototype is tough work. Your other options for construction materials are cardboard, wood, foam, hot glue, etc.

These can be hard to work with and really costly (in money and time) (also tears).

3D printing offers a cheap, quick, and reliable method. With innovations in material allowing for many different uses







Use of 3D Printing

Prototypes

Arts

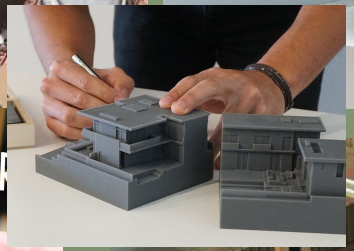
Bio-printing

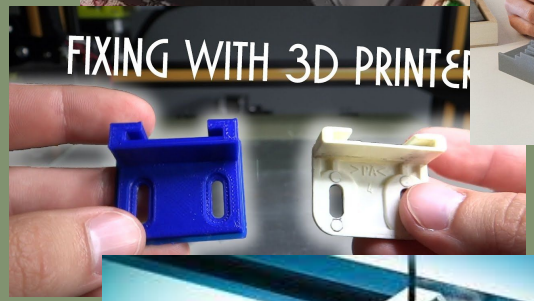
Specific Parts

Repair

Models

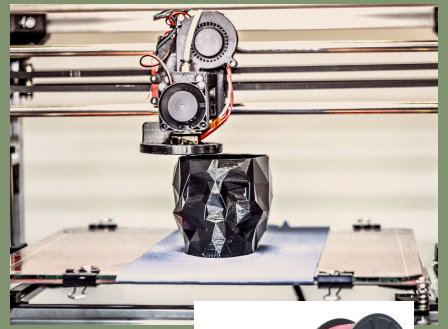
Houses & more!

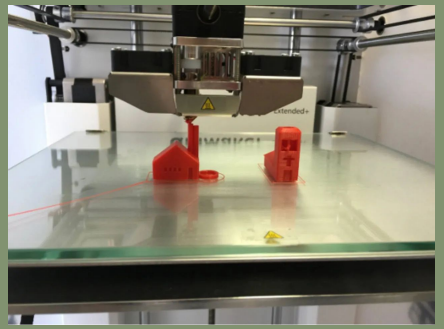


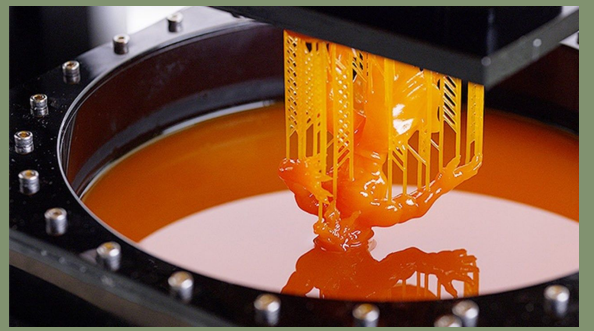


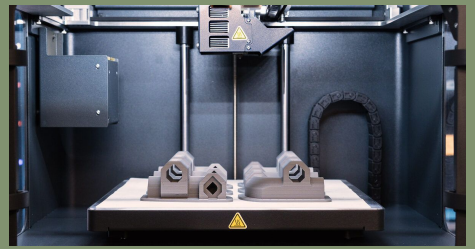
Types of 3D Printing

1. Types and how they work
    a. Standard (FDM) : Plastic filament is extruded to create layers that build up to the product
    b. Resin (SLA): Cures liquid plastic (hardens it with UV light) to build product upside down
    c. Metal / Powder: Printer loads metal powder and uses a layer to create layers of build





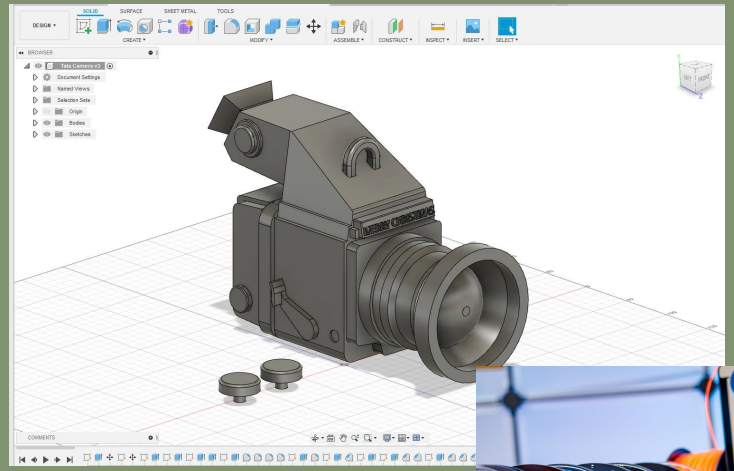


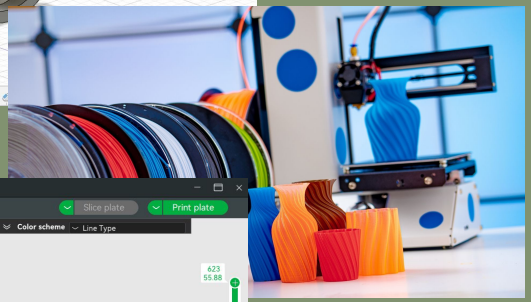


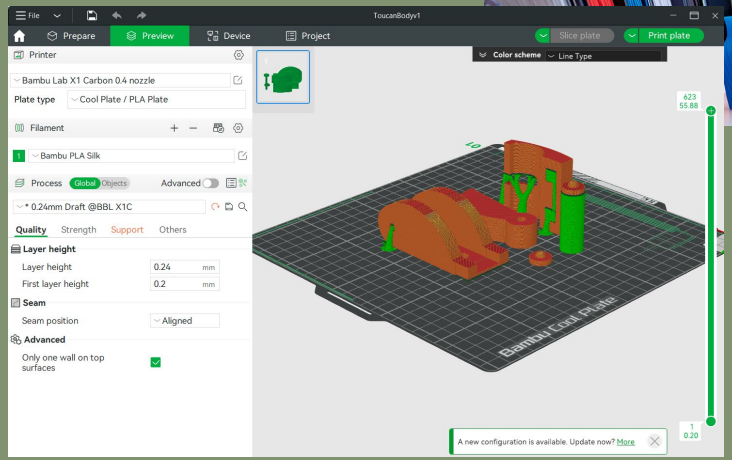
Standard 3D Printing

1. Steps
    a. Designing part (fusion 360)
    b. Loading filament (PLA)
    c. Slicing part (cura slicer)
    d. Printing

Can skip the design by finding parts online thingiverse.com







3D Printing at UVA

Difficult to get into...

Have you tried?

What do you need?

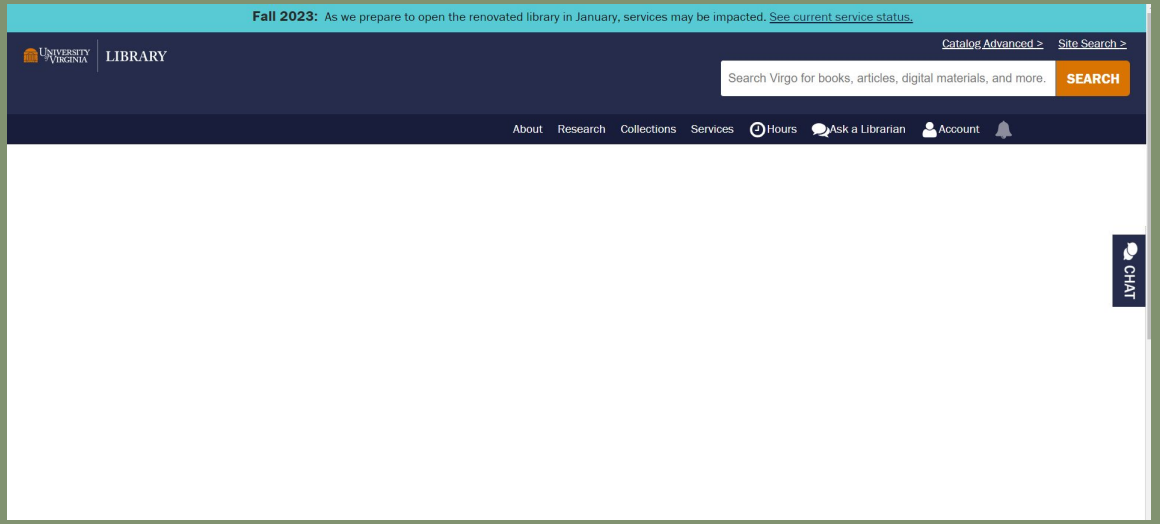
-Access to a printer

-Filament

-Workshops?

-Maintenance

What would you want to print?



How to 3D Print your idea

I have access to 3D printers, so consider the step of finding a printer done!

The most important things to consider is:

How does the piece look on a slicer?

Explanation: how easy is this to print?

Printing your 3D model

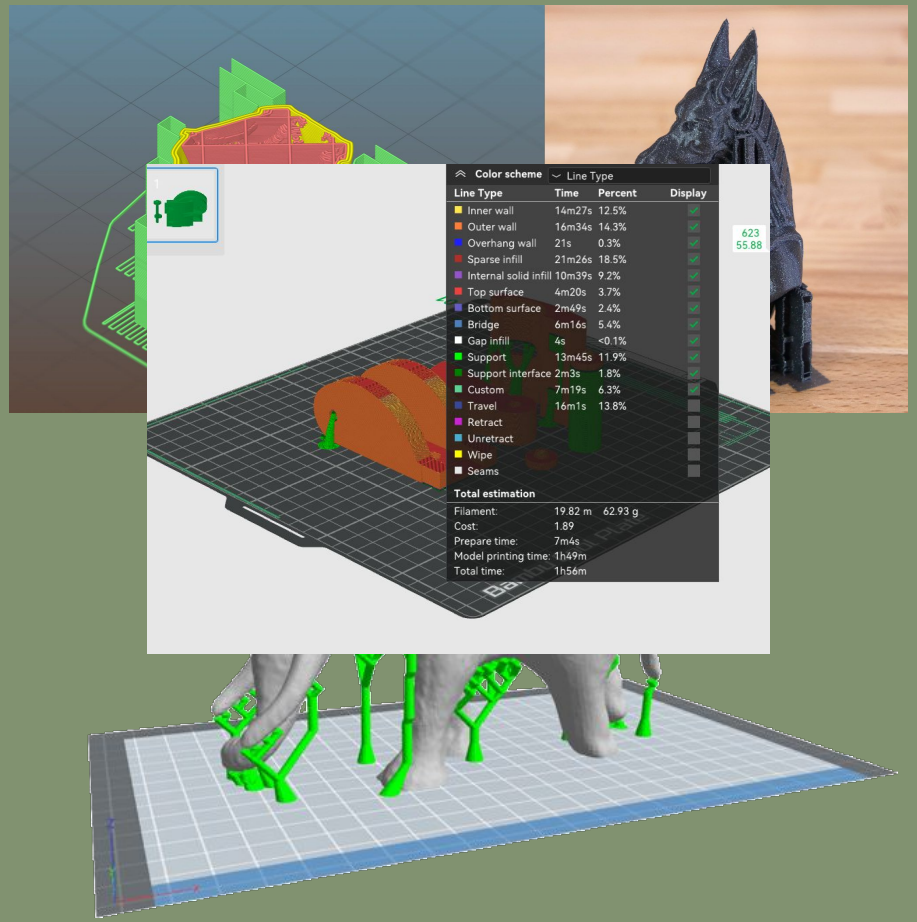
Ultimaker Cura Slicer:

Import the downloaded file (stl format)

Hit slice

Printing something complex?

You may need supports (choose tree)

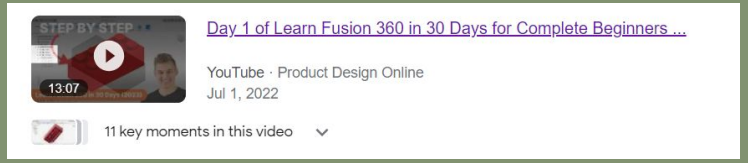


Want to model your idea?

I have access to 3D printers, so consider the step of finding a printer done!

The most important things to consider is:

How will it print? (explained in workshop)



Learning:

- Online tutorials are great for introducing you to the different tools in the modeling software
- I recommend fusion360 first then blender if you want something harder/more robust

Let’s Break Down an Object

What components are in this toucan lamp?

What does each component need to do?

1. Eye
2. Beak
3. Body
4. Feet

What does each part need to do?

1. Eye
    a. Button?
2. Beak
    a. Rotate?
    b. Hold lightbulb
3. Body
    a. House cord
4. Feet
    a. Support Lamp

What does each part look like?

1. Eye
    a. Button?
2. Beak
    a. Rotate?
    b. Hold lightbulb
3. Body
    a. House cord
4. Feet
    a. Support Lamp

What does each part look like?

1. Eye (concentric circle with half sphere houses axle for beak)
    a. Button?
2. Beak (oval box with open side flat, attach lightbulb holder)
    a. Rotate?
    b. Hold lightbulb
3. Body (Same as beak but open side is the curved side, hole for cord)
    a. House cord
4. Feet (side view extruded with one cut for toes after)
    a. Support Lamp

What does each part look like?

Now, talk me through what you would do for each part.

- What would you draw?
- What would you use to make it 3D
- How would you get it to perform its desired function?
- How do they assemble together?

3D Modeling

Fusion 360 is parametric modeling

- Shaped by dimensional modeling, not free sculpting (Blender)
- Design with least steps in mind
    - Which shape captures the most of the design
- Design in stages rather than one complete sketch
    - Break down into components

Other method: Surface modeling (worth the google)

Fusion 360 Basics

Sketches:

- Every 3D design must start with a sketch
- Sketches can be dimensioned by hitting “D” then click sides
- A constrained side becomes black
    - Over-constraining is applying dimensions when it contradicts another dimension

Fusion 360 Basics

Sketches:

- Project
    - Incorporate forms from another sketch/body
- Spline
    - Non-uniform line from points
    - Less points the better

Fusion 360 Basics

Creating 3D Bodies from Sketches

- Extrude
    - Sketch grows out of itself in a single direction
    - Can be used to cut, combine, or create new bodies
- Revolve
    - For rounded objects, revolve a sketch around an axis (picture a half circle rotated around its flat side to make a sphere
- Loft
    - Difficult but fun. Creates a body between two sketches that are separated by offset planes

Fusion 360 Basics

- Combine
  - You can design separates parts and then use Move or Align to assemble the pieces
  - Combine can be used to combine parts, or to use one part to cut a hole out of another
- History Bar (bottom of screen)
  - This allows you to go back and edit previous steps
  - Benefit of parametric design

Fusion 360 Basics

Tutorial on how to make a class ring:

UVA Class Ring Tutorial

(good addition to what you've done for ENGR1624)

Also available for any questions you may have

Thought for the class:

"Everybody needs a passion. That's what keeps life interesting. If you live without passion, you can go through life without leaving any footprints."

-Betty White

Recommended Media:
“Why we all need to have more fun”

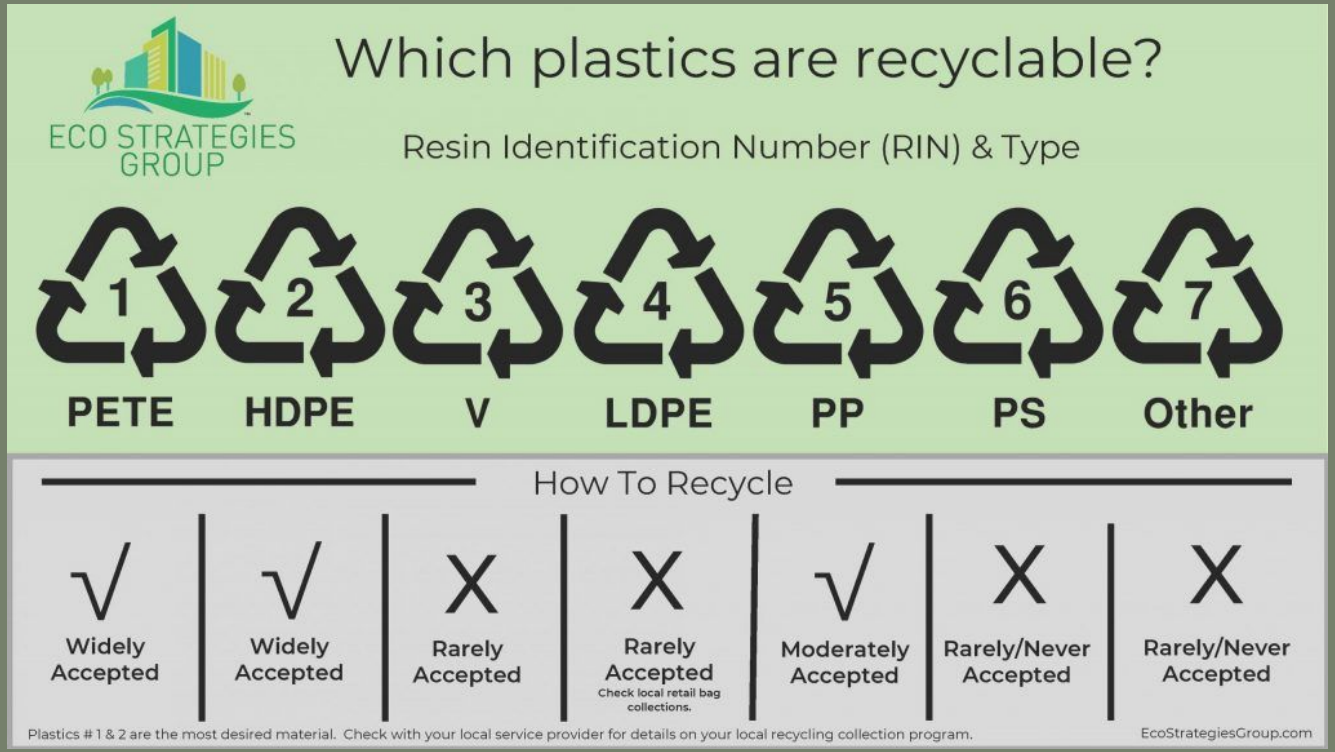
Appendix Slides

Type of Plastics: Broad

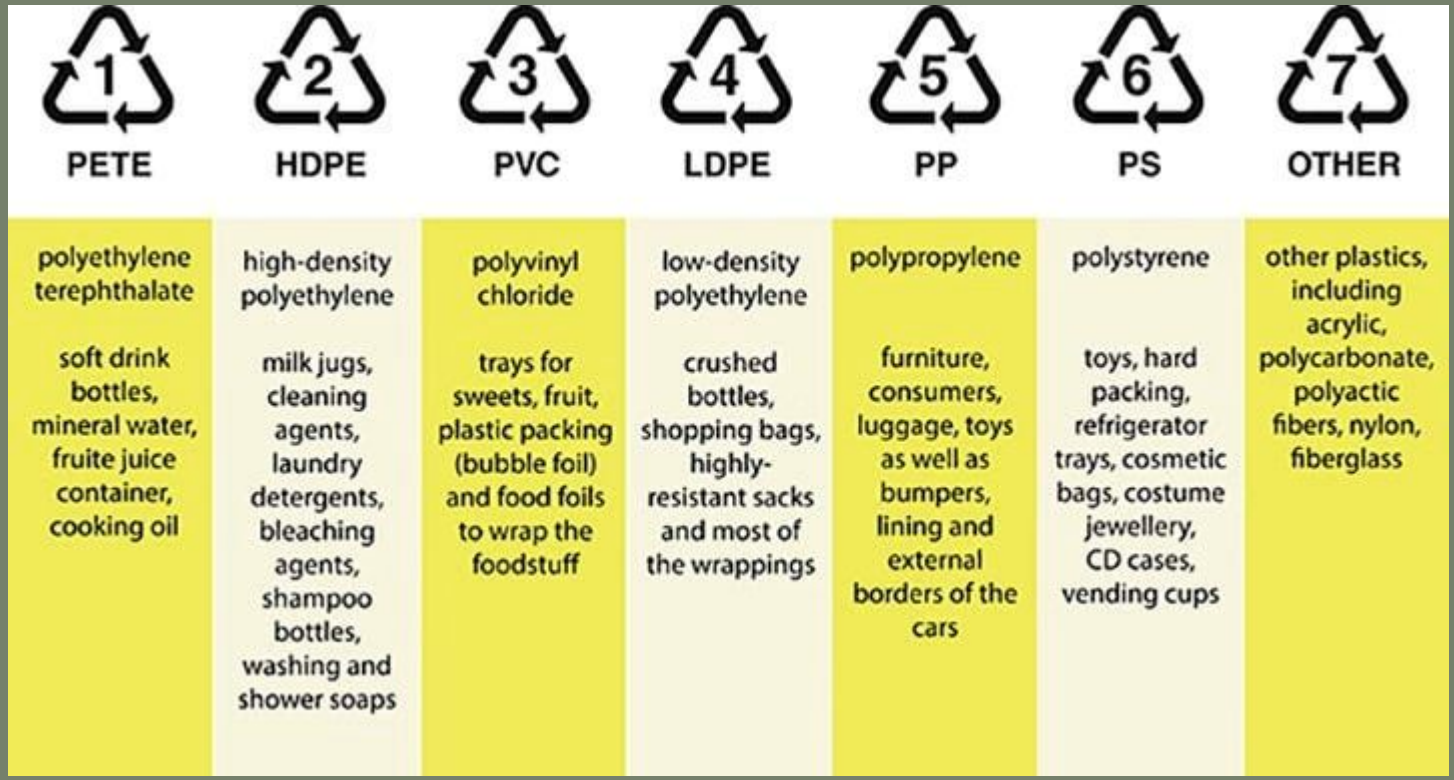
- **Thermoplastics** soften on heating and harden on cooling. Examples include polyethylene (PE), polypropylene (PP), polytetrafluoroethylene (Teflon), polyethylene terephthalate (PET), polyamide (PA), polyvinyl chloride (PVC) and polystyrene (PS).
- **Thermosets** never soften once they have been molded. Examples include Epoxy resins, polyurethane (PU), polyester resins, and Bakelite.
- **Elastomers** are elastic in character, so they can return to their original shape after stretching. Examples include rubber and neoprene.

Microplastics - less than 5mm

Type of Plastics: Numbers and Initials



Type of Plastics: Numbers and Initials



1	2	3	4	5	6	7
PETE	HDPE	PVC	LDPE	PP	PS	OTHER
polyethylene terephthalate soft drink bottles, mineral water, fruite juice container, cooking oil	high-density polyethylene milk jugs, cleaning agents, laundry detergents, bleaching agents, shampoo bottles, washing and shower soaps	polyvinyl chloride trays for sweets, fruit, plastic packing (bubble foil) and food foils to wrap the foodstuff	low-density polyethylene crushed bottles, shopping bags, highly-resistant sacks and most of the wrappings	polypropylene furniture, consumers, luggage, toys as well as bumpers, lining and external borders of the cars	polystyrene toys, hard packing, refrigerator trays, cosmetic bags, costume jewellery, CD cases, vending cups	other plastics, including acrylic, polycarbonate, polyactic fibers, nylon, fiberglass

Current Plastic Recycling

1. Sort
2. Wash
3. Shred
4. Melt
5. Pellet

Precious Plastic

Teardown Steps

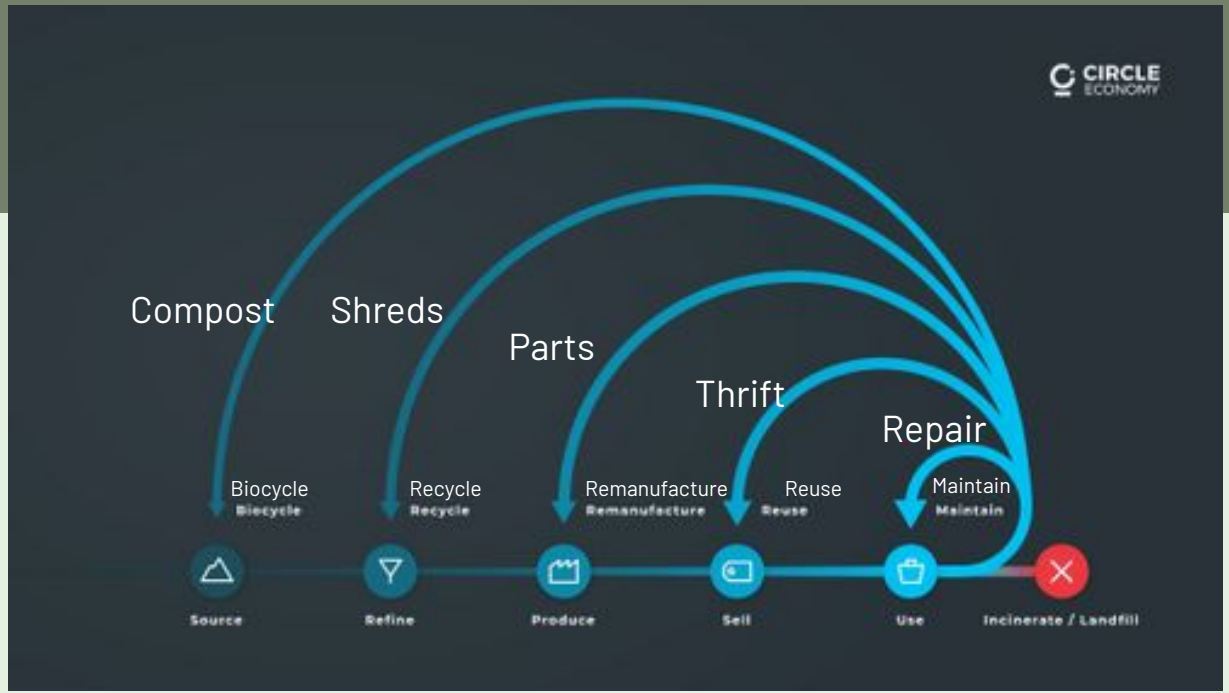
1. Safety
2. Disassembly
3. Identification
4. Sorting

E-Waste Recycling Process

1. Collection
2. Storage
3. Disassembly
    a. Data Deconstruction
    b. Toxic Waste Removal
4. Recovery (Recycle, Remanufacture, etc.)
5. Reintegration (Donation/Selling)

CIRCLE ECONOMY

Common Language for reintegration process



Class Naming Convention of 12 Principles

1. Safety First
2. Prevention
3. Low resource separation and purification
4. Optimization
5. Limit Extraneous thinking
6. Hard Work to Salvage Gold
7. Realistic Design Goals (Durability)
8. Necessary design
9. Minimize material diversity
10. Integration and interconnectivity of resources
11. Long-term designing
12. Renewable sources

The 12 Principles of Green Engineering

Principle 1: Designers need to strive to ensure that all material and energy inputs and outputs are as inherently nonhazardous as possible.

Principle 2: It is better to prevent waste than to treat or clean up waste after it is formed.

Principle 3: Separation and purification operations should be designed to minimize energy consumption and materials use.

Principle 4: Products, processes, and systems should be designed to maximize mass, energy, space, and time efficiency.

Principle 5: Products, processes, and systems should be "output pulled" rather than "input pushed" through the use of energy and materials.

Principle 6: Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse, or beneficial disposition.

Principle 7: Targeted durability, not immortality, should be a design goal.

Principle 8: Design for unnecessary capacity or capability (e.g., "one size fits all") solutions should be considered a design flaw.

Principle 9: Material diversity in multicomponent products should be minimized to promote disassembly and value retention.

Principle 10: Design of products, processes, and systems must include integration and interconnectivity with available energy and materials flows.

Principle 11: Products, processes, and systems should be designed for performance in a commercial "afterlife".

Principle 12: Material and energy inputs should be renewable rather than depleting.

Through *the* 12 Principles GREEN *Engineering*

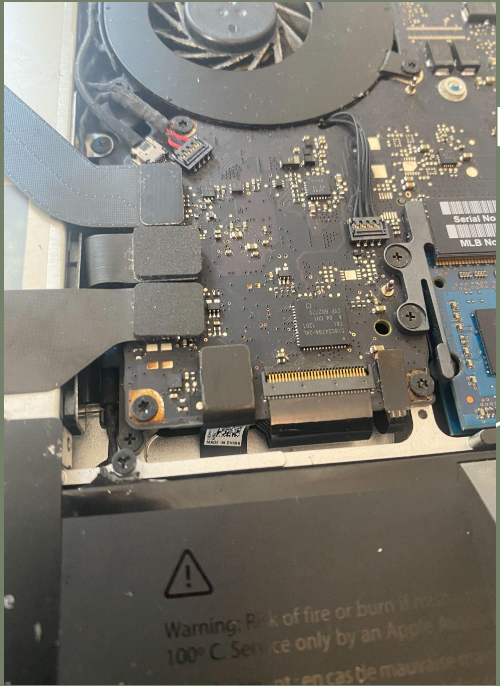
Let's make a memorable summary phrase/word for each principle so they can be easily referenced

We will also go through any questions you all have on the principles for how to implement and what they mean.

We will be testing Miro for this, so please go to the announcements page on Collab

How Companies Design Waste?

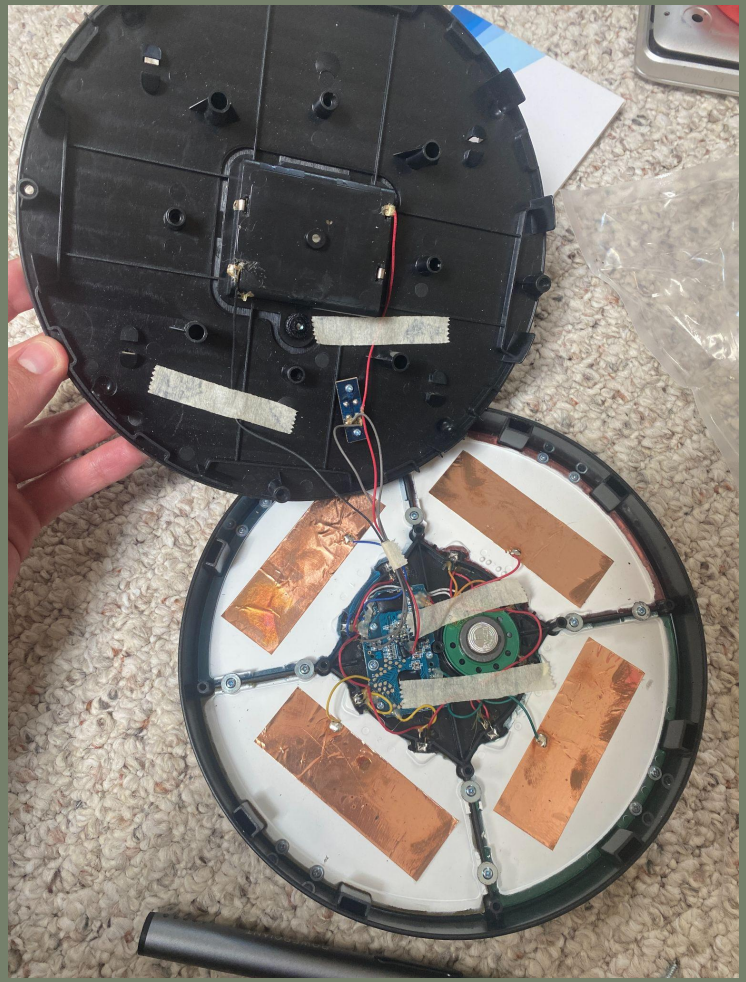
1. Hardware
2. Software
3. System

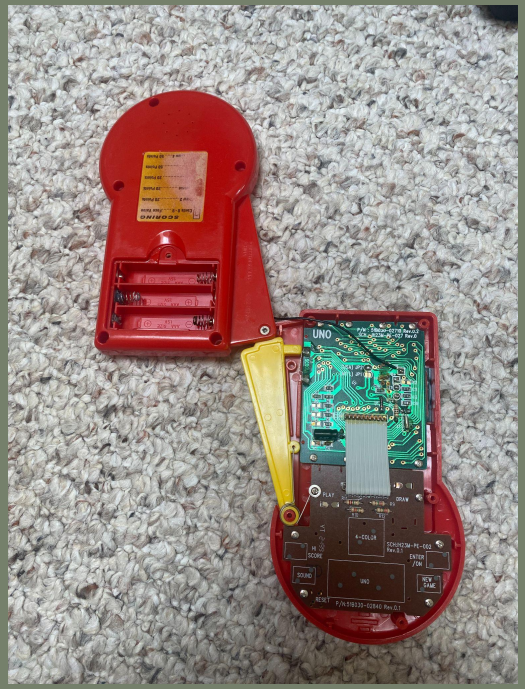

Serial No
MLB No

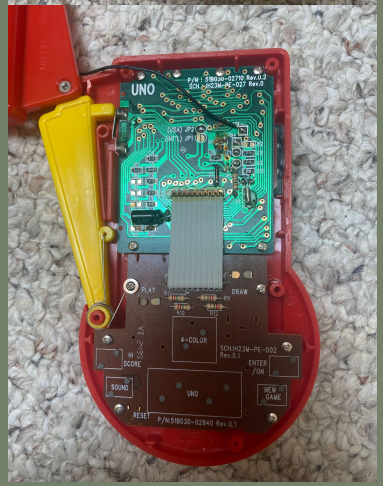

HGST
www.hgst.com
HGST Japan,Ltd.
Don't shock/
push cover
SATA
5400RPM
5V 700mA
500GB 2.5inch AT 7mm

Macbook Air


Serial No
MLB No
MADE IN CHINA







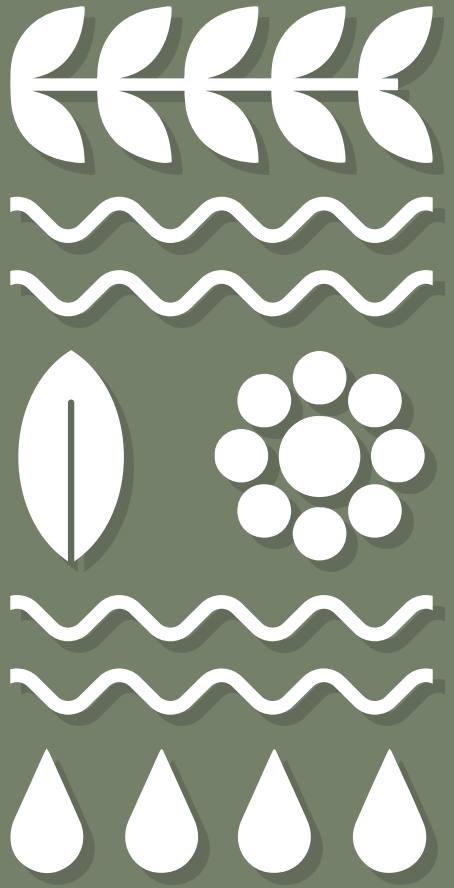
Simon Game

Uno Game

That means each year we waste 90 billion tons of resources. This also means that we create 90 billion tons of potential resources.

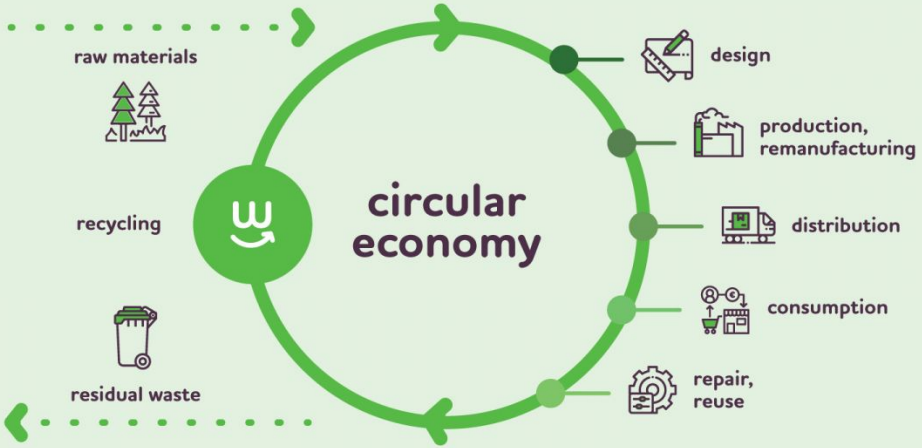
The current dominant economy is linear in its processes: it takes resources, makes goods, and quickly wastes them.

-CIRCLE REPORT, 2021



CIRCLE ECONOMY

The circular economy is an economic system where waste is designed out, everything is used at its highest possible value for as long as possible and natural systems are regenerated.



These 2 will be our main focus

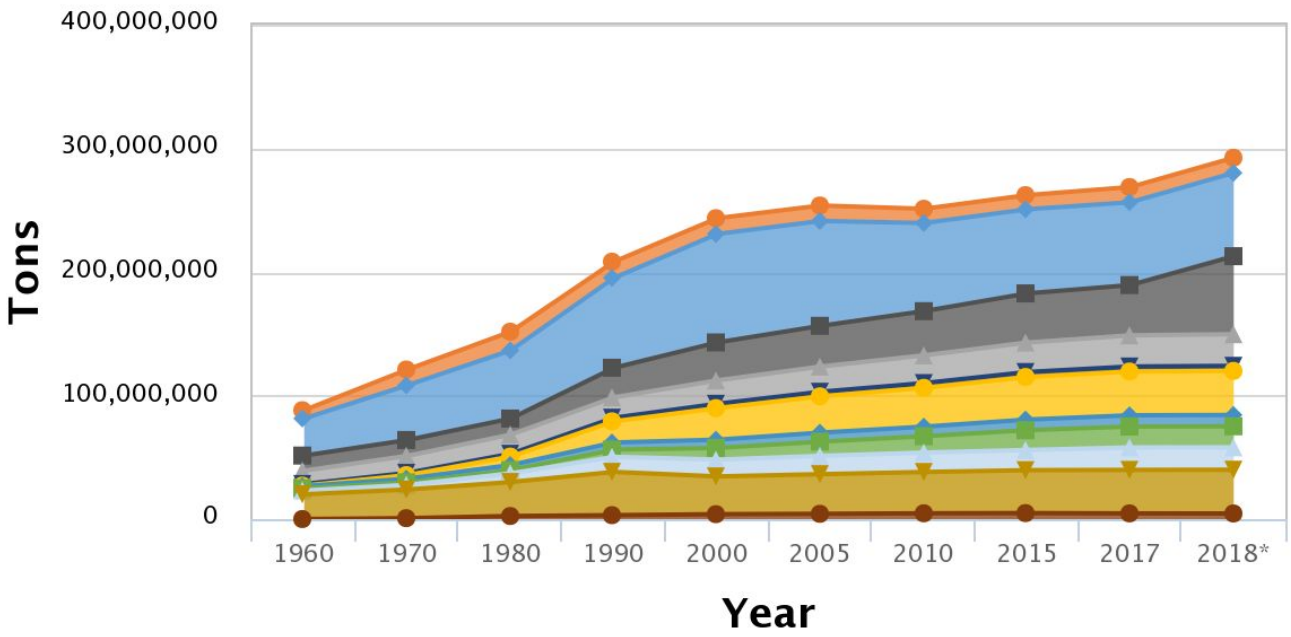
USE **WASTE** AS A RESOURCE

Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.

STRETCH THE LIFETIME

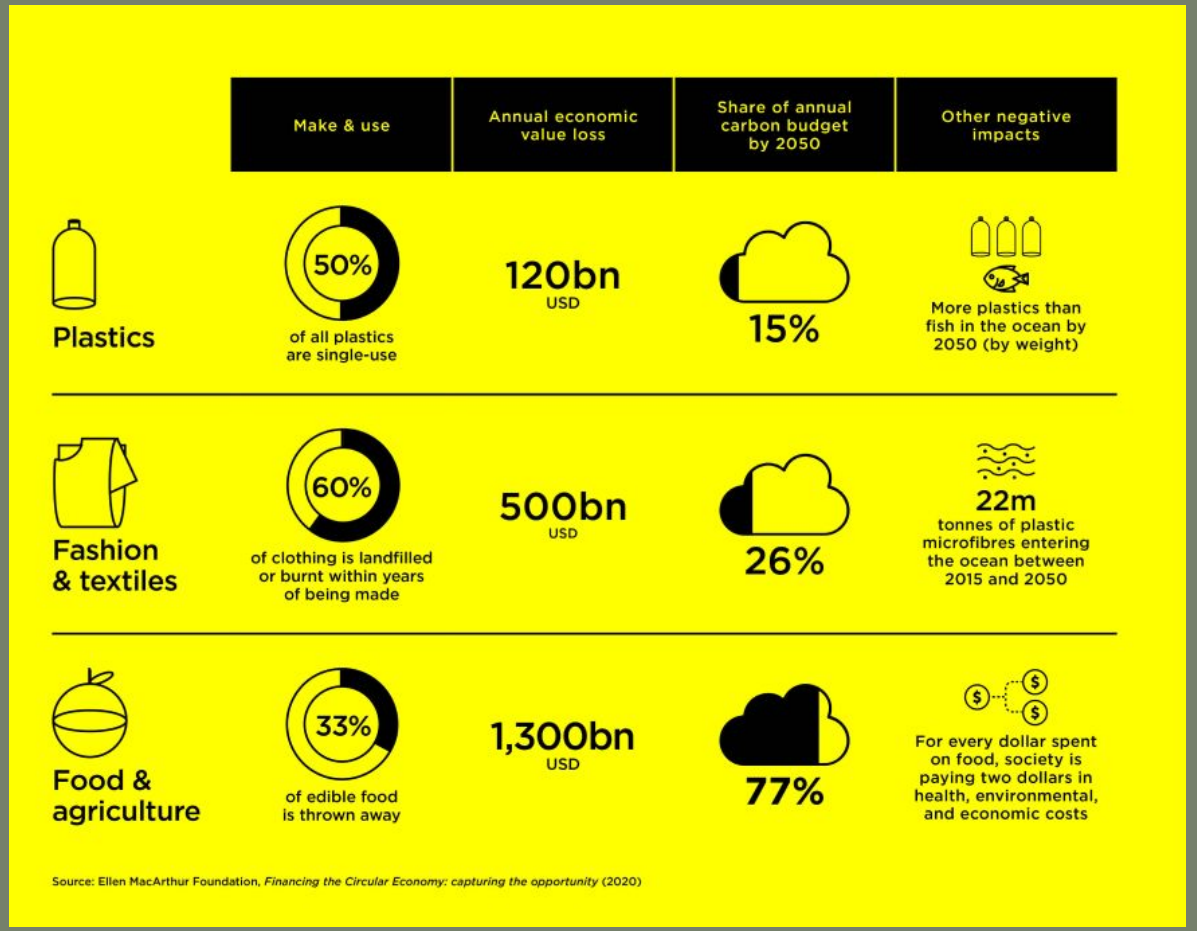
While resources are in-use, maintain, repair and upgrade them to maximise their lifetime and give them a second life through take back strategies when applicable.

- Average U.S. person produces 4.9 pounds of waste per day
- That's 1,788.5 pounds a year. Almost a full TON per person.



By 2000, global material production per year was at 54.9 billion tons and as of 2019, it surpassed 100 billion tons,

Of the 100 billion tons of resources used by the global economy each year, only 8.6% are cycled back.


Make & use
Annual economic value loss
Share of annual carbon budget by 2050
Other negative impacts
Plastics
50%
of all plastics are single-use
120bn
USD
15%
More plastics than fish in the ocean by 2050 (by weight)
Fashion & textiles
60%
of clothing is landfilled or burnt within years of being made
500bn
USD
26%
22m
tonnes of plastic microfibres entering the ocean between 2015 and 2050
Food & agriculture
33%
of edible food is thrown away
1,300bn
USD
77%
For every dollar spent on food, society is paying two dollars in health, environmental, and economic costs
Source: Ellen MacArthur Foundation, Financing the Circular Economy: capturing the opportunity (2020)