BRIEF SUMMARY OF CIRCULAR ECONOMY

Circular Economy is optimally designing, manufacturing, and using resources/products:

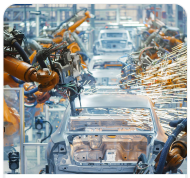
1. To promote renewability-reusability-recyclability, longevity/durability, and environmentally sustainability of a resource (chemical, substance, material, product, asset) throughout its lifecycle.

2. To reduce the uptake of new-virgin resources and the output of wastes into the environment

Historically, the flow of products, materials, wastes, and emissions have been in a linear cradle-to-grave pattern.

Raw Material Extraction

Transportation of Materials



Production

Destribution

Consumption

Disposal

This results in high material/energy resource uptake and waste output at each stage to re-make new products useable in the economy.

- 1/3 of food produced in world (1.3 bil. tonnes) is lost or wasted
- Construction makes ~1/3 of global wastes and ~40% of CO2 emissions.
- 380 mil. tonnes of plastic are produced and ~10 mil. tonnes of plastic are disposed in the world's oceans annually.
- coal-electricity has been identified as the primary source of climate change with a total of 46% of the earth's total CO2 emissions traced to it.

Circular Economy seeks to eliminate the conventional "take-make-waste" linear lifecycle.

Circular Economy also encompasses the following areas:

Eco-Innovation/Green Design: product modularity, upgradability, easy disassembly, resource efficiency and sustainability source bio-organic materials.

Digitalisation: production process automatisation and performance optimisation, or even online services

Bio-/Green economy: using bio-organic matter for the manufacture of sustainable material/ energy products.

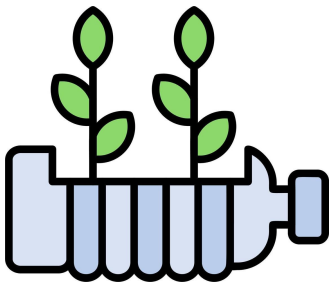
EXAMPLES OF CIRCULAR ECONOMY IN ACTION

Recycling (R8) Material products made with recycled (solid, liquid, to gases) wastes. Or technologies (or processes) which are intended for:

- collecting/ sorting
- recycling
- treating
- valorising material wastes (solid, liquid, to gases) for use in production or as an input for a material product's manufacture.

Remanufacturing (R6): taking end-of-life products and wastes and remaking the original product of an identical value.

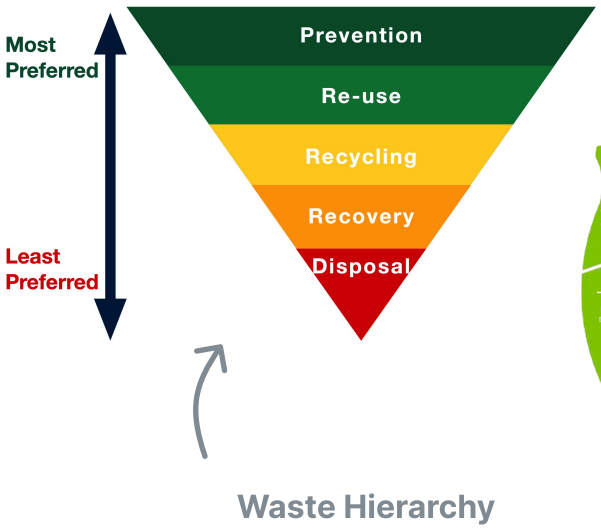
Repurposing with waste (R7): taking end-of-life products and wastes and converting them into alternative products of different value.



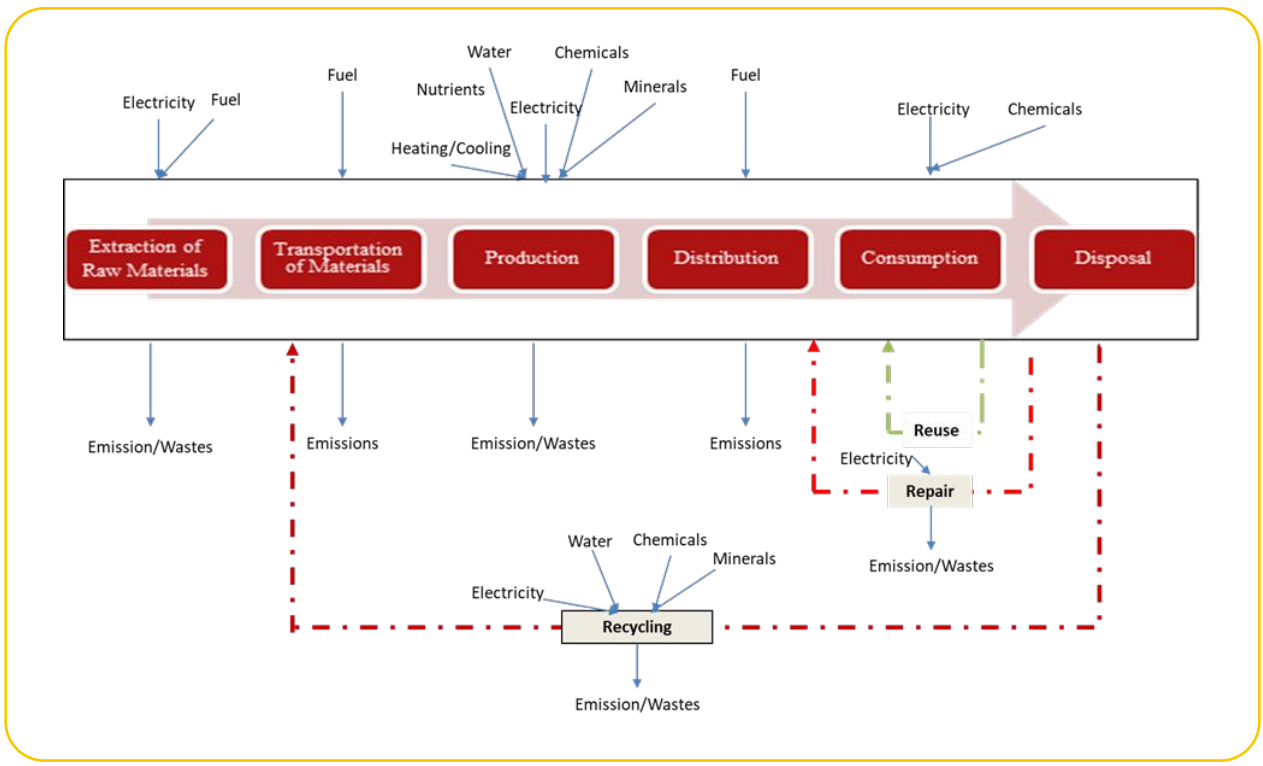
Reducing (R2) material-energy efficiency/conservation (e.g., via new/improved technologies, processes, methodology, non-hazardous/toxic chemical/substances, renewable-organic matter etc.)

CIRCULAR ECONOMY ACTIVITIES AND THEIR PERFORMANCE

The **9 Rs of Circular Economy** and the **Waste Hierarchy** are 2 good frameworks and predictors of a waste-to-resource activity's general performance compared to other technologies. As can be seen, energy recovery and disposal are the 2 worst treatment options!



Overall reuse, and activities which support reuse (e.g., repair), have lower impacts compared to recycling activities as is described in the picture below due to more materials and energy required.



CIRCULAR ECONOMY IN RELATION TO ENERGY

Energy Recovery (R9) is typically not acceptable if it is the main activity since the waste (or resource) is converted into energy (electricity or heat) which has a temporary use.

However, there may be exceptions when **green energy** (e.g., biofuels, biogas) or **renewable energy** technologies (e.g., PV, wind, hydro) are supporting the main waste-based activity.

In our research, energy consumption has one of the largest impacts on the carbon emissions per product at well over 40.0%.

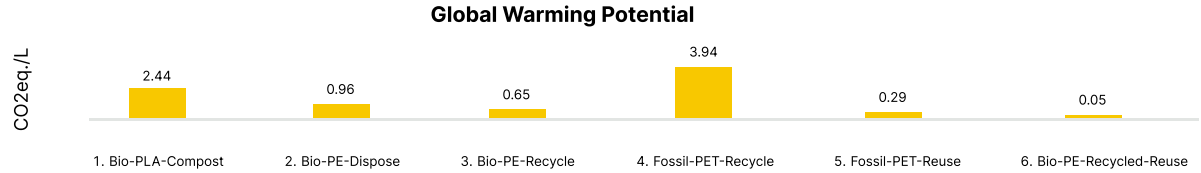
CIRCULAR ECONOMY IN PRODUCT ORIGIN

Today, fossil oil and gas remains the primary source of everyday energy and material products. Thus, this has major consequences on the carbon footprint and sustainability of products from the get-go. The "foot-print" of the product is also carried on at its end-of-life and into the circular lifecycle as well.

- 99.0% of plastic is produced from fossil carbon. EU has the capacity to recycle 38.0% of plastic.
- ~40% of steel produced currently has recycled steel content.

Although products made from renewables (biomass/bio-waste) or recycled material may seem ideal

- Surprisingly, both polylactic acid (PLA) bio-plastic water bottles and recycled fossil PET water bottles have been reported to have high carbon footprints relative to alternatives



As well, so-called biodegradable packaging material can take a very long time to decompose in the environment (up to a year or more) and have to be recovered and treated.

Therefore, a product's origin whether its from circular material or bio-based material can be highly influential on its overall environmental impact.