# 10.016 SUSTAINABLE WORLD


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## Silicon

### Material used
1. Silicon is widely used in the chip industry particularly in the CPU
2. In contrast to typical metals utilized for conducting electricity, silicon functions as a "semiconductor," indicating that its ability to conduct can be enhanced by combining it with additional substances like phosphorus or boron.

### Environmental Impacts
1. Silicon refining and semiconductor manufacturing consume substantial energy, often from fossil fuels
2. Require significant water usage, potentially straining ecosystems in water-scarce regions.

### End of life
1. Recycling silicon helps reduce the need for new raw materials, conserves resources, and minimizes waste.
2. However, the recycling process for silicon may not always be as straightforward or efficient as recycling other materials.

## Copper

### Material used
1. Bare copper wire offers excellent conductivity, durability, ductility, and malleability, making it ideal for jumper wires.
2. Copper also provides superior electrical and thermal properties, crucial for effective signal transmission and heat dissipation which are great for an SBC.

### Environmental Impacts
1. Copper does not break down easily and thus, can accumulate in nearby plants and animals when found in soils which can affect the survivability of most plants.
2. Recycling rate for non-ferrous metal (copper included) scrap is 84% in Singapore.

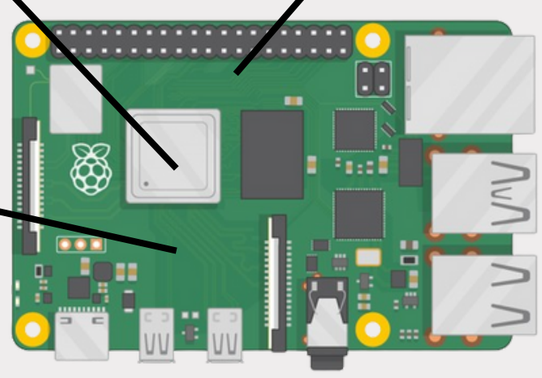
### End of life
1. Copper is 100% recyclable and does not lose its performance.
2. It takes 23 years on average for a ton of in-use copper to reach the end of its life.

## Polyvinyl Chloride (PVC)

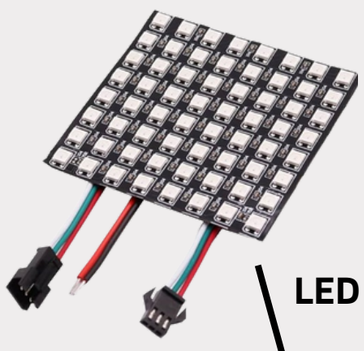
### Material used
1. PVC offers superb electrical insulation between the circuit board and nearby chassis components.
2. This prevents electrical shorts and interference, promoting proper functioning of the SBC.

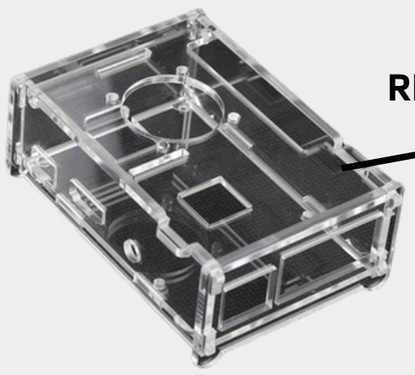
### Environmental Impacts
1. PVC production relies on ethane from fracking natural gas, which emits methane, a major climate change driver.
2. A 2020 study found PVC has a "higher global warming potential" than other plastics due to its energy use and CO2 emissions.

### End of life
1. PVC can last up to 100 years. It is 100% recyclable although not preferred because it requires separation from other plastics.
2. PVC is non-biodegradable but its still being used due to its tough nature.










## Acrylic

### Material used
1. Our Pi is housed in an acrylic case to protect it against the elements,
2. Acrylic is a popular choice as the entire case can be cut and assembled from a single sheet. The transparent properties of clear acrylic also adds to its visual appeal since it allows for the Pi's components to be visible.

### Environmental Impacts
1. Emissions from manufacture is dependent on its origin (fossil fuel, synthetic fiber or recycled acrylic)
2. Due to its low weight and ease of packaging, acrylic leaves minimal footprint during transportation

### End of life
1. Acrylic is recyclable, however it is neither compostable nor biodegradable.
2. Despite its recyclability, waste acrylic is usually disposed of in landfills or via burning, which releases greenhouse gases

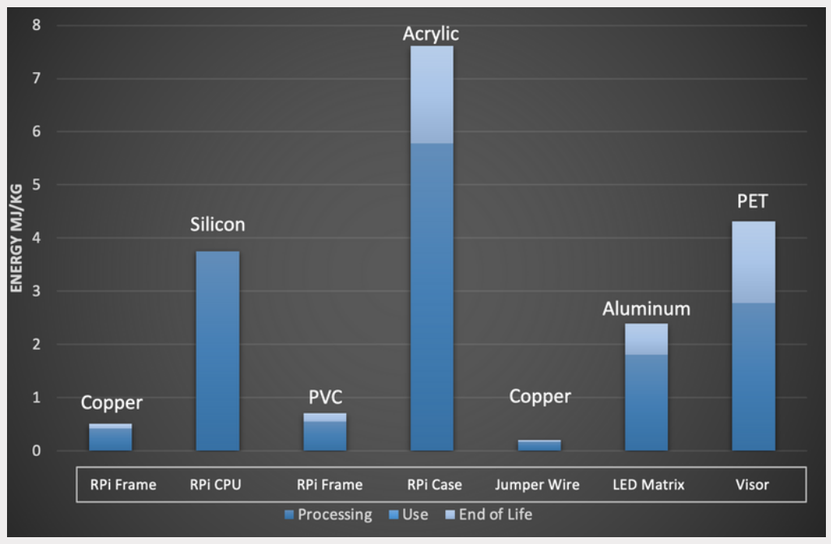


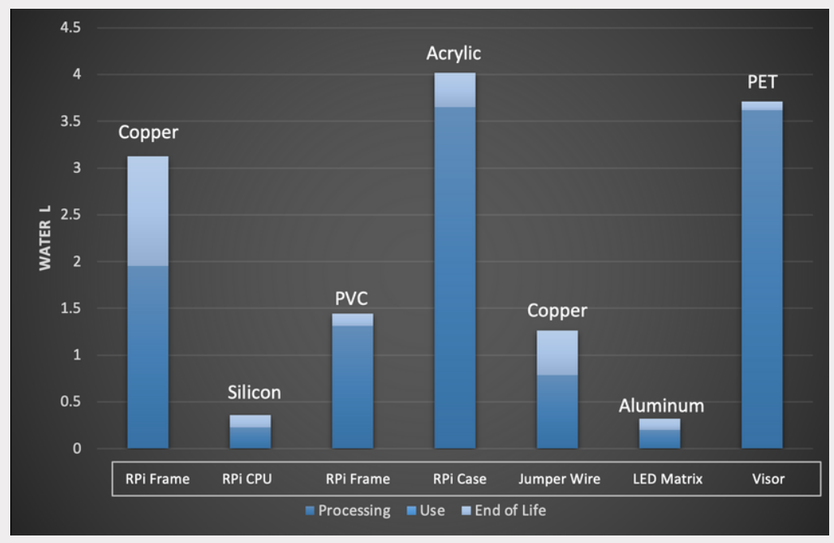

## Aluminum

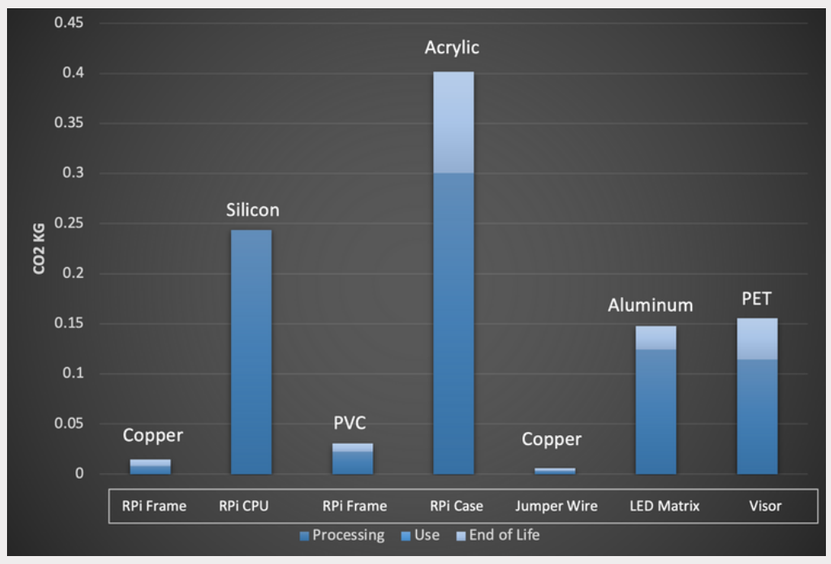
### Material used
1. The frame of the LED matrix is made up of aluminum because of its ability reflect light and manage heat.
2. When exposed to air, aluminum instinctively generates a protective oxide that has high corrosion-resistance properties.
3. Aluminum is also malleable allowing us to bend the LED matrix to fit a wearable (i.e., a visor).

### Environmental Impacts
1. The melting point of aluminum is so high which entails a greater amount of water and energy needed to extract the material for production.
2. 3% of the world's greenhouse gases occur in aluminum production.

### End of life
1. Aluminum can be recycled indefinitely without compromising its quality, making it one of the most recycled materials worldwide.
2. Nearly 75% of the total 1.5 billion metric tons of aluminum ever manufactured remains in active use presently.




## Polyethylene terephthalate (PET)

### Material used
1. Polyesters are used in hats for its abrasion and moisture resistance.
2. Polyester dries sweat to keep a person dry and comfortable on a sunny day.

### Environmental Impacts
1. Polyester is not sustainable because it is derived from non-renewable resources which contributes to CO2 emissions.
2. It also generates massive amounts of plastic waste and microfibers.

### End of life
1. Polyester is not biodegradable and can take up to 300 years to degrade completely.
2. Polyester can last for 5 years if handled properly.

## Overall Analysis

- After combining the two Raspberry Pi frame components with the CPU component, the total consumption of a single raspberry pi is approximately 5.5 MJ of energy, 5 liters of water, and 0.255 kg of CO2 emissions. Based on this estimate, the RPI produces the second highest footprint after acrylic.
- Raspberry pi uses a little amount of electricity (144Wh/518kJ) which releases small amounts of greenhouse gases.
- Most of the materials used in the final product, such as copper and aluminum, are recyclable or have a long lifespan that helps decrease overall carbon emissions. However, certain materials like plastics will likely become waste due to their challenging properties that make recycling difficult. (or a separate facility is used).
- The overall energy cost of a Raspberry Pi goes beyond its operational energy cost, which accounts for less than 50% of the total. The full lifecycle includes energy for obtaining raw materials, manufacturing components, assembling, transporting to users, running the device, and recycling waste. The same goes for water and CO2 emissions.

## Considerations:

- Based on the LCA graphs, we deduce that the RPI case yields the highest energy consumption and CO2 emissions even after the combining components for the RPI.
- We could consider alternative for the case such as polystyrene but it would mean that the RPI is more vulnerable because acrylic is much tougher.
- A replacement for silicon would be gallium nitride (GaN) which is more efficient and requires less power. However, due to the abundance of silicon and the lack of GaN, companies are still utilizing silicon to produce semiconductors.
- As for the visor, typical hats are made of polyester due to its comfort when wearing and its ability to last longer. Other alternative would be nylon but it is also not environmentally friendly resulting in polyester being the better option.

**DETAILED LCA REPORT FOR OUR PRODUCT WITH DATA AND ASSUMPTIONS**