Sustainability in Electronics Design

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Why are we focused on sustainable electronics?

Workshop Goals

- Understand embodied and operational carbon in electronics
- Learn the basics of Life Cycle Assessment as a tool
- Recognize how material choices and energy use affect a device's environmental footprint.
- Apply sustainable thinking to consider a product's entire life cycle.

01

Carbon Footprint

Carbon Footprint

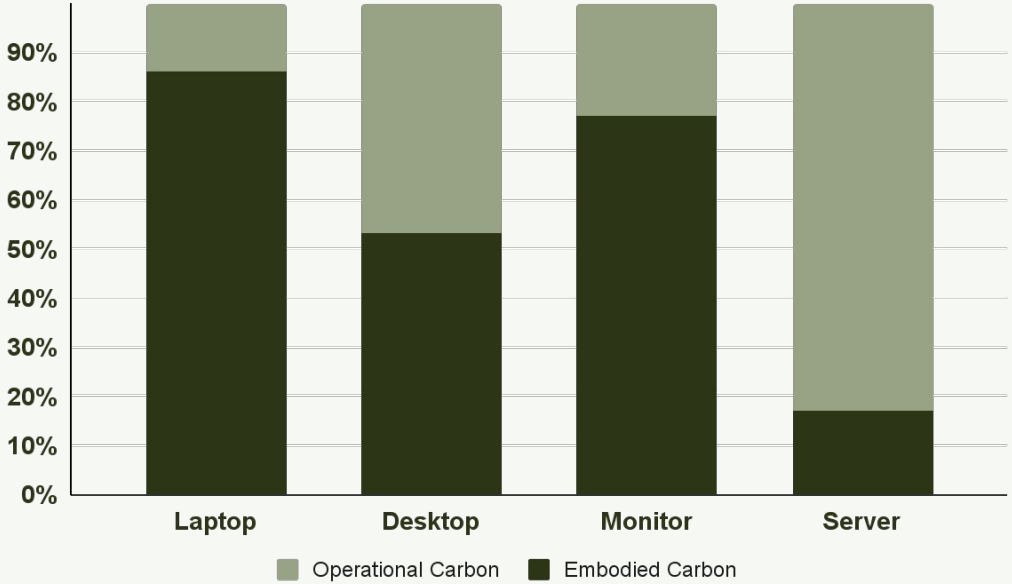
Embodied Carbon	Operational Carbon
Pre-Use Emissions	Use-Phase Emissions
Emitted during manufacturing, materials extraction, transport, and end-of-life processing.	Emitted while the device is in operation.

Example

For a typical laptop

About 80% of its total CO_2 emissions come from manufacturing and materials.

Embodied vs. Operational Carbon Usage



Scott Logic, “Hardware Life Cycle Emissions,” Technology Carbon Standard, 2024, https://www.techcarbonstandard.org/technology-categories/lifecycle#:~:text=For%20devices%20such%20as%20laptops%2C,devices%20like%20laptops%20or%20smartphones.

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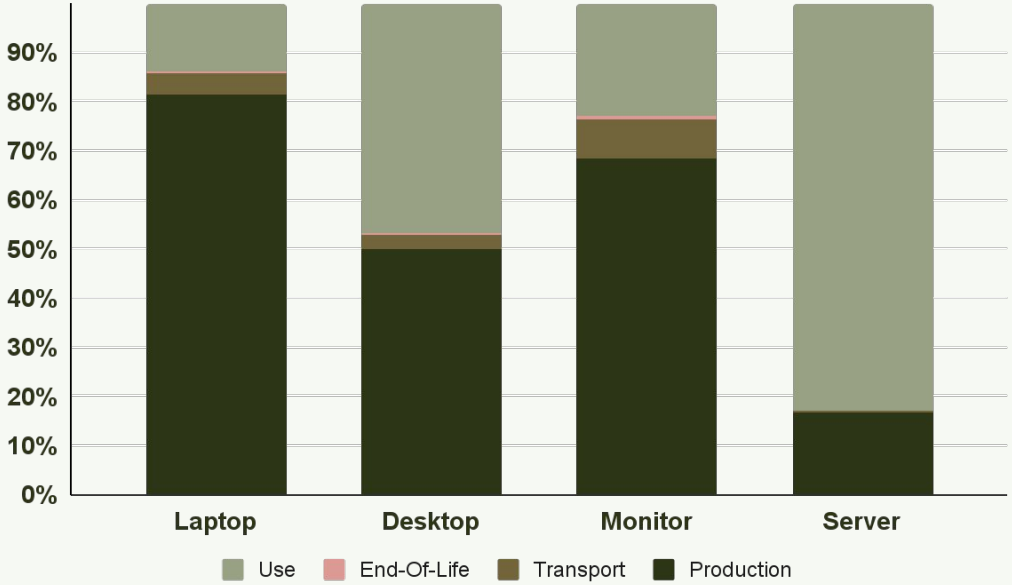

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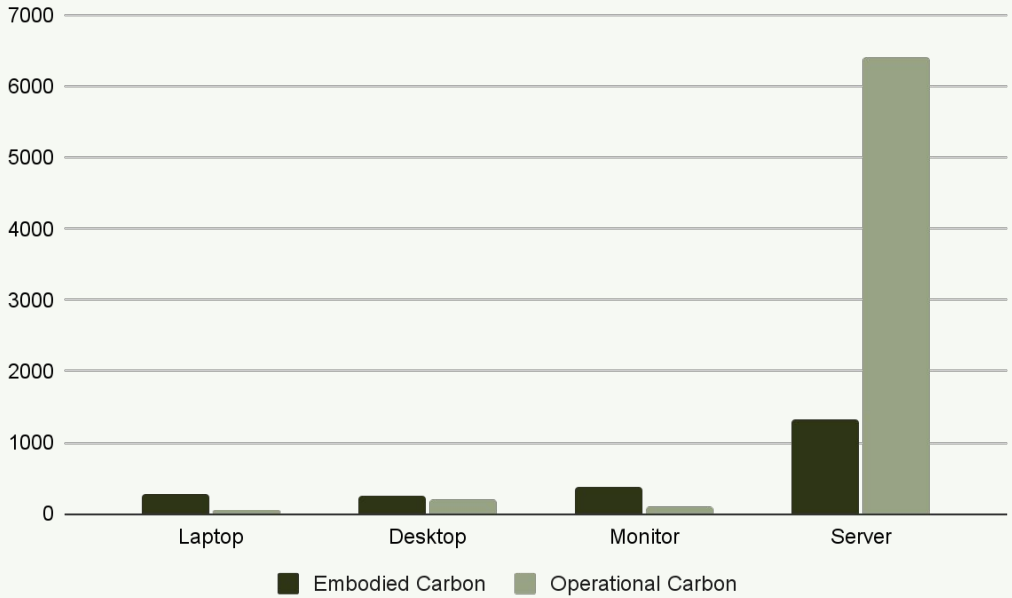

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Pause And Think

1. What surprised you most about these splits?
2. Why do you think knowing this split matter for design choices?

How do you consider the full life cycle of a product?

1. What would you include in your assessment?
2. What are important things to consider at each stage?

02 Life Cycle Assessment

Life Cycle Assessment

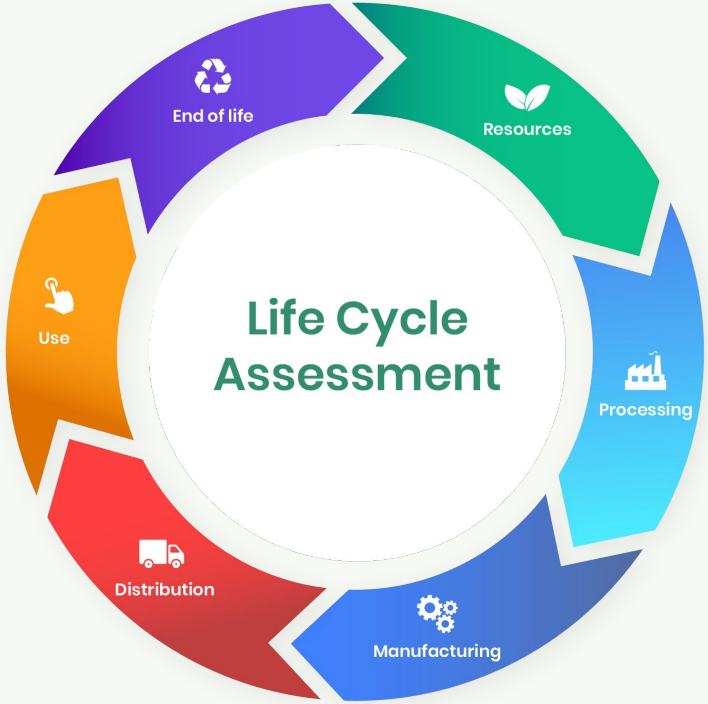
Definition

A systematic method to **quantify** the environmental impacts of a product across its entire life cycle.

How it works

Collect data on **inputs and outputs** of a product, then calculate impact indicators (carbon footprint)

Life Cycle Assessment



Life Cycle Thinking

“Cradle to Grave” Perspective

Consider **all stages** of a device’s life

Holistic Design

Improvements at any stage can reduce total impact

Flexible

Can also track other metrics (water use, toxicity, etc.)

Online LCA Tools

OpenLCA

- Open-source
- Builds a model of product's life cycle
- Calculates impacts

SimaPro

- Commercial
- Extensive databases
- More detailed sustainability assessments

Pause And Think

1. What makes an LCA different from just “estimating” a product’s sustainability?
2. Where might an LCA fall short?

Material vs. Energy Tradeoffs

Materials

- Electronics contain plastics, glass, and rare metals.
- Each requires mining or chemical processes → **Embodied carbon**.

Energy

- Usage depends on device design and energy source.
- **Operational carbon** adds up over time

Circular Design

Choose materials that are **easy to disassemble** and **recycle**

Efficiency

- Product level - Low power/eco-mode
- Production - Manufacture with clean energy

💡Key Insight💡

When an LCA shows most of the footprint is **embodied**, it can be worth accepting **moderate increases in operational energy** if you can **dramatically** cut embodied carbon.

High Performance

High Carbon Footprint

Embodied Carbon

“Green” Design

Low Carbon Footprint

Operational Carbon

How might you design for a device meant to run for 10 years versus one meant to last 1 year?

03

Design Activity

Objectives

1. See how **material choice** affects **performance**
2. Practice **quantitative** trade-offs with real materials
3. Consider how **small design choices** have big sustainability impacts

Activity

Examples

1. **Apple: Macbook Pro 2024, Macbook Air (M4) 2025**
    a. Increased use of recycled materials in PCBs
    b. Moved to low-carbon suppliers for manufacturing
    c. **~45% reduction** in total CO_2e emissions
2. **Microsoft: Xbox Series X**
    a. Uses high end GPU/CPUs for top-tier performance
    b. Accepts **+50% embodied carbon** for nearly a **40% decrease** in operational carbon
    c. Net Xbox CO_2e per hour is **15% less** than previous generation

Thank you