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# EMISSION FREE EUROPEAN UNIVERSITIES

Handout for the class on

Environmental Footprint of a Manufactured Product

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# HANDOUT FOR THE ACTIVITY WORKSHEET:
## Analysing the Life Cycle of a T-Shirt

This activity builds on the class 'Environmental Footprint of a Manufactured Product' and aims to consolidate your understanding of Life Cycle Thinking by analyzing a short TED-Ed video available on Youtube: Angel Chang (2018) – *'The Life Cycle of a T-Shirt'*

The exercise connects to the three footprint indicators studied in class:
• Carbon footprint (kg $CO_2e$) – GWP100 indicator, climate change contribution.
• Water footprint ($m^3$ water eq) – freshwater consumption and degradation.
• Energy footprint (MJ) – cumulative primary energy demand.

## 1. Life Cycle Thinking

Every manufactured product has a measurable environmental impact, from the extraction of raw materials to its end-of-life. This concept, known as Life Cycle Thinking (LCT), provides a framework to analyze how products consume resources and generate emissions throughout their life span.

In Life Cycle Assessment (LCA), these impacts are grouped into categories, each represented by a measurable footprint indicator. The most relevant for product analysis are carbon, water, and energy footprints.

## 2. Carbon Footprint (Climate Change Impact)

The carbon footprint quantifies the total amount of greenhouse gases (GHG) emitted across all life cycle stages of a product. It is expressed in kilograms of carbon-dioxide equivalent (kg $CO_2e$) and represents the product's contribution to climate change.

• Indicator: Global Warming Potential – GWP100

- Main sources: fossil-fuel combustion, electricity generation, transport, and agricultural emissions.
- Typical unit: kg $CO_2$e per functional unit (e.g., per kg of product or per use).
- Example: Manufacturing a cotton T-shirt emits roughly 2–3 kg $CO_2$e, with the highest share coming from electricity use in textile processing and fuel use in transport.
- Interpretation: Lowering energy intensity, switching to renewable electricity, or replacing high-impact materials (e.g., animal-based ingredients, virgin plastics) reduces total GWP.

## 3. Water Footprint (Freshwater Use and Pollution)

The water footprint measures the total freshwater consumed and degraded during the life cycle of a product. It accounts not only for the amount of water withdrawn but also for regional scarcity and pollution effects.

- Indicator: Water Scarcity Index (WSI) or AWARE model.
- Components:
  - Blue water – water drawn from rivers and aquifers.
  - Green water – rainwater stored in soil and vegetation.
  - Grey water – the theoretical volume required to dilute pollutants.
- Typical unit: cubic metres ($m^3$ $H_2O$ eq) per functional unit.
- Example: Producing one cotton T-shirt can require 2 000–2 700 litres of water, mostly from irrigation during cotton cultivation and washing during use.
- Interpretation: Switching to drip irrigation, recycled water systems, or synthetic fibres with lower water demand can significantly reduce this footprint.

## 4. Energy Footprint

The energy footprint, quantifies the total primary energy used in all life cycle stages: direct (electricity, fuels) and indirect (energy embodied in materials or equipment).

- Indicator: energy footprint.
- Typical unit: megajoules (MJ) per functional unit.

- Main contributors: manufacturing processes, heating/drying, transport, and packaging.
- Example: A standard T-shirt may require 30–40 MJ of primary energy to produce and distribute, depending on the energy mix and process efficiency.
- Interpretation: Process optimisation, renewable electricity, and efficient logistics lower energy demand and simultaneously reduce carbon emissions.

## 5. Redesign Proposal

Each footprint reflects a specific environmental dimension, but they are interconnected:

- Energy use drives both carbon and water impacts.
- Material choices affect energy demand, water use, and emissions simultaneously.
- A single design change may improve one footprint while worsening another — a phenomenon known as a trade-off.

## 6. Why This Matters for the EFEU Class

Understanding these footprints will help you interpret the environmental profiles presented in the class examples. You will use these indicators to:

- Map environmental burdens along a product's life cycle.
- Identify which stages dominate the impact.
- Suggest feasible redesign measures to reduce emissions, water consumption, or energy use.

By the end of the class, you should be able to apply these concepts to any manufactured product and discuss the implications for sustainable production and consumption in the context of Emission-Free European Universities (EFEU).

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