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SMARt COmmunities Skills Development in Europe

Green Transition and Sustainability' in Smart Communities – UNIT 3

P. Fitsilis (fitsilis@uth.gr)
University of Thessaly

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Unit 3- ESG and Life Cycle Assessment (LCA) for Cities

Equip participants with tools and frameworks to **measure, report, and improve** urban sustainability through **ESG** (Environmental, Social, Governance) principles and **LCA** (Life Cycle Assessment).

- **Key Concepts**
  - **ESG for Cities:** Strategic framework to assess sustainability performance.
    - **E:** Energy, emissions, waste, biodiversity
    - **S:** Equity, health, safety, participation
    - **G** **:** Transparency, ethics, accountability
  - **LCA:** Evaluates environmental impacts across the full life cycle of urban systems (buildings, mobility, energy, waste).

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Sustainable design– Ecodesign – Circular design

Dimension	SUSTAINABLE DESIGN	ECODESIGN	CIRCULAR DESIGN
Definition	Designing a product in a way that takes the reduction of social, environmental, and economic impacts at the heart. Minimize these impacts as much as possible.	Ecodesign focuses on reducing environmental impact in every step of your product's life cycle. The foundation for Ecodesign is environmental data on a product.	Circular design means designing a product or service that creates no waste and pollution and keeps products and materials in use.
In practice	Look at design choices that reduce social and environmental impacts along every step in the life cycle of your products. From production to the waste phase. Where can you improve?	Environmental data is calculated through Life Cycle Assessments (LCA). The result: 15+ impact categories for each step in a product's life cycle. Analyze which process, material, or component causes your biggest impact – and improve your design.	Analyze and improve your product's design with two specific goals: (1) Minimum (preferably zero) waste & pollution throughout your product's life cycle. (2) Make sure your product's value doesn't decrease at the end of its life.
Examples	• **Analyze social impact:** Are workers being paid fair wages? Will your product have health-endangering effects on consumers when it's used? • **Analyze environmental impact:** Which materials in production are impact-intensive? Which processes could be sustainably optimized?	• **Product stewardship:** Take full responsibility for your product's entire lifecycle. And make sure the product doesn't get lost at the end of its life – but stays in the value system. • **Dematerialization:** Reduce the weight, size, and number of materials you use in your design.	• **Designing for inner loops:** Materials in your product should maintain the highest value during – and after – the end of its life. • **Moving from products to services:** Shifting from ownership to access. Instead of purchasing, you offer your product as a service.

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The climate change

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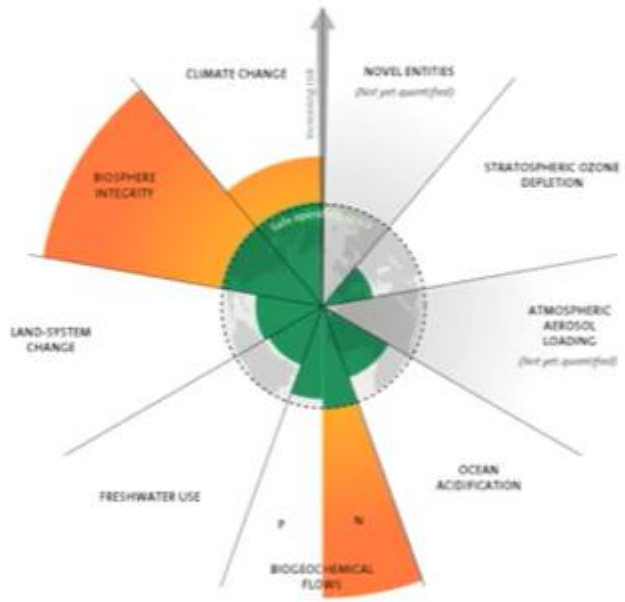
Evolution of planetary boundaries

2009



3 boundaries crossed

2015

4 boundaries crossed

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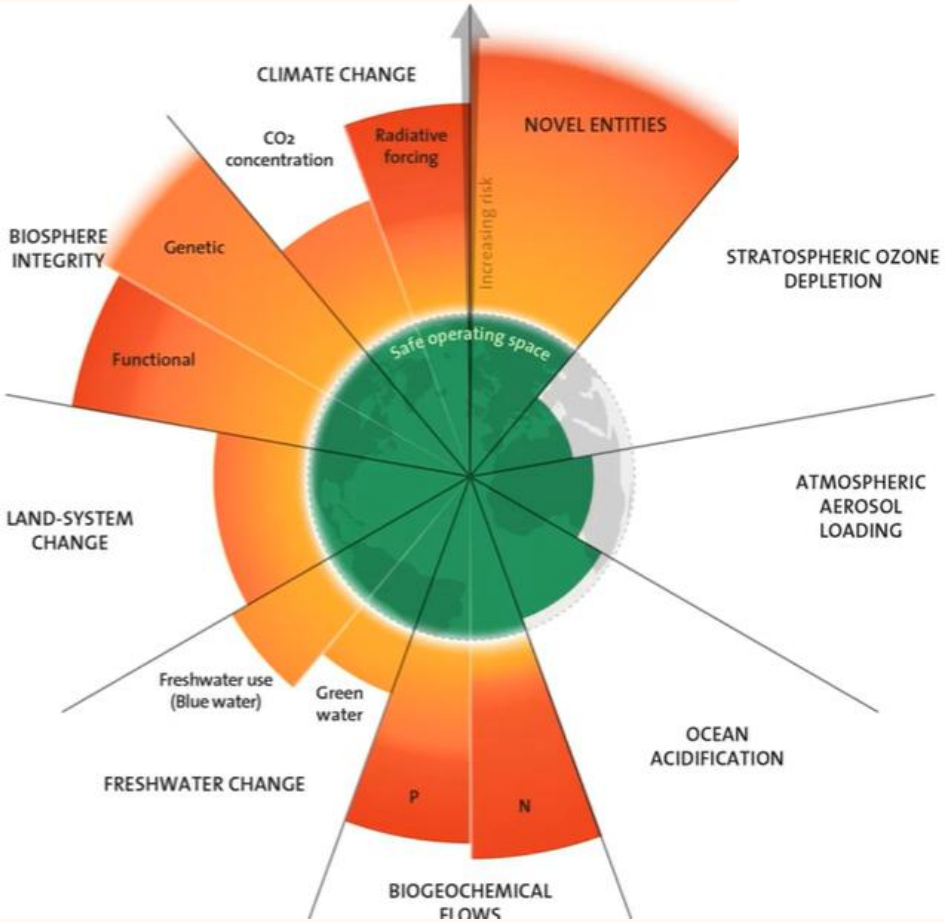
6 boundaries were crossed in 2023



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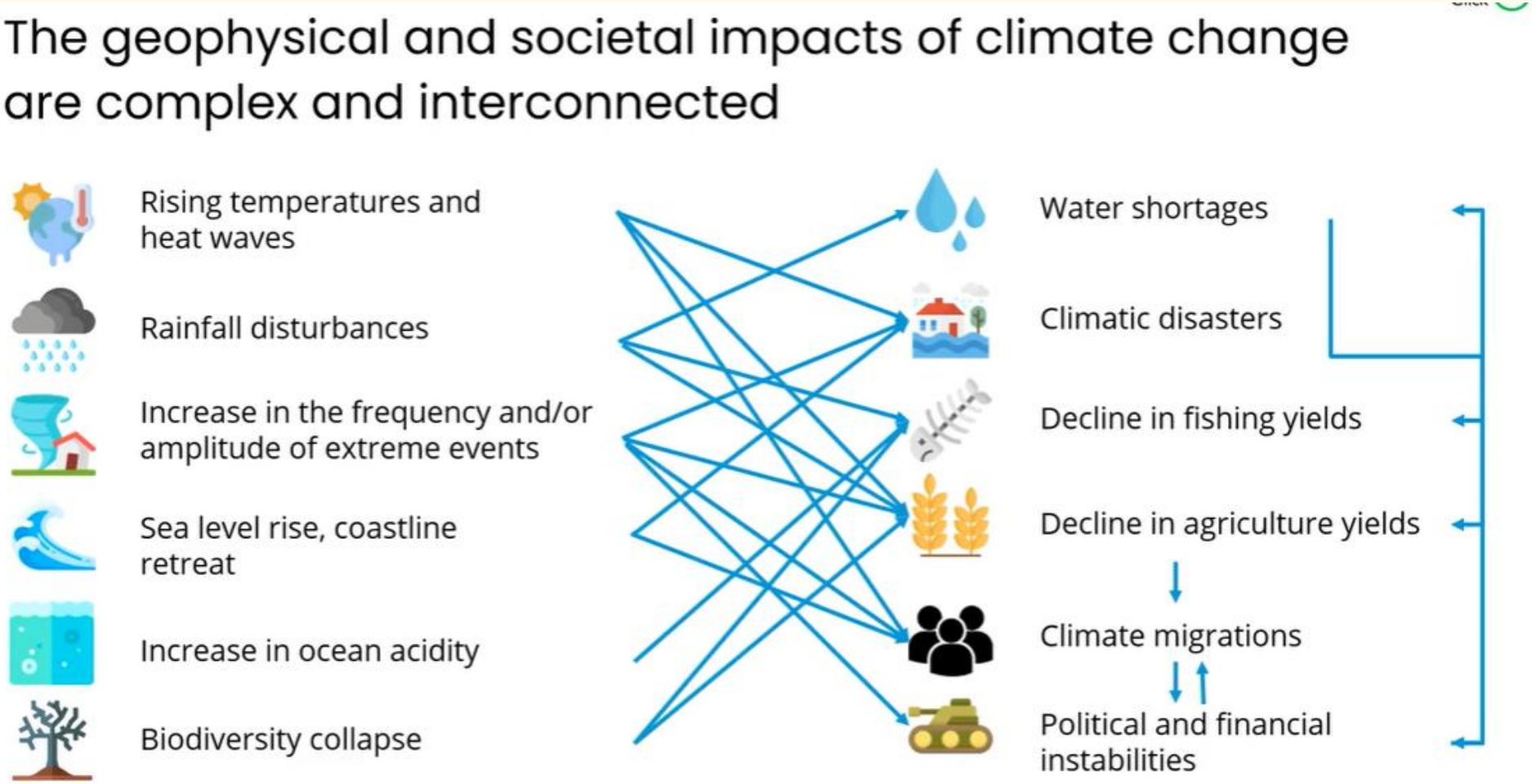
The geophysical and societal impacts of climate change are complex and interconnected



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ESG (Environmental, Social, Governance)

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ESG refers to a framework for evaluating an organization's environmental, social and governance performance in order to determine whether it operates with sustainability, responsibility and transparency.

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1. Environmental dimension

- Product sustainability relies heavily on the environmental axis of ESG, including:
  - CO_2 and other pollutant emissions during production.
  - Use of sustainable raw materials.
  - Energy efficiency of the product during use.
  - Recyclability, reuse and circular design (cradle to cradle).
  - Waste reduction at all phases of the life cycle.
  - A product is considered environmentally sustainable when it has a low carbon footprint, long-term lifespan, and reduced impact on the ecosystem.

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Impact of Environmental factors

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2. Social dimension

- The human and social impact of the production and use of the product shall be assessed:
- Fair working conditions in the supply chain.
- Consumer safety and health (toxicity, safety of use).
- Inclusion and access to vulnerable groups (e.g. accessible products for people with disabilities).
- Impact on the local community (e.g. support for local production or negative impacts)

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Social factors

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3. Governance

- Corporate governance is about how decisions are made about the product and whether they are consistent with transparency and sustainability:
  - Integration of sustainable goals in product design (eco-design).
  - Transparency in environmental declarations (e.g. EPDs – Environmental Product Declarations).
  - Regulatory compliance with regulations such as the EU Green Deal, the Ecodesign Directive, CSRD, etc.
  - Internal policy for responsible and sustainable innovation.

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ESG governance

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SDG and ESG

- **SDGs = Global goals for governments, businesses, and civil society (macro-level)**
  - Universal, policy-driven
  - Cover 17 goals, 169 targets
  - Broadly define what a sustainable future should look like

- **ESG = Corporate and investment-level tool to measure how organizations operate sustainably**
  - Micro-level performance framework
  - Used by companies, investors, and regulators
  - Focused on risk, value, and transparency

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ESG reporting (for companies)

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ESG reporting

- **1. Global Reporting Initiative (GRI)**
  - https://www.globalreporting.org/
  - The most widely used ESG reporting framework globally.
  - Offers guidelines, sector standards, and free online course
  - Aligns with SDGs and supports double materiality.
- 2. **European Commission – Sustainable Finance**
  - https://finance.ec.europa.eu/sustainable-finance/
  - Covers:
    - EU Green Taxonomy
    - CSRD (Corporate Sustainability Reporting Directive)
    - ESG ratings regulation
  - Critical for understanding EU-level ESG regulation.

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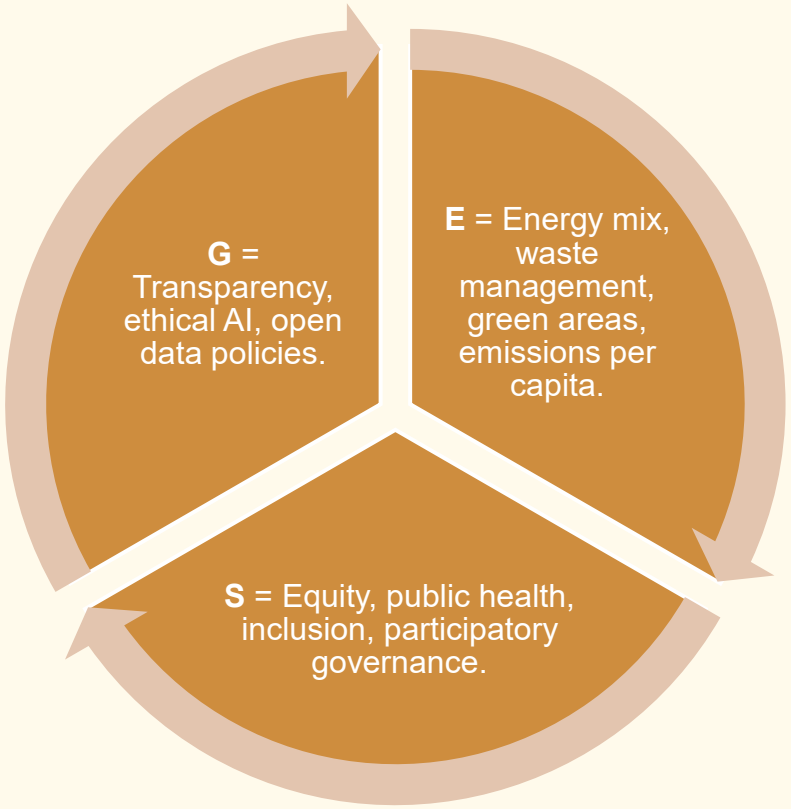
From Product ESG to Urban ESG

- We need to translate ESG pillars from corporate → municipal context:



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Case Study – Amsterdam: ESG-Driven Circular and Inclusive Smart City

ESG Dimension	Smart-City Implementation	Indicators / Tools
E – Environmental	• Amsterdam Circular Strategy (2020–2025) • Building material passports (LCA-based) • Smart energy grids and real-time emissions tracking	68 % construction waste reused **Energy intensity** ↓ 15 % since 2018
S – Social	• "WoningNet" housing fairness index • Community repair cafés and circular maker spaces • Digital inclusion programs for residents	80 % of citizens involved in sustainability initiatives **Social inclusion index** ↑ annually
G – Governance	• ESG-aligned municipal procurement (EU Green Deal & CSRD) • Open sustainability dashboards • Public–private innovation platforms (AMS Institute)	100 % procurement tenders include ESG clauses by 2030. **200+ open datasets** on urban materials

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Life Cycle Assessment

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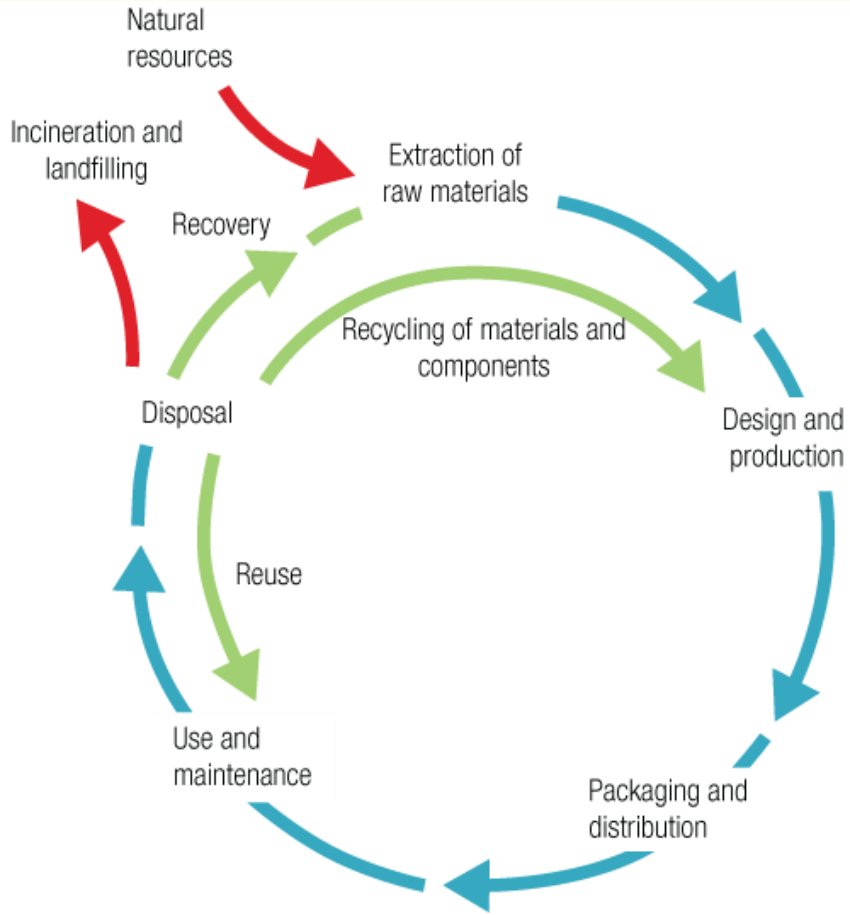
Life Cycle Thinking (LCT)



LIFE CYCLE THINKING

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Definition of Life Cycle Assessment

- LCA stands for **Life Cycle Assessment**. It is a methodology for assessing the environmental impacts associated with all the stages of a product's life — from raw material extraction through production, use, and disposal.

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Integrating Life-Cycle Thinking in Urban Planning

Shift from *product lifecycle* → *urban lifecycle*:

Buildings, transport networks, water systems.

Cradle-to-cradle design for materials reuse.

Example: Comparing lifecycle CO_2 between conventional asphalt vs. recycled pavement.

Reflect on:

Which phase of a city's life cycle (construction, operation, or demolition) contributes most to environmental impact?

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Why LCA is important?

- Identify Hotspots
- Decision Support
- Performance & Cost Measurement
- Communication & Marketing

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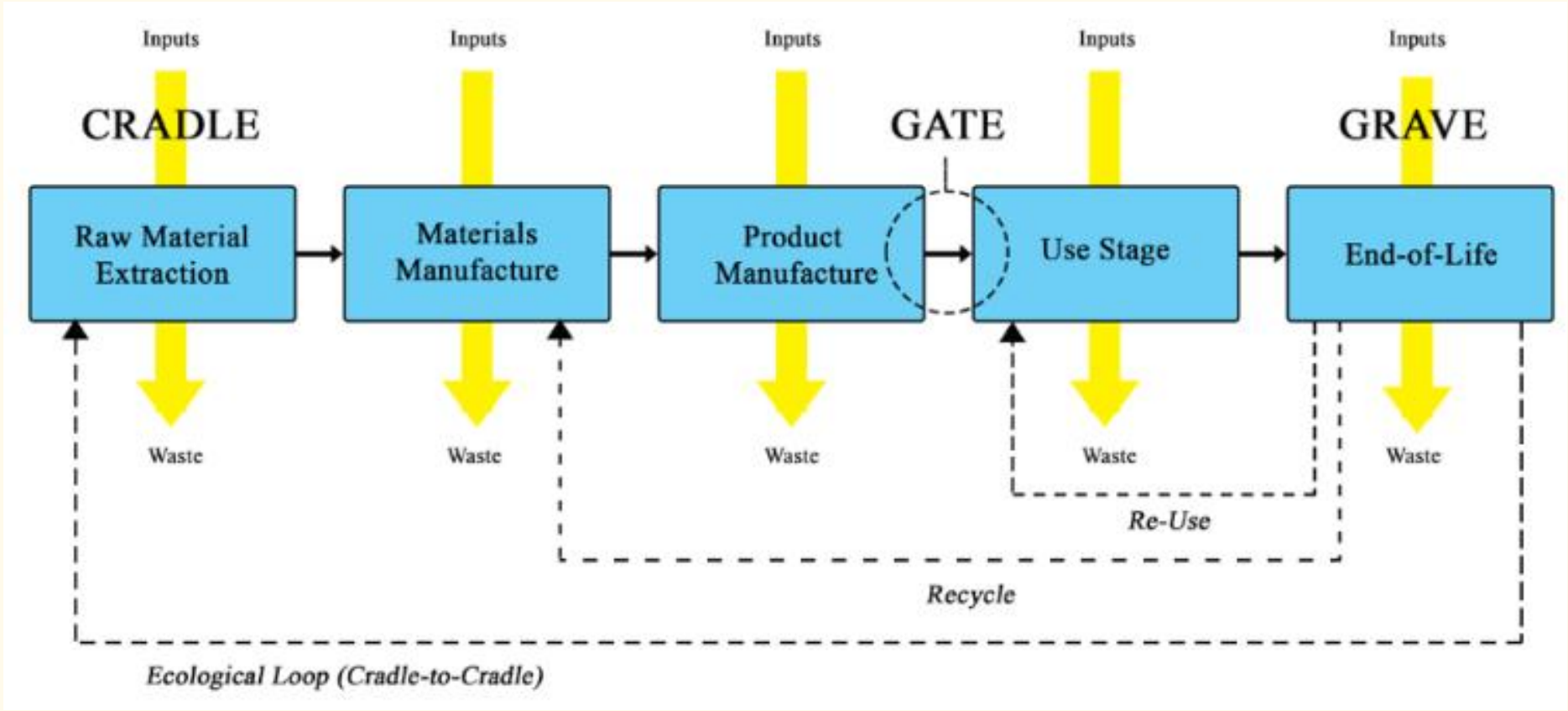
Life cycle example



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Terminology

- Cradle to grave
  - From production to final disposal
  - From the beginning to the end of a product's life cycle
- Cradle to cradle
  - Circular product design
  - From production to reuse
- Sustainable life cycle
- Gate-to-gate
  - From the input to the output of the production process
- In-factory phase
  - Evaluation of the production process of a single stage or installation

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Key Aspects of LCA

Goal and Scope Definition	• Define what you are assessing and for what purpose. • Set boundaries (e.g., cradle-to-grave, cradle-to-gate).
Inventory Analysis (LCI)	• Quantify energy, materials, emissions, and waste inputs/outputs across each life cycle stage.
Impact Assessment (LCIA)	• Evaluate potential environmental impacts (e.g., global warming, ozone depletion, acidification).
Interpretation	• Analyze results, draw conclusions, and make recommendations.

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Digital Technology for ESG & LCA in Smart Cities

- IoT sensors → monitor E indicators (energy use, emissions).
- AI analytics → predict social impact (S pillar).
- Open-data dashboards → transparency (G pillar).
- Digital twins for lifecycle scenario testing.
- **Reflect on:**
- How could IoT data improve the accuracy of ESG and LCA assessments at the city scale?

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LCA example from building construction

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The global building stock will double in 40 years

Equal to building a New York city every month

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Embodied carbon from this expansion alone will accelerate climate change by 4 years

Carbon emissions → **Global climate impact** → **Resource depletion**

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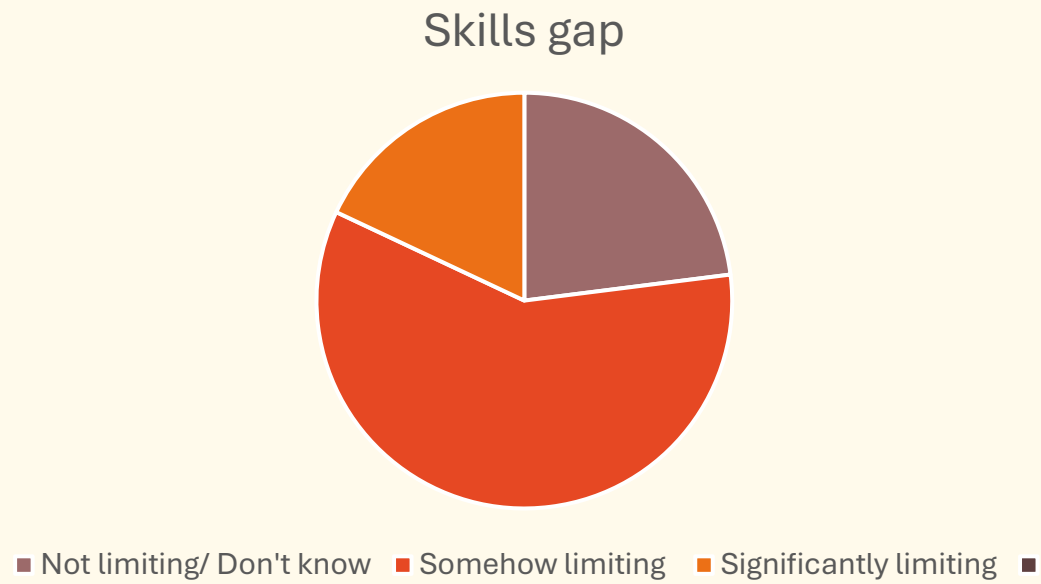
Skills gap for LCA management

- Experts think that there is a skill gap that limits the progress



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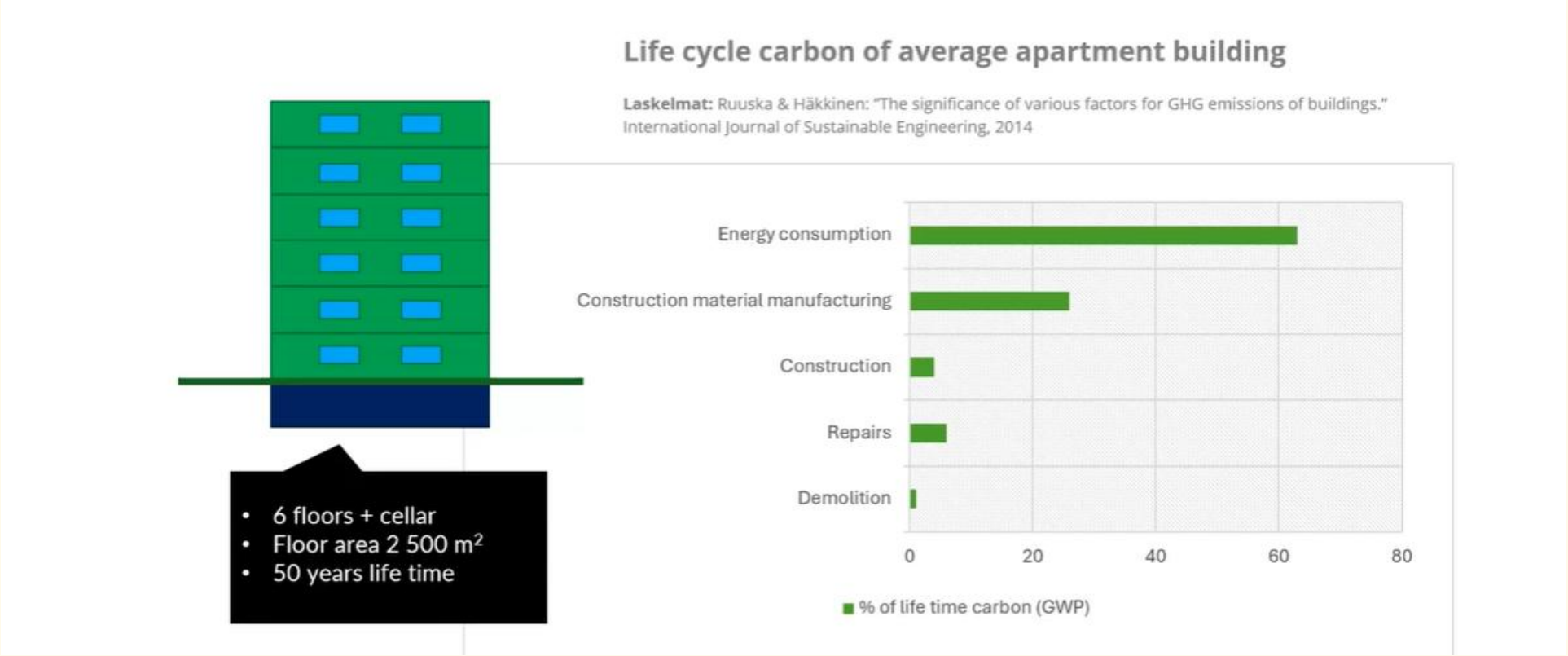
Where climate impacts come from?



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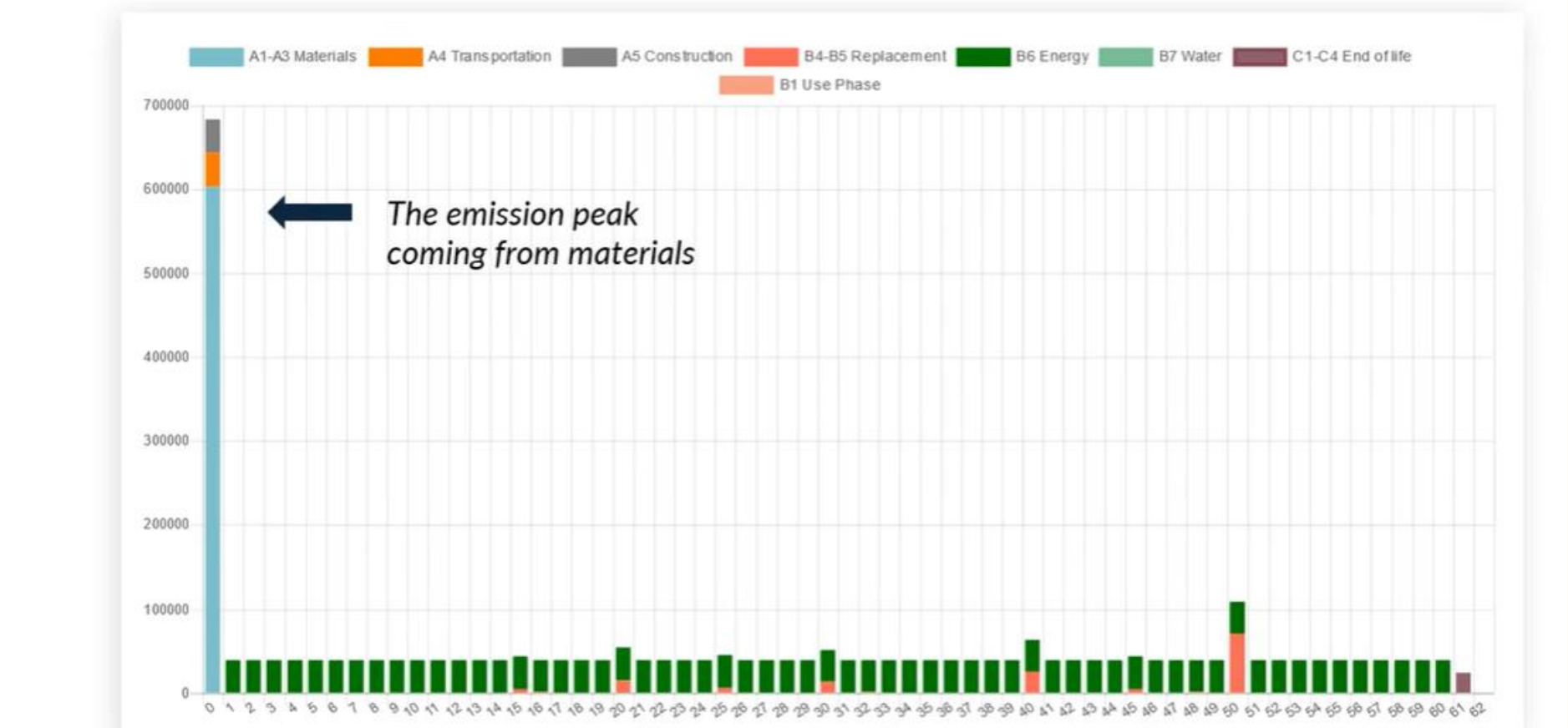
Emissions over time



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Sources of embodied carbon across the construction life-cycle

A1 - A3 Product stage
A1 Raw material extraction
A2 Transport to manufacturing site
A3 Manufacturing

A4 - A5 Construction stage
A4 Transport to construction site
A5 Installation / Assembly

B1 - B5 Use stage
B1 Use
B2 Maintenance
B3 Repair
B4 Replacement
B5 Refurbishment

C1 - C4 End of life stage
C1 Deconstruction & demolition
C2 Transport
C3 Waste processing
C4 Disposal

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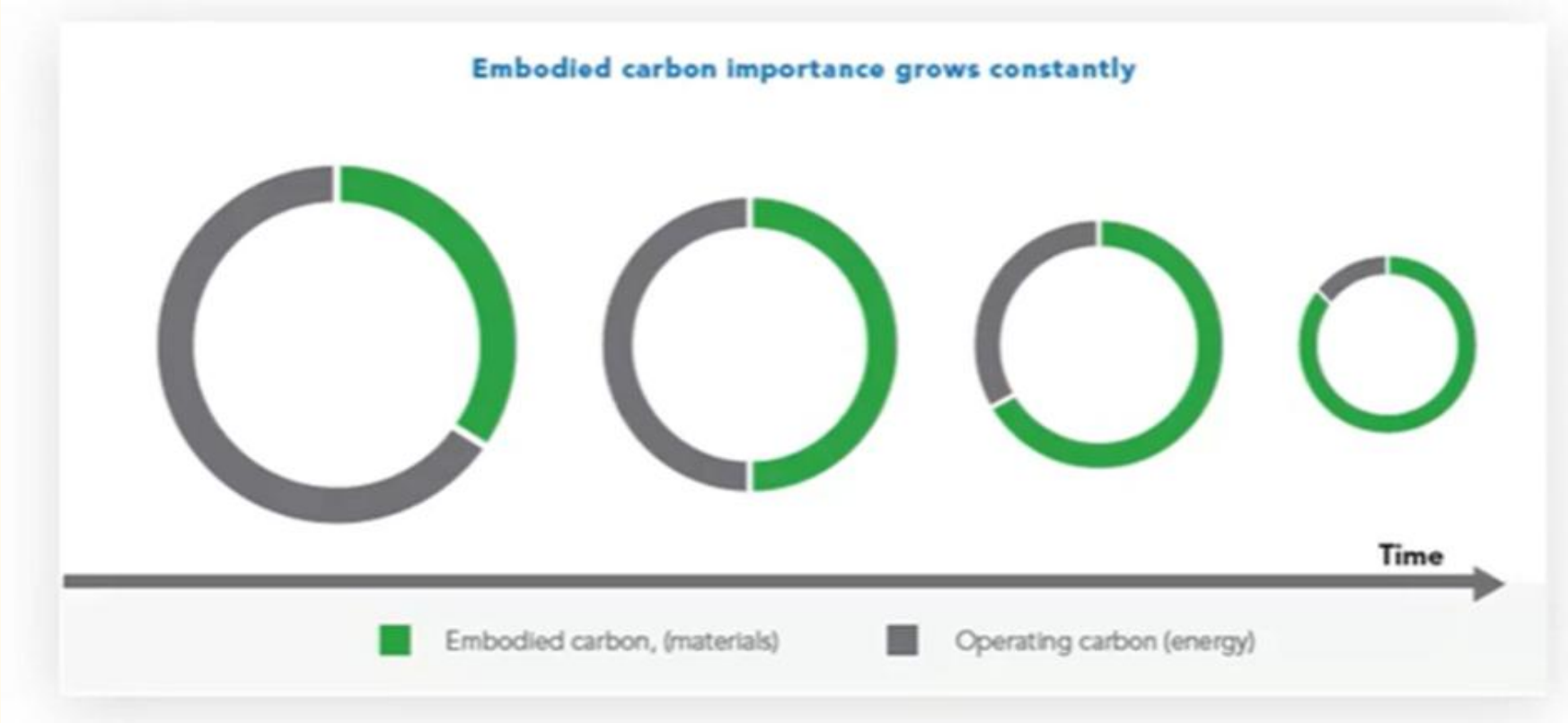
Materials will be the dominant source of CO2 emissions



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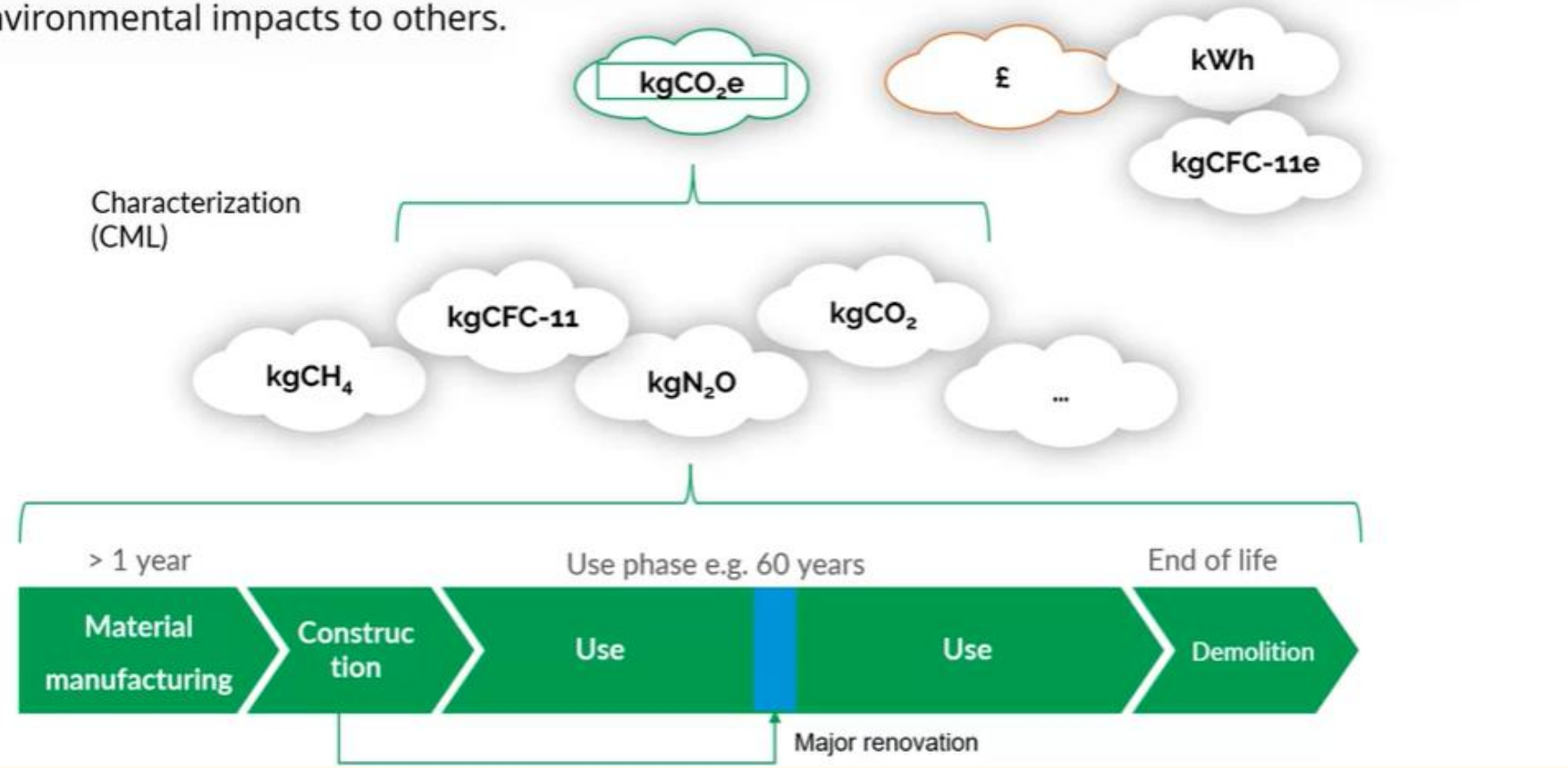
Life-Cycle Assessment gives you the big picture

LCA ensures you get a holistic picture of the performance that helps avoid sub-optimization. It ensures a scientific basis for environmental impacts. It also makes it impossible to shift burden of environmental impacts to others.



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Building a Smart-City ESG + LCA Action Plan

Six steps for local authorities:

- Define scope (district/building/sector).
- Collect IoT and open data.
- Select ESG & LCA indicators (ISO 37122 + 14040).
- Analyze hotspots and social risks.
- Publish dashboards and annual reports.
- Engage citizens in co-creation.

Reflect on

If your city had to publish an ESG report next year, which dataset would be hardest to collect—and why?

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Further reading

- ISO 37122 (2019) – Indicators for Smart Cities.
- ISO 14040 & 14044 – Life Cycle Assessment Principles and Framework.
- European Commission (2023) – EU Taxonomy for Sustainable Activities and Green Deal Implementation Guide.
- Global Reporting Initiative (GRI, 2023) – Universal Standards.
- United Nations Environment Programme. (2024, November 19). *Launch: A guide to using Life Cycle Assessment in policymaking* [Webinar]. https://www.unep.org/events/webinar/launch-guide-using-life-cycle-assessment-policymaking
- NetZeroCities (2024) – Mission 100 Climate-Neutral and Smart Cities Case Studies.

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Unit Completed - What's Next?

To consolidate your learning and reflect on the key concepts covered, please take a moment to complete this quiz.

Your feedback and results will help you track your progress and support continuous improvement of the training experience.

By completing this quiz, you will also become eligible to receive a certificate of successful training completion.

Click the link to begin the quiz!

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Panos Fitsilis bio page

University of Thessaly

fitsilis@uth.gr

UNIVERSITY OF THESSALY

- **Professor Dr. Panos Fitsilis** is a full Professor at Business Administration Dept. of the University of Thessaly, Greece., Director of Research Lab for "Management, Digital and Educational Skills" (MANDEIS) of UTH, and academic coordinator of the module "Software Design" at Hellenic Open University.
- He has extensive project management experience with the development and deployment of large IT systems and extensive management experience in various senior management positions. His research interests include Smart Cities, Smart Factories, Industry 5.0, Business Information Systems, Social Systems, Educational Technology, Software Project Management, etc.

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