GreenDiLT

Life Cycle Assessment (LCA) Game on Digital Education

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Life Cycle Assessment (LCA) Game on Digital Education

Target: Faculty, Support staff, Students

The LCA Game can be effectively integrated into a variety of educational and organizational contexts, including:

- **Institutional events**, to raise awareness of life cycle thinking and the environmental impacts associated with products, services, and activities among a broad audience.
- **Internal workshops**, to encourage discussion, collaboration, and the application of LCA principles in decision-making and sustainability strategies.
- **Class sessions**, as an interactive and engaging learning tool that helps students understand LCA concepts, develop systems-thinking skills, and actively explore sustainability challenges and solutions.

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Context: Why This Matters?

A survey conducted among GreenDiLT stakeholders identified four key learning needs:

- **Understanding digital environmental impacts** — impacts are often invisible and poorly understood
- **Learning how environmental impacts are measured** — through methods such as Life Cycle Assessment
- **Identifying effective eco-actions** — ranked by their actual environmental impact
- **Building institutional strategies** — to develop effective policies for reducing digital environmental footprint at scale

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Instructions

General pupose: The board game provides education stakeholders with an immersive and interactive learning experience focused on life cycle assessment and the environmental impacts of digital education.

1. Read carefully the case study (15 min)
2. Define the life cycle phases starting from Scenario1 (face-to-face) (15 min)
3. Define the resources consumed in each phase (15 min)
4. Estimate the first impact using coins (10 min)
5. Estimate the second impact using coins (10 min)
6. Estimate the third impact using coins (10 min)
7. Sensitivity analysis: expected changes for the hybrid scenario and fully on line scenario (20 min)
8. Share your solution with other groups (6/7 min per group)
9. Compare the results with the solutions and discuss it (15 min)

Total time: 1 h 30 min / 2 h

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Case study - Goal and Scope Definition

This case study examines the Life Cycle Assessment (LCA) of a **student** at Politecnico di Milano, considering the different study modalities that the university has continued to offer beyond the pandemic period.

The analysis compares the **traditional in-person mode**, in which students physically attend classes on campus, with the **hybrid mode**, which combines on-campus attendance, live-streamed lectures, and access to recorded lessons.

By evaluating these alternative learning modalities, the study explores and compares their respective **environmental impacts**, providing insights into potential differences in sustainability performance.

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Case study - System Boundaries

The data used in this analysis were obtained from the ERASMUS+ GreenDiLT project and from the Master's thesis by Francesca Sarti, “*Evaluating the Environmental Impact of Digitally-Enhanced Education: A Comparative Life Cycle Assessment of Educational Scenarios in an Italian University*”. The dataset serves as the basis for assessing and comparing the sustainability performance of alternative approaches to higher education.

The data considered in **this study relate exclusively to core educational activities**, excluding food consumption and other ancillary activities occurring outside the academic setting, such as the use of libraries, cafeterias, and other campus services. Consistent with the selected functional unit, the analysis focuses specifically on the environmental impacts associated with different study modalities and the use of technological devices required for learning activities.

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Case study - Functional unit

The **functional unit** was defined as **25 hours of education per student**, consisting of **10 hours of lectures** and **15 hours of individual study**. In addition, the functional unit includes the **time devoted by faculty members to preparing teaching materials and examinations**, as well as the **support activities carried out by administrative staff**.

Faculty-related activities were estimated at 40 hours, including 30 hours for lesson preparation and 10 hours for exam preparation and grading. Administrative support activities were estimated at 6 hours. To allocate these impacts to an individual student, both values were divided by the total number of students enrolled in the course. This approach ensures that the environmental impacts associated with teaching and administrative support are proportionally assigned to the functional unit of a single student.

Functional unit	Characterization
10 hours	Number of contact hours (lesson) between professor and students
30 hours	Average number of hours spent by a professor to prepare learning materials
10 hours	Average number of hours spent by a professor to prepare and review the exam
15 hours	Number of hours spent by a student for individual study
6 hours	Average number of hours spent by support staff for back office work

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Case study - Scenario 1

Face-to-Face (In-Person)

The first scenario analyzed, **face-to-face learning without streaming or recording**, represents the traditional educational model in which all teaching activities take place on campus and students, faculty members, and administrative staff are physically present at the university.

The main sources of energy consumption in this system are associated with the operation of university facilities, including classroom lighting, heating, ventilation, and air conditioning (HVAC) systems, as well as the use of information and communication technology (ICT) equipment such as projectors and classroom computers. Individual study activities are also assumed to occur on campus, generating additional energy consumption using laptops, lighting, and other electronic devices.

In addition to student-related activities, the system encompasses the contributions of faculty and administrative staff, including lesson preparation, examination-related tasks, and administrative support activities. These processes are included to provide a comprehensive assessment of the environmental impacts associated with the traditional in-person educational model.

For faculty activities:

- **75%** of lesson and exam preparation is assumed to take place at **home**
- **25%** of lesson and exam preparation is carried out at the **university campus**.

For administrative staff support activities, the workload is divided equally:

- **50%** is performed remotely from **home**
- **50%** takes place on **campus**.

Case study - Scenario 2

Hybrid (In-Person with Streaming and Recording)

This model combines traditional **face-to-face** education with digital components, including **live-streamed and recorded lectures**. In addition to the infrastructure required for in-person teaching, the hybrid system relies on supplementary ICT resources, such as streaming equipment, servers, and software platforms used to deliver and record educational content.

The system also includes the creation, storage, management, and distribution of online learning materials. Consequently, environmental impacts are associated with data storage servers, content management systems, streaming platforms, and the transmission of digital content.

Compared with the fully in-person model, student commuting is reduced, depending on the proportion of students participating remotely. Faculty and administrative staff activities are distributed between home and the university according to the same assumptions adopted in the face-to-face scenario, ensuring consistency in the comparison of educational modalities.

For students:

- **75%** attend lectures in person, resulting in lower energy consumption at home during teaching hours
- **12.5%** attend lectures via live streaming
- **12.5%** access recorded sessions

For **faculty** activities:

- **75%** of lesson and exam preparation is assumed to take place at **home**
- **25%** of lesson and exam preparation is carried out at the **university campus**.

For **administrative staff support** activities, the workload is divided equally:

- **50%** is performed remotely from **home**
- **50%** takes place on **campus**.

Both remote participation modes increase household energy consumption due to the use of ICT devices, lighting, internet connectivity, and, where applicable, heating, ventilation, or cooling systems.

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Case study - Scenario 3

Fully on line (Streaming and Recording)

This scenario combines the two fully online learning modalities, with **75% of students attending lectures via live streaming (synchronous learning)** and **25% accessing the recorded content of the lectures (asynchronous learning)**. All other characteristics remain consistent with those of the fully online synchronous and asynchronous scenarios.

The system relies entirely on digital infrastructure for the delivery of educational activities. Consequently, it involves the use and management of online educational content through **streaming platforms, content management systems, and servers for storing and distributing recorded lectures**. These components contribute to the environmental impacts associated with data transmission, data storage, and ICT infrastructure operation.

As all teaching and learning activities take place remotely, **student commuting is completely avoided**, eliminating transportation-related impacts. However, energy consumption is transferred to the home environment, where students use personal ICT devices, internet connections, lighting, and, where applicable, heating or cooling systems to participate in lectures and complete individual study activities.

- **75% of students** participate in lectures remotely through live streaming, resulting in increased household energy consumption due to the use of ICT devices, internet connectivity, lighting.
- **25% of students** access lectures through recorded sessions, which similarly increases energy consumption associated with personal devices, internet use, lighting, and home climate control systems.

For **faculty** activities:

- **75%** of lesson and exam preparation is assumed to take place at **home**
- **25%** of lesson and exam preparation is carried out at the **university campus**.

For **administrative staff support** activities, the workload is divided equally:

- **50%** is performed remotely from **home**
- **50%** takes place on **campus**.

What are the environmental impacts of a POLIMI student?

Functional Unit

25 hours of education per student

Climate Change (in CO_2 Emissions)

Freshwater Ecotoxicity

Human Ecotoxicity

NOTE: the environmental impacts have been chosen on the base of the POLIMI LCA study conducted in the framework of the GreeDILT project

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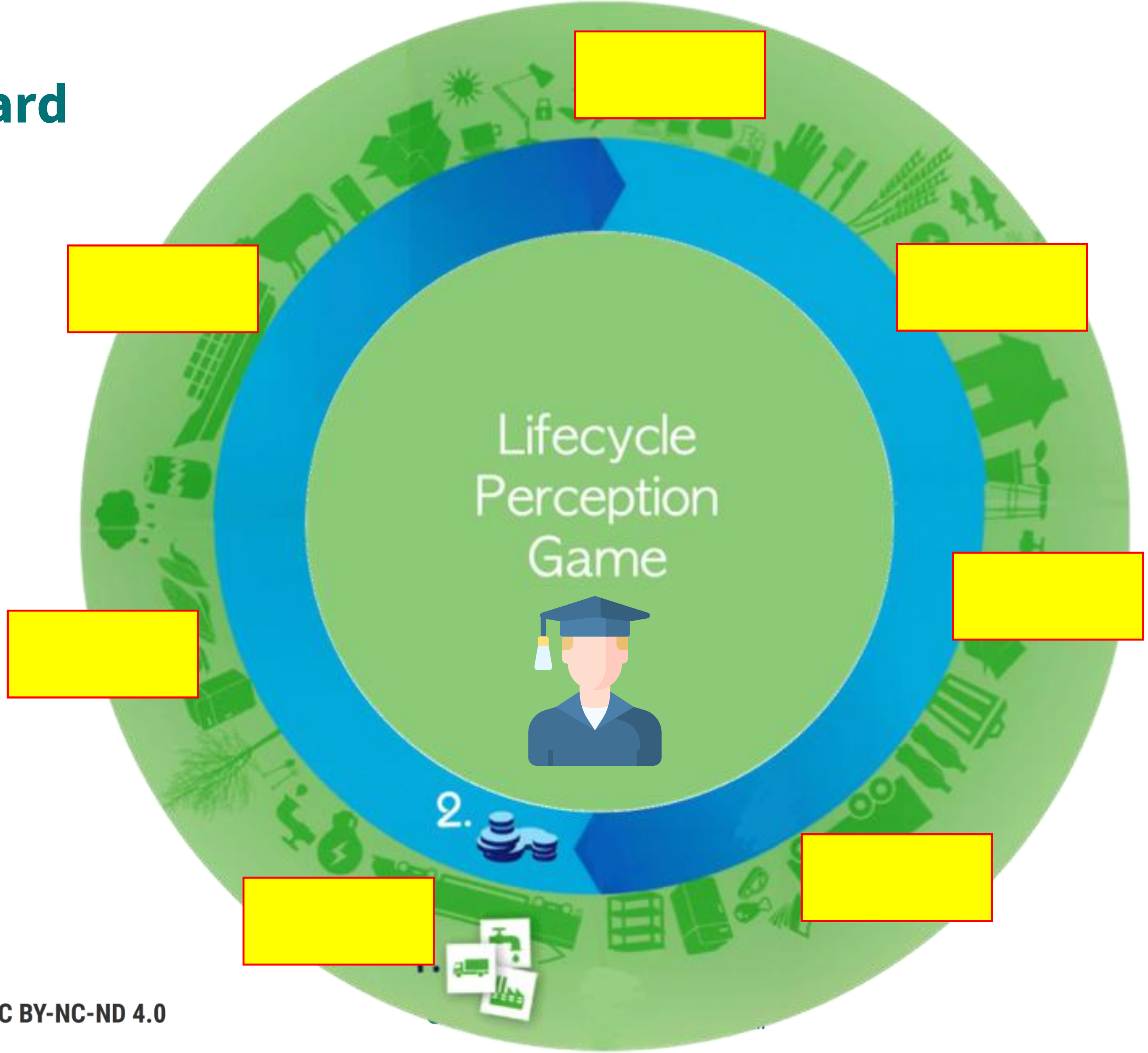
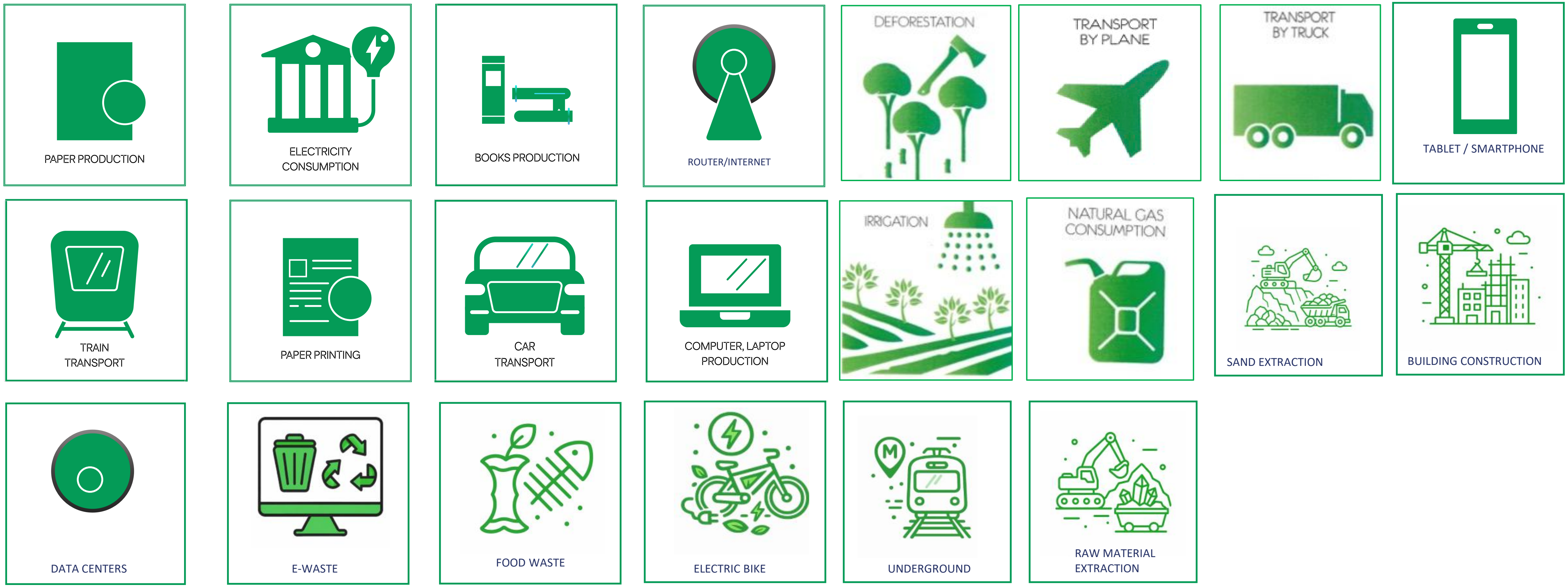
Board



Resources



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Warning

Note: You do not need to use all the cards.
Choose the ones that best fit the activity and the topics you want to explore.

You are free to consider them or not!

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Impacts estimation – constrains

Token Indicator 1 (100%)

2% 2%
5% 5%
10% 10%
30% 30%

Token Indicator 2 (100%)

2% 2%
5% 5%
10% 10%
30% 30%

Token Indicator 3 (100%)

2% 2%
5% 5%
10% 10%
30% 30%

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Work discussion

1. Present the results of your group work.
2. Identify any potential data gaps or uncertainties in the Life Cycle Inventory (LCI).
3. What are the main differences among the three scenarios analyzed?
4. Besides climate change, are there other environmental impact categories that should be considered? Why?
5. What are the main limitations of your analysis?
6. Based on the results, what recommendations would you make to reduce the environmental impacts of the product or system under study?

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Results – Scenario 1 FACE-TO-FACE

Climate Change
(in CO2 Emissions)

Freshwater Ecotoxicity

Human Ecotoxicity

Climate Change	FACE -TO-FACE
Car transport	57%
Train/underground transport	29%
Electricity	7%
Computer, laptop	4%
Printed paper / books	2%
Others	2%
Total	100%

Freshwater ecotoxicity	FACE -TO-FACE
Car transport	70%
Computer, laptop	13%
Train/underground transport	9%
Router, internet	3%
Electricity,	2%
Others	2%
Printed paper/books	1%
Total	100%

Human carcinogenic ecotoxicity	FACE -TO-FACE
Car transport	67%
Train/underground transport	24%
Computer, laptop	3%
Electricity	2%
Printed paper /books	2%
Others	2%
Total	100%

Results – Scenario 2 HYBRID

Climate Change
(in CO2 Emissions)

Freshwater Ecotoxicity

Human Ecotoxicity

Climate Change	HYBRID
Car transport	51%
Train/underground transport	25%
Electricity	10%
Natural gas for heating	6%
Computer, laptop	3%
Printed paper/books	3%
Consumer electronics, mobile device, tablet	1%
Router, internet	0%
Others	1%
Total	100%

Freshwater ecotoxicity	HYBRID
Car transport	64%
Computer, laptop	16%
Train/underground transport	8%
Router, internet	4%
Electricity,	3%
Others	1%
Printed paper/books	2%
Consumer electronics, mobile device, tablet	1%
Total	100%

Human carcinogenic ecotoxicity	HYBRID
Car transport	63%
Train/underground transport	23%
Electricity	4%
Computer, laptop	3%
Printed paper/books	2%
Natural gas for heating	1%
Consumer electronics, mobile device, tablet	1%
Router, internet	1%
Others	1%
Total	100%

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Results – Scenario 3 FULLY ON LINE

Climate Change
(in CO2 Emissions)

Freshwater Ecotoxicity

Human Ecotoxicity

Climate Change	FULLY ON LINE
Natural gas for heating	48%
Electricity	36%
Printed paper/books	6%
Computer, laptop	6%
oOthers	4%
Total	100%

Freshwater ecotoxicity	FULLY ON LINE
Computer, laptop	52%
Electricity	17%
Router, internet	15%
Natural gas for heating	6%
Printed paper/books	5%
Others	5%
Total	100%

Human carcinogenic ecotoxicity	FULLY ON LINE
Electricity	34%
Natural gas for heating	19%
Computer, laptop	22%
Printed paper/books	14%
Router, Internet	4%
Others	7%
Total	100%

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