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Calculation of the carbon footprint of books and E-readers through the stages of the product life cycle

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Introduction

The CO_2 equivalent is commonly used to measure environmental impact, converting various greenhouse gases into an equivalent amount of CO_2 based on their GWP. This calculation shows how much heat a particular gas retains in the atmosphere compared to CO_2 over a 100-year period. When analyzing the carbon footprint of books, it's essential to consider other greenhouse gases, such as methane ($CH_{4)}$, which is emitted from landfills, and nitrous oxide (N_2O), released during fertilizer use for growing trees used in paper production.

Carbon footprint is an important factor in understanding environmental impact. Calculating the carbon footprint helps identify the largest sources of greenhouse gas emissions within an organization, process or product. The obtained data have a qualitative and quantitative dimension of reporting on emissions and thus can contribute to easier achievement of sustainability.

Awareness of one's carbon footprint can motivate individuals and organizations to adopt more sustainable practices. This paper will present a carbon footprint for a book and an e-reader. The stages of LCA of the listed products will be compared and possible places in production or individual habits that can contribute to reducing the carbon footprint will be defined.

Problem Description

Calculating the carbon footprint of books and e-books is key to understanding, monitoring and reducing greenhouse gas emissions. The calculation can contribute to raising awareness, contribute to a lifestyle with the aim of a more sustainable business and lifestyle, and contribute to global efforts in the fight against climate change.

Methods

LTo define the product life cycle, all phases of the product life cycle are identified: procurement of raw materials, production, distribution, use and disposal or recycling. All relevant scientific literature related to greenhouse gas emissions and the carbon footprint of various materials and processes in scientific databases, reports of industrial organizations, environmental protection agencies and non-governmental organizations were reviewed. In addition to the aforementioned, the specifications and declarations of manufacturers and websites that offer carbon footprint calculators were reviewed. Collection and analysis of data for calculating the carbon footprint of products required a systematic approach and the use of a large number of enumerated data sources.
Using CO_2 equivalents, contributions to various greenhouse gases were calculated, which contributed to a comprehensive assessment of the real impact of books and E-readers on climate change. To ensure the credibility of the results, the accuracy of certain parts of the product life cycle phases was checked with other studies or reference values.

Results

Calculation of carbon footprint for book

The life cycle of a physical book is shown in Figure 1. If we assume that the average book has about 200 to 300 pages, that 1 kg of paper emits 1.2-1.5 kg of CO_2-eq. Printing processes, including the use of ink, printing machines and materials in finishing processes such as glue and packaging, emit approximately 1-2 kg of CO_2-eq. In total, for the production of one book of 1 kg of paper, approximately 2.2-3.5 kg of CO_2-eq is emitted. The distribution assessment includes different modes of transport. Trucks and airplanes tend to have higher emissions than ships. The total emission during the transport phase is approximately 0.5-1 kg CO_2-eq per book. The paper recycling process includes collection, transport to recycling facilities and an energy-consuming recycling process. Paper recycling according to EPN can reduce CO_2-eq emissions by about 1.4 kg CO_2-eq per kilogram of paper, and according to the IPCC about 0.3-0.6 kg CO2-eq per kilogram of paper.

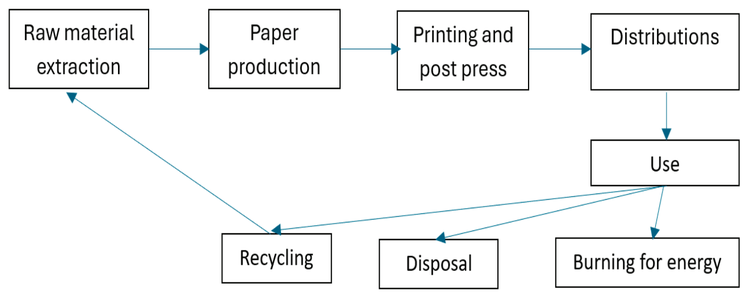

Figure 1. ***The life cycle of a book***

The life cycle of the e-reader is shown in Figure 2. Emissions from metal extraction and refining are about 30 kg CO_2-eq. The production of screens (e-ink or LCD) emits about 40 kg of CO_2-eq, batteries about 20 kg of CO_2-eq, and other electronic components about 30 kg of CO_2-eq. The installation of components in the finished device amounts to about 10 kg of CO_2-eq. Emissions in the transport phase amount to about 38 kg CO_2eq. During the transport phase, the E-reader emits 500 g of CO_2-eq per ton of product per kilometer. During the phase they emit about 168 kg of CO_2-eq. Transport related to moving the device from the place of production to the end user is about 10 kg CO_2-eq. E-readers consume very little energy, about 1-2 W. Recycling of electronic devices emits about 2-4 kg CO_2-eq per device, incineration (with energy recovery) about 1-3 kg CO_2-eq per device, and landfills emit about 1-2 kg CO_2-eq per device. The total carbon footprint of the e-reader is approximately 183.27 kg CO_2-eq.

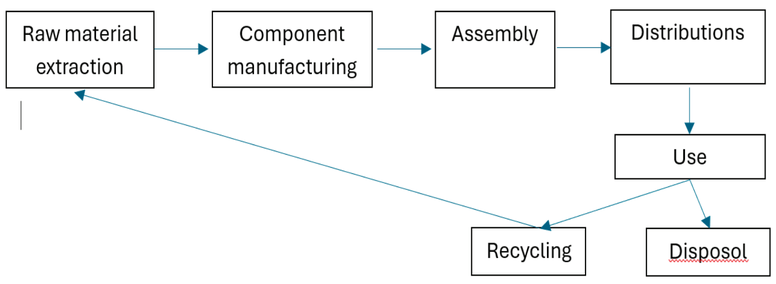

Figure 2 ***The life cycle of a e-reader***

Discussion / Conclusion

E-readers have a larger initial carbon footprint due to complex manufacturing processes, but may be more sustainable in the long run if used to read a large number of books. By changing lifestyles, such as extending the life of appliances, using renewable energy sources, optimizing readings and responsible disposal, their overall carbon footprint can be significantly reduced.
People who read a lot of books may have a larger carbon footprint if they only use printed books. Their carbon footprint could be reduced if people used public libraries or e-readers. The impact of e-readers on the environment is greatly reduced as the number of books read increases, so it is a good option for avid readers. Active recycling of paper and electronic devices should be encouraged.
At the beginning of product design, the use of recycled or biodegradable materials for e-reader components should be maximized. Recycled plastics can be used to make the case, while recycled metals can be used for the internal components. In addition, attention should be paid to easy disassembly of the device for more successful recycling. In order to reduce the CO_2-eq of transport, logistics should be simplified to reduce the distance and frequency of shipments. Such solutions should be combined with the use of low-emission transport such as electric trucks for local deliveries and maritime transport instead of air transport for international transport. E-readers should be designed to be more durable and resistant to damage, which extends their lifespan, and should allow for regular software updates to keep older devices functional and secure, reducing the need for frequent replacements. Optimizing device hardware and software to consume less energy, such as incorporating energy-efficient displays and processors, can contribute to eCO_2 reduction. Return programs for the collection of old devices and proper recycling of e-readers and cooperation with certified e-waste recycling services will contribute to increasing the recycling of e-reader components. Increasing the availability and variety of digital books will make e-readers a more attractive option for consumers and reduce their carbon footprint per book copy.

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