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Sustainable Material Selection in the Era of Artificial Intelligence

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Key takeaways for policy actors

1. Selecting materials for creating physical objects traditionally required finding a balance between cost and performance. But there is now an ethical duty and practical necessity to consider a third factor: sustainability.

2. Sustainable material selection must be integrated into our use of AI. This includes focusing both on energy consumption and on the environmental and social impacts of the materials used for computing devices.

3. We must ensure that finite resources like rare earth elements are ethically sourced, and enhanced recycling and alternative materials should be explored.

4. This requires increased incentivization, professional training, regulation, and collaborative projects to encourage sustainable material selection.

Introduction

Selecting materials for creating physical objects has traditionally been guided by two key considerations: performance and cost.[1] The technical performance of a material must be balanced by its cost. Recently, however, a third important consideration has emerged: sustainability.

Selecting the right materials is essential to ensuring sustainable consumption and production. Various policy mechanisms like carbon credits can be used to promote the use of sustainable materials.[2]

However, as artificial intelligence (AI) takes up an increasingly large share of global economic activity, novel efforts will be needed to ensure that sustainable material selection is not overshadowed by demands for rapid innovation.

Sustainability in material selection

The 17 Sustainable Development Goals (SDGs) adopted by all United Nations Member States in 2015 represent a radical new way of thinking about development, seeking to place sustainability at the forefront of decision-making processes. This sustainability-oriented approach extends to selection of materials for all kinds of industry, construction, and production. In particular, SDG 12 aims to ensure responsible production and consumption patterns, including by reducing the global material footprint, promoting the selection of sustainable materials, and reducing waste generation through prevention, reduction, recycling and reuse.[3]

A sustainable approach to material selection thus requires decision makers to look beyond immediate performance and cost savings.[4] Rather, it is necessary to consider the overall material footprint and the long-term environmental impact of materials used.[5] This entails assessing materials based on their environmental impact, renewability, recyclability, and prospective reuse.[6] Education and training are essential for promoting sustainability among engineering, design, and construction professionals, as they equip these professionals with the requisite knowledge and skills to incorporate sustainable materials.[7]

Benefits of sustainable material selection

The positive effects of sustainable material selection are far-reaching. Integrating sustainability principles into the selection process helps to decrease resource depletion, pollution, and waste.[8] Readily recycled or repurposed materials also help promote a circular economy, in which waste is reduced and resources are reused continuously, closing the material loop.[9]

Sustainable materials can also have unique qualities that actually increase performance: advanced composites produced from natural fibers, for example, can have high strength-to-weight ratios.[10] Sustainable materials can thus lead to decreased maintenance demands, longer product lifespans, and cheaper disposal expenses.[11]

These benefits extend beyond SDG 12, touching on multiple other Goals, such as good health and well-being (SDG 3), industry, innovation and infrastructure (SDG 9), and sustainable cities and communities (SDG 11).

Sustainable materials in the era of AI

The principles of sustainable material selection must be incorporated into our use of emerging technologies, particularly as AI and computing continue to make up an increasingly large share of our economic activities and consumption.[12] While discussions about AI and sustainability often focus on reducing energy consumption and cutting the carbon footprint, it is equally important to consider the environmental impact of material selection.[13]

AI systems, particularly large-scale machine learning models, demand substantial processing resources, resulting in elevated energy usage. While this is highly relevant to discussions around sustainable AI, it has often overshadowed the fact that the construction of large data centres and the increased production of specialized computing hardware have also amplified global demand for various finite materials. Most notably, the hardware enabling AI technologies often relies on rare earth elements (REEs) and other non-renewable resources.[14]

These resources are not only limited in supply, but are frequently linked to unethical mining practices and negative environmental impacts.[15] Materials must be selected in a way which limits human rights abuses, maximizes benefits to local communities, reduces dependency on finite resources, and promotes the use of recycled materials where possible. The negative externalities of REEs must be accounted for and sustainable alternatives should be explored through research and development, public-private partnerships, and collaborative projects that spur innovation and accelerate the commercialization of sustainable materials.

The life cycle of AI-related materials

The rapid evolution of AI and increased competition in the industry pose a risk of outdated hardware contributing to electronic waste as the average lifespan of hardware decreases. Despite their scarcity, less than 1% of REEs used globally are recycled.[16] To mitigate waste and promote the continual use of resources, products should be designed for longevity and repairability, and scarce materials should more frequently be recycled, repurposed, or replaced with sustainable alternatives.[17]

Moreover, the sustainability of the materials used to enable AI is not only determined by their scarcity, but also by their supply chain. The sourcing of REEs and other materials for AI hardware involves complex global supply chains with significant environmental footprints and far-reaching social impacts.[18] A sustainable approach to material selection must consider the entire life cycle of the material, from extraction to disposal. This entails addressing complex issues like labour conditions and ecological footprints in the mining sector.

Policymakers can promote the selection of more sustainable materials in AI hardware by offering financial incentives, carbon credit systems, and recognition programmes.[19] Strengthening national regulatory frameworks to require sustainable materials in critical industries and aligning with international standards are also crucial.[20]

Conclusion

Integrating sustainability into material selection is critical for tackling global environmental concerns and securing a sustainable future. By incorporating sustainability concepts into the conventional criteria of performance maximization and cost reduction, we can design materials and products that are efficient, cost-effective, ecologically responsible, and socially suitable.

Promoting this approach is particularly important in the context of AI, which, despite its rapid growth, remains dependent on scarce finite resources. Implementing a comprehensive approach in this emerging sector will necessitate coordinated efforts across education, incentives, policies, regulations, standards, and institutional structures. We can accelerate the transition to sustainable material choices through focused effort and cooperation and contribute to a more resilient and sustainable society.

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EDITORIAL INFORMATION

About the research
This technology brief is part of a UNU series highlighting specific areas of global technology governance related to the Global South and sustainable development.

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