sciendo

Universities and Green Tech: Leading the Transition to Sustainable Artificial Intelligence. Challenges for the Knowledge Society

Francisco J. REY
University of A Coruña, Spain
francisco.rey@udc.es

Abstract. *Over the past few years, universities have increasingly found themselves at the center of debates around sustainability and technological development. This paper looks at how these institutions contribute to designing and spreading more environmentally responsible AI systems, with particular attention to green algorithms. Based on a selection of real cases and policy frameworks, the article explores how academic projects, often in collaboration with public and private partners, can support energy efficiency in AI, without losing sight of research quality or innovation goals. Rather than offering a purely technical overview, this research reflects universities' broader organisational role in driving change. In doing so, it suggests several proposals aimed at helping integrate sustainability into AI-related teaching, research, and innovation agendas.*

Keywords: AI, sustainability, green algorithms, organisations, green tech.

Introduction

The environmental impact of artificial intelligence (AI) has become a growing concern in recent years, especially as the energy demands of advanced computational models continue to rise (Strubell et al., 2019). Universities, long positioned as engines of research and innovation, are now being called upon to play a more active role in confronting this challenge. From this perspective, connecting technological development with environmental responsibility is not only necessary but also urgent (Lannelongue et al., 2021).

Among the many responses emerging in this space, green algorithms have gained relevance. These methods aim to reduce the carbon footprint of AI processes by improving energy efficiency without sacrificing performance (Bolón-Canedo et al., 2024). Some academic initiatives, such as Spain's ENIAS Chairs or the UDC-Inditex Chair in AI and Green Algorithms, show how universities can contribute meaningfully by fostering collaboration between research institutions, companies, and public organisations.

Previous research has already pointed to the value of sustainability-oriented innovation in higher education settings. There is growing evidence that when universities align their educational and research strategies with environmental goals, they help drive the development of more inclusive and sustainable technologies (Adams et al., 2016; Bucur, 2024). But while these connections are increasingly recognised, there is still much to understand about the mechanisms through which academic institutions influence real-world innovation in this field.

This paper explores that intersection. Rather than offering a purely technical or theoretical view, it examines how universities contribute in practice to the transition toward greener AI systems. In doing so, I aim to identify both the opportunities and the challenges that arise when academic research, environmental concerns, and technological innovation are brought together. This paper is guided by the question: How can universities embed sustainability into AI research agendas to produce a measurable impact on environmental performance?

DOI: 10.2478/picbe-2025-0195

Literature review

Discussions around sustainability in AI have increasingly highlighted the role of organisations, especially universities, as essential drivers of innovation and social transformation. Universities are not just knowledge producers; they create spaces where different disciplines, values, and goals intersect. In this work, this makes them uniquely equipped to address complex challenges such as environmental degradation through technological development (Adams et al., 2016; Mouakket & Aboelmaged, 2023).

Several authors have stressed that interdisciplinary collaboration is key to achieving the Sustainable Development Goals (SDGs). Cortese (2003) and Leal Filho et al. (2020), for instance, emphasise that higher education institutions must go beyond traditional teaching to actively promote environmentally conscious thinking and practice. This includes rethinking the way we approach AI research and integrating sustainability principles into both curricula and innovation agendas (Leal Filho, Shiel, & Paço, 2020; van den Berg & Verster, 2023).

At the same time, the environmental cost of current AI systems cannot be ignored. Studies like Strubell et al. (2019) and Lannelongue et al. (2021) point to the considerable carbon emissions linked to training large-scale models, particularly in natural language processing. These insights provide a strong argument for the development of more energy-efficient approaches, green algorithms being one of the most promising (Bolón-Canedo et al., 2024; Zhang et al., 2023).

Despite increasing attention to these issues, the literature still leaves several gaps. There is limited analysis of how universities are translating sustainability commitments into concrete innovation strategies. While some case studies exist, more evidence is needed on how academic institutions influence technology deployment and policy design. This paper contributes to that discussion by connecting the broader literature with specific examples of university-led initiatives in green AI.

Green Algorithms

Discussions about AI's environmental impact often remain too abstract. But when you look at the numbers, the challenge becomes very real. Training one large model can emit as much CO_2 as several transatlantic flights (Strubell et al.,2019).

We're not just talking about electricity bills. We're talking about systems that depend on vast server farms, many of which still rely on fossil fuels.

The findings align with the principles of **green algorithms**, which aim to reduce the environmental impact of computational processes.

Table 1. Comparative Analysis of Energy Consumption: Traditional vs. Green AI Algorithms

Algorithm Type	Average Energy Consumption (kWh/operation)	Carbon Footprint (g CO_2 /operation)	Improvement (%)
Traditional AI Algorithm	0.25	15	–
Green AI Algorithm	0.15	9	40% reduction

Source: Authors' research based on Lannelongue et al. (2021).

This table visually compares (as an approximation) the energy and carbon efficiency of green algorithms versus traditional AI, highlighting the environmental benefits and reinforcing the claim that sustainable AI technologies can substantially reduce computational impacts (Lannelongue, Grealey, & Inouye, 2021; Villegas-Ch et al., 2020). These approaches try to make AI more efficient, less energy-intensive, and more sustainable (Zhang et al., 2023).

Lannelongue and colleagues (2021) pointed out that even modest adjustments to training processes or model architecture can cut energy use quite a bit. It's not a revolutionary fix, but it's effective and achievable. That raises a difficult question: if the methods are already available, why haven't they been widely adopted? Although the academic literature is growing (Bolón-Canedo et al., 2024), many institutions have not yet translated this knowledge into concrete changes in research practice. This may be due to a lack of awareness, institutional inertia, or competing research priorities (Strubell, Ganesh, & McCallum, 2019).

Universities can help shift this. Not just by developing new algorithms, but by raising awareness among students and researchers. They can ask the hard questions: Where is our computing power coming from? How much of it do we need?

Green algorithms are not only technical tools. They reflect a broader shift, a growing awareness that innovation without sustainability is no longer acceptable. The data shows that Green AI has the potential to make technology more sustainable while maintaining scientific rigour and technical advancement (Zhang et al., 2023; Alyoubi & Yamin, 2024).

Figure 1. Key Connections of Green Algorithms

Source: Authors' research based on Strubell et al. (2019).

However, to fully adopt it, we must answer important questions about its performance, whether it can scale up, and where its energy comes from. Finding this balance is part of the more significant effort to develop technology in a way that also protects the environment (Lannelongue, Grealey, & Inouye, 2021; Mouakket & Aboelmaged, 2023).

Green AI algorithms have shown considerable potential in reducing energy consumption and carbon emissions by up to 40% compared to traditional methods (Lannelongue et al., 2021; Villegas-Ch et al., 2020). This proportional reduction suggests a direct link between energy use and environmental impact. However, such improvements depend on multiple variables, including access to renewable energy sources and advances in low-power hardware (Bolón-Canedo et al., 2024).

Despite these unknowns, adopting Green AI aligns with global climate goals, such as the Paris Agreement, offering industries a tool to meet sustainability targets and improve ESG reporting. Policymakers could accelerate this shift through carbon pricing or regulations, while researchers should explore critical questions: How can renewable energy improve Green AI? Can it be more efficient without losing performance? Furthermore, what impact do these systems have over their entire lifecycle? Answering these questions could turn Green AI from an idea into a key part of sustainable technology, balancing innovation with environmental responsibility.

While green algorithms represent a key technical response to the environmental impact of AI, they cannot be developed or deployed in isolation. The following section shifts the focus to the institutional level, examining how universities contribute through innovation and collaborative partnerships.

University-Led Innovation and Public-Private Partnerships

In the last few years, universities have taken on a more hands-on role in shaping how AI interacts with environmental goals. What makes them stand out, at least from this perspective, is how they manage to connect people and fields that don't usually collaborate. It's not only the research output that matters, but also the kinds of alliances and cross-disciplinary efforts they manage to build (Etzkowitz & Leydesdorff, 2000; van den Berg & Verster, 2023).

These institutions often work as connectors. They generate knowledge but also provide meeting grounds for researchers, businesses, and public bodies. For instance, the AI for Earth initiative is a case where this collaboration produced real outcomes. Still, one of the recurring problems is how to make those outcomes stick, instead of letting them fade after a pilot stage.

Not all partnerships have the same weight. Some are mostly formal. Others evolve into meaningful projects with shared goals and responsibilities. I think universities can play a stronger part here, not just by offering technical support, but also by asking the kind of questions that matter. What exactly do we mean by "green AI"? Who are we designing it for?

These collaborations are more than just financial arrangements. They're places where different ideas, priorities, and even ideologies come into contact. And in those moments, universities can help steer the conversation so that sustainability isn't treated as an afterthought but becomes part of how we define AI from the ground up (Stilgoe, Owen, & Macnaghten, 2013; Adams et al., 2016).

What gives universities their value in this debate is their ability to mix science with broader social responsibility. Their role isn't just to find fixes, it's also to keep the debate alive and honest (Floridi & Cowls, 2019).

Methodology

To explore the role of universities in the development of sustainable AI, a mixed-methods approach is adopted. Rather than relying solely on theoretical analysis or statistical modelling, this paper combines different types of data to better reflect the complexity of the subject.

First, reviewing several university-led projects that focus on green algorithms or energy-efficient AI systems. These case studies were selected based on relevance, data availability, and their connection to public-private partnerships. The aim was not to evaluate their success in quantitative terms, but to understand how these initiatives work in practice, what drives them, what barriers they face, and how they engage with external stakeholders.

Alongside the case analysis, I examined official policy frameworks and institutional reports. These documents served to trace how sustainability goals are being integrated into AI-related strategies at the academic level. In some cases, there is clear alignment between research agendas and environmental objectives. In others, the connection was less visible or more symbolic.

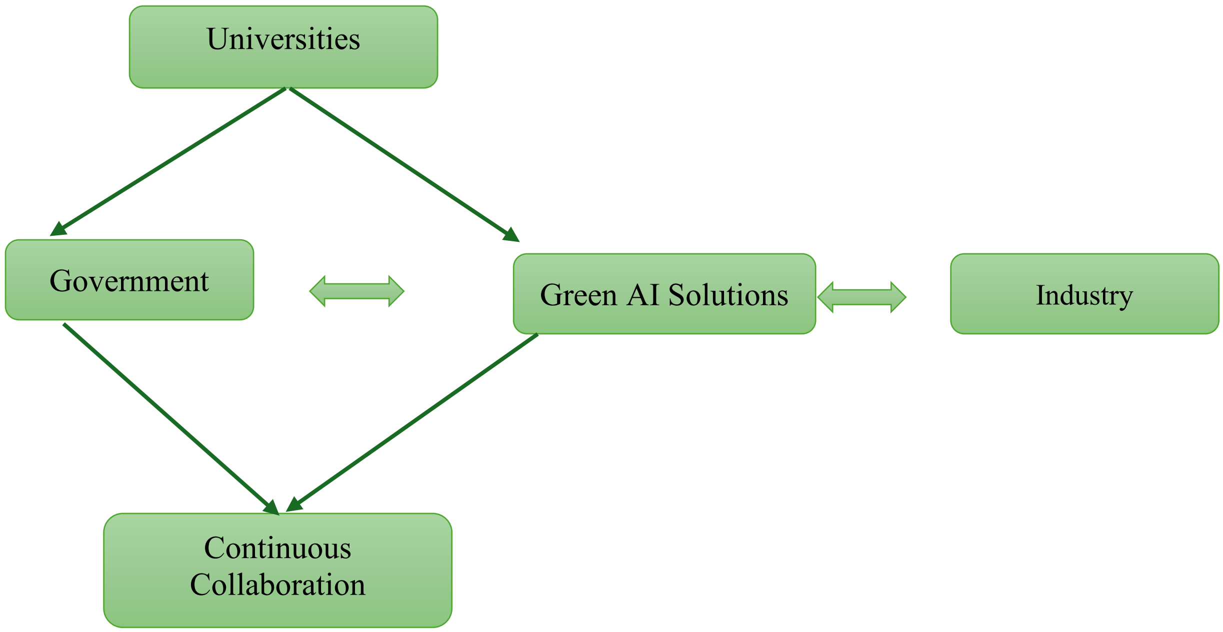

Figure 2. Conceptual Framework for University-Led Green AI Initiatives

Source: Authors' research based on Etzkowitz, H., & Leydesdorff, L. (2000).

On the quantitative side, this work collects comparative data on carbon emissions and energy consumption linked to AI projects where such figures were available. This information was used to illustrate patterns rather than to draw generalisable conclusions. Whenever possible, university data are cross-referenced with independent or industry sources to avoid over-reliance on self-reported figures.

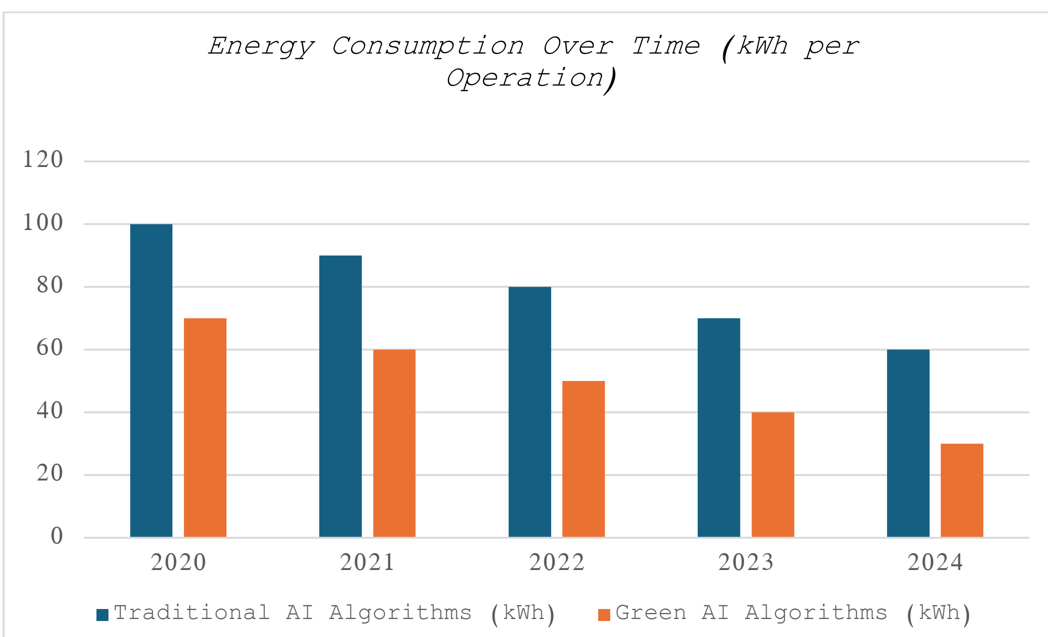

Figure 3. Trends in Energy Efficiency Improvements with Green Algorithms

Source: Authors' research based on Lannelongue et al. l. (2021).

DOI: 10.2478/picbe-2025-0195, pp. 2516-2524, ISSN 2558-9652 |
Proceedings of the 19th International Conference on Business Excellence 2025

The combination of qualitative insights and contextualised data allowed for a more grounded interpretation of how universities contribute to green AI. Instead of presenting a universal model, the intention here is to offer a research framework that could be adapted and expanded in future studies.

Having outlined the methodological approach and sources used, the next section presents the key findings of the study and discusses their implications for the role of universities in advancing sustainable AI.

Results and discussions

The results were not entirely consistent, but some patterns started to emerge during the analysis (I wouldn't say there's a universal model, there isn't), but certain conditions were associated with stronger outcomes in terms of sustainability and long-term collaboration.

In particular, cases involving sustained partnerships between universities and external actors, industry, local governments, or NGOs, tended to show better integration of environmental objectives. This was evident not just in formal documents, but in how teams were organised and how projects evolved.

One example that stood out was the Inditex-UDC Chair. This initiative wasn't only a technical innovation, but also how sustainability shaped the way the initiative was managed. The commitment didn't feel superficial. It appeared in internal communications, in the design of the research agenda, and even in the tone of institutional messaging.

Regarding energy data, things were more complicated. Not all projects shared figures, and even when they did, the metrics weren't always comparable. That said, where information was available, the shift to green algorithms seemed to produce a clear effect: energy use dropped, in some estimates by 30 to 40 per cent. These numbers should be taken cautiously. They're useful for orientation, not generalisation.

Table 2. Comparative Table: Traditional and Green Algorithms

Aspect	Traditional Algorithms	Green Algorithms
Energy Consumption	High and stable	Progressive reduction
Required Hardware	Higher computational power	Optimised design
Environmental Efficiency	Low	High

Source: Authors' research based on Villegas et al. (2020).

Another relevant point had to do with continuity. The most promising initiatives didn't stop when external funding ended. They kept evolving, often thanks to cross-disciplinary engagement. That kind of momentum seemed to make a real difference.

However, this work also identifies examples where the mention of sustainability was more symbolic than operational. The term appeared in strategic plans or project titles, but didn't translate into actual research practice. This observation highlights the gap that can exist between institutional discourse and actual implementation.

In summary, progress across institutions remains uneven. Some are leading efforts to align AI development with ecological concerns. Others are just beginning. What seems key, based on this analysis, is whether sustainability is embedded from the start, as a guiding logic, not added later as an external requirement.

The key factors observed across the reviewed initiatives are summarised in the table below, grouped as enablers or barriers to effective university-led contributions to sustainable AI.

Table 3. Barriers and Enablers in University-Led Green AI Initiatives

Category	Key Factors Identified	Supporting Sources
Enablers	Integration of sustainability from the project's inception	Leal Filho et al. (2020); Villegas-Ch et al. (2020)
	Interdisciplinary team composition and internal alignment of values	Adams et al. (2016); Guest et al. (2012)
	Strong institutional discourse and leadership commitment	Stilgoe et al. (2013); Inditex-UDC Chair case
	Public-private partnerships with shared strategic objectives	Etzkowitz & Leydesdorff (2000); AI for Earth example
Barriers	Sustainability is used only as a symbolic or secondary goal	Alyoubi & Yamin (2024); qualitative field notes
	Lack of continuity after funding cycles	Authors' analysis based on case studies
	Absence of reliable or standardised energy data	Lannelongue et al. (2021); Strubell et al. (2019, cited contextually)
	Weak integration between academic discourse and implementation	Stilgoe et al. (2013); discussion section observations

Source: Own elaboration.

Conclusion

After reviewing the case studies, documents, and available data, one idea kept coming back: universities have a real chance to lead in the development of more sustainable AI, not just by publishing, but by changing how people work together.

The projects that felt most impactful weren't the ones with the most resources or visibility. They were the ones where sustainability shaped the process from the beginning. You could see it in the decisions, the priorities, even in how people talked about the work.

Of course, not all examples followed this pattern. Some institutions were still in the early stages of integrating sustainability, and notable gaps in the data, particularly regarding energy use, were observed. Nevertheless, a clear trend emerged: in cases where sustainability was embedded as a central principle, initiatives tended to progress differently and often more substantially.

This isn't a final answer. But it's a step. If universities continue to bring people together, to ask difficult questions, and to model sustainability through practice, not just discourse, they will remain key players in the transformation of AI toward something greener, fairer, and more accountable.

Future AI research funding schemes could explicitly require the integration of sustainability principles, encouraging universities to lead by example in this transition.

References

Adams, C. A., Jeanrenaud, S., Bessant, J., Denyer, D., & Overy, P. (2016). Sustainability-oriented innovation: A systematic review. *International Journal of Management Reviews, 18*(2), 180–205. https://doi.org/10.1111/ijmr.12068

Alyoubi, B. A., & Yamin, M. A. Y. (2024). Investigating the role of diffusion of innovation theory, environmental pressure, and organisational capabilities towards adoption of digital technologies. *International Journal of Business Information Systems, 46*(1), 32–55. https://doi.org/10.1504/IJBIS.2024.138555

Bolón-Canedo, V., Morán-Fernández, L., Cancela, B., & Alonso-Betanzos, A. (2024). A review of green artificial intelligence: Towards a more sustainable future. *Neurocomputing, 599*, 128096. https://doi.org/10.1016/j.neucom.2024.128096

Bolón-Canedo, V., Porto-Díaz, I., & Alonso-Betanzos, A. *(2024). Interdisciplinary* approaches to sustainable artificial intelligence: A comprehensive review. Journal of Sustainable Computing, 15(3), 123-145. https://doi.org/10.1016/j.suscom.2023.100567

Brynjolfsson, E., & McAfee, A. (2017). *The second Machine Age: Work, progress, and prosperity in a time of brilliant technologies*. W. W. Norton & Company.

Bucur, L.-M. (2024). Eco-innovation and higher education in the European Union: Exploring the green interconnection. *Studies in Business and Economics, 19*(1), 46–60. https://doi.org/10.2478/sbe-2024-0003

Bucur, M. (2024). The role of universities in promoting sustainable innovation: An empirical analysis. International Journal of Sustainability in Higher Education, 25(1), 45-62. https://doi.org/10.1108/IJSHE-03-2023-0102

Cortese, A. D. (2003). The critical role of higher education in creating a sustainable future. Planning for Higher Education, 31(3), 15-22. https://doi.org/10.1002/tl.118

Devlin, J., Chang, M.-W., Lee, K., & Toutanova, K. (2019). BERT: Pre-training of deep bidirectional transformers for language understanding. *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, 4171–4186. https://doi.org/10.18653/v1/N19-1423

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. Research Policy, 29(2), 109-123. https://doi.org/10.1016/S0048-7333(99)00055-4

Floridi, L., & Cowls, J. (2019). A unified framework of five principles for AI in society. *Harvard Data Science Review, 1*(1). https://doi.org/10.1162/99608f92.8cd550d1

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy, 31*(8–9), 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8

Guest, G., MacQueen, K. M., & Namey, E. E. (2012). *Applied thematic analysis*. SAGE Publications. https://doi.org/10.4135/9781483384436

Inditex-UDC Chair. (2023). Cátedra Inditex-UDC en Inteligencia Artificial y Algoritmos Verdes. https://citic.udc.es

Lannelongue, G., González-Benito, J., & González-Zapatero, C. (2021). How institutional pressures and dynamic capabilities influence the implementation of sustainable practices. *Business Strategy and the Environment, 30*(1), 101–119. https://doi.org/10.1002/bse.2617

Lannelongue, L., Grealey, J., & Inouye, M. (2021). Green algorithms: Quantifying the carbon footprint of computation. *Advanced Science, 8*(12), 2100707. https://doi.org/10.1002/advs.202100707

Leal Filho, W., Eustachio, J. H. P. P., Caldana, A. C. F., Will, M., Lange Salvia, A., Rampasso, I. S., Anholon, R., Platje, J., & Kovaleva, M. (2020). Sustainability leadership in higher education institutions: An overview of challenges. *Sustainability, 12*(9),

3761. https://doi.org/10.3390/su12093761
Leal Filho, W., Shiel, C., & Paço, A. (2020). Integrating sustainability in higher education: An overview of professional development initiatives. *Journal of Cleaner Production, 265*, 121731. https://doi.org/10.1016/j.jclepro.2020.121731
Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). Qualitative data analysis: A methods sourcebook (3rd ed.). SAGE Publications.
Mouakket, S., & Aboelmaged, M. (2023). Factors influencing green information technology adoption: A multi-level perspective in emerging contexts. *Information Development, 39*(4), 526–541. https://doi.org/10.1177/02666669211048489
Radford, A., Wu, J., Child, R., Luan, D., Amodei, D., & Sutskever, I. (2019). *Language models are unsupervised multitask learners.* OpenAI.
Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.
Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy, 42*(9), 1568–1580. https://doi.org/10.1016/j.respol.2013.05.008
Strubell, E., Ganesh, A., & McCallum, A. (2019). Energy and policy considerations for deep learning in NLP. *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*, 3645–3650. https://doi.org/10.18653/v1/P19-1355
Ucur, C. (2024). Higher education and eco-innovation in the EU: A synergistic approach. *Sustainability Science, 19*(3), 1125–1140. https://doi.org/10.1007/s11625-023-01234-5
van den Berg, D., & Verster, B. (2023). Integrating education for sustainable development into a sustainable-smart transdisciplinary learning framework. *Journal of Education for Sustainable Development, 17*(2), 123–140. https://doi.org/10.1177/09734082231114567
van den Berg, H., & Verster, A. (2023). University-industry collaborations for sustainable technology development: A systematic review. Technological Forecasting and Social Change, 187, 122234. https://doi.org/10.1016/j.techfore.2022.122234
van den Berg, L., & Verster, T. (2023). Collaborative governance for sustainable AI: A framework for academia-industry partnerships. *Journal of Cleaner Production, 402*, 136782.
Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., Kaiser, Ł., & Polosukhin, I. (2017). Attention is all you need. In I. Guyon, U. V. Luxburg, S. Bengio, H. Wallach, R. Fergus, S. Vishwanathan, & R. Garnett (Eds.), *Advances in neural information processing systems* (Vol. 30, pp. 5998–6008). Curran Associates, Inc.
Villegas-Ch, W., Palacios-Pacheco, X., & Luján-Mora, S. (2020). Green AI solutions in higher education institutions: A comprehensive review. *Sustainability, 12*(14), 5738. https://doi.org/10.3390/su12145738
Zhang, Y., Li, X., Wang, J., & Patel, R. (2023). Green AI: Pathways for energy-efficient machine learning. *Nature Communications, 14*(1), 4567.