

AN AUDITING FRAMEWORK AND CHECKLIST TO GUIDE GREEN IT ASSESSMENT IN BUSINESSES

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ABSTRACT

There are several drivers that contribute to the increasing importance of green information technology (IT) for both researchers and practitioners, while the field still allows for more applied research and improved professional practices. Businesses would welcome a tool to assist in their green IT assessment, both as a way to determine where they stand and as a method to guide their IT greening adoption. To this end, this paper proposes an auditing framework and an indicative auditing checklist, following a few interviews with IT and environmental issues auditors, in conjunction with literature review. Auditing is strong as an assessment tool, if it is used within a specific meaningful and actionable framework. The proposed auditing framework followed by an indicative checklist of 25 items, promotes research and professional practice in the sustainability area relating to IT that represent the lion's share in today's business budgets and energy consumption bills.

Keywords: green IT, green IT auditing framework, green IT checklist, IT environmental sustainability, sustainable IT management.

1 INTRODUCTION

All businesses nowadays rely on information technologies (IT) for their daily operations as well as strategy and planning functions, apart from the smart devices embedded in various devices, transportation systems, buildings, etc. The use of IT by corporates is energy savvy and has an impact on the environment, although it may not seem obvious at first sight. It is therefore imperative to monitor the level of energy consumption and eco-friendliness of IT in corporations, since it is the only type of resources that is used by any kind of businesses in any sector of the economy. The IT service providers themselves, such as cloud service providers, as well as IT-intensive businesses like those in banking and finance, run big proprietary data centres, accommodating a significant amount of IT infrastructure which interacts with the environment through energy, heat, water, disposal of aged equipment, etc. Businesses that are sensitive in the area of corporate social responsibility (CSR) often neglect to look into the greenness of their IT functionality, IT procurement and IT operations. 'While cost cutting is the largest impact and factor of implementing green IS practices in an organization, environmental stewardship follows closely behind. [...] By adopting initiatives that have a positive effect on the environment, they save money, and at the same time, use technology more efficiently. Great opportunities lie in the IT department, where reducing the environmental footprint of technology is now top of mind for many IT leaders' [1].

Although green IT has been identified as 'an economic, as well as an environmental, imperative' in, as early as, 2008, and also that 'the IT sector and users must develop a positive attitude toward addressing environmental concerns and adopt forward-looking, green-friendly policies and practices' [2], its emergence 'as an academic discipline is still by far too slow relative to the needs of society' [3]. A model to systematically investigate green IT adoption, Green IT Adoption Model (GITAM), has been proposed to 'predict the intention and the breadth and depth of Green IT adoption' [4]. Apart from that, and a green readiness model [5], which identifies 'its key dimensions and develops a reliable and valid instrument



to operationalize it', there is no actionable roadmap or framework to lead decisions makers towards IT greening.

As computer consumption rises, maintaining green computing practices over a computer's entire life cycle becomes increasingly important [6]. Drawing from governance, quality and auditing disciplines, this paper proposes an auditing framework for assessing IT greenness to provide a meaning and actionable blueprint that may guide decisions and practices towards greening IT in corporations. Through auditing, managers identify areas for improvement within the organization's operations, processes, and internal controls [7]. The proposed auditing framework offers an indicative checklist of 25 items as guidance, which can be further detailed as businesses mature towards green IT. The benefits for businesses that pursue continuous improvement in green IT relate to cost, CSR and sustainability compliance.

2 DRIVERS TOWARDS GREEN IT

'IT practitioners need to understand how different types of IT resources, when integrated with complimentary business resources, contribute differently to firms' overall sustainability strategy to achieve different objectives across the four quadrants [today/tomorrow, internal/external] of the integrated sustainability framework' [8]. This leads us to evaluate, from a green IT perspective, suppliers, use of IT and related resources (e.g. paper) by IT and end-users, elasticity of IT resources to respond to fluctuations of demand etc.

Computing resources are energy savvy. According to Raza et al. [9] 'a typical desktop computer with a 17-inch flat panel LCD consumes 874 kilowatt hours of electricity and release around one ton of CO₂; data centers typically account for 25% of total corporate IT budgets and for information-intensive organizations, it can account for over 50% of the total corporate carbon footprint; data center power and cooling costs have increased 800% since 1996.'

The aforementioned factors, in conjunction with new laws and regulations (for example, Clean Air Act and Clean Water Act in the USA, European Union Emissions Trading System, Environmental Protection Act in the UK also include penalties for non-compliance) as well as international targets to reduce the environmental impact of all kinds of business activities, represent drivers towards green IT. Their momentum is increasing quantitatively and qualitatively, and, hence, its importance for researchers and practitioners.

3 WHY AN AUDITING FRAMEWORK?

In today's dynamic business environment, managers face numerous challenges in making informed decisions that align with organizational goals and objectives. Decision making requires access to reliable and accurate information, which can be achieved through effective auditing processes.

Internal or external audits evaluate an organization's adherence to legal requirements, industry standards, and internal policies. European and international laws and regulations in the area of eco-friendliness are becoming more and more demanding, including fees and penalties. Auditing plays a critical role in ensuring compliance with laws, regulations, and internal policies. Regulatory audits assess an organization's adherence to legal requirements, helping managers mitigate legal risks, avoid penalties, and maintain regulatory compliance as well as reputation [10].

Furthermore, auditing serves as a tool for identifying operational inefficiencies and areas for improvement. Operational audits, for example, help in evaluating the efficiency and effectiveness of processes, enabling managers to make informed decisions on optimizing resource allocation and enhancing productivity [7].



Adopting internal and external auditing as well as standards certification, when applicable, enhances stakeholder confidence in the organization's operations, strategy achievement and governance processes. Stakeholders, including investors, creditors, and regulatory authorities, rely on auditing report to assess the organization's performance and integrity [11].

Based on the analysis of an audit findings report, actionable recommendations as well as requirements can be established to guide towards a green IT strategic plan with concrete objectives and ensure legal and regulatory requirements. It may also lead to corrective actions in areas of potential improvement. Also, it offers a basis for comparison of green IT performance indicators on regular periods. 'Continuous auditing allows us to monitor the organizational processes that are in place [...] and take appropriate actions to rectify them in the most efficient manner' [12].

For all the reasons, it is appropriate for an organization to start developing an auditing framework in the area of green IT in relation to its overall sustainability – ESG strategy. After all, using ESG criteria as an investment considerations are gradually becoming a common practice [13], paving the way for green decisions in all areas of organizations and paying attention to IT as well.

4 AN AUDITING FRAMEWORK FOR GREEN IT

As in every business initiative, the starting point is strategy. Green IT strategy is considered to include components such as 'energy efficiency, resource conservation, sustainable procurement, recycling and disposal, telecommuting, and green data centers/cloud providers [14]. The strategy has to clearly define the areas which may have a direct or indirect impact on the environment and subsequently, the quality of life of those living within the impact zone of business operations.

As soon as a strategy is set up, then governance issues have to be addressed. The initial question is whether current IT governance frameworks address properly the green IT issues. A study aiming to identify 'the presence of sustainability aspects in the COBIT (Control Objectives for Information and Related Technologies) model of IT management' showed 'a weak relationship with environmental and economic aspects' [15]. Therefore, a typical IT governance framework needs to be enriched with environmentally sensitive policies within the business, such as a quality management system on environment protection and management. If the company is certified with ISO standards, such as 14000 (environment protection), 50000 (energy consumption) etc., it is more likely that green IT falls within their scope of its strategic intent. However, having run a short survey in 20 small and medium size businesses in Greece, green IT seems quite often to be excluded from the scope of ISO standards application related to sustainability, due to ignorance, lack of strategic intent and relevant data. Moreover, the IT governance framework should include green IT because it has to take, by default, into account regulatory compliance. As part of a green IT governance framework, it is necessary for business to establish the role of a corporate green IT champion, or, otherwise called, sponsor. The results of a quick field survey show that the role of green IT sponsor is assigned to one of these executives: the head of ESG, or the CIO, or the Chief Compliance Officer or the CSR manager. There are arguments in favour of each one of these alternatives, however some of them reflect a very narrow scope of focus on the issue. The broader the role, the more likely for such a person to look at the issues from a leadership perspective, if the assignee is appropriately informed and trained. Possible responsibilities for such a role are provided by O'Neill [16]; the performance of this rules certainly falls within the scope of an audit in this area.

Regarding IT functionality, the audit focus must be the adoption of methods to use computing resources on demand, to the extent possible. The use of modern software engineering technologies, such as software micro-services, can support on-demand upscaling and downscaling, to save energy, reduce heat and consumption of coolants etc. ‘Tricentis’s Turner urges IT decision-makers to adopt test-driven development (TDD) as a sustainable IT methodology. In his experience, TDD offers a powerful technique that can significantly contribute to the creation of green code, characterised by higher quality and efficiency’ [17]. The impact of AI on the environment has recently raised concerns [18]; the research community aims at creating efficiency in AI algorithms [19] in order to make the impacts of its usage more compatible with sustainability demands. ‘When you add AI to an application, you increase its power usage by 10 times,’ said Chuck Dubuque, head of direct product marketing for OpenShift at RedHat [17].

An auditor should also look at the IT procurement procedures and practices of a corporation. IT supplies and supplier evaluation from a green IT perspective should look at software with fewer IT resources consumption levels, at hardware with fewer energy consumption and at telecoms with centralized equipment which could be more effectively eco-managed as compared to dispersed telecoms equipment. The suppliers’ engagement into green IT is an integral part of the overall IT greenness in organizations.

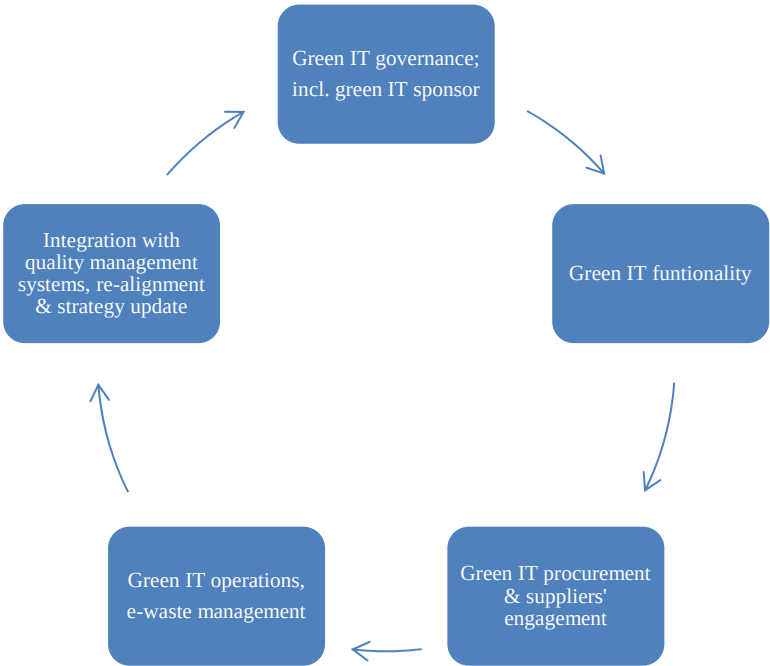


Figure 1: A green IT auditing framework as a continuous improvement cycle.

IT operations must be audited with particular emphasis on the data centre infrastructure and equipment. Tools and ideas for environmental sustainability attainment in enterprise data centres can be found, for example, in Kosik [20], Anthony et al. [21], Schulz [22] and Papadopoulos and Wurm [23]. The EU Code of Conduct for Data Centres [24], a voluntary

initiative managed by the Joint Research Centre, encourages organizations to adopt best practices for energy efficiency in data centres, providing guidelines for designing, operating, and maintaining data centres to minimize energy consumption and environmental impact. Moreover, the Waste from Electrical and Electronic Equipment (WEEE) directive [25], which sets the EU rules on treating waste electrical and electronic equipment to contribute towards a circular economy, may also provide a source of auditing items.

All the aforementioned components shape a green IT auditing framework (Fig. 1) which can be further analysed by auditors to arrive at checklists for their auditing purposes. The framework can be used as a blueprint for an organizational green IT strategy. An indicative auditor's check list based on the proposed framework should include at least the following topics (Table 1).

Table 1: An indicative auditor's checklist following the proposed auditing framework.

Auditing framework	Indicative auditor's checklist items according to the auditing framework
Green IT governance	1. Green IT sponsor: assess role, responsibilities and performance. 2. Integration of green IT principles into the IT governance framework and procedures. 3. Training and awareness: Ensure that employees are educated about green computing practices and the environmental impact of IT decisions.
Green IT functionality	4. Virtualization: Verify the implementation of virtualization technologies to optimize server utilization and reduce the need for physical hardware. 5. Power management: Confirm that power management features are enabled on computers and devices to minimize energy usage during periods of inactivity. 6. Optimized software development: Assess the software development practices to minimize resource-intensive coding and encourage efficient programming. Check efficiency of AI and other software engineering techniques. 7. Use of testing-driven software development methodologies.
Green IT procurement	8. Supplier engagement: Encourage collaboration with IT suppliers who follow environmentally friendly practices and provide eco-friendly products. 9. Green certifications: Check for certifications like ENERGY STAR [26] for IT products or other green computing certifications that demonstrate a commitment to environmental sustainability. 10. E-waste management: Assess procedures for the disposal of electronic waste through agreements with suppliers for recycling and reusability.

Table 1: Continued.

Auditing framework	Indicative auditor's checklist items according to the auditing framework
Green IT operations	11. Hardware lifecycle: Evaluate the organization's hardware lifecycle management to promote the responsible disposal and recycling of outdated equipment. 12. Energy efficiency: Assess the energy consumption of IT equipment, including servers, workstations, and networking devices. Ensure that energy-efficient technologies and practices are in place. 13. Data centre cooling: Review the cooling systems in data centres to ensure energy-efficiency and effective maintenance of the required temperature. 14. E-waste management: Assess procedures for the disposal of electronic waste, ensuring compliance with environmental regulations and responsible recycling practices. 15. Green data storage practices: Assess data storage practices, including data deduplication and tiered storage, to optimize storage space and reduce energy consumption. 16. Remote server management: Evaluate the utilization of remote server management tools to optimize performance without physical presence. 17. Cloud computing optimization: Verify that cloud computing resources are optimized for efficiency, with consideration given to server consolidation and resource scaling. 18. The EU code of conduct for data centres [27]: the annually revised best practices document [28] can also serve as a source of auditing topics and checklist items.
Green IT as a quality management system	19. Remote work policies: Examine policies and practices related to remote work to reduce the need for commuting and physical office space, promoting a more sustainable work environment. 20. Paperless initiatives: Confirm the adoption of paperless processes and digital documentation to reduce the environmental impact of paper usage. 21. Renewable energy sources: Investigate whether the organisation is incorporating renewable energy sources, such as solar or wind power, into its IT infrastructure. 22. Monitoring and reporting: Implement systems for continuous monitoring of energy consumption and environmental impact, with regular reporting for ongoing improvement. 23. Compliance with environmental regulations: Ensure compliance with local and international environmental regulations governing IT operations. 24. End-user education: Confirm that end-users are educated on responsible computing practices, such as turning off equipment when not in use. 25. Regular audits and update: Conduct regular audits to reassess and update green computing initiatives, ensuring ongoing alignment with best practices and emerging technologies



5 CONCLUSIONS

Regarding climate change, ‘it may be both individually and collectively rational for firms to commit to a purpose beyond profit maximization even if such a commitment is costly in the short term’ [29]. Greening IT can serve as such an organizational purpose, with multiple cascading benefits for the IT unit, the organization in which it operates and the organizational context as well. Given that ‘the IS (information systems) field has not yet fully realized the magnitude of the problem nor embraced sustainability as an integral part of its research agenda’ [30], this paper offers a green IT auditing framework to assess IT greening as a first attempt towards a green IT strategic objective. Following some discussions with IT auditors and environmental management systems auditors, in conjunction with literature review, an indicative auditor’s checklist has been compiled. When applied by auditors, this checklist aims to collect evidence, to thoroughly assess the energy-saving measures, and to evaluate the effectiveness of the data centre’s green IT strategies by addressing important areas like energy efficiency, renewable energy usage, cooling efficiency, monitoring and management, compliance, green IT policies, waste management and recycling as well as continuous improvement of the green IT vision.

Given that, ‘green Information Technology (IT) is emerging as an increasingly important issue as organizations come under pressure to address environmental sustainability concerns’ [5], the proposed framework for green IT assessment can initially be used as a meaningful and actionable tool for self-auditing. A study by Khanna and Widyawati [31] has concluded that ‘facilities that self-audit are more likely to be in compliance with Clear Air regulation’. The proposed auditing framework and checklist can then be further refined and extended in synchronization with the overall organizational maturity in sustainability and eco-friendliness issues. Further research is needed to develop this auditing framework into a blueprint for a strategic plan on green IT, which can be integrated with CSR and environmental business initiatives, as well as with related ISO certification areas. It could also be useful to further investigate the accommodation of green IT strategies into the existing, generic IT governance frameworks, such as COBIT, ITIL, ISO 20000, etc. as well as IT project management methodologies, such as PRINCE2, PM², etc.

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REFERENCES

- [1] Raisinghani, M.S. & Idemudia, E.C., Green information systems for sustainability. *Green Business: Concepts, Methodologies, Tools, and Applications*, IGI Global, pp. 565–579, 2019.
- [2] Murugesan, S., Harnessing green IT: Principles and practices. *IT Professional*, **10**(1), pp. 24–33, 2008. <https://ieeexplore.ieee.org/abstract/document/4446673>.
- [3] Gholami, R., Watson, R.T., Hasan, H., Molla, A. & Bjorn-Andersen, N., Information systems solutions for environmental sustainability: How can we do more? *Journal of the Association for Information Systems*, **17**(8), 2, 2016.
- [4] Molla, A., GITAM: A model for the adoption of green IT. *ACIS 2008 Proceedings*, **64**, 2008.
- [5] Molla, A., Cooper, V.A. & Pittayachawan, S., IT and eco-sustainability: Developing and validating a green IT readiness model. *Proceedings of the International Conference on Information Systems*, Phoenix, AZ, USA, **141**, 2009.
- [6] Saha, B., Green computing. *International Journal of Computer Trends and Technology (IJCTT)*, **14**(2), pp. 46–50, 2016.



- [7] Ghadban, R., *Auditing: Theory and Practice*, Wiley, 2018.
- [8] Dao, V., Langella, I. & Carbo, J., From green to sustainability: Information technology and an integrated sustainability framework. *The Journal of Strategic Information Systems*, **20**(1), pp. 63–79, 2011.
- [9] Raza, K., Patle, V.K. & Arya, S., A review on green computing for eco-friendly and sustainable it. *Journal of Computational Intelligence and Electronic Systems*, **1**(1), pp. 3–16, 2012.
- [10] Pahuja, S., Environmental compliance audit. *Encyclopedia of Sustainable Management*, eds S.O. Idowu, R. Schmidpeter, N. Capaldi, L. Zu, M. Del Baldo, & R. Abreu, Springer: Cham, 2023. https://doi.org/10.1007/978-3-031-25984-5_564.
- [11] DeFond, M. & Zhang, J., A review of archival auditing research. *Journal of Accounting and Economics*, **58**(2–3), pp. 275–326, 2014.
- [12] Namuduri, K., Information systems auditing: Going beyond compliance. *International Journal of Auditing Technology*, **1**(1), pp. 45–51, 2013.
- [13] Winegarden, W., *Environmental, Social, and Governance (ESG) Investing: An Evaluation of the Evidence*, Pacific Research Institute: San Francisco, USA, 2019.
- [14] Allen, G., What is green IT strategy? A complete guide to getting started. LinkedIn, 2023. <https://www.linkedin.com/pulse/what-green-strategy-complete-guide-getting-started-gregory-allen/>.
- [15] Machado, M.C., Hournaux, F. & Sobral, F.A., Sustainability in information technology: An analysis of the aspects considered in the model COBIT. *Journal of Information Systems and Technology Management*, **14**, pp. 88–110, 2017.
- [16] O'Neill, M., *Green IT for Sustainable Business Practice: An ISEB Foundation Guide*, BCS: Swindon, 2010.
- [17] Saran, C. & Bridgwater, A., Making software development greener. *Computer Weekly*, 2024. <https://www.computerweekly.com/feature/Making-software-development-greener>.
- [18] Financial Times, AI boom sparks concern over Big Tech's water consumption. <https://www.ft.com/content/6544119e-a511-4cfa-9243-13b8cf855c13>.
- [19] Schwartz, R., Dodge, J., Smith, N.A. & Etzioni, O., Green AI. *Communications of the ACM*, **63**(12), pp. 54–63, 2020.
- [20] Kosik, W.J., Energy and sustainability in data centers. *Data Center Handbook*, ed. H. Geng, Wiley, pp. 27–63, 2014. <https://doi.org/10.1002/9781118937563.ch2>.
- [21] Anthony Jr, B., Abdul Majid, M. & Romli, A., A collaborative agent-based green IS practice assessment tool for environmental sustainability attainment in enterprise data centers. *Journal of Enterprise Information Management*, **31**(5), pp. 771–779, 2018.
- [22] Schulz, G., *The Green and Virtual Data Center*, CRC Press. 2016.
- [23] Papadopoulos, C. & Wurm, A., Trends, pressures and factors that affect data center management taking environmental sustainability into account. Master's thesis, Department of Informatics, Lund University, Sweden, 2016. <https://lup.lub.lu.se/luur/download?func=downloadFile&recordId=2770601&fileId=2770602>. Accessed on: 11 Apr. 2024.
- [24] EU Science Hub, European Code of Conduct for Energy Efficiency in Data Centres. EU, 2022. https://joint-research-centre.ec.europa.eu/scientific-activities-z/energy-efficiency/energy-efficiency-products/code-conduct-ict/european-code-conduct-energy-efficiency-data-centres_en. Accessed on: 11 Apr. 2024.
- [25] Energy, Climate Change, Environment, Waste from Electrical and Electronic Equipment (WEEE). EU. https://environment.ec.europa.eu/topics/waste-and-recycling/waste-electrical-and-electronic-equipment-weee_en.



- [26] ENERGY STAR, ENERGY STAR Certification. <https://www.energystar.gov/about/how-energy-star-works/energy-star-certification>.
- [27] Joint Research Centre, European Energy Efficiency Platform (E3P), Data Centres Code of Conduct. <https://e3p.jrc.ec.europa.eu/communities/data-centres-code-conduct>.
- [28] Bertoldi, P., Booth, J. & Acton, K., 2024 Best Practice Guidelines for the EU Code of Conduct on Data Centre Energy Efficiency. Joint Research Centre, European Energy Efficiency Platform (E3P), 2024. <https://e3p.jrc.ec.europa.eu/publications/2024-best-practice-guidelines-eu-code-conduct-data-centre-energy-efficiency>.
- [29] Henderson, R. & Serafeim, G., Tackling climate change requires organizational purpose. *American Economic Association Papers and Proceedings*, **110**, pp. 177–180, 2020.
- [30] Seidel, S. et al., The sustainability imperative in information systems research. *Communications of the Association for Information Systems*, **40**(1), pp. 40–52, 2017.
- [31] Khanna, M. & Widyawati, D., Fostering regulatory compliance: The role of environmental self-auditing and audit policies. *Review of Law and Economics*, **7**(1), pp. 125–160, 2011.

