Position Paper – Enterprise Architecture Principles for Sustainability

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Coalitie
Duurzame
Digitalisering

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1. Abstract

The growing importance of sustainability in IT systems and software development, driven by new regulations and strategic business goals, shows that sustainability requirements should be addressed early in the IT solution development process. Enterprise Architecture (EA), which operates at the strategic level of IT planning, plays a key role in aligning long-term business and IT strategies. This positions EA as a promising lever for promoting sustainability in the development process of software-intensive systems. However, architects often face a lack of incentives or concrete guidance on how to incorporate sustainability into architectural decisions. Since architecture principles are a key input in architecture practices, they provide an important opportunity to embed sustainability considerations. In this article, we describe our work with researchers and practicing architects to systematically review, revise, and extend existing EA principles. Our work builds on a set of published enterprise principles [1].Through a collaborative process, we developed and articulated six sustainability-oriented EA principles, drawing on expert experience. These principles aim to provide actionable guidance for architects seeking to align IT landscapes with environmental sustainability objectives.

2. Introduction

Sustainability is becoming a central concern in digital strategy [2,3] and EA, driven by global climate goals, growing public awareness, and by regulatory pressure such as the Corporate Sustainability Reporting Directive (CSRD). This directive obliges organizations to report transparently on their environmental, social, and governance (ESG) performance. At the same time, societal expectations are evolving rapidly, with consumers, clients, employees, and partners demanding clear and credible sustainability actions. Organizations that fail to meet these expectations risk reputational damage and competitive disadvantage. [4,5,6]

Sustainability is increasingly embedded in organizational strategy and culture. It is no longer seen merely as a compliance requirement, but as a guiding principle that shapes decision-making, fosters innovation, and drives long-term value creation across the enterprise. As sustainability becomes woven into in strategic goals, it must also be translated into the structural and operational fabric of the organization. The proposed principles should serve as a starting point for integrating sustainability and digital innovation into the company's mission, vision, and strategy. This means that sustainability and digital considerations should be reflected and embedded within the EA. In doing so, IT systems and processes can actively support the organization's sustainable ambitions. It is therefore advisable to explicitly capture sustainability in architectural principles, so that strategic ambitions are translated into concrete design and decision-making criteria within the IT landscape.

3. Suggested Enterprise Architecture Principles

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Our approach

The work group was started by the NCDD (in Dutch: de Nationale Coalitie Duurzame Digitalisering - NCDD). The starting point for developing the proposed EA principles was the foundational set of sustainability principles established by SustainableIT.org [7]. Building on this foundation, our work group of experts reviewed, refined, and extended the principles to better align with current enterprise architecture practices, personal experience, and projected needs of our peers. While the principles developed by SustainableIT.org offer a solid starting point, we saw an opportunity to further elaborate and deepen them. Our goal was to translate these high-level concepts into detailed, actionable guidelines that enterprise architects can directly apply in their practice and organizations. By adding specificity and contextual nuance, we aimed to bridge the gap between broad sustainability goals and practical architectural decision-making.

To develop a more tailored and actionable set of principles, we conducted a collaborative brainstorming session with experts from the field, resulting in six key EA principles. We acknowledge that these principles do not comprehensively cover all layers of architecture. Notably, valuable foundational principles addressing the data and application(system) layers have been articulated by organizations such as the NCDD. For instance, the NCDD's guide on emission-free online workspaces offers insightful starting points for sustainable data governance and application management [8]. We acknowledge that our work mostly focuses on environmental sustainability, and not social and governance. Additional work will be started to address sustainability in the other steps in architecture by our, and other work groups of NCDD, as well as work to address the previously mentioned gaps.

Six Architecture Principles for Sustainability

To effectively embed sustainability into the digital architecture of organizations, we present six EA principles. These are:

1. Sustainability May Justify Higher Costs;
2. Take a Full Lifecycle perspective while looking at IT Sustainability;
3. Cater for Continuous Rightsizing of Infrastructure Reaching Optimal Resource Efficiency;
4. Acknowledge Different Data Center Impacts and Metrics;
5. Sustainability may need and trigger Innovations;
6. Software (design) caters for Resource Efficiency and Energy Optimizations.

These principles have been co-developed by domain experts to provide practical, actionable guidance on integrating environmental, social, and economic sustainability considerations into strategic IT decision-making. Each principle is structured following a TOGAF-inspired format—comprising a Name, Statement, Rationale, Implications, and References—facilitating clear communication and implementation within EA practices.

Principle 1

Name	**Sustainability May Justify Higher Costs**
Statement	In our organization, sustainability is not a side issue but a core matter, and we recognize that it may involve additional costs. When making decisions, a higher price is never a reason to avoid choosing the sustainable option.
Rationale	We want to set a good example! As customers consider sustainability as increasingly important, we need to act on this. However, we don't want to engage in window dressing. We want to demonstrate that we take the implementation seriously. Sustainability is an investment in the long run, for the short term it may add cost, time or complexity. Over the full lifetime of the products and services it will yield benefits (avoiding energy use, carbon emission and cost or stranded assets). Having sustainable products and services will strengthen the company's license to operate.
Implications	Sustainability in its various aspects – such as product longevity, material durability, energy and carbon impacts on the environment, and social conditions for those involved – should be incorporated into design and selection criteria and given significant weight. This must be factored into the associated costs. We may need to accept a lower margin or longer development time because sustainability is integrated. The consequence for supplier selection is that we prioritize the most sustainable option rather than the purely economically advantageous (cheapest) one. We choose solutions, such as SaaS offerings, provided by vendors with a clear and verifiable sustainability strategy, and select products made from sustainable, recyclable materials. These products must also be disposed of in a sustainable manner at the end of their lifecycle.
Related to	N/A
References	N/A

Principle 2

Name	**Take a Full Lifecycle perspective while looking at IT Sustainability**
Statement	Sustainability is the starting point when designing and managing the entire lifecycle of IT systems, from architecture and development to operations and decommissioning.
Rationale	Designing with end-of-life, and therefore replacement and recycling in mind enables the development of products that can truly be recycled. Recycling can take two forms: first, reusing the created solutions or architectural building blocks for additional solutions, which also facilitates faster delivery of new solutions by leveraging the appropriate building blocks. Second, recycling involves the proper disposal of old IT systems, including both hardware and software. By adopting this approach, we can create an efficient IT environment while integrating ESG considerations into everything we build.
Implications	When designing IT systems and selecting their components, sustainability across the entire lifecycle is a key criterion. We assess sustainability based on two aspects: Building an efficient IT environment: The solution must be manageable, flexible, scalable, and adaptable. This is achieved by applying well-known architectural principles, such as capturing data once and using it multiple times, connecting systems through data pipelines, and reusing recurring functionalities in building blocks. Using materials and resources responsibly: Components should comply with ESG recommendations while minimizing pressure on the materials cycle. Selection is based on the environmental impact over the full lifecycle, not just on initial costs or performance metrics. Factors considered include recyclability, material emissions, energy consumption, and water usage.
Related to	Principle 1: “Sustainability may justify higher costs.”
References	Architecture Model - “Sustainability by Design” [9]

Principle 3

Name	**Cater for Continuous Rightsizing of Infrastructure Reaching Optimal Resource Efficiency**
Statement	Systems are designed for maximum energy and resource efficiency. During development and production continuous rightsizing is used to maintain efficiency.
Rationale	This principle arises from a sufficiency standpoint, because efficient use of resources reduces the environmental footprint. We need to ensure that no more resources are allocated than needed at every moment in time. By continuously right-sizing the environment needed for the task, we gain flexibility and can more easily scale services up—and especially down—when needed. An additional advantage from a business point of view is the focus on cost efficiency and the manageability of the IT chain. As an example, specialized micro-services are often more (cost) efficient for performing tasks compared to generic solutions, such as Virtual Private Servers (VPS) setups. Using microservices also presents the opportunity to scale specifically and thus more efficiently. Managing microservices is generally more straightforward than managing generic solutions. Better manageability prevents services from “running in oblivion” and from uncontrolled expansion. This principle also contributes to better manageability of the IT portfolio.
Implications	This principle may require investment in more efficient, albeit potentially more expensive, technologies to achieve long-term savings and environmental benefits. Metrics related to maintaining legacy infrastructure can be leveraged to strengthen the business case. Another way to apply this principle, from an efficiency perspective, is in the allocation of different environments for Dev, Test, Pre-Prod and Prod. By defining clear patterns and specifications, teams understand the procedures required for each environment. Establishing monitoring protocols and rules allows us to manage the hours these environments are active and to shut them down when not in use, resulting in reduced resource consumption.

	• Higher knowledge threshold: cloud designs require more specialized expertise, making the design phase more complex. 'Lift and shift' approaches are limited, as redesign is often necessary. Not all needs and requirements are suitable for the cloud, particularly when dealing with legacy systems. • Production environments will be scaled in such a way that they deliver the functionalities and performance required, but not to overdeliver. • Development, test, acceptance and other environments will be (automatically) shut-down whenever possible.
Related to	N/A
References	S-rating model [10]

Principle 4

Name	Acknowledge Different Data Center Impacts and Metrics
Statement	We take a holistic and supply chain view while determining and accounting for data center impacts. As impact comes from energy use with related carbon emissions, material, water, and land use.
Rationale	Data centers are significant resource and energy consumers. We need to understand how efficiently they operate, what kind of energy is used and what happens in their supply chain. This is especially relevant for businesses that rely on data centers for cloud services, as their own carbon reporting depends on the transparency and practices of their providers. • Improving energy efficiency reduces impact (like carbon footprint); • Using green energy reduces impact; • Most impact comes from Energy use, but also the data center supply chain entails a footprint to acknowledge (scope 3 of GHG); • Determine, allocate and distribute the embodied footprint of data center buildings, infrastructure and hardware across its users. The realities of energy supply and carbon reporting need to be made transparent. • Market-based reporting ◦ Based on renewable energy contracts/Power Purchase Agreements and/or certificates. • Location-based reporting ◦ Based on the operating location's grid mix and actuals. • If/what compensation instruments were applied. ◦ Offsetting (Quality and Reliability).
Implications	By getting familiar with sustainability impacts and metrics that are relevant for data centers allows architects to assess what choices to make. These include for example: • Amount of renewable energy used by data centers.[11] • Sustainability of cooling systems and water usage. • Sustainability of cloud use depends on configuration and processes made in the implementation of the cloud.
Related to	N/A
References	• Datacenter Energy Efficiency Regulation (DC EED)[12,13] • The Guardian: Data center emissions probably 662% higher than big tech claims. Can it keep up the ruse?[14]

Principle 5

Name	**Sustainability may need and trigger Innovations**
Statement	Sustainability demand will necessitate and trigger innovation. Innovation initiatives will provide measurable contributions to business operations and sustainability outcomes, focusing on sustainability benefits that align with our strategic objectives.
Rationale	Sustainability-driven innovation ensures that new technologies and processes adopted within the EA create value by reducing environmental impacts and resource costs, enhancing social well-being, and delivering economic efficiency (ESG). Moreover, adopting sustainability-driven innovations also enables us to future-proof ourselves against upcoming regulations and customer demands, maintain competitiveness and adapt more quickly to external requirements.
Implications	• Innovation Definition: Innovation encompasses new or significantly improved technologies, processes, or business models. • Sustainability Assessment: Innovation initiatives must undergo systematic trade-off analysis of their ESG impacts, compared to alternative innovations. If it is not done properly, we might invest to implement an innovation which will have to be revised before the end of lifecycle, because it might not be in line with sustainability regulations. • Governance: Innovation initiatives must present mechanisms to monitor and evaluate their taken sustainability measures, such as energy consumption, or resource efficiency.
Related to	N/A
References	• Gartner Hype Cycle for Environmental Sustainability (ID G00831288) [15]

Principle 6

Name	**Software (design) caters for Resource Efficiency and Energy Optimization**
Statement	Sufficient and efficient use of software resources reduces the environmental footprint and operational costs. Sustainable software usage ensures optimal resource utilization, leading to cost savings, improved performance, and reduced environmental impact.
Rationale	Software drives the resource use of infrastructure. Systems (software components) are designed for maximum energy and resource efficiency and thus we choose IT-efficient solutions in architecture. Systems should be designed, built, or selected to operate efficiently, reducing software resource usage and minimizing the impact on infrastructure and energy consumption. Principles such as 'less is more' (frugal design and application rationalization), shared functionality, on-demand activation, software durability and adaptability, and removing unused code should be integral to the Business-IT dialogue and embedded in architecture practices, as well as in the work of product owners and development teams when defining functional requirements and designs.
Implications	• Acknowledge the differences in energy use by programming languages. • Applying green coding best practices. • Employees must be trained in the sustainable usage of software. IT architects (both software and hardware) and software developers could be trained on architecting, creating and building sustainable software and hardware solutions. • May invest in more efficient, albeit initially costlier, technologies to achieve long-term savings and environmental benefits. Metrics associated with maintaining legacy infrastructure should be used to help make the business case. • We may accept reduced speed or other factors if it benefits sustainability. • Whenever possible do not overprovision. Be mindful of bloated software that implements more than necessary. • Software solutions must be evaluated throughout their lifecycle based on their sustainability, energy efficiency, and environmental impact, in addition to functionality and cost.
Related to	Principle 1: Sustainability may justify higher costs Principle 2: Continuous rightsizing of infrastructure (good symbiosis between Software design and hardware/infrastructure capabilities is needed to reduce resource use/impact and cost)
References	N/A

4. Recommendations

To successfully align IT landscapes with sustainability objectives, organizations must embed sustainability within their overall strategy and culture, as well as in their EA. This means that sustainability becomes a core value that shapes leadership decisions, everyday practices, and architectural choices. EA principles play a crucial role in this process by providing structured guidance that reflects sustainability goals and outcomes. The principles presented in this paper should serve as a set of initial suggestions. Organizations are advised to tailor, expand and adapt these principles to their specific context, needs, and maturity level to ensure most effective implementation.

A next step from EA is to formulate explicit domain and system level standards, guidelines and patterns that focus on achieving sustainability goals. These should be clear and actionable, to serve as an even more practical guiding framework for IT investment decisions and system design choices. By regularly revisiting and refining the EA principles, standards and patterns, organizations can stay responsive to emerging technologies and regulatory requirements, ensuring continuous alignment with sustainability ambitions. Our formulated principles can be a foundation for this.

Preparation for regulatory and market changes is essential. Organizations must build mechanisms to collect, analyze and report on sustainability metrics in compliance with regulations like the Corporate Sustainability Reporting Directive (CSRD). Proactively engaging customers, partners, and other stakeholders helps ensure sustainability communications and practices align with their expectations, while monitoring emerging standards allows timely adaptation of IT strategies.

Finally, collaboration and knowledge sharing are indispensable in the journey toward sustainable digital systems. Participating in cross-sector coalitions and working groups fosters collective learning and accelerates progress. Sharing best practices, case studies, and lessons learned broadens the impact of sustainability efforts. Investing in training and capacity building further enhances organizational expertise, empowering teams to embed sustainability in every facet of EA.

5. Next steps for the working group

The next steps will focus on engaging with relevant organizations to discuss and refine the current set of principles. This includes expanding the principles with additional elements where needed (for example in the field of data management and possibly monitoring), as well as initiating dialogue with SustainableIT.org to align on shared priorities and ensure consistency across frameworks. We will also incorporate other relevant principles and reference frameworks identified through further research, ensuring that the approach remains comprehensive, up to date, and reflective of best practices.

6. About the Nation Coalition of Digital Sustainability (NCDD)

Digitalization offers the Dutch economy and society many opportunities but also has an impact on the environment and climate. The digital system produces emissions, consumes electricity and raw materials are needed for hardware and other physical components. At the same time, digitalization can also contribute to limiting its own energy consumption, environmental impact and to sustainability challenges in other sectors. Much is already happening within digital systems, with IT end users taking the initiative. At the same time, the urgency to address the energy system is greater than ever, creating opportunities to leverage digitalization while tackling the associated challenges. But we are not alone with this approach. There are preconditions in the Netherlands that need to be addressed. From a systemic perspective, we see that there is a need and necessity to guide this transformation in phases, with a number of key processes, roles of stakeholders and actions in the short, medium and long term that need to be orchestrated. The NCDD indicates and organizes these actions.

7. Ambition and focus

As a digital frontrunner with sustainable ambitions and a well-developed R&D ecosystem, it suits the Netherlands to be a leader in the development of innovations and solutions in a sustainable digital system. If we do not make our operations more sustainable, this will be at the expense of economic growth and we will not contribute sufficiently to reducing the impact on the environment, as intended in the Sustainable Development Goals, the Dutch Climate Agreement and the sustainability objective of 'Europe's digital decade: objectives for 2030' (European Commission, 2023). In order to have sufficient traction and focus, we choose to initially focus on making the digital system more sustainable and on promoting the relationship and integration of the energy system and the digital system. In addition, we are working on necessary preconditions such as awareness, consistent and clear legislation and regulations and skills at the intersection of sustainability and digitalization.

8. About the Authors

This paper was developed by members of the Enterprise Architecture working group within the National Coalition for Digital Sustainability (NCDD). The authors bring together diverse expertise from both the public and private sectors, as well as academic and research backgrounds. Their shared goal is to foster a sustainable digital future by integrating sustainability into strategic IT planning and EA practices.

The contributing authors collaborated through a structured and iterative process, including co-creation in pairs, plenary refinement sessions, and broader peer review. This collective effort ensures that the proposed principles are grounded in both practical relevance and theoretical rigor.

The authors are committed to ongoing dialogue and welcome feedback, case studies, and suggestions from fellow practitioners to help refine and expand this initial version of the architecture principles.

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Mohamed Ali is an enterprise architect with a strong background in digital transformation and sustainable IT strategy. With experience across various sectors, he focuses on aligning architecture practices with business and sustainability goals. As an active contributor to the NCDD initiative, Mohamed combines hands-on implementation experience with a strategic mindset to embed sustainability into complex IT landscapes.

Markus Funke is a researcher and practitioner in the field of software engineering, with a particular focus on sustainability in software architecture. As a contributor to both academic research and practical frameworks, Markus brings a strong analytical perspective to the development of architecture principles. His work bridges theory and practice, aiming to embed sustainability aspects into architectural thinking.

Markus Funke

Joost van Lier

Joost van Lier is a strategic advisor and Enterprise Architect with a strong commitment to embedding sustainability in digital transformation. Drawing from his experience in both government and industry settings, Joost focuses on the alignment between architecture, policy, and organizational change. As an initiator and co-author within the NCDD working group, he brings a systems perspective to sustainable architecture.

Wiebren van der Zee is a seasoned enterprise architect with extensive experience in complex IT environments and digital governance. He has contributed to numerous national initiatives aimed at improving digital sustainability and public sector innovation. Wiebren's work emphasizes cross-organizational collaboration and long-term strategic planning in the digital domain.

Wiebren van der Zee

Jules van den Berg

Jules van den Berg is an enterprise architect and strategic advisor on responsible by design, with a deep focus on the intersection of sustainability and technology. With a background in both (AI) system design and innovation management, Jules advocates for embedding sustainability into the early stages of digital design. Her contributions to the NCDD initiative reflect her commitment to creating responsible and future-proof digital ecosystems.

References

[1] Published by SustainableIT.org. See: Sustainability Principles for Enterprise Architecture v1 final.pdf

[2] See: https://unctad.org/system/files/official-document/der2024_en.pdf

[3] See, https://www.architectureandgovernance.com/applications-technology/the-missing-sustainability-perspective-in-cloud-architecture/

[4] Eccles, R. G., Ioannou, I., & Serafeim, G. (2014). The impact of corporate sustainability on organizational processes and performance. *Management science*, *60*(11), 2835-2857

[5] Oxford research finds association between sustainability and happiness | Saïd Business School

[6] Sustainability: Driving Financial Returns and Strategic Growth

[7] Accessible here: SustainableIT.org Principles Document.

[8] See: NCDD Emission-Free Online Workspace Guide

[9] See the NCDD Wiki page on the model: https://wiki.coalitieduurzamedigitalisering.nl/index.php/Hoofdpagina

[10] See the NCDD Wiki page on this model: https://wiki.coalitieduurzamedigitalisering.nl/index.php/Hoofdpagina

[11] Net Zero claims are often discussed. In our point of view true net zero is: if measured according to location-based emission factors, including the supply chain effects and containing only the highest level and assured offsetting quality instruments.

[12] The DC EED is part of the broader Energy Efficiency Directive (EED). See: Energy Efficiency Directive

[13] See also: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13818-Data-centres-in-Europe-reporting-scheme_en and https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en

[14] See: Data center emissions probably 662% higher than big tech claims. Can it keep up the ruse? | The Guardian

[15] See: Hype Cycle for Environmental Sustainability, 2024