Green IT, Purchasing Guide

Janne Kalliola, Exove

EXOVE

Purchasing Guide

Version 2025-05-12

Do not print this book.
The carbon footprint of the paper needed is about 480 gCO_2eq[1].

Cover photo: Alexandre Guimont / Unsplash

ISBN 978-952-65306-4-2

[1] Ana Cláudia Dias, Luís Arroja, Comparison of methodologies for estimating the carbon footprint – case study of office paper, Journal of Cleaner Production, Volume 24, 2012, Pages 30-35, ISSN 0959-6526, doi.org/10.1016/j.jclepro.2011.11.005.

Janne Kalliola

Janne Kalliola is one of the founders of Exove and currently serves as the Chief Growth Officer.

He has been coding since 1983 and, in his youth, published several commercial applications both in Finland and internationally.

Janne is an active speaker and has presented at open-source events as well as Green ICT conferences.

He has been fascinated by green coding and overall eco-efficiency for years and actively speaks and consults on these topics.

Additionally, he serves as the chairman of the board of Code from Finland association and initiated the development of a carbon neutrality label for software companies in 2022.

kallio.la

linkedin.com/in/jannekalliola

Exove

Exove is a design and software company founded in 2006, where analytical thinking and technological expertise are combined with human understanding. We focus on creating digital solutions that help combat digital frustration. Exove is part of the Rebl Group, a NASDAQ Helsinki listed public company.

We have offices in Helsinki, Tampere, Oulu, Lahti, and Jyväskylä, with approximately 110 experts working in the company.

Our most significant clients include Neste, Sanoma, Loiste, Rukakeskus, the University of Oulu, the University of Eastern Finland, LUT University, Jyväskylä University of Applied Sciences, and the cities of Tampere and Jyväskylä.

exove.com

linkedin.com/company/exove

Exove Sustainability Compass

We have developed Exove's sustainability program, the Sustainability Compass, which guides our sustainability efforts across four dimensions. We recognize our impact both internally at Exove and externally through our partners and customer projects, considering both social and environmental responsibility perspectives.

The four dimensions of the Sustainability Compass are:

1. Responsible software design and development
2. Social responsibility
3. Environmental responsibility
4. Responsible corporate governance

exove.com/sustainability/

Contents

1 Foreword

Despite good intentions and public statements, climate change advances relentlessly. The year 2024 was the warmest on record and the first in which the average global temperature clearly exceeded 1.5°C[2].

The IT sector's energy use and emissions continue to grow, and new innovations, such as artificial intelligence, are accelerating this trend. While we work hard to improve business efficiency and our industry has a significant carbon handprint[3], we could achieve the same effect with a significantly smaller carbon footprint.

To make this happen, everyone must participate. Some have already taken voluntary steps, and the ideas and concept of green coding and sustainable IT are spreading among developers and designers. But to truly accelerate change, money needs to be put on the table. This is where procurement comes into play.

Money talks. If organizations purchasing IT services, solutions, and systems start demanding greener implementations, suppliers will take notice, and the industry will produce more sustainable solutions.

This guide is designed for all buyers, helping you choose more energy-efficient solutions and influence the course of climate change. I hope you find it useful and that it leads to lasting change in IT procurement. As Uncle Ben from Spider-Man once said, "*With great power comes great responsibility.*[4]" My goal with this guide is to help you use your purchasing power to make the world a better place.

Espoo, May 2, 2025, with KMFDM's *Being Boiled* playing in the background.
Janne Kalliola

---

[2] climate.copernicus.eu/global-climate-highlights-2024

[3] Pajula, T., Vatanen, S., Pihkola, H., Grönman, K., Kasurinen, H., & Soukka, R. (2018). Carbon Handprint Guide. VTT Technical Research Centre of Finland, cris.vtt.fi/ws/portalfiles/portal/22508565/Carbon_Handprint_Guide.pdf

[4] en.wikipedia.org/wiki/With_great_power_comes_great_responsibility

2 Climate Change and IT

Human activity and the resulting explosive growth in energy consumption over recent decades are the most significant forces driving climate change. The rise in energy consumption and emissions threatens to destabilize critical biophysical systems and cause irreversible environmental changes, which could have catastrophic effects on human well-being[5].

Urgent and radical changes are required from all actors to limit global warming to 1.5°C, as outlined in the Paris Climate Agreement. Exceeding this threshold will result in extreme rainfall and droughts, rising sea levels, ocean acidification, species loss, and an increase in both floods and intense cyclones[6].

According to the UN, the primary drivers of climate change include electricity and heat production from fossil fuels, emissions from mining and industrial processes, deforestation, transportation of goods and people, food production, building heating and cooling, and overconsumption, particularly in the wealthiest nations[7].

The U.S. Energy Information Administration (EIA) predicts that global energy consumption will increase by 34% between 2022 and 2050, with energy-related CO_2 emissions rising by 15% over the same period. While renewable energy production is expected to grow faster than other energy sources, it will not be suffi-

[5] J. Rockström et al., "Planetary boundaries: Exploring the safe operating space for humanity," Ecol. Soc., vol. 14, p. 32, Nov. 2009, doi: 10.5751/ES-03180-140232.

[6] Intergovernmental Panel on Climate Change (IPCC), Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2023. doi: 10.1017/9781009325844.

[7] "Causes and Effects of Climate Change," United Nations. un.org/en/climatechange/science/causes-effects-climate-change

cient to meet rising demand. As a result, the use of liquid fuels and natural gas—and consequently CO_2 emissions—is expected to increase, while coal emissions are projected to remain at 2022 levels[8]. Key drivers of electricity consumption growth include electric vehicles, heat pumps, and data centers[9].

2.1 The Role of IT

Depending on the assessment method, the IT sector consumes between 7–10% of the world's energy[10]. While global energy consumption is growing by 1–2% per year[11], IT energy use is increasing at a faster rate: 2.7–7.9% in data centers, 2.4–7.3% in networks, and 58.4–67.8% in cryptocurrency mining[12]. It's worth noting that cryptocurrency mining now primarily takes place in data centers, and these figures predate the recent rise in AI usage over the past two to three years.

Beyond energy consumption, the IT sector contributes to greenhouse gas emissions, resource depletion, increased energy and water use, and air, water, and soil pollution[13].

Scientific studies have repeatedly assessed IT's carbon footprint. Earlier research estimated that IT accounts for 1.4% of global emissions[14], while more recent stud-

[8] "International Energy Outlook 2023," U.S. Energy Information Administration, Oct. 2023.

[9] G. Micheletti, N. Raczko, C. Moise, D. Osimo, and G. Cattaneo, "European Data Market Study 2021–2023 – Final Report on Policy Conclusions," European Commission, Feb. 2024.

[10] T. Ojala, M. Mettälä, M. Heinonen, and P. Oksanen, "The ICT sector, climate and the environment – Interim report of the working group preparing a climate and environmental strategy for the ICT sector in Finland," Oct. 2020.

[11] H. Ritchie, P. Rosado, and M. Roser, "Energy Production and Consumption," Our World in Data, 2020.

[12] V. Rozite, E. Bertoli, and B. Reidenbach, "Data Centres and Data Transmission Networks," International Energy Agency.
iea.org/energy-system/buildings/data-centres-and-data-transmission-networks

[13] M. Matthews, A. Clark, and K. Carr, "Building a Sustainable ICT Ecosystem: Strategies and Best Practices for Reducing Environmental Harms in a Digital World," Information and Communications Technology Council, Jan. 2024.

[14] J. Malmodin and D. Lundén, "The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010–2015," *Sustain. Sci. Pract. Policy*, vol. 10, no. 9, p. 3027, Aug. 2018, doi: 10.3390/su10093027.

ies suggest 2.1–3.9%[15]. The variation in estimates is due to differences in how life-cycle and supply chain emissions are considered. The IT supply chain is complex, and many of the sector's environmental impacts are neither visible nor fully understood—even by industry professionals.

2.1.1 The Carbon Handprint of IT

The carbon handprint refers to the positive climate impacts caused or enabled by products or services—such as new IT solutions. These positive impacts can include emission reductions resulting from energy savings, material efficiency, climate-friendly raw material alternatives, or improved recyclability of products.[16]

The carbon handprint of IT is significant because it has enabled major efficiency improvements in other areas of business over the past decades. Unfortunately, increased efficiency has largely led to new investments and accelerated consumption, which in turn contributes to the worsening of climate change.

[15] C. Freitag, M. Berners-Lee, K. Widdicks, B. Knowles, G. S. Blair, and A. Friday, "The real climate and transformative impact of ICT: A critique of estimates, trends, and regulations," *Patterns (N Y)*, vol. 2, no. 9, p. 100340, Sep. 2021, doi: 10.1016/j.patter.2021.100340.

[16] Carbon handprint, sitra.fi/en/dictionary/carbon-handprint/

Summary

1. The rise in energy consumption and emissions threatens irreversible environmental changes, negatively impacting human well-being.

2. The main causes of climate change include fossil-fuel-based energy production, industrial processes, deforestation, transportation, food production, and overconsumption.

3. Global energy consumption is projected to increase by 34% by 2050, with CO_2 emissions rising by 15%, primarily due to liquid fuels and natural gas.

4. The IT sector consumes 7–10% of global energy, with its energy use growing faster than other industries. It contributes 2.1–3.9% of global emissions and has significant environmental impacts due to its complex supply chain.

3 The Buyer’s Responsibility

Purchasing climate-friendly technology will become increasingly important—and in some cases, critical—in the future. Organizations should proactively adjust their actions and thinking to avoid being unprepared when regulations take effect.

If climate considerations were taken into account when purchasing software—which is rarely done today—it would benefit users, the planet, and financial departments. More efficient software consumes fewer resources, energy, servers, and network capacity, resulting in direct cost savings for buyers. It also provides a better user experience and correlates with user trust. Users with lower bandwidth or older devices would benefit from more efficient software.

For public sector organizations, responsible procurement is especially crucial. These entities exist to improve citizens' well-being and opportunities, so ensuring a sustainable future through climate-conscious decisions should be an inherent responsibility. Unfortunately, public organizations currently seem to lag behind private ones in sustainability efforts, but hopefully, this will change soon. Although, it must also be said that not all private enterprises are leaders in sustainable procurement either.

In all organizations, buyers hold significant power. As the saying goes: “*Whoever holds the gold makes the rules.*”

3.1 Assessing Responsibility

A commonly used scientific model[17] for assessing sustainability can be used to categorize IT's benefits and impacts into three levels:

1. **First-order (direct) impacts**: Effects directly related to IT use throughout a product's lifecycle, including production, usage, and disposal.
2. **Second-order (enabling) impacts**: Effects of IT that transform processes in other sectors, such as transportation and industrial production.
3. **Third-order (structural) impacts**: Long-term changes in behavior and economic structures due to IT accessibility, such as capital accumulation, shifts in social norms, and regulatory changes.

These impacts can be interdependent—for instance, adopting a more energy-efficient solution may lead to increased usage, ultimately raising overall energy consumption. This phenomenon is known as Jevons Paradox[18].

Additionally, software sustainability can be analyzed through five interconnected dimensions[19]:

- **Individual**: Personal freedoms, agency, dignity, and self-actualization.

[17] L. M. Hilty and M. D. Hercheui, "ICT and Sustainable Development," in *IFIP Advances in Information and Communication Technology*, Berlin, Heidelberg: Springer Berlin Heidelberg, 2010, pp. 227–235. doi: 10.1007/978-3-642-15479-9_22.

I. Røpke, "The unsustainable directionality of innovation – The example of the broadband transition," *Res. Policy*, vol. 41, no. 9, pp. 1631–1642, Nov. 2012, doi: 10.1016/j.respol.2012.04.002.

C. Becker et al., "Requirements: The Key to Sustainability," IEEE Softw., vol. 33, no. 1, pp. 56–65, Jan.-Feb 2016, doi: 10.1109/MS.2015.158.

L. M. Hilty and B. Aebischer, "ICT for sustainability: An emerging research field," in Advances in Intelligent Systems and Computing, in Advances in intelligent systems and computing. , Cham: Springer International Publishing, 2015, pp. 3–36. doi: 10.1007/978-3-319-09228-7_1.

[18] en.wikipedia.org/wiki/Jevons_paradox

[19] C. Becker *et al.*, "Requirements: The Key to Sustainability," *IEEE Softw.*, vol. 33, no. 1, pp. 56–65, Jan.-Feb 2016, doi: 10.1109/MS.2015.158.

B. Penzenstadler, A. Raturi, D. Richardson, and B. Tomlinson, "Safety, Security, Now Sustainability: The Nonfunctional Requirement for the 21st Century," IEEE Softw., vol. 31, no. 3, pp. 40–47, May-June 2014, doi: 10.1109/MS.2014.22.

- **Social**: Relationships and trust structures between individuals and groups.
- **Economic**: Business value, capital growth, liquidity, investments, and financial activities.
- **Technical**: Maintainability, flexibility, and system migration capabilities.
- **Environmental**: Resource use, energy consumption, waste generation, and climate impact.

These models provide a 5x3 framework for structuring IT procurement’s benefits and impacts.

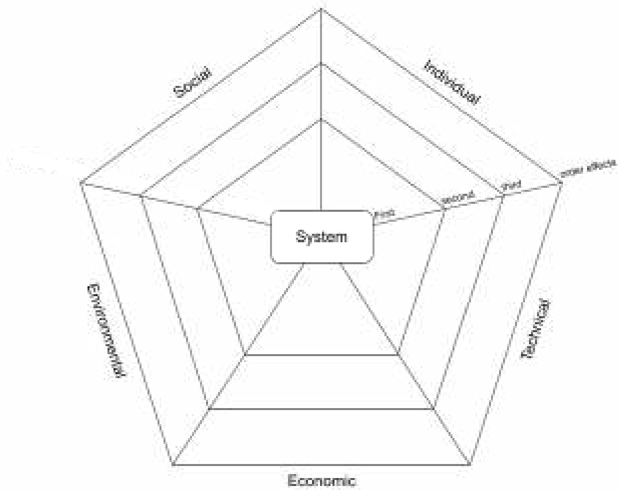

Figure 1. System impact areas: social, personal, economic, technical, and environmental, along with their three different levels[20].

Sustainability in software can also be categorized into three aspects[21]:

[20] Duboc, L., Betz, S., Penzenstadler, B., Akinli Kocak, S., Chitchyan, R., Leifler, O., Porras, J., Seyff, N. & Venters, C. C. (2019) ‘Do we Really Know What we are Building? Raising Awareness of Potential Sustainability Effects of Software Systems in Requirements Engineering’, 2019 IEEE 27th International Requirements Engineering Conference (RE), Jeju, South Korea. pp. 6-16. DOI: 10.1109/re.2019.00013.

[21] E. Kern, M. Dick, S. Naumann, and A. Filler, “Labelling sustainable software products and websites: Ideas, Approaches, and Challenges,” in *Proceedings of EnviroInfo and ICT for Sustainability 2015*, Paris, France: Atlantis Press, 2015. doi: 10.2991/ict4s-env-15.2015.10.

- **Efficiency**: How software behaves in terms of resource consumption.
- **Feasibility**: Support for sustainability aspects, divided into resource-oriented feasibility (focusing on environmental impacts) and well-being-oriented feasibility (focusing on social impacts).
- **Perdurability**: The extent to which software can be modified, adapted, and reused over time.

Software lifecycles follow an eight-phase sustainability model[22], influenced by cradle-to-grave frameworks. These phases are: development, distribution, procurement, deployment, usage, maintenance, decommissioning, and disposal. Based on this, the GREENSOFT model was developed, combining sustainability criteria, lifecycle impacts, process models, recommendations, and tools into five key phases: development, distribution, usage, deactivation, and disposal[23].

While these models provide a solid framework for software lifecycles, they primarily outline key considerations at each stage rather than offering ready-made solutions.

3.2 CSRD and CSDDD

CSRD (Corporate Sustainability Reporting Directive)[24] and CSDDD (Corporate Sustainability Due Diligence Directive)[25] are EU regulations promoting corporate

---

[22] M. Hirsch-Dick and S. Naumann, “Enhancing software engineering processes towards sustainable software product design,” *EnviroInfo*, pp. 706–715, 2010.

M. Dick, S. Naumann, and N. Kuhn, “A Model and Selected Instances of Green and Sustainable Software,” in *What Kind of Information Society? Governance, Virtuality, Surveillance, Sustainability, Resilience - 9th IFIP TC 9 International Conference, HCC9 2010 and 1st IFIP TC 11 International Conference, CIP 2010, Held as Part of WCC 2010, Brisbane, Australia, September 20-23, 2010. Proceedings*, unknown, Jan. 2010, pp. 248–259. doi: 10.1007/978-3-642-15479-9_24.

[23] S. Naumann, M. Dick, E. Kern, and T. Johann, “The GREENSOFT Model: A reference model for green and sustainable software and its engineering,” *Sustainable Computing: Informatics and Systems*, vol. 1, no. 4, pp. 294–304, Dec. 2011, doi: 10.1016/j.suscom.2011.06.004.

[24] finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

[25] commission.europa.eu/business-economy-euro/doing-business-eu/sustainability-due-diligence-responsible-business/corporate-sustainability-due-diligence_en

responsibility and sustainable development. They support the EU Green Deal, which aims for carbon neutrality by 2050. CSRD focuses on standardizing sustainability reporting, while CSDDD enforces corporate due diligence obligations throughout the supply chain. These regulations require companies to report on their sustainability efforts and take responsibility for their environmental and human rights impacts.[26]

CSRD mandates standardized reporting on Environmental, Social, and Governance (ESG) factors, improving comparability and transparency for stakeholders. It also pressures supply chains, as companies must calculate the carbon footprint of purchased products and services, extending reporting requirements to even the smallest businesses. CSRD non-compliance may result in sanctions in certain European countries.

CSDDD, in contrast, legally obligates companies to identify and prevent harmful environmental and human rights impacts across their value chains. CSDDD includes sanctions for non-compliance. While some countries may impose financial penalties, others—such as Finland—organizations may only experience reputational risks from poor reporting.

CSRD applies to large corporations and listed SMEs in phases from 2024 to 2026, while CSDDD initially affects companies with 500+ employees and €150M revenue or smaller firms in high-risk industries. Both directives also apply to non-EU companies operating in the EU under specific criteria.

These directives provide a strong incentive for IT sustainability efforts, as compliance will generate valuable data required for reporting.

[26] CSDDD vs. CSRD: what’s the difference?
blog.worldfavor.com/csddd-vs-csrd-whats-the-difference

Summary

1. In software procurement, the climate perspective will become increasingly significant in the future, and taking it into account can bring both ecological and economic benefits. More efficient software consumes fewer resources and reduces costs.

2. The impacts of IT can be divided into three levels: direct impacts, enabling effects on other industries, and long-term structural effects. Additionally, software sustainability can be assessed through five dimensions: individual, social, economic, technical, and environmental impacts.

3. Software sustainability can be classified based on efficiency, feasibility, and perdurability. Its lifecycle includes development, distribution, use, and disposal, and sustainability-supporting models can be applied to it.

4. The EU's CSRD and CSDDD directives require companies to report on their responsibility and consider environmental and human rights impacts throughout the entire value chain. This increases pressure on procurement chains and even affects smaller companies.

5. CSRD and CSDDD compel companies to monitor and report their environmental impacts, making IT environmental efforts even more critical. Considering sustainability in software development helps meet these requirements while also providing valuable data for reporting.

4 Why Is IT Energy Consumption Increasing?

The consumption of IT services continues to grow. According to Statista's[27] statistics, as of January 2024, 66.2% of the world's population uses the internet[28]. The European Strategy and Policy Analysis System predicts that this figure will rise to 75% by 2030[29]. Statista also forecasts that the number of internet users will grow from 5.36 billion in 2022 to 7.32 billion by 2029[30]. While the absolute growth is nearly two billion people, the compound annual growth rate (CAGR[31]) is just under 4.0%.

Globally, IT service prices continue to decline, gradually approaching the International Telecommunications Union's target of 2% of gross national income per capita[32]. Lower prices are a prerequisite for the strong growth in IT usage. Affordable and widely available technology fosters the innovation of new applications,

---

[27] Statista is a global data and business intelligence platform founded in Germany in 2007. It offers a vast collection of statistics, reports, and analyses on over 80,000 topics from 22,500 sources across 170 industries. statista.com

[28] A. Petrosyan, "Worldwide internet user penetration from 2014 to January 2024," Statista. statista.com/statistics/325706/global-internet-user-penetration

[29] F. Gaub, "Global Trends to 2030 – Challenges and Choices for Europe," The European Strategy and Policy Analysis System, Apr. 2019.

[30] J. Degenhard, "Number of internet users worldwide from 2014 to 2029." Jan. 30, 2024. statista.com/forecasts/1146844/internet-users-in-the-world

[31] en.wikipedia.org/wiki/Compound_annual_growth_rate

[32] "Policy brief - The affordability of ICT services 2023," International Telecommunication Union, itu.int/en/ITU-D/Statistics/Documents/publications/prices2023/ICTPriceBrief2023.pdf

further accelerating usage. Due to the low cost of energy, there is insufficient focus on energy-saving innovations[33].

The research firm Arthur D. Little predicts that in developed countries, the average time spent online will stabilize at 3–4 hours per day per mobile subscription and 6–10 hours per day per household for fixed broadband. Similarly, the growth in video consumption is expected to level off at 4–5 hours per day[34].

However, even though internet penetration in developed countries has not increased significantly[35], and the number of hours spent online for various activities —such as social media usage or video watching—has remained relatively stable between 2015 and 2023[36], the amount of data transmitted is expected to rise. For example, telecommunications statistics from the Nordic and Baltic countries between 2017 and 2022[37] show significant growth in transmitted data, despite the number of subscriptions remaining stable or growing only moderately (except in Lithuania and Estonia):

Country	Subscription Growth	Data Growth
Denmark	1.8 %	253.6 %
Estonia	37.5 %	350.4 %
Finland	-2.3 %	174.5 %
Iceland	1.5 %	384.4 %
Latvia	7.1 %	258.9 %
Lithuania	11.7 %	482.9 %

33 I. Røpke, “The unsustainable directionality of innovation – The example of the broadband transition,” Res. Policy, vol. 41, no. 9, pp. 1631–1642, Nov. 2012, doi: 10.1016/j.respol.2012.04.002.

34 N. Jakopin, G. Mohr, E. Cafforio, G. Peres, M. Weber, and K. Burkhanov, “The Evolution of Data Growth in Europe,” Arthur D. Little, May 2023.

35 A. Petrosyan, “Global internet penetration rate as of April 2024, by region.” May 07, 2024. statista.com/statistics/269329/penetration-rate-of-the-internet-by-region

36 A. Petrosyan, “Average daily time spent using the internet by online users worldwide from 3rd quarter 2015 to 4th quarter 2023.” Apr. 30, 2024. statista.com/statistics/1380282/daily-time-spent-online-global

37 Traficom, “Telecommunications Markets in the Nordic and Baltic Countries 2022,” Sep. 2023.

Country	Subscription Growth	Data Growth
Norway	-0.1 %	200.1 %
Sweden	-0.8 %	256.1 %

Several demand-side factors are driving this growth, including improved video resolutions, the increased use of short-form videos on social media, and AI-generated content. On the supply side, the most significant growth drivers include affordable or fixed-price mobile plans, the expansion of fiber-to-the-premises (FTTP) broadband, and improved 5G network coverage.

Additionally, while consumption patterns for certain internet uses have stabilized, new rapidly growing use cases—such as the Internet of Things (IoT) and artificial intelligence (AI)—have emerged, and their growth is not expected to slow down in the near future[38]. Although their bandwidth requirements are significantly lower than consumer-driven video streaming, video consumption continues to grow, contributing to overall demand.

4.1 The Cornucopian Paradigm

The prevailing model for designing and implementing digital services, which researchers have termed the Cornucopian Paradigm[39], is based on the belief in Moore's Law[40] and the "infinite scalability" of cloud services. This paradigm includes several design principles that drive the growth of digital consumption:

- **Personal** – users increasingly expect services traditionally designed for groups to be available individually.
- **Variety** – users expect a wide variety of services to be available.

[38] C. Freitag, M. Berners-Lee, K. Widdicks, B. Knowles, G. S. Blair, and A. Friday, "The real climate and transformative impact of ICT: A critique of estimates, trends, and regulations," Patterns (N Y), vol. 2, no. 9, p. 100340, Sep. 2021, doi: 10.1016/j.patter.2021.100340.

[39] C. Preist, D. Schien, and E. Blevis, "Understanding and Mitigating the Effects of Device and Cloud Service Design Decisions on the Environmental Footprint of Digital Infrastructure," in Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, in CHI '16. New York, NY, USA: Association for Computing Machinery, May 2016, pp. 1324–1337. doi: 10.1145/2858036.2858378.

[40] en.wikipedia.org/wiki/Moore%27s_law

- **Instant** – users expect services to be instantly accessible.
- **Shareable** – users create content that can be shared with others.
- **High quality** – users expect an increasingly high quality of service.
- **Pervasive** – users expect the services to be available readily from any device.
- **Continuous access** – users expect the services to be available at any time in any location.
- **Eternal** – users expect their created content to always be available.
- **Ephemeral** – users create content without concern for its future use.
- **Rich, cross-modal and ubiquitous** – users expect services to interact with each other and enhance their overall experience. Services are often used in the background of users' attention, leading to more frequent usage and the simultaneous use of multiple services, which amplifies demand and reinforces the impact of the other nine principles.

Changing or at least slowing down the Cornucopian Paradigm should be on every organization's agenda. Unfortunately, many IT business models are based on this paradigm and are therefore harmful to nature and the climate. When purchasing IT services, organizations should consider whether they have been exposed to this paradigm and whether they perceive it as normal—making it difficult to challenge.

Summary

1. By 2030, 75% of the world's population is expected to use the internet, increasing IT service consumption and energy demand.
2. Lower costs and greater accessibility drive digital service usage and innovation but reduce motivation for energy-efficient solutions.
3. Although internet penetration has stabilized in developed countries, data transmission volumes are rising significantly.
4. IoT and AI are increasing IT consumption, and their growth is not expected to slow down in the near future.
5. The design of digital services is based on the principles of unlimited scalability and continuous availability, which increases consumption and environmental impact.

5 Software Energy Consumption and Emissions

The energy consumption of modern software can be divided into three different parts:

1. End-user devices
2. Network
3. Servers and cloud environments

5.1 End-user devices

Modern end-user devices are becoming increasingly energy-efficient, but their number—especially small devices—continues to rise in households. According to statistics compiled by Statista, there were 14.02 billion mobile data-connected devices worldwide in 2020, and this number is expected to grow to 18.22 billion by 2025[41]. This figure includes not only mobile phones but also internet-connected cars and IoT devices. The compound annual growth rate (CAGR) is 5.38%.

There are several challenges related to the lifecycle of digital end-user devices. First, devices are not designed to be durable, repairable, recyclable, or upgradeable. Second, the amount of raw materials used is increasing, and material compositions are becoming more complex. Third, devices are not properly recycled, resulting in growth of electronic waste. Fourth, materials are not being reused. Finally, environmental factors have little influence on consumer pur-

[41] F. Laricchia, "Number of mobile devices worldwide 2020-2025." Mar. 10, 2023. statista.com/statistics/245501/multiple-mobile-device-ownership-worldwide

chasing decisions[42]. The relatively short life- span of digital devices accelerates the depletion of Earth's resources, particularly scarce and hard-to-obtain materials[43]. The manufacturing of devices consumes freshwater and energy, and generates embedded emissions.

Another factor to consider is the frequent replacement of end-user devices. Eurobarometer consumer research results[44] indicate that the most common reasons for purchasing a new device are the breakdown of the old device (38%), a significant decline in its performance (30%), incompatibility with certain applications or software (18%), or the desire for new service features (14%). Notably, performance degradation and software incompatibility—both linked to software efficiency, although performance issues may also stem from hardware failures—account for nearly half (48%) of purchasing decisions. The EU is addressing this issue by requiring the easy replacement of batteries in portable devices[45].

Further, planned and unintentional obsolescence worsen the matter. The market's drive toward newer and more powerful devices, and fast production cycles create a burden to the developers that causes software support to be cut short for older devices.

5.2 Network

The volume of transmitted data is growing at a significant rate. For example, in Finland, mobile data usage has been recorded since 2011. In 2011, data usage was 60 petabytes, whereas in 2023, it reached 4,823 petabytes[46], with a CAGR of

[42] L. Toivonen, "Laitteiden elinkaaren aikaiset ympäristövaikutukset," presented at the ICT-alan ilmasto- ja ympäristöstrategian 2. seurantafoorumi, Nov. 23, 2021. api.hankeikkuna.fi/asiakirjat/4de2baff-8867-4712-8b67-a250fb5f9e26/5d463e6f-7dfb-4bd1-9453-68c11a582ab7/LIITE_20230130100159.PDF

[43] TWI2050-The World, The Digital Revolution and Sustainable Development: Opportunities and Challenges. Report prepared by the World in 2050 initiative. Laxenburg, Austria: International Institute for Applied Systems Analysis (IIASA), 2019. doi: 10.22022/TNT/05-2019.15913.

[44] "Special Eurobarometer 503 – Attitudes towards the impact of digitalisation on daily lives," European Union, Dec. 2019.

[45] environment.ec.europa.eu/topics/waste-and-recycling/batteries_en

[46] Traficom, "Volume of data transferred in communications networks." Apr. 15, 2024. tieto.traficom.fi/en/statistics/volume-data-transferred-communications-networks

44.1%. A similarly clear and comprehensive dataset on fixed broadband data transfers is unavailable, as data collection only began in 2021.

On the other hand, the overall impact of networks is small compared to that of end-user devices and data centers. A study conducted by ADEME and the French Communications Regulatory Authority (ARCEP) indicated that only 4% of CO_2 emissions are attributable to networks—including both embedded and use-related emissions—while the remaining emissions are due to end-user devices (50%) and data centers (46%)[47].

The majority of network traffic consists of video content. It was estimated that by 2020, 78% of global internet traffic was video, and by 2022, this share rose to 82%[48]. Research indicates that 92% of internet users have watched at least one video per week[49]. Today, the average European spends approximately three to four hours per day watching videos. By 2030, the bandwidth required for video consumption is expected to rise to 6 gigabytes per hour, mainly due to the shift to 4K video[34].

The second-largest source of data transfer is the wide array of web services accessed via browsers[50]. The HTTP Archive has documented the evolution of websites in its annual Web Almanac report[51]. Data shows that the size of desktop websites has tripled, and mobile versions have grown nearly sevenfold over the past decade. Despite this, visitors still access websites primarily for text-based content, which constitutes only 1/50th of the downloaded data[52].

[47] Actualisation des chiffres de l'impact du numérique en France, ecoresponsable.numerique.gouv.fr/actualites/actualisation-ademe-impact/

[48] T. Barnett Jr, S. Jain, U. Andra, and T. Khurana, “Cisco Visual Networking Index (VNI) Complete Forecast Update,” presented at the APJC Cisco Knowledge Network, Dec. 2018. cisco.com/c/dam/m/en_us/network-intelligence/service-provider/digital-transformation/knowledge-network-webinars/pdfs/1213-business-services-ckn.pdf

[49] “Digital 2024: Global Overview Report,” Meltwater, Jan. 2024. datareportal.com/reports/digital-2024-global-overview-report

[50] Robert Istrate, Victor Tulus, Robert N Grass, Laurent Vanbever, Wendelin J Stark, and Gonzalo Guillén-Gosálbez. The environmental sustainability of digital content consumption. Nature Communications, 15(1):3724, 2024.

[51] J. Indigo and D. Smart, “Page Weight,” in Web Almanac, HTTP Archive, 2022, pp. 651–671.

[52] J. Kalliola, Green Code. Exove, 2023.

The amount of JavaScript required by modern websites is typically several megabytes uncompressed, regardless of the website's purpose[53]. While JavaScript compresses efficiently due to its text-based and repetitive nature, the end result is still significant in size. Further, a consequential portion of website images are poorly optimized, leading to excessive data transfer relative to their informational content. The growing inclusion of images and videos on websites will require a bandwidth of 1 gigabyte per hour by 2030[34].

The prevailing cornucopian paradigm in digital service design is fundamentally at odds with efforts to limit data demand efficiently[54].

When considering the energy consumption of transmission networks, it is important to note that the elasticity of fixed networks is very low. For example, in the case of optical fiber, the laser beam transmitting the signal remains on and consumes energy regardless of whether data is being transmitted[55]. On the other hand, wireless networks have a relatively linear energy consumption pattern after a certain baseline level is reached, in relation to the amount of data transmitted.

For fixed networks, reducing or slowing data growth delays the need for capacity expansion, which in turn reduces both embedded and operational emissions.

If the consumer's terminal device is not fixed—such as a television or game console—it is highly likely to be connected wirelessly. In addition, fixed devices are increasingly being connected wirelessly, as this makes the installation look cleaner. The energy consumption of mobile connections per transmitted gigabyte is significantly higher than that of fixed connections[56]. Consequently, the last-mile connection may consume more energy than the rest of the network between the server and the terminal device combined.

[53] N. Prokopov, "JavaScript Bloat in 2024", tonsky.me/blog/js-bloat

[54] J. Morley, K. Widdicks, and M. Hazas, "Digitalisation, energy and data demand: The impact of Internet traffic on overall and peak electricity consumption," Energy Research & Social Science, vol. 38, pp. 128–137, Apr. 2018, doi: 10.1016/j.erss.2018.01.018.

[55] D. Mytton, D. Lundén, and J. Malmodin, "Network energy use not directly proportional to data volume: The power model approach for more reliable network energy consumption calculations," J. Ind. Ecol., Jun. 2024, doi: 10.1111/jiec.13512.

[56] Joonas Nuutinen, A Comparison of the Energy Consumption of Broadband Data Transfer Technologies, joonasnuutinen.fi/wp-content/uploads/2022/01/Nuutinen2021_A-Comparison-of-the-Energy-Consumption-of-Broadband-Data-Transfer-Technologies.pdf

5.3 Servers and Cloud Environments

In this guide, the terms "cloud" and "data center" are used interchangeably. While data centers are defined as physical facilities and cloud computing refers to the provision of computing resources, cloud services are delivered from data centers, making them two aspects of the same overall system. It is important to note that cloud services can allocate resources more efficiently than traditional data centers and are generally more energy-efficient in operation[57]. However, major cloud service providers such as Amazon, Microsoft, and Google have not disclosed sufficient data in an open manner to allow for a comprehensive assessment of their environmental impact[58].

It is also worth noting that data centers, and especially cloud service providers, primarily sell their services based on capacity. This means that inefficient software and increased capacity usage are actually sources of revenue for them, which may reduce their incentive to limit resource consumption. Another approach is usage based billing for higher level services, such as serverless or managed services. This model does not have direct connection between used capacity and pricing, so optimizing services makes sense for the cloud providers.

The number of data centers is growing globally in response to increasing computing power and data transmission demands[59]. According to a 2024 estimate by Statista, annual spending on cloud-based IT infrastructure will grow steadily from $22.3 billion to $104.8 billion by 2023[60].

The largest energy consumer in data centers is IT load, accounting for 45% of total consumption, followed by cooling at 38%, power supply at 8%, and network infrastructure at 5%[59]. Besides energy, cooling requires freshwater and its consumption may be a serious issue in areas suffering water shortage[61].

---

[57] M. Zhang, "Cloud vs Data Center: A Comprehensive Guide," Dglt Infra. dgtlinfra.com/cloud-vs-data-center

[58] D. Mytton, "Hiding greenhouse gas emissions in the cloud," Nat. Clim. Chang., vol. 10, no. 8, pp. 701–701, Jul. 2020, doi: 10.1038/s41558-020-0837-6.

[59] K. M. U. Ahmed, M. H. J. Bollen, and M. Alvarez, "A Review of Data Centers Energy Consumption and Reliability Modeling," IEEE Access, vol. 9, pp. 152536–152563, 2021, doi: 10.1109/ACCESS.2021.3125092.

[60] L. Vailshery, "Global cloud IT infrastructure spending 2013-2026." May 29, 2024. statista.com/statistics/503686/worldwide-cloud-it-infrastructure-market-spending

[61] Revealed: Big tech's new datacentres will take water from the world's driest areas, theguardian.com/environment/2025/apr/09/big-tech-datacentres-water

It's important to note that compromises must be made between IT load, cooling, and the product-related emissions of servers. For example, operating servers at 100% capacity reduces the number of servers needed, but significantly increases cooling costs. On the other hand, if servers run at only 10% capacity, ten times more servers would be required, resulting in corresponding product-related emissions. However, in that case, the energy used for cooling would be only a fraction of that in the previous example.

Data center energy efficiency is primarily measured[62] using Power Usage Effectiveness[63] (PUE), which compares total energy consumption to the energy used by actual computing hardware[64].

PUE is a crucial metric for reducing the carbon footprint of data centers, as lower values indicate higher efficiency[65]. However, accurately calculating PUE is challenging due to a lack of publicly available energy data. Additionally, PUE calculations do not account for server utilization rates, meaning a low utilization rate and low PUE value may actually indicate inefficiency compared to a high utilization rate with a slightly higher PUE. Despite its limitations, PUE has helped improve energy efficiency in the ICT sector and has provided benchmarks for data center energy consumption.

Although data center energy efficiency has improved in recent years[14]—world-class hyperscale data centers already operate with a PUE of 1.1 or lower, approaching the practical minimum[66]—and despite growing awareness of software carbon intensity[67], there remains a significant gap between these efforts. Infras-

---

[62] K. Kant, "Data center evolution," Comput. Netw., vol. 53, no. 17, pp. 2939–2965, Dec. 2009, doi: 10.1016/j.comnet.2009.10.004.

[63] C. Malone and C. L. Belady, "Metrics to Characterize Data Center & IT Equipment Energy Use," Proceedings of the Digital Power Forum, September, vol. 18, p. 20, 2006. researchgate.net/publication/337801067

[64] T. Kennes, "Measuring IT Carbon Footprint: What is the Current Status Actually?," Jun. 08, 2023.

[65] G. A. Brady, N. Kapur, J. L. Summers, and H. M. Thompson, "A case study and critical assessment in calculating power usage effectiveness for a data centre," Energy Convers. Manage., vol. 76, pp. 155–161, Dec. 2013, doi: 10.1016/j.enconman.2013.07.035.

[66] E. Masanet, A. Shehabi, N. Lei, S. Smith, and J. Koomey, "Recalibrating global data center energy-use estimates," Science, vol. 367, no. 6481, pp. 984–986, Feb. 2020, doi: 10.1126/science.aba3758.

[67] The International Organization for Standardization, "Information technology — Software Carbon Intensity (SCI) specification," 21031:2024.

tructure lacks the ability to inform software developers about current energy use and potential inefficiencies[65].

The energy consumption of IT workloads in data centers can be estimated using various models[59]:

- **Additive power models** sum up the power consumption of individual components such as the CPU, memory, and motherboard.
- **Baseline-active (BA) power models** separate power consumption into idle (baseline) energy use and active energy use caused by computational workloads.
- **Regression models** correlate power consumption with performance metrics of functional units such as CPUs, memory, and storage.
- **Utilisation-based power models** use the CPU's power consumption as a proxy for the entire server's power usage.

Each model has its limitations. For example, additive models require tracking each component's power use, baseline-active models have large errors for low-CPU systems, and regression/usage-based models are limited to specific configurations[59].

Instead of models, real-time energy consumption measurements could be used. Unfortunately, comprehensive public data on data center energy consumption is lacking, and current tracking methods are inadequate[10, 68].

Despite a tenfold increase in internet traffic between 2010 and 2020, data center energy consumption has remained relatively stable[69]. The European Commission predicts that while workloads and data traffic in EU data centers will grow by 25% annually, energy use will only increase from 78 terawatt-hours (TWh) in 2015 to 90 TWh in 2030[70]. Additionally, although the total emissions from data centers

[68] M. Avgerinou, P. Bertoldi, and L. Castellazzi, "Trends in data centre energy consumption under the European code of conduct for data centre energy efficiency," Energies, vol. 10, no. 10, p. 1470, Sep. 2017, doi: 10.3390/en10101470.

[69] L. Gynther, T. Kiuru, and J. Meetteri, "Energy Efficiency of Data Centers in Finland – Indicators, Policies and Good Practices," Motiva, Nov. 2022.

[70] C. Koronen, M. Åhman, and L. J. Nilsson, "Data centres in future European energy systems—energy efficiency, integration and policy," Energ. Effic., vol. 13, no. 1, pp. 129–144, Jan. 2020, doi: 10.1007/s12053-019-09833-8.

have increased due to the construction of new facilities, the carbon footprint of operational energy consumption has decreased, primarily due to the growing use of renewable energy sources[71]. However, there is no available data on the volume of discarded older devices or their potential reuse or recycling.

From the perspective of data center operators, revealing detailed information about the electricity consumption of an individual data center could lead to competitors gaining access to specific operational data. Currently, there are no anonymized methods for aggregating energy consumption data, which prevents a broader and more comprehensive overview and monitoring[72].

An alternative approach would be to focus on emissions instead of energy consumption, as emissions can serve as a proxy for energy use due to the strong correlation between these two variables[73]. The largest cloud service providers offer carbon emission reporting. However, transparency, scope—meaning which of the three scopes of carbon emissions[74] are considered and to what extent—and the methodologies used in carbon footprint calculations are not clearly and objectively disclosed.

Boavizta[75] has analyzed the carbon emission reporting of the three largest cloud service providers: Amazon, Google, and Microsoft. The analysis[76] revealed that all three have several shortcomings in their current reporting practices. These include a lack of transparency in some or all areas, missing or only partially covered aspects, the use of opaque scaling factors, and less reliable calculation methods for energy-related emissions. Additionally, the study highlighted the lack of standardization, which leads to different approaches and makes comparisons be-

[71] U. Gupta et al., “Chasing Carbon: The Elusive Environmental Footprint of Computing,” arXiv [cs.AR], Oct. 28, 2020. arxiv.org/abs/2011.02839

[72] “The 2023 Annual Climate Summary – Global Climate Highlights 2023,” Copernicus, Jan. 2024. climate.copernicus.eu/global-climate-highlights-2023

[73] J. Li et al., “The Relationship between Energy Consumption, CO2 Emissions, Economic Growth, and Health Indicators,” Int. J. Environ. Res. Public Health, vol. 20, no. 3, Jan. 2023, doi: 10.3390/ijerph20032325.

[74] What are scope 1, 2 and 3 carbon emissions?, nationalgrid.com/stories/energy-explained/what-are-scope-1-2-3-carbon-emissions

[75] Boavizta is a French association helping organizations to assess, manage and reduce the environmental impact of their digital in a simple, fast and reliable way. boavizta.org/en

[76] “Understanding the results of cloud providers’ carbon calculators,” Boavizta. boavizta.org/en/blog/calculettes-carbone-clouds-providers

tween calculations challenging. There has been positive progress in this area; for example, the Software Carbon Intensity (SCI) Specification v1.0 has become an ISO standard[77].

In addition to energy consumption, data centers use a significant amount of water, primarily for cooling purposes. In Finland, water availability is not an issue, but in other parts of the world, drought and water scarcity are major problems. For example, in the United States, about 20% of data centers are located in areas affected by drought[78]. Unfortunately, only 16% of the companies behind data centers have published information about their water usage[79].

5.3.1 Artificial Intelligence

The use of artificial intelligence has grown significantly over the past two to three years, with new AI applications emerging weekly. At the same time, the quality of AI-generated outputs has improved considerably, particularly in the case of generative AI.

On the other hand, awareness of AI solutions' energy consumption and emissions has also increased globally. The widespread use of AI has led to the establishment of new data centers, resulting in increased operational and embedded emissions.

Assessing AI's energy consumption has long been hindered by the lack of standardized data. AI providers have been—understandably—reluctant to disclose energy usage details, instead offering only general insights into their consumption. However, AI energy consumption has been the main reason behind Microsoft and Google's struggles to reduce their carbon footprints. Both companies' emissions increased last year, and at this rate, neither is on track to meet their previously set carbon targets.

---

[77] Software Carbon Intensity (SCI) Specification Achieves ISO Standard Status, Advancing Green Software Development, greensoftware.foundation/articles/sci-specification-achieves-iso-standard-status

[78] Md Abu Bakar Siddik, Arman Shehabi and Landon Marston, The environmental footprint of data centers in the United States, Environmental Research Letters, Volume 16, Number 6, iopscience.iop.org/article/10.1088/1748-9326/abfba1

[79] Erin Johnson and Kata Molnar, ESG Risks Affecting Data Centers: Why Water Resource Use Matters to Investors, sustainalytics.com/esg-research/resource/investors-esg-blog/esg-risks-affecting-data-centers-why-water-resource-use-matters-to-investors

In 2024, the first scientific articles on AI's energy consumption and emissions were published. However, these studies still acknowledge that the topic remains largely under-researched.

For example, an article[80] published by Alexandra Sasha Luccioni and her team measured the carbon footprint of various AI-driven tasks, such as text and image classification, object recognition, summarization, and caption generation. Since all tests were conducted within the same cloud service, their carbon footprint directly reflects energy consumption.

The differences between types of tasks were substantial. Text classification consumed the least energy, at 0.002 kWh per thousand operations, while image generation consumed the most, at 2.9 kWh per thousand operations. These figures are averages from multiple tests using different AI models. The extremes were even more pronounced—the least efficient image generation consumed 6,833 times more energy than the most efficient text generation. In general, text processing was found to be significantly more energy-efficient than image processing, primarily due to the number of tokens[81] required.

Similarly, model size affects energy consumption—larger models consume more than smaller ones. However, the impact of model size is smaller than that of its intended use. Overall, the variability in measurements was significant, though results for different tasks tended to cluster, albeit with some overlap.

A key finding was that models designed for a specific task consumed significantly less energy than general-purpose models used for the same task. For example, task-specific summarization models generated 4–10 gCO_2eq per thousand operations, while general-purpose models produced 20–30 gCO_2eq for the same task. This is understandable since the task-specific models had a maximum of 600 million parameters, while the largest general-purpose models contained approximately 11 billion parameters.

It is important to note that the test setup was considerably simpler than real-world use of large language models in the cloud, where workloads are higher. Additionally, AI models vary widely depending on the use case—AI can range

[80] Alexandra Sasha Luccioni, Yacine Jernite, and Emma Strubell. 2024. Power Hungry Processing: Watts Driving the Cost of AI Deployment?. In ACM Conference on Fairness, Accountability, and Transparency (ACM FAccT '24), June 3–6, 2024, Rio de Janeiro, Brazil. Doi: 10.1145/3630106.3658542

[81] What is an AI Token? miquido.com/ai-glossary/ai-token

from a simple regression model making loan decisions to large-scale generative models.

The Green Web Foundation has created a brief guide[82] to increase the environmental friendliness of AI. The main themes of the guide are as follows:

- There's a large and growing environmental impact associated with AI adoption
- Mass adoption of AI is jeopardising existing company sustainability goals
- AI's footprint can be estimated, but it's an emerging discipline
- Changing your choice of AI model and task impacts the footprint
- Any AI code can be run in ways that reduce the footprint

Energy Consumption of Training

In addition to runtime energy consumption, AI systems also require energy for collecting, cleaning, and organizing training data, as well as for training the models themselves.

Unfortunately, little information is available on the energy consumption of training AI models commonly used as cloud services. If training AI models in-house, it is advisable to measure energy consumption and explore ways to reduce it. One straightforward way to lower emissions from a company's perspective is to train models in countries with low-carbon electricity generation. Finland and other Nordic countries are good candidates for this. However, it is also important to remember that global energy consumption is growing faster than renewable energy production, making energy conservation essential wherever possible.

[82] Hannah Smith and Chris Adams, Thinking about using AI? thegreenwebfoundation.org/publications/report-ai-environmental-impact/

Summary

1. The number of end-user devices is increasing, leading to higher energy consumption. Devices are not durable, repairable, or recyclable, and their lifespan is short. Additionally, inefficient software affects device longevity and drives demand for new hardware, increasing environmental impact.

2. The volume of data transmission is growing rapidly, particularly due to video consumption. Overall, website sizes have multiplied, and data demand has not been effectively restricted. This increases energy consumption as larger and more complex online services require more resources.

3. The number of data centers is increasing to meet communication needs, but overall energy consumption has remained stable due to improved efficiency and the use of renewable energy. However, assessing the environmental impact of cloud services remains difficult due to a lack of transparency. Additionally, carbon emissions reporting is inconsistent.

4. AI usage has grown significantly, and initial research on its energy consumption has begun to emerge—specialized models consume less energy than general-purpose models in similar environments. Data processing and model training contribute to total emissions, making it challenging to assess the environmental impact of AI technology.

6 Measuring Energy Efficiency

Software energy efficiency could be significantly improved by incorporating efficiency as a core design principle[83]. Energy consumption and emissions from software can be reduced by selecting appropriate architectures, optimizing software and algorithms, choosing more efficient programming languages[84] and compilers, optimizing operating systems, scheduling programs, load balancers, and managing data center system deployments[71].

The architecture of a software system has a significant impact on its energy efficiency[85]. Additionally, the deployment model and workload distribution between the end-user device and the cloud/data center can greatly influence energy consumption[86].

6.1 General Efficiency

Software energy efficiency and overall efficiency are closely linked—the more efficiently a software operates, the less energy it typically consumes. Thus, all tools used for measuring software efficiency, of which there are many, can be

[83] E. Capra, C. Francalanci, and S. A. Slaughter, "Is software 'green'? Application development environments and energy efficiency in open source applications," Information and Software Technology, vol. 54, no. 1, pp. 60–71, Jan. 2012, doi: 10.1016/j.infsof.2011.07.005.

[84] R. Pereira et al., "Ranking programming languages by energy efficiency," Science of Computer Programming, vol. 205, p. 102609, May 2021, doi: 10.1016/j.scico.2021.102609.

[85] Jagroep, E., van der Werf, J.M., Brinkkemper, S. et al. Extending software architecture views with an energy consumption perspective. Computing 99, 553–573 (2017). doi.org/10.1007/s00607-016-0502-0.

[86] D. A. Temesgene, "Cyber foraging for green computing, improving performance and prolonging battery life of mobile devices," Lappeenranta University of Technology, 2016.

utilized. However, these tools do not provide a precise understanding of changes in energy consumption, but they can be sufficient for ensuring efficiency.

Managing such tools is a fundamental part of software development and should be required as part of project delivery or testing. This guide does not delve into these tools and processes in detail.

6.2 Energy Efficiency

To understand efficiency benefits, it is first necessary to develop an energy efficiency metric that is relevant to the specific application[83]. Measurements should aim to simulate real-world use cases as accurately as possible, using data that closely resembles production environments. The volume of data processed should also reflect actual conditions.

Measuring software energy efficiency is challenging for several reasons, including the diversity of software, layered architectures that obscure implementation details and hardware usage, and the lack of standardization[87].

Generally, measurement methods can be divided into two categories: Black-box measurements, where the system is measured externally without understanding its inner workings, and white-box measurements, which focus on instrumenting source code to pinpoint resource-intensive components[88].

Black-box measurements are dependent on the software being analyzed, meaning their results cannot be generalized. White-box measurements, on the other hand, impose high costs on developers due to the need to establish measurement environments and develop appropriate testing procedures, especially for complex software. Currently, there are no off-the-shelf software solutions for this purpose,

[87] G. Kalaitzoglou, M. Bruntink, and J. Visser, “A practical model for evaluating the energy efficiency of software applications,” in Proceedings of the 2014 conference ICT for Sustainability, Paris, France: Atlantis Press, 2014. doi: 10.2991/ict4s-14.2014.9.

[88] T. Johann, M. Dick, S. Naumann, and E. Kern, “How to measure energy-efficiency of software: Metrics and measurement results,” in 2012 First International Workshop on Green and Sustainable Software (GREENS), IEEE, Jun. 2012, pp. 51–54. doi: 10.1109/GREENS.2012.6224256.

as most research efforts have chosen to develop custom measurement tools for specific problems[89].

However, this does not mean that energy efficiency should not be measured. The market offers various ready-made solutions tailored to specific needs, available both as commercial products and open-source implementations. A knowledgeable provider can find or even recommend different solutions, at the very least when required in a project proposal.

Modern hardware includes features for measuring processor energy consumption either as a whole (Intel's RAPL interface[90]) or per process (Apple's powermetrics[91]). Using these tools directly requires deep technical expertise, but various solutions have been built on top of them.

One practical application of these measurements is Firefox Profiler[92], which can measure the energy consumption of web applications within a browser. Similarly, Kepler[93] measures the energy consumption of containerized services, making it useful for assessing energy usage in server applications and microservices.

Creating a universal measurement environment suitable for all software is challenging due to high costs, labor intensity, lack of scalability, and the fact that hardware-based profiling is highly accurate only for the specific device it was designed for. Additionally, software-based profiling is influenced by the accuracy of available sensors[94], such as battery voltage levels or smart battery sensors. These challenges are further exacerbated by operating system limitations, the high overhead of profiling, and the trade-off between accuracy and profiling speed.

89 S. Nurmivaara, "Green in Software Engineering: A Systematic Literature Review," Master of Science, University of Helsinki, 2023.

90 What is RAPL?, https://greencompute.uk/Measurement/RAPL

91 How to See Individual Core CPU Usage on Mac with powermetrics, osxdaily.com/2024/07/05/how-to-see-individual-core-cpu-usage-on-mac-with-powermetrics

92 Firefox Profiler, profiler.firefox.com

93 github.com/sustainable-computing-io/kepler

94 R. W. Ahmad, A. Gani, S. H. A. Hamid, F. Xia, and M. Shiraz, "A Review on mobile application energy profiling: Taxonomy, state-of-the-art, and open research issues," Journal of Network and Computer Applications, vol. 58, pp. 42–59, Dec. 2015, doi: 10.1016/j.jnca.2015.09.002.

In conclusion, even if measurement proves difficult, software optimization and efficiency should always be considered. It is also beneficial to explore different viable strategies and models for measurement so that energy efficiency can eventually be validated through quantifiable means.

Summary

1 Software energy efficiency can be improved by optimizing architectures, applications, algorithms, programming languages, operating systems, and data center system management.

2 Measuring energy efficiency is challenging due to software diversity and the lack of standardization. Measurements are divided into black-box methods (external measurements) and white-box methods (instrumenting source code).

3 Creating a general measurement environment is costly and difficult to scale. Measurement results are influenced by hardware profiling limitations, sensor accuracy, and operating system constraints.

7 Reducing Software Energy Consumption

As discussed in previous sections, reducing energy consumption is essential and should be done quickly. In practice, the IT sector's energy consumption is increasing due to both the growth in the number of users and usage, as well as software bloat. While an individual company may find it difficult to curb the increase in overall usage, it is possible to address the energy consumption of the software it acquires.

There is no single method to reduce energy consumption across all software. Instead, the approach must be tailored to each specific software application, considering its architecture, data models, and functionality.

Wilco Burggraaf, in his article *The 12 Principles of Sustainable IT: Rethinking the Future of Technology*[95], provides valuable insights into responsible software development:

- **Sustainability is not a limitation but an optimization opportunity.** Efficiency is not just about speed or cost but also about the smart use of resources. Sustainable development is a technological challenge that requires smarter software and energy-efficient infrastructure.

- **Build for change.** IT systems must adapt to evolving regulations, energy solutions, and technologies. Sustainable software does not become obsolete quickly but instead adapts over time.

---

95 medium.com/@wilco.burggraaf/the-12-principles-of-sustainable-it-rethinking-the-future-of-technology-ea1f59f3f3b7

- **Measure impact, but don't let metrics define success.** Tracking carbon footprint, energy consumption, and device lifespan is important, but focusing solely on numbers may overlook broader impacts.
- **Reduce complexity, but remember that software is not simple.** Excessive complexity wastes resources, but forcing simplicity can make systems inefficient. A sustainable system is optimized yet flexible.
- **Think about the entire lifecycle, not just deployment.** The sustainability of technology is not just about rapid deployment but about considering its entire lifecycle—from production to decommissioning.
- **Energy efficiency is important, but timing also matters**. The carbon footprint of electricity varies. A sustainable system uses energy wisely—shifting computing tasks to times when electricity production is greener.
- **Device efficiency is about longevity, not just speed.** Instead of constantly upgrading to new devices, software should be developed to extend the lifespan of existing hardware and reduce e-waste.
- **Reduce waste, but don't over-optimize.** Over-optimized systems can become too rigid. Sustainability means scalability and adaptability, not just maximizing efficiency.
- **Make sustainability a shared responsibility.** Sustainability is not just the responsibility of a single team—everyone, from developers to product managers, should make decisions that support long-lasting and energy-efficient solutions.
- **Reevaluate performance—everything doesn't need to happen instantly.** Immediate performance increases energy consumption. Not everything needs to be processed in real-time—sometimes, the most sustainable solution is allowing delays and using resources wisely.
- **Automate wisely.** The efficiency of automation depends on how intelligently it is used. Not all processes need to run continuously; they should be optimized based on actual needs.
- **Continuously assess, learn, and adapt.** Sustainability is not a fixed goal but an ongoing process. New technologies and research findings change best practices, so systems must evolve accordingly.

7.1 Design

Design work related to software sets the framework for actual implementation, and considering energy consumption at the design stage is of utmost importance.

Design is divided into conceptual, visual, and technical design:

- **Conceptual design** defines the software's functionalities, their detailed operation, response to user actions, and user navigation within the software. The software concept can significantly impact energy consumption and other sustainability effects, so it should be developed and evaluated from a sustainability perspective.

- **Visual design** involves building the software's user interfaces and creating the desired user experience. The most significant impact on energy consumption from the UI comes from clarity and reducing errors, both of which decrease time spent using the software and, consequently, energy consumption.

- **Technical design** develops the software architecture, identifies necessary components, and plans their internal structure and interactions. At the same time, data models are defined, key algorithms are selected, and integration agreements are made. Technical design has a significant impact on energy consumption and must consider energy efficiency aspects.

7.2 Waste and Its Elimination

Every application is unique in its strengths and weaknesses. To analyze this more systematically, it can be approached with the concept of waste from Lean methodologies[52].

In Lean, "waste" refers to unnecessary, unproductive activities that slow down processes or create unnecessary costs[96].

From an energy efficiency perspective, waste can be defined as extra, unproductive operations that unnecessarily consume energy. As in Lean, there are different types of energy waste.

[96] en.wikipedia.org/wiki/Lean_manufacturing

Addressing different types of waste assumes that the application is otherwise implemented correctly. If an application performs a thousand unnecessary database queries due to a poorly written loop in every operation, this is primarily a programming error rather than just waste. Waste is more about a lack of thought or inefficient implementation than actual mistakes, and eliminating waste is rarely straightforward.

7.2.1 Examples of Waste

There are many types of waste, and their impact on energy efficiency varies significantly depending on the nature of the software, its usage, and the surrounding architecture.

- **Redundant software** – Software that no longer serves any purpose consumes resources needlessly and should be decommissioned. Collaborating with the finance department can help identify and remove redundant software.

- **Improper use** – Using software for unintended purposes can cause inefficiencies and unnecessary load. If an application does not support required functions, it may slow down work and increase costs. However, this should not be confused with software that lacks necessary features—such a case is not just waste but also a mismatch between the application and its intended use.

- **User mistakes** – User errors increase unnecessary workload and energy consumption, so applications should prevent them through clear UI design and accessibility considerations. The best solutions eliminate the possibility of errors altogether.

- **Wrong architecture** – Poorly designed or outdated architecture increases complexity, energy consumption, and error rates. Fixing architecture is labor-intensive but may be necessary for long-term efficiency.

- **Wrong data models** – Inefficient or inadequate data models can make data processing harder and increase system load. Choosing the right data model is critical since changing it later can be difficult and risky.

- **Redundant data** – Applications often accumulate unnecessary data, which increases storage costs and slows down the system. Data models should enable the controlled removal of old data to ensure resource efficiency and compliance with requirements of data privacy laws, such as GDPR.

- **Non-optimised data** – Optimizing data transfer reduces energy consumption and improves performance. This can be achieved by limiting transferred data, optimizing file formats, and efficiently utilizing caches.
- **Redundant data transfers** – Data is often transferred multiple times "just in case," increasing energy consumption. Synchronization libraries and distributed protocols can reduce this, but their implementation can add complexity and risks.
- **Algorithmic inefficiency** – The efficiency of chosen algorithms and data structures significantly impacts software performance. More efficient solutions may be more complex, but optimizing critical points yields the biggest savings.
- **Misguiding users** – Users may be intentionally or unintentionally misled in services, causing unnecessary energy consumption. Good UX design and user research help avoid misleading solutions.
- **Too much code** – Applications often include too many libraries, only a small portion of which are needed. Packaging tools and careful library selection can reduce unnecessary code and improve performance, though they may also add development complexity.
- **Inefficient programming language** – Programming languages vary significantly in efficiency and suitability for different tasks. For example, C, Rust, and C++ are the most energy-efficient. However, instead of switching languages, it is often more effective to optimize existing code and use efficient runtime environments.
- **Waste in starting a software** – Software should perform only essential tasks at startup. Faster startup enables more resource-efficient architectures, such as cold standby solutions.
- **Redundant redundancies** – Extra visual effects and animations can increase energy consumption without real user benefit. Design should focus on functional benefits rather than unnecessary "eye candy." However, aesthetics do matter for user acceptance, so applications should not be stripped down to the point of being unattractive.

These topics are discussed in more detail in the free book *Green Code* by Exove.

7.3 Minimization

Software energy efficiency can also be approached through minimization—creating a solution as compact as possible while still meeting essential requirements.

Minimization requires careful planning. Every requirement should be questioned to determine whether it is truly necessary. However, essential functions must still be implemented; if minimization results in an incomplete system that needs fixing later, inefficiency can quickly increase. A well-designed minimal solution is typically elegant to implement and straightforward to use.

For successful minimization, business and user needs must be well understood. It works particularly well when challenges are precisely defined. Additionally, numerical comparisons help grasp scale, avoiding biases and assumptions in decision-making.

When the core purpose of a service is emphasized, the service becomes clearer, the user experience improves, conversion rates increase, and user paths shorten—benefiting both business results and energy efficiency.

Beyond eliminating unnecessary needs, narrowing the target audience simplifies minimization by removing certain usage scenarios. Segmentation should be role-based—for example, should payroll software also provide views for executives and employees, or should their needs be addressed differently? Expert users may also benefit from dedicated interfaces, preventing clutter in the primary user experience.

Excessive minimization, however, can lead to workarounds or misuse, which could ultimately worsen energy efficiency. In consumer services, it is crucial to ensure that narrowing the target audience does not exclude any user group, potentially leading to discrimination. For example, removing accessibility features is not a valid form of minimization.

A key benefit of minimization is simplification—shorter user paths, fewer functions and error-handling cases, a clearer UI, reduced cognitive load, and a less overwhelming visual experience.

7.4 Green Software Patterns

In August 2022, the Green Software Foundation published its Green Software Patterns catalog[97], which includes software design patterns for reducing emissions. The catalog provides practical, immediately applicable solutions for various software scenarios. The patterns are not universal, and the right choices depend on the technology.

Their impact also varies, which is indicated in pattern descriptions, but the final effect depends on the environment in which they are applied.

Anyone can propose new patterns, which go through a short evaluation process, ensuring that patterns in the catalog contribute to reducing software emissions. Currently, the catalog includes patterns for AI, cloud services, and web applications.

7.5 Considering Carbon Intensity

There are libraries and other solutions that allow applications to adapt based on the carbon intensity[98] of available energy. For example, Grid Aware SDK[99] and Carbon Aware Computing[100] offer ways to determine carbon intensity and make decisions accordingly.

The Green Web Foundation Grid Aware Websites[101] project is developing a similar solution for websites. (The author of this guide is an advisor on the project.)

These solutions typically do not reduce energy consumption per se but aim to shift it to periods with lower emissions. As renewable energy production increases, carbon intensity fluctuates significantly. Moving heavy computations to low-emission periods is reasonable, but large-scale shifts could lead to increased hardware demand.

---

[97] Green Software Patterns, patterns.greensoftware.foundation

[98] What is carbon intensity? nationalgrid.com/stories/energy-explained/what-is-carbon-intensity

[99] Carbon-Aware SDK, github.com/Green-Software-Foundation/carbon-aware-sdk

[100] Carbon Aware Computing, carbon-aware-computing.com

[101] Grid-aware websites, thegreenwebfoundation.org/news/introducing-our-grid-aware-websites-project

An alternative to delaying tasks is to avoid them altogether—but if a task can be skipped when energy is clean, it could likely be skipped altogether. The third approach is to provide reduced service—such as stripped web pages—during periods of higher carbon intensity.

7.6 Practical Solutions

In addition to the conceptual models, there are practical solutions to reduce software energy consumption:

- **Minimizing stored data** – The data model of an application should be streamlined by removing unnecessary and outdated information, limiting user inputs, and using efficient storage formats. Optimizing images and videos and managing the controlled storage of analytics data can reduce the amount of data. Cold storage of data can be an alternative when it cannot be completely removed.

- **Minimizing transferred data** – Data transfer can be reduced by increasing the interval between transfers, compressing data, selecting energy-efficient protocols and transfer formats, and avoiding unnecessary HTTP redirects and headers. Transferring only changed data, generating presentation data at the client device, and combining data transfers can reduce the amount of data and energy consumption.

- **Reducing code** – Dead code should be removed, libraries and features should be trimmed, and the application size should be reduced. Software that needs to be compiled for different environments may be lighter if optimized separately for each platform. Controlled code minimization can speed up the application and reduce its resource requirements.

- **Improving application efficiency** – Choosing the right algorithms and data structures improves performance and reduces energy consumption. By optimizing critical points and avoiding premature optimization, efficiency can be achieved without unnecessary complexity. Refactoring, optimizing the runtime environment and programming language, and considering background processing can improve the application's eco-efficiency.

- **Using external solutions** – Content delivery networks (CDNs), caching, and load balancing solutions can reduce server load and speed up data delivery to users. These solutions can improve performance or energy efficiency, but require careful design and balancing.

These are discussed in more detail in the book *Green Code* published by Exove, which you can download for free.

Summary

1. Unnecessary functionality, misuse of software, user errors due to poor usability, and poor architecture increase energy consumption in software. Minimizing these problems improves efficiency and reduces unnecessary energy consumption.

2. Software energy efficiency can be improved by minimizing unnecessary features and data, while focusing on core functionality. A well-designed, clear solution reduces both user and system load.

3. The design patterns published by the Green Software Foundation can help reduce software emissions. These patterns offer practical solutions for various technologies, such as AI, cloud services, and web applications.

4. Optimizing data storage and transfer, reducing excess code, and using efficient algorithms and data structures improve software performance and reduce energy consumption.

5. Various external services, such as content delivery networks, caching, and load balancing, can reduce server load, improve performance, or reduce energy consumption when used correctly.

8 Supplier's Carbon Footprint

The supplier's carbon footprint is particularly important when making responsible purchasing decisions for services. The carbon footprint of equipment and other physical products is usually pre-calculated by responsible suppliers, but this is not always the case with services. For calculating scope 3, which includes emissions from the supply chain and procurement, it is essential to know the carbon footprints of purchased services and products.

From the buyer's perspective, the easiest approach is to require the supplier to provide a carbon footprint calculation. However, the calculation should be verified, and the methods and boundaries used in the calculation should be compatible with the buyer's own carbon footprint calculation.

8.1 General Information on Carbon Footprint Calculation

Carbon footprint calculation is a complex process involving a wide range of factors, such as calculation boundaries, data used, and result validation. International guidelines and standards, such as the GHG Protocol or ISO 14064, govern the calculation. Emissions calculations are a key step toward climate-friendly practices, and getting started is more important than achieving perfect accuracy right away. However, data accuracy should still be kept in mind when decisions are being made based on it.

There are various methods available for modeling carbon footprints. However, results from different methods may vary, making comparison challenging. The lack of transparency in the calculation methods and the emission factors used complicates comparison, even though transparency is crucial for the reliability and comparability of calculations. Common calculation boundaries include the “cradle-to-grave” model, which considers all emissions over the product's lifecycle, and the “cradle-to-gate” model, which focuses only on emissions from raw material production to the factory gate.

In software consulting, the cradle-to-gate model may be more practical, excluding emissions from the software's usage phase and production environment. These emissions are then included in the carbon footprint of the software buyer and user.

In the European Union, the Environmental Footprint Method (PEF) supports carbon footprint calculations, which assesses a product's environmental impacts over its lifecycle in 16 different impact categories. PEF guidelines define the necessary input data and evaluation models for each product group, providing more precise frameworks for calculations. These methods aim to create common and reliable ways to assess and reduce the environmental impacts of products and services.

In carbon footprint calculations, both primary and secondary data are used, complementing each other and significantly impacting calculation reliability. Primary data consists of directly collected data, such as quantities of raw materials or energy consumption, and it is sourced from suppliers or production processes. This original data is critical at every lifecycle stage, enabling accurate and reliable emissions estimates.

Secondary data, on the other hand, is based on databases, statistics, or published general emission factors, such as those for raw material production, transportation, or other lifecycle stages. Secondary data is typically used when primary data is unavailable, but its reliability depends on the transparency of the methodology used to collect the data. Ensuring the quality of both types of data is important for achieving accurate and comparable carbon footprint results.

Secondary data can be used to calculate carbon dioxide emissions using European emission factors. Emissions can be estimated based on accounting data by multiplying the amount of money spent on a product or service by its average emission factor. This approach is used for simplicity or when other data is unavailable. However, the margin of error in this method is the largest.

8.2 Software Development's Carbon Footprint

The carbon footprint of development work is largely similar to the carbon footprint of normal office work. Software developers use computers in much the same way as other office workers. Additionally, the carbon footprint of supporting systems for software development, such as version control, test servers, ticketing systems, build pipelines, etc., should also be calculated.

Projects may share resources whose carbon footprints should be allocated proportionally to usage. This is not always easy, so estimates are often necessary. The key is to ensure the footprint is allocated in its entirety, but not multiplied.

8.3 Software Carbon Footprint

The carbon footprint of software consists of the energy consumed and the lifecycle emissions of the required hardware. Sometimes, energy usage is included in the lifecycle, so care should be taken not to double-count emissions.

The energy consumption of software correlates largely with the time the application is running, regardless of the programming language. A faster application is, therefore, more energy-efficient. It's also important to note that applications should run in the same environment, meaning a faster computer does not make the application more energy-efficient.

Similarly, the amount of transferred data affects the footprint, depending on the transmission path. Some networks, typically fixed networks, consume the same amount of energy regardless of how much data is transferred.

The energy consumption and emissions of user devices can either be included or excluded from the carbon footprint calculation. This decision depends on how the software is used. For example, for internal use, the energy consumption of user devices should be included, but for software offered to corporate clients, the consumption of devices may be included in said corporation's own carbon footprint calculations. In consumer software, drawing the line can be difficult. However, it is essential to make a decision either way and provide written justification, making it easier to audit the calculation later.

8.4 Carbon Neutrality

In practice, no software-related business can be entirely and truly carbon-neutral, as it always produces greenhouse gas emissions. In this context, carbon neutrality refers to calculating and minimizing the operation's carbon footprint and offsetting the remaining emissions by purchasing an equivalent amount of climate units from voluntary carbon markets[102]—typically by compensating for or, less often, capturing and sequestering the corresponding amount of CO_2. It should be noted that some offsets are based on CO_2 capture and sequestration using specific technical processes, while others may involve forest growth or the removal of CO_2 sources.

An essential part of carbon neutrality is calculating all company climate-related emissions. All three scopes of the GHG Protocol must be carefully reviewed. Materiality analysis can help identify insignificant emission sources, which can then be disregarded.

After the calculation, emissions can be offset to achieve carbon neutrality. However, the buyer should ensure that the company has made sufficient efforts to minimize its own carbon footprint before offsetting. The offset method used should be verified to ensure that the result is real, measurable, permanent, and additional[103, 104]. Claims related to offsetting should be treated with caution. For example, the Finnish government provides guidance on the matter[105, 106], and it should also be noted that the criteria for climate units have changed and tightened significantly in recent years, and this process is still ongoing.

[102] Voluntary carbon markets, ym.fi/en/voluntary-carbon-offsetting

[103] Cydney Posner, Cooley PubCo, Is buying a carbon offset like buying a medieval indulgence?, cooleypubco.com/2022/06/27/carbon-offset-medieval-indulgence/

[104] Additionality is determined by assessing whether the proposed project is distinct from its baseline scenario. The baseline scenario is a prediction of the future behavior of the actors proposing, and affected by, a project's activities in the absence of any carbon revenue incentives, holding all other factors constant. offsetguide.org/high-quality-offsets/additionality/

[105] the Ministry of the Environment of Finland, Voluntary carbon markets, ym.fi/en/voluntary-carbon-offsetting

[106] Laine, Anna et al., Guide to good practices for voluntary carbon markets : Supporting voluntary mitigation action with carbon credits, julkaisut.valtioneuvosto.fi/handle/10024/164732

In Finland, software companies can apply for the Carbon Neutrality Label[107] managed by the Code from Finland association. To obtain the label, a company must commit to the following conditions:

- The company is a member of the Code from Finland association.
- The company calculates its own carbon footprint annually using methods commonly used in the industry.
- The company is committed to minimizing its carbon footprint.
- The company compensates for its entire carbon footprint at least annually through one or more reliable compensation service providers.
- The compensation methods used align with the criteria for good compensation.

A global approach is to apply for B Corporation certification[108] from B Lab. The certification is a third-party standard requiring companies to meet social sustainability and environmental performance standards, meet accountability standards, and be transparent to the public according to the score they receive on the assessment. To be granted and to maintain certification, a company must receive a minimum score of 80 from an assessment of its social and environmental performance.

8.4.1 Green Claims Directive

The European Parliament approved Directive (EU) 2024/825 in March 2024, which bans unsubstantiated environmental claims and misleading product information. Member states have until March 27, 2026, to integrate the directive into their national legislation.

According to the directive, the use of general environmental claims such as “environmentally friendly,” “eco-friendly,” and “green” is prohibited unless substantiated with scientific evidence and verifiable justification.

Other terms banned include:

- Climate neutral

[107] Carbon Neutrality label, koodiasuomesta.fi/en/symbols/carbon-neutrality-label/

[108] B Corporation, en.wikipedia.org/wiki/B_Corporation_(certification)

- Certified carbon dioxide neutral
- Carbon positive / carbon negative
- Net-zero impact
- Climate-compensated
- Less environmental impact
- Low carbon footprint

The ban applies to products, services, as well as company names, marketing names, environmental labels, and claims. The ban covers all forms of information: text, images, graphic elements, and symbols.

The directive also limits claims based on emissions' compensation. Such environmental claims are allowed only if:

- They apply solely to residual emissions after all possible emission reduction actions have been implemented.
- They are verified by an independent third party.

Furthermore, the use of sustainability labels will be more strictly regulated. Only third-party certified or government-recognized labels will be allowed. Companies cannot create their own environmental labels without external verification.

The EU's green claims directive further tightens the rules related to environmental claims, aiming to eliminate unsupported claims about the greenness and eco-friendliness of products and services. The goal is to reduce misleading claims that confuse consumers and give companies an incorrect impression of their environmental impacts or benefits.

To achieve these objectives, the EU prohibits[109]:

- General environmental claims that cannot be proven.
- Claims that a product has a neutral, reduced, or positive environmental impact because the manufacturer compensates for its emissions.

[109] europarl.europa.eu/topics/en/article/20240111STO16722/stopping-greenwashing-how-the-eu-regulates-green-claims

- Sustainability labels that are not based on approved certification systems or have not been approved by authorities.

To ensure that consumers receive reliable, comparable, and verifiable environmental information about products, the proposal includes[110]:

- Clear criteria on how companies should prove their environmental claims and labels.
- Requirements for independent and accredited verifiers to check these claims and labels.
- New rules for managing environmental labeling systems to ensure they are stable, transparent, and reliable.

[110] Green Claims, environment.ec.europa.eu/topics/circular-economy/green-claims_en

Summary

1 Knowing the supplier's carbon footprint is particularly important in responsible service procurement. Calculations should be compatible with the buyer's own carbon footprint calculations, and the buyer should request transparent and verifiable calculations from the supplier.

2 Carbon footprint calculations are based on international standards, and using different methods can lead to variations in results. The quality of primary and secondary data impacts the accuracy of calculations, and care should be taken to avoid double counting emissions.

3 The carbon footprint of software development work is similar to office work, but it also includes systems used in development. Software usage carbon footprint is influenced by energy consumption, device lifecycle, and data transfer efficiency. Clear boundaries should be set in the calculation.

4 Software business cannot be fully carbon-neutral, but emissions can be offset once the carbon footprint has been minimized. Offset methods should be reliable, measurable, permanent, and additional, and marketing claims should be treated with skepticism.

5 The EU Green Claims Directive bans unsubstantiated environmental claims and requires scientific evidence for all environmental-related claims. Companies cannot claim their products are carbon-neutral solely based on compensation, and sustainability labels must be third-party certified or government-recognized.

9 Purchasing Guidelines

Sustainable purchasing involves various approaches, depending largely on the specific characteristics of the services, equipment, or intangible rights being acquired. The guidance in this section primarily addresses ecological sustainability, energy consumption, and emissions. While ethical and social aspects of sustainability are also important, this guide focuses solely on ecological sustainability.

It is crucial to maintain consistency in sustainability requirements and ensure that they are directly related to the procurement in question. Consistent, standardized sustainability criteria will help increase sustainability efforts, but randomly demanding different details of sustainability in each procurement process may have a negative impact, as unpredictability and inconsistency can reduce companies' motivation to engage in sustainability efforts.

Instead, suppliers' sustainability performance should be scored in relevant areas that are taken into account in the procurement process. This approach has several benefits:

- Suppliers that offer the most relevant sustainability measures for the procurement receive higher scores.
- It avoids situations where no supplier can meet overly strict requirements or excessive workload.
- Scoring allows for better differentiation between suppliers compared to simple yes/no criteria.
- A more comprehensive approach to sustainability encourages suppliers to adopt broader sustainability practices.
- A flexible approach promotes innovation in sustainability initiatives.

9.1 General Sustainability of Suppliers

During a procurement process, suppliers should be required to provide a report on their sustainability efforts, both in general and specifically regarding green IT. The more detailed the report, the better it reveals the supplier's stance on sustainability, its current state, and future plans. However, writing, reviewing, and evaluating detailed reports can be time-consuming for all parties.

Whenever possible, sustainability-related questions should be formatted to allow yes/no answers, predefined options, or scalable responses. This simplifies proposal comparison and ensures a clear scoring process that suppliers cannot easily dispute.

Beyond the scored answers, it is essential to investigate how sustainability measures are actually implemented. Specific details should be prioritized over generic statements like "we care about nature" or "we are a sustainable company." The depth of details and the comprehensiveness of sustainability integration indicate the company's true level of understanding. If the procurement department lacks sufficient experience in assessing the level of responsibility, it is advisable to seek help from experts.

In addition to sustainability documentation, practical implementation should be assessed. Examples of sustainability actions or reference descriptions with contact details should be requested.

In long-term collaboration projects or partnerships, it is advisable to request the assessment and report again at regular intervals, for example annually or every couple of years.

Standards and certifications also provide good ways to ensure supplier sustainability. For example, ISO offers a comprehensive set of standards related to sustainability[111]. When it comes to standards and certifications, it is important to consider the possibility of providing equivalent information without committing to a standard, as such commitment may limit smaller organizations' ability to offer their solutions or services.

[111] Sustainability standards from ISO, iso26000.info/sustainability-standards-from-iso/

9.1.1 Environmental and Energy Management Systems

If a supplier has external certifications or other evidence of compliance with environmental or energy management systems, this reduces the workload for both parties. In such cases, an external authority has already assessed the supplier.

However, it is essential to understand what commitment to a given system or certification entails and how it is verified. It is also important to determine whether the certification criteria are relevant to your organization's operations.

To ensure fairness, suppliers should be allowed to participate in the bidding process even if they lack a specific certification. Instead, key elements of the certification should be extracted, and suppliers should be given the option to respond to related questions as an alternative. This approach ensures that smaller and newer companies also have a chance to participate.

9.1.2 Sustainability Reporting and Commitments

Sustainability reporting and communication allow companies to share information transparently about their social responsibility and environmental impact. These reports also demonstrate a company's commitment to sustainable practices.

Through sustainability reporting, businesses document their environmental, social, and economic impacts, supporting their sustainability work and enabling continuous improvement. Additionally, reports provide valuable information to stakeholders, including customers, employees, investors, and the broader community. Using standardized reporting frameworks enhances comparability within an industry.

Sustainability reporting helps companies identify and manage risks related to sustainability, such as environmental impacts, social responsibility, and governance. It also serves as a tool for developing and monitoring sustainable business practices.

Sustainability reporting should be integrated into broader business reporting, such as financial statements, to support comprehensive corporate management and decision-making.

In addition to sustainability reports, companies can also publish sustainability commitments, where they outline key sustainability themes and potentially set timelines for achieving sustainability goals.

External Sustainability Commitments

Beyond their own commitments, companies can also join third-party sustainability initiatives. These initiatives provide structured frameworks and predefined goals or metrics that can help guide sustainability efforts.

One example is the UN Global Compact[112], a United Nations initiative and the world's largest corporate sustainability network, with over 20,000 companies and nearly 4,000 other organizations across more than 160 countries. Over 1,700 companies from the Nordic region have already joined. Participants commit to promoting ten principles of corporate sustainability and advancing the UN's Sustainable Development Goals (SDGs), forming a global sustainability framework.

Launched in 2000, the UN Global Compact aims to accelerate corporate action in support of sustainable development and achieving the SDGs.

The initiative addresses key sustainability challenges and offers solutions, with a particular focus on urgent issues such as human rights, gender equality, labor rights, decent work, climate change, anti-corruption efforts, and integrating sustainable development into business strategies.

Using Sustainability Reports and Commitments in Procurement

A company's sustainability reports and commitments provide valuable insight into the ambition and feasibility of its sustainability efforts. These documents should be requested as part of the procurement process, while also allowing companies to provide equivalent information without pre-existing reports.

It is important to recognize that these reports are often broad and may only briefly address IT-related aspects. Therefore, procurement decisions should not be based solely on these documents. However, their existence is a positive indicator, suggesting that the company has taken the time to thoroughly assess and consider sustainability.

[112] unglobalcompact.org/about

To ensure comparable proposals, suppliers should be asked to answer specific questions when submitting their sustainability documents and to reference relevant sections in their reports where applicable.

9.1.3 Carbon Footprint Calculation

Several different methods exist for calculating carbon footprints[113], with the Greenhouse Gas Protocol (GHG)[114] being the most commonly used. In addition to the calculation method, adherence to certain frameworks can impact the results. For instance, the Science Based Targets initiative (SBTi)[115] requires companies to meet their emissions reduction targets without relying on carbon offsetting. This means that offsets must be excluded when assessing a company's actual carbon footprint.

If a supplier has calculated its carbon footprint using a widely accepted method, the results can generally be considered sufficiently accurate. It should be noted that carbon footprint calculations in general involve significant uncertainties and variations, even within the same methodology.

Key considerations include knowing the boundaries, assumptions and data sources used in the calculation, as well as ensuring that estimates and formulas are based on the most accurate information available.

For customers, it is essential to understand their share of a supplier's carbon footprint. This can be calculated based on revenue proportions, hours worked for the customer, or other relevant data that distinguishes the customer's impact from the supplier's overall operations.

Online Carbon Footprint Calculators

There are many online carbon footprint calculators designed for various purposes, but they should be used with caution. Some calculators are intended to promote the services of the companies providing them, while others may be overly simplistic or alarmist.

For example, the commonly used *websitecarbon.com* has several issues: It bases calculations solely on data transfer volume, uses outdated global average energy

---

[113] Carbon Accounting, en.wikipedia.org/wiki/Carbon_accounting

[114] GHG Protocol, ghgprotocol.org/

[115] Science Based Targets Initiative, en.wikipedia.org/wiki/Science_Based_Targets_initiative

carbon intensity figures and cannot process JavaScript, which can lead to significant inaccuracies for modern websites. It can be used for educational purposes, but using it to assess carbon emissions of a website cannot be recommended.

In general, the simpler the calculation model, the less accurate the results. Carbon footprint calculations remain complex, and shortcuts often rely on averages and broad category groupings.

9.2 Device Procurement

20–50% of a device's total lifecycle carbon emissions occur during manufacturing[116], as shown in the table below. Therefore, procurement guidelines should promote purchasing devices that are produced as sustainably as possible. Whenever feasible, the purchase of new devices should be reduced or delayed by extending the lifespan of existing devices or acquiring used ones.

Emissions	Data Center Equipment	Network Equipment	User Devices
Operational	82%	82%	49%
Embedded	18%	18%	51%

9.2.1 Device Lifecycle and Carbon Footprint

Maximizing the lifecycle of devices is crucial in minimizing their carbon footprint. Approximately half of consumer device emissions originate from manufacturing, making each additional year of use significantly impactful.

To extend device lifespan, the following considerations should be prioritized:

- **Quality** – High-quality devices last longer, reducing downtime and maintenance needs.
- **Durability** – Robust devices withstand handling and extreme conditions better.

[116] J. Malmodin, N. Lövehagen, P. Bergmark, and D. Lundén, "ICT sector electricity consumption and greenhouse gas emissions – 2020 outcome," Telecomm. Policy, vol. 48, no. 3, p. 102701, Apr. 2024, doi: 10.1016/j.telpol.2023.102701.

- **Modularity** – Easily replaceable or upgradable components extend usability, though this can sometimes challenge durability.
- **Repairability** – Devices should be serviceable at a reasonable cost while maintaining their original functionality.
- **Spare Parts Availability** – Access to spare parts is critical, especially for long-term maintenance.
- **Long-term Support & Maintenance** – Availability of service and support beyond the warranty period should be ensured.
- **Swap-Repair Service** – The ability to exchange faulty devices for refurbished ones minimizes downtime.
- **Extended Warranties** – Warranties longer than three years indicate a well-built and sustainable device.
- **Standardized USB-C Charging** – Ensures compatibility, reduces electronic waste, and eliminates the need for unnecessary cables and chargers.

Devices should also have relevant environmental certifications, such as *TCO Certified*, *EPEAT*, *Blue Angel*, or *Energy Star*. The criteria for these certifications should be reviewed to assess their alignment with sustainability goals.

Device Emission Calculation

Device emissions are categorized into two types: embedded emissions and operational emissions. Emission calculations for devices—and other physical products—should always follow a cradle-to-grave approach, covering the entire lifecycle from manufacturing to disposal, unless there is a justified reason for a narrower scope.

Embedded Emissions

Embedded emissions refer to the emissions generated from raw material extraction, device manufacturing, logistics, and disposal.

Most device manufacturers provide detailed reports on embedded emissions, often broken down by lifecycle stages. These reports may also include estimates for operational emissions, but such estimates can be misleading when applied to local conditions due to the location's higher or lower electricity carbon intensity compared to the global average.

Proper disposal of devices can reduce their calculated emissions, but this requires correct recycling to ensure raw materials are reused efficiently.

Operational Emissions

Operational emissions for digital devices primarily stem from the electricity consumed during use. In data centers, cooling systems and water consumption also contribute to these emissions.

Operational emissions vary significantly depending on the device’s purpose. Devices that remain powered on continuously and operate under high load generally consume far more energy than similar devices used intermittently. Battery-powered devices can often reduce energy consumption when usage decreases, whereas the energy efficiency of mains-powered devices varies and should be assessed at the time of purchase.

In addition to energy consumption, operational emissions are influenced by the carbon intensity of the electricity used, meaning the amount of CO_2 emissions produced per kilowatt-hour of energy. This varies by location and time of use. While Nordic countries typically offer cleaner energy, emissions differ significantly in other regions.

The most accurate way to assess operational emissions is to calculate them based on real-time electricity consumption if live carbon intensity data is available. However, for most cases, using daily, monthly, or annual consumption data along with the average carbon intensity for the same period is sufficient. For greater accuracy, it is advisable to obtain carbon intensity data from the specific electricity provider rather than relying on national averages, such as those provided by Our World in Data.

9.2.2 Device Reuse and Purchasing Used Equipment

The IT industry is still far from a circular economy, as devices are rarely designed for repair, and outdated hardware often collects dust in storage rather than being reused or recycled.

In addition to device procurement, it is also important to consider device decommissioning and potential reuse. The industry's best providers offer devices with a lifespan of up to 12 years across three users while also reducing the use of low-cost devices—whose lifespan falls far short of 12 years—in sectors where acquiring expensive equipment is not an option. To achieve this lifespan, the device is serviced twice during its lifecycle.

Acquiring used devices, both for individual users and service operations, should be seriously considered. Many hardware components, such as network switches, experience minimal wear over time and remain suitable for professional use. For example, several Finnish online retailers now offer affordable used smartphones and laptops with a one-year warranty.

Advantages of purchasing used devices:

- Cost savings
- Lower carbon footprint
- Reduced electronic waste
- Conservation of natural resources (including minerals and fossil fuels, reducing risks of human rights violations in mining operations)

When purchasing used devices, the following criteria should be used to ensure their quality and suitability. The same criteria also apply when offering devices for reuse, as not every device has a viable future, and attempting to reuse unsuitable devices in businesses can result in unnecessary time and effort.

- **Data Security** – All stored data must be securely erased and documented.
- **Software & Updates** – Devices must still support firmware and OS updates, and be compatible with required applications.
- **Warranty** – It is advisable to request a warranty for the device; for example, a used laptop should come with a 2–3 year warranty.
- **Clean and Intact Condition** – The device must not be dirty, and it should not have dents or scratches that could interfere with its use or disturb the user. In this regard, covering devices with stickers can be problematic, as they may not be removable. On the other hand, stickers can also be used to cover scratches.

- **Testing** – Devices should be tested to confirm proper functionality and no diagnostic errors.
- **Battery Health** – Battery cycles, charge retention, and discharge rates should be evaluated. Devices should also support battery replacements if needed.
- **Take-Back Policy** – The vendor should offer a return or buyback program, with transparency on how devices are repurposed after their initial reuse cycle.

9.2.3 Device Management

To effectively implement the aforementioned practices, devices must be properly managed and cataloged:

- The location and user of each device should be known.
- Clear guidelines and rules must be in place for device usage, upgrades, and disposal.
- Data collected on devices and their usage should be leveraged for decision-making—this becomes increasingly important as a company grows.
- Device management should be continuously developed, monitored, and evaluated to ensure ongoing improvements.

9.3 Software Requirements

Energy consumption and emissions should be incorporated into software requirements in the same way that security and data protection have been integrated in recent years. This ensures that these aspects are considered from the initial design phase and that appropriate tests and metrics can be developed to monitor them.

However, requirements should remain reasonable to avoid unnecessary complexity. The challenge is further complicated by fragmented or missing data. Additionally, experience with energy-saving digital solutions is still limited—except in energy-intensive fields (such as data centers) or those dealing with minimal energy consumption (such as embedded systems).

A culture of experimentation can be applied when drafting requirements, fostering active dialogue with suppliers. This allows for an initial, practical baseline to be established, which can then be improved year after year.

9.3.1 Implementation

Software can be acquired as an off-the-shelf product, a customizable solution, based on open source, or developed from scratch. Each approach has its advantages, but their differences are not discussed in detail in this guide.

From a sustainability and responsibility perspective, certain key factors should be included in software requirements.

Compatibility with Older Devices

Premature or planned obsolescence creates pressure for users to upgrade their devices, leading to increased embedded emissions from new device manufacturing.

Research[117] on mobile devices has identified several reasons for upgrades, including: lack of storage space, issues with updating the device—leading to security vulnerabilities, increased errors and performance issues in devices and software, decreased availability of applications for older devices, missing features, and social factors, such as envy of newer device owners or difficulties in work and social life due to outdated technology.

Some of these issues can be addressed through technical solutions. For example, software providers can choose to support older devices. While newer devices may introduce additional features, should the absence of these features prevent the software from functioning on older devices?

In some cases, obsolescence happens unintentionally. If a new version of a software library no longer supports older devices, the software may stop working for some users when that library is adopted—whether for security reasons or general improvements. Since developers typically use newer devices, they may not notice the issue until customers report it.

117 Léa Mosesso, Nolwenn Maudet, Edlira Nano, Thomas Thibault, Aurélien Tabard. Obsolescence Paths: living with aging devices. ICT4S 2023 - International Conference on Information and Communications Technology for Sustainability, Jun 2023, Rennes, France. DOI: ff10.1109/ICT4S58814.2023.00011

To manage support for older devices, companies should define a policy that addresses the following questions:

- How old can supported devices be? Note that when it comes to web services, browser support is more essential information than the devices themselves.
- How much investment is allocated to supporting older devices? How much testing is done to ensure that older devices and browsers are supported?
- How should situations be handled where a lack of manufacturer support creates security risks that affect the software or company operations? Who bears the responsibility for the possible consequences of the decision?
- Who decides when to discontinue support for older devices, and how is this decision documented?
- Who is responsible for monitoring the hardware compatibility of software libraries and components? How should conflicts arising from incompatibilities be resolved?
- How is testing for older devices organized?
- How is the list of supported devices maintained, and how is the removal of support communicated to users?

E-waste

Electronic waste, or waste from digital devices, is one of the fastest-growing waste categories in the world – its growth rate is five times faster than the growth of its recycling rate[118]. In 2023, only 22.3% of electronic waste was recycled in an environmentally responsible manner[119]. This figure is expected to decrease fur-

[118] The Global E-waste Monitor 2024, ewastemonitor.info/wp-content/uploads/2024/12/GEM_2024_EN_11_NOV-web.pdf

[119] Joanna Murzyn, Branch Magazine, Echoes of electronic waste, branch.climateaction.tech/issues/issue-8/echoes-of-electronic-waste

ther, with projections showing only 20% recycling by 2030, largely due to the high production volumes of digital devices[120].

It is extremely responsible to extend the lifespan of devices and encourage staff to use them for significantly longer periods than they currently do.

9.3.2 Hosting, Data Centers, and Cloud

Software still requires hardware to function, and it can be obtained in several different ways. The key consideration is, of course, that the hardware is suitable for the software's operation and usage. In this context, it's also important to highlight environmental and energy issues. For example, containerization[121] and virtual machines[122] create additional layers that consume some power, but, on the other hand, offer opportunities to share a physical device among multiple software systems or facilitate the transfer or distribution of services between servers.

When choosing data centers and cloud services, there are several factors that should be considered:

- The renewability of the electricity used and the overall carbon intensity.
- Utilization of waste heat.
- The efficiency of the data center (PUE value).
- Water usage and circulation in the data center.
- Lifecycle emissions of devices and optimization of the lifespan.
- Possible environmental certifications.

Not all of this information is typically available, at least not directly and easily. Information about cloud services may not be available, or it may cover a wider geographic area.

[120] The global E-waste Monitor 2024 – Electronic Waste Rising Five Times Faster than Documented E-waste Recycling, ewastemonitor.info/the-global-e-waste-monitor-2024

[121] en.wikipedia.org/wiki/Containerization_(computing)

[122] en.wikipedia.org/wiki/Virtual_machine

It's also worth noting that just using renewable energy is not sufficient; energy should be saved wherever possible. Global energy consumption is still growing faster than the production of renewable energy sources.

EU Regulation

The EU has started increasing regulation of data centers in response to their growing energy consumption and the need to reduce their economic, environmental, and energy security impacts. The aim is to guide and encourage data center operators and owners to reduce energy consumption cost-effectively without compromising the critical functions of data centers.

The EU taxonomy is a classification system created to identify and promote environmentally sustainable economic activities. Its goal is to increase transparency and direct capital towards investments that support sustainability.

For data centers, the taxonomy includes criteria in *Activity 8.1: Data processing, hosting, and related activities*[123], with an emphasis on sustainability and energy efficiency.

For data centers, the criteria include:

- **Adoption of relevant practices**: Data centers must adopt the practices defined in the European Code of Conduct for Energy Efficiency in Data Centres. This implementation must be validated by an independent third-party auditor at least every three years.
- **Operational sustainability KPIs**: Data centers must establish systems and procedures to measure, record, and report data on operational sustainability-related information and key performance indicators (KPIs). These systems will allow the data center to effectively monitor its sustainability performance.
- **Avoiding significant harm to other environmental goals**: It must be ensured that the operation of the data center does not harm, for example, water usage, pollution prevention, biodiversity protection, or circular economy practices.

[123] Assessment Framework for Data Centres in the Context of Activity, e3p.jrc.ec.europa.eu/sites/default/files/documents/publications/jrc_assessment_framework_final_v2.pdf

The Data Centres Energy Efficiency Code of Conduct[124] aims to achieve the EU's goals by improving understanding of data center energy consumption, raising awareness, and recommending energy-efficient best practices and objectives.

The Code of Conduct (CoC) is a framework for identifying data center development opportunities and a collection of best practices. It is not intended nor developed for auditing purposes, and there is no certification opportunity associated with it. It aims to bring interested stakeholders together and coordinate actions among device manufacturers, suppliers, consultants, and energy companies. Parties committed to the rules are expected to adhere to its principles and fulfill agreed-upon commitments.

The EU Energy Efficiency Directive[125] (EED) requires data centers to actively monitor and report their energy consumption and emissions to ensure alignment with the EU's sustainability goals. The latest updates to the directive include a binding target to reduce the EU's final energy consumption by 11.7% by 2030. Additionally, the directive sets incremental annual energy savings targets: currently 0.8%, 1.3% for 2024–2025, 1.5% for 2026–2027, and 1.9% from 2028 onwards. The directive emphasizes the implementation of energy management systems and systematic energy audits.

Starting from May 15, 2024, EU data center owners and operators are required to report their annual energy efficiency to a Europe-wide database. Additionally, the Draft Delegated Act (DDA) introduces a public consultation on a common energy efficiency classification system for EU and EEA data centers. The DDA defines the key energy use and sustainability indicators (KPIs) to be reported, and the col-lected data will be published publicly.

Key Provisions of the EED for Data Centers:

- **Mandatory Reporting**: Data center operators with a total capacity of at least 500 kilowatts (kW) must publicly report their energy efficiency data annually. The report includes energy consumption, Power Usage Effectiveness (PUE) ratio, temperature settings, waste heat utilization, water consumption, and renewable energy usage.

[124] Data Centres Code of Conduct, e3p.jrc.ec.europa.eu/communities/data-centres-code-conduct

[125] Energy Efficiency Directive, energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en

- **Utilization of Waste Heat**: Data centers with a total capacity exceeding 1 megawatt (MW) must utilize their waste heat for heating or other energy recovery, unless it is technically or economically unfeasible. This promotes circular economy practices and reduces reliance on fossil fuels.

- **Use of Renewable Energy**: Data centers are primarily encouraged to use renewable energy sources for their electricity needs, which reduces their carbon footprint and supports sustainable energy production.

- **Optimization of Energy Consumption**: Data centers must implement measures to improve energy efficiency, such as optimizing cooling systems, using more energy-efficient equipment, and adopting virtualization and server consolidation technologies.

From the buyer's perspective, the above regulations set a minimum standard for data centers operating in the European region. This level is already quite high, but it is always worthwhile to encourage your suppliers to aim for even better performance.

Conversely, data centers located outside the EU are not subject to these regulations. In such cases, ensuring energy efficiency largely falls on the customer. However, major data center operators often have facilities worldwide, and for them, reducing energy consumption directly cuts costs.

9.3.3 Data Usage – Storage and Transfer

Data usage is increasing year by year, and a significant portion of data is stored even if it will never be used again. The challenge lies in identifying which data will be needed in the future—hence, it is often easier just to keep everything.

Storing data is generally cheaper than cleaning and destroying it. However, it is worth considering the data lifecycle already in the design phase and identifying points at which data becomes obsolete and can be safely deleted. This deletion should be automated, as relying on people to remember to delete data is not effective.

It is important to note that data volumes can easily multiply. Multiple copies of data are often stored in cloud services to ensure availability or minimize latency. In addition, data backups are created, and data is copied for purposes such as test environments. As a result, deleting data has a cumulative effect.

The GDPR restricts the processing of personally identifiable information, and its fundamental principles should also serve as a guideline for handling data that falls outside the regulation's scope.

Considering data transfer, it is worth noting that a significant portion of the energy consumption of data transfer networks is not elastic. In other words, a network consumes the same or nearly the same amount of energy whether it is transmitting data at full capacity or not at all. The main exception to this is wireless networks, which consume less energy when there is no data to transmit.

Reading, preparing, sending, processing, displaying, and storing transferred data all consume energy on both the sending and receiving devices. Additionally, as data transfer volumes grow, network capacity must be expanded, leading to emissions from both manufacturing and usage.

Recommendations

- Collect only the data you truly need and that provides business value.
- Consider whether it is necessary to store data immediately for future needs or if it is acceptable to wait for new data to accumulate.
- Prefer derived data over raw data when possible.
- Delete unused data, archive it, or convert it into time series data. The latter allows to make trend analysis based on data that is sparse.
- Transfer data only when necessary.
- Comply with GDPR regulations.

9.3.4 Artificial Intelligence (AI)

AI has become one of the biggest energy consumers in the IT industry. Its use is expected to grow rapidly, and currently, energy consumption has been increasing in parallel with usage. In the future, more energy-efficient AI models will likely be developed, and as AI becomes cheaper to use, there will be greater scrutiny of its energy consumption.

At present, energy consumption is not a major concern because AI is relatively new, and its benefits far outweigh the costs. However, from a sustainability perspective, AI's energy consumption and emissions should be addressed now—

buyer pressure to reduce consumption will also drive the development of more energy-efficient AI solutions.

Currently, reliable data on AI energy consumption is scarce, but academic research is underway. Future EU regulations for data centers may require cloud providers to disclose their energy consumption. Until then, decisions must be made with incomplete information.

Reducing AI Energy Consumption

AI's energy consumption and emissions can be reduced through the following measures:

- Select AI use cases carefully—only use AI where necessary.
- Use a task-specific model instead of a general model whenever possible. Keep in mind that, in addition to the model itself, the execution environment also affects energy consumption. For example, a general model running in the cloud may be more efficient than a task-specific model executed locally.
- Optimize AI prompts carefully—avoid including unnecessary data.
- Compare energy usage between models when information is available.
- Train AI models in low-carbon data centers, preferably when overall electricity demand is lower or when renewable energy production exceeds normal consumption levels.

9.3.5 Accessibility

Accessibility refers to the usability of a digital service and its content, regardless of the user's personal characteristics or method of use. The digitalization of services and their development with accessibility in mind present an unprecedented opportunity to make information more easily available to everyone[126].

In digital services, accessibility consists of three key aspects: technical implementation, visual interface, and content. For software to be truly accessible, all these aspects must be considered not only at the time of release but throughout the en-

[126] Exove, Guide to the Accessibility of Digital Services (available only in Finnish), exove.com/fi/saavutettavuusopas

tire lifecycle of the digital service. In other words, accessibility must be continuously maintained by monitoring content quality, ensuring that accessibility considerations are included in both small and large development projects, and possibly training content creators and editors. This ensures that the achieved level of accessibility remains as intended.

Accessibility is often discussed in connection with specific user groups, but in reality, an accessible and user-friendly service benefits all users in different usage situations.

Guidelines to Follow

Digital accessibility is generally assessed based on the Web Content Accessibility Guidelines (WCAG)[127] recommendations. At the time of writing this guide, the recommendation is at version 2.2, which was published in December 2024.

The WCAG guidelines are based on four principles: perceivable, operable, understandable, and robust. These guidelines are brief and directive, without specifying how implementation should be carried out. WCAG guidelines are further broken down into detailed success criteria[128]:

- **Perceivable**: Ensuring that service content and user interfaces are perceivable in necessary formats, regardless of any limitations.
- **Operable**: Users must be able to operate the interface, in other words the interface cannot require interaction that a user cannot perform.
- **Understandable**: Content, functionalities, and services should be understandable, predictable, and error-tolerant.
- **Robust**: The service must be as compatible as possible with current and future user applications, including assistive technologies.

Implementing Accessibility

The approach to implementing accessibility depends on whether the software is newly developed or already existing. If working with an existing software, it is advisable to start with an accessibility audit conducted by an expert.

[127] Web Content Accessibility Guidelines (WCAG) 2.2, w3.org/TR/WCAG22

[128] Exove, Guide to E-Commerce Accessibility (available only in Finnish), exove.com/fi/verkkokaupansaavutettavuusopas

An audit tests the software's accessibility using various tools to provide a comprehensive overview of its current state. As a result of the evaluation, the client receives a report outlining areas for improvement, potential challenges, and clear recommendations for enhancement. After implementing the necessary changes, the client can create an accessibility statement based on the report and corrections.

When acquiring new software, it is crucial to include accessibility requirements in the procurement and specification phases. These goals should remain in focus throughout the project, guiding planning and implementation.

Additionally, before releasing the software, an accessibility audit should be conducted to ensure compliance with requirements and keep the accessibility statement up to date. Accessibility levels typically deteriorate over time, so regular training and periodic checks using appropriate tools help maintain accessibility.

Besides accessibility, it is also essential to ensure general usability. While accessibility and usability often go hand in hand, the best way to verify usability is through real-user testing.

It's important to understand that accessibility is not a one-time project that starts and ends—it requires ongoing maintenance even after the initial development phase. When new content or elements are added to a service, accessibility must be considered continuously. Maintaining accessibility often requires training for content creators and administrators.

This guide does not go into detail about the implementation of accessibility.

Accessibility Directive

For some organizations, accessibility is a legal requirement due to the EU Web Accessibility Directive[129], while for others, it presents an excellent opportunity to create more user-friendly, understandable, and error-reducing digital solutions.

The directive has been converted into local accessibility laws in the EU countries. These laws have differences in their exact requirements, but in general they should mandate accessibility compliance for all public authorities, including state organizations and enterprises, municipal organizations and enterprises, schools, public-law associations and institutions, universities, and universities of applied

[129] Accessibility of public sector websites and mobile apps, summary, eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:4314916

sciences. Additionally, the laws apply to companies that perform public statutory or administrative tasks, such as vehicle inspection offices, insurance companies, energy and water utilities, and banks.

Indirectly, the directive also affects companies that provide, supply, or develop digital services for public administration entities or the sectors mentioned above. These service providers should take accessibility requirements into account when offering their services.

All public sector entities and private sector organizations covered by the local laws must comply with accessibility requirements within the legally defined timeframe. Compliance is monitored by the local authority, for example in Finland, the Regional State Administrative Agency of Southern Finland. These organisations have the authority to impose penalty fines to enforce accessibility requirements.

Currently, the directive refers to WCAG 2.1, although the latest published version is WCAG 2.2. While WCAG 2.2 is not yet required, the regulatory authorities recommend adopting the latest available version to prepare for future legal updates.

The directive requires that every service subject to the regulation publishes an accessibility statement[130], describing the current state of accessibility on the website. This statement must outline any accessibility deficiencies and provide instructions for users on how to give feedback regarding accessibility.

In EU countries, local laws on the accessibility of digital services–based on the EU directive–are extending to e-commerce, requiring that all users, regardless of their abilities, have equal opportunities to use online stores. E-commerce businesses will be required to comply with the WCAG accessibility standard at the AA level, publish an accessibility statement, and provide any relevant accessibility information related to the products or services they sell.

Additionally, as an extra requirement, online stores must provide information about the accessibility and usability of the products and services they sell if the responsible economic operator, such as the manufacturer or importer, has provided such information. However, this does not impose an obligation on the service provider to request or inquire about such information, although it is recommended.

[130] An example accessibility statement can be found at
gov.uk/government/publications/sample-accessibility-statement

9.4 Purchasing IT Services

A large portion of companies and other organizations have outsourced the production of IT services to a partner. Most likely, these outsourcing agreements do not significantly address responsibility or energy efficiency. If the partner, in addition to their own services, procures equipment or services on behalf of the client, this shortcoming accumulates.

It is recommended to include dedicated sections on sustainability and energy efficiency in IT service agreements with partners. When acting on behalf of the client, they should ensure energy efficiency and be aware of the energy consumption and emissions of all services and devices acquired through them, including carbon intensity if necessary—since this facilitates the assessment of different services' emission factors.

Key indicators of sustainability and efficiency should be identified and monitored with the partner at least annually, or more frequently for larger companies. Goals should be set for the development of these indicators, in collaboration with the supplier—everything cannot be left solely to the supplier, as the way the client's staff uses the services also affects energy consumption.

If possible, incentives or penalties should be linked to these indicators—preferably rewards for good performance and improvement, with penalties reserved only for significant failures or negligence. This approach keeps sustainability improvements positive for the partner as well.

9.5 Purchasing Software Development

A considerable amount of software development is outsourced to subcontractors. The most common models include hiring individual consultants or teams under client supervision or procuring turnkey solutions at either a target-based or fixed price.

The more responsibility the buyer assumes for managing subcontractors, the greater their role in ensuring energy efficiency in projects. If the work is distributed among multiple suppliers, dedicated processes for energy efficiency should be established for these projects. It is also beneficial to explore suppliers' existing practices and adopt proven effective methods.

At a general level, it is advisable to require that suppliers' staff be trained at least in the fundamentals of green coding and possess deeper expertise within their own organization—making this expertise available to the client when needed.

Similarly, if the client's organization is being trained or supported in green coding, these training sessions or support measures should also be extended to subcontractors involved in projects.

9.5.1 Design Services

The energy consumption, emissions, and overall sustainability of digital solutions and systems are significantly influenced by service design and concept planning. Thoughtful design can minimize emissions, while poor planning may constrain software developers even before implementation begins. It is therefore essential to address energy consumption considerations right from the design phase.

Energy consumption is impacted by the overall concept chosen, the selection and detailed design of available features, the complexity of the user interface, error tolerance, and accessibility. Front-end performance, in particular, may be overlooked, as it imposes no direct costs on the service provider and is distributed across millions of end-user devices.

Sustainable user experience (UX) and interface design can be promoted through the following means[131]:

- **Reducing waste** – This includes avoiding unnecessary or overly resource-intensive content such as large PDFs, images, animations, and videos.
- **Removing outdated or misleading content** – Content should be actively removed or unpublished when no longer relevant.
- **Maximizing reusability** – Applies to all aspects of design, from UI components and design processes to models and content production.

[131] Vitaly Friedman, Sustainable Design Patterns For UX Designers, linkedin.com/pulse/sustainable-design-patterns-ux-designers-vitaly-friedman-iiihe/

- **Helping users make more sustainable choices** – Providing sustainable default settings and options[132] while minimizing the time needed for critical tasks and key user flows.

Sustainable Web Design[133] offers 94 design guidelines and strategic recommendations to help designers create more sustainable digital products and services. The catalog is categorized and tagged for easy access to relevant information.

The Decarbonisation Management System[134] is a framework for planning, monitoring, and managing the implementation of Sustainable Web Design principles. Similarly, The Sustainable UX Network has compiled a comprehensive set of sustainability-related solutions into a single document[135].

IBM Design for Sustainability[136] guide includes a useful sustainability checklist, which can also serve as a procurement requirement.

When procuring design services, it is crucial to verify the supplier's expertise and willingness to design energy-efficient services. Beyond general assurances, suppliers should be asked to explain how these considerations are integrated into their work, as well as the tools, methods, or frameworks they use.

9.5.2 Programming Services

The programming phase of applications and systems ultimately determines the durability and responsibility of the final solution. Earlier stages serve as inputs for programming, while later stages ensure the quality of the final product before it is deployed into production.

[132] Artiom Dashinsky, Product Design for Sustainability, uxdesign.cc/product-design-for-sustainability-3fffbb2a7f0e

[133] Sustainable Web Design, sustainablewebdesign.org/

[134] James Chudley, Decarbonisation Management System (v1.0), axiomatic-block-3be.notion.site/Decarbonisation-Management-System-v1-0-15e0e84c56b28062bccafb7528b600ea

[135] SUX Network - Resource Collection, suxnetwork.notion.site/SUX-Network-Resource-Collection-36fe841f898b4fe9a8f37b66368852c49

[136] IBM Design for Sustainability, ibm.com/design/practices/design-for-sustainability/design-for-sustainability-positionpaper.pdf

There are no clear-cut, universally applicable guidelines that guarantee energy-efficient or sustainable software. Software usage needs and environments vary significantly, requiring different approaches. This guide has previously outlined ways to mitigate or reduce software energy consumption. However, translating these into procurement criteria is not always straightforward.

Using ready-made software or components, such as open-source frameworks and libraries, reduces the need to implement everything from scratch. These components are typically tested by numerous people, which often results in fewer issues and better performance — though this is not guaranteed.

AI-based programming, also known as vibe coding[137], has increasingly been practiced since the beginning of 2025. With the help of AI, a programmer's efficiency increases significantly, but unfortunately, the energy efficiency of the produced solutions has not yet been determined. Considering that AIs use source code found online as their training material, the energy efficiency of the end result is likely to reflect that of the source material—which is, in all likelihood, quite mixed.

Motiva's maintained Criteria Bank[138] includes some criteria for software developed within the Green ICT MitViDi project[139], with more to be added over time. These criteria are worth reviewing to select those relevant to specific use cases.

However, it's important to note that without programming expertise, one might end up using inappropriate or even harmful requirements to determine software efficiency. For example, requiring software to have a sleep capability is not always appropriate for all architectures or environments. In microservices architecture, for instance, software does not consume energy when no requests are made to it, but it is also not technically "asleep." Therefore, consulting programming experts when selecting and scoring criteria is recommended.

For web services, the Web Sustainability Guidelines[140] provide a comprehensive set of recommendations and energy-efficient approaches for common web ser-

[137] Vibe coding, en.wikipedia.org/wiki/Vibe_coding

[138] Motiva Kriteeripankki, kriteeripankki.fi/en

[139] Green Metrics for Public Digitalization Acquisitions - MitViDi, tieke.fi/en/projects/green-metrics-for-public-digitalization-acquisitions-mitvidi/

[140] Web Sustainability Guidelines, w3c.github.io/sustainableweb-wsg/

vice needs. While still a draft at the time of writing, its content is already available and can be used to derive procurement criteria for web services.

However, some criteria are highly specific, and applying them without careful consideration may unnecessarily complicate procurement without significantly improving sustainability.

9.5.3 Testing Services

The testing phase is crucial to ensuring that the designed and implemented solution meets system requirements. If the requirement list includes criteria related to energy efficiency or device compatibility, these should also be reflected in test cases. Test plans and cases should be carefully reviewed to ensure the system is tested against established responsibility requirements.

Beyond test documentation, monitoring test execution is also important. It may be necessary to request access to test run logs, which provide insights into execution instances, pass rates, or failures.

Code quality has its own impact on energy consumption, and it is advisable to use linters[141] and similar tools to ensure that the code adheres to coding standards and best practices.

Testing energy efficiency is similar to load testing, as both assess system performance and load capacity. When selecting vendors, it's advisable to verify whether they have expertise in load testing if they lack direct experience in energy consumption testing.

To prevent user errors, usability and accessibility testing is essential. Various tools can mechanically identify accessibility issues in web pages or applications, catching most common errors and significantly speeding up testing. However, tool usage alone is not sufficient; expertise in accessibility and usability testing is also required.

If accessibility for assistive technologies such as screen readers or keyboard navigation is a goal, testing must be conducted with these tools—ideally with people who use the tools in their daily lifes. Even minor design or implementation issues can create significant obstacles for assistive technology users.

[141] wikipedia.org/wiki/Lint_(software)

Test Environments and Continuous Integration Solutions

Energy consumption of a testing solution implementation also includes the energy used by test environments and CI/CD (Continuous Integration / Continuous Delivery) systems. If changes are made frequently in version control, the CI/CD system runs accordingly, often testing on a broader scale than necessary.

Modern test and CI/CD systems can prioritize tests based on past errors, but test energy consumption cannot directly dictate test order. However, test intensity can be estimated by execution times, allowing tests to be scheduled so that heavier tests are run last (if previous tests pass) or only once daily instead of after every change.

It's also worth considering whether testing should stop after the first detected error or a certain number of errors, or if all tests should always be executed. The first approach saves energy, while the second reveals more issues at once, speeding up project progress.

When procuring testing services, it’s advisable to require energy-efficient CI/CD system design and request descriptions of implemented energy-saving solutions.

9.5.4 Deployment to Production

The deployment of software into production should be a well-planned and rehearsed process, preferably automated. This helps avoid errors when introducing a new version of the software into production.

Only a tested and approved version of the software should be deployed. This process must be clearly defined and consistently followed for all production deployments. Additionally, a separate emergency patching process may be in place to expedite the repair and restart of software that has crashed due to a critical issue.

If the software is installed on users' devices, each new production version requires users to update their software. This process is typically automatic when distributing software through app stores. However, frequent updates due to quality issues result in significant energy consumption, as users repeatedly download and install new versions. This can also negatively impact the user experience.

Of course, if a critical security vulnerability or severe issue is discovered, the software should be updated as soon as possible. Ideally, such problems would be detected in earlier phases, but no process can guarantee 100% success in preventing issues.

Summary

1 Responsible purchasing focuses on sustainability, energy consumption, and emissions. Vendors' responsibility should be scored during procurement, ensuring the selection of the best providers, fostering innovation, and encouraging broader sustainability practices.

2 When acquiring devices, preference should be given to long-lasting and environmentally certified options, as manufacturing contributes significantly to emissions. For data centers and cloud services, factors such as energy efficiency, renewable energy usage, and waste heat utilization should be considered.

3 The EU imposes energy efficiency requirements on data centers, including reporting obligations and savings targets. When outsourcing IT services, energy efficiency must be included in contracts, and sustainability should be monitored using key performance indicators.

4 Data storage and transfer should be minimized to avoid unnecessary energy consumption, and GDPR principles can be applied more broadly. AI energy consumption can be reduced by optimizing models, minimizing resource usage, and utilizing low-emission data centers.

5 Software design should incorporate energy efficiency from user interfaces to programming. Test environments' energy consumption should be minimized, and deployment to production should be optimized to prevent errors and reduce unnecessary energy use.

10 Examples of Procurement Criteria

This chapter presents examples of various procurement criteria that can be used to evaluate and score the energy efficiency and carbon neutrality of a supplier or delivery. The scoring examples provided are for reference, and the weighting of points as well as specific descriptions should be adjusted according to individual needs and values.

Not all criteria are suitable for every procurement. As previously mentioned, incorrect criteria can be detrimental to both buyers and suppliers. If the technical implementation of the purchased solution is not clearly defined, it is highly recommended to involve technical experts in drafting the criteria.

These criteria are freely available for use and modification. If you would like to add new criteria to the list, please contact us through the book's feedback form. Keep in mind that any newly added or modified criteria should also remain freely available for use and adaptation, just like the ones presented here.

Green Architecture and Software Development

The supplier's project personnel—designers, developers, and testers—are trained in writing green and energy-efficient code.	0	Not trained
	1	Trained once
	2	Included in the company onboarding with refresher training at least once a year

The supplier can present recent references for green code implementations.	0 No references 1 One reference 2 Two or more references
The supplier has experience in developing software that adjusts operations based on carbon intensity. *Note! This requirement can only be used when procuring software where adjustment based on carbon intensity is beneficial.*	0 No experience 1 Experience available
The supplier's conceptual/technical design process takes energy efficiency into account. *You can select either one or both design processes.*	0 Does not take into account 1 Takes into account at a basic level 2 Takes into account at a detailed level *The definitions of basic and detailed levels should be specified in the request for proposal, and they should align with the procurement task.*
The supplier can explain the impact of different implementation choices on energy efficiency.	0 Cannot explain 1 Can explain at a basic level 2 Can explain in detail – *to be defined in the request for proposal*

The supplier has experience with the impact of different architectures, programming languages, algorithms, components, libraries, installation package size, runtime environments, file sizes, and formats on energy consumption.	0 No experience 1 Basic experience 2 Extensive experience *The definitions of basic and extensive experience should be specified in the request for proposal, and they should align with the procurement task.*
The supplier has analyzed the energy consumption of the components, libraries, and systems they commonly use.	0 Not analyzed 1 Analyzed on a project basis 2 Analyzed at the company level
The supplier minimizes the amount of data stored by the delivered systems.	0 Does not minimize 1 Minimizes
The supplier optimizes internal and external data flows of the delivered systems.	0 Does not optimize 1 Optimizes
The supplier has a policy to prevent premature obsolescence of devices.	0 No policy 1 Policy applies to the supplier's own software development 2 Policy also applies to third-party software solutions used by the supplier

The supplier can ensure software functionality on older devices. *The supplier should be asked about possible limitations of this policy. If possible, the devices used should also be specified.*	0	Cannot ensure
	1	Supports devices up to five years old
	2	Supports devices up to ten years old
	3	Supports devices over ten years old
The energy consumption of AI used in the supplier's software development is minimized.	0	Not considered or not minimizable
	1	The supplier can provide a report on minimization, or AI is not used

Design

The supplier has guidelines for designing green and energy-efficient solutions.	0	No guidelines
	1	Guidelines focus only on design
	2	Guidelines are tightly integrated into the green application development process
The supplier's design guidelines minimize the energy consumption of the delivered solution.	0	Does not minimize
	1	Guidelines exist at a general level
	2	Guidelines are detailed and allow for assessment of energy consumption changes
The supplier has a process for evaluating the benefits and drawbacks of design features.	0	No process
	1	Process described at a basic level
	2	Process described in detail, including examples and/or calculation formulas

The supplier can present recent references for green design implementations.	0 1 2	No references One reference Two or more references
The supplier's design process reduces the number of user errors.	0 1	Does not reduce or not considered The process considers and actively minimizes user errors
The supplier's design process takes accessibility into account. *Note that the law applicable to your organization may require a certain level, and in terms of accessibility, the WCAG 2.1 or 2.2 AA level is considered the baseline.*	0 1 2	Does not take into account Takes into account at a basic level Takes into account in detail and complies with WCAG 2.2 AA standard
The supplier can present recent references for accessible software that meets WCAG requirements. *Select WCAG version (2.1 or 2.2) and level A, AA or AAA. Note that AAA level implementations are very rare.*	0 1 2	No references One reference Two or more references

Testing and Deployment

The supplier has experience in energy consumption testing.	0 1 2	No experience Experience from individual projects Experience from multiple projects

The supplier can measure the energy consumption of software as part of testing.	0	Cannot measure
	1	Can measure by arranging separately
	2	Can measure in every test cycle
The supplier's automated testing energy consumption is managed and minimized.	0	Energy consumption not considered
	1	Energy consumption considered at a basic level
	2	Energy consumption is a key principle in test design
The supplier has a defined deployment process.	0	No process
	1	Manual process
	2	Automated process
The supplier’s processes minimize the need for application updates for users, such as fixing discovered issues.	0	No process
	1	Simple process – for example, repeatable but not measurable
	2	Clear, consistent, and measurable process

Platform Services and Cloud

The energy consumption of platform services or cloud can be measured.	0	Energy consumption cannot be measured
	1	Energy consumption can be measured in some services
	2	Energy consumption can be measured in all services

The emissions of platform services or cloud can be measured.	0	Emissions cannot be measured.
	1	Emissions can be measured in some services or some scopes
	2	Emissions can be measured in all services and all scopes
Platform or cloud services are optimized to reduce energy consumption and emissions.	0	Not optimized
	1	Some services are optimized
	2	All services are optimized, and optimization is an ongoing process
Additionally, review energy usage requirements that may also apply to platform services.		

Artificial Intelligence (AI)

The supplier has a policy for energy-efficient use of AI.	0	No policy
	1	Energy consumption is considered at a basic level
	2	Energy consumption is a key design principle for AI usage
The supplier limits AI usage by considering its benefits and harms.	0	No limitations
	1	Basic limitations
	2	Detailed limitations applicable to multiple use cases
The supplier's AI selection and usage process considers energy consumption.	0	Does not consider
	1	Considered at a basic level
	2	Considered in detail, addressing both training and usage separately

Energy Usage		
The supplier uses renewable energy sources in its own operations.	0	Renewables are not used, or no information is available
	1	Renewables are used
The energy used by the supplier's cloud or managed services is renewable.	0	Renewables are not used, or no information is available
	1	Renewables are used
The carbon intensity of the used energy can be determined.	0	Carbon intensity cannot be determined
It is recommended that offsets are not included in carbon intensity calculations.	1	Carbon intensity can be determined
	2	Carbon intensity is reported regularly
	3	Carbon intensity is available in real time, with historical data accessible (note: not applicable in all cases)
The carbon intensity of the used energy is low.	0	Carbon intensity cannot be determined or exceeds the threshold
Offsets should not be considered in carbon intensity calculations.	1	Carbon intensity is below the annual regional average
	2	Carbon intensity is below half of the annual regional average
	3	Carbon intensity is below a quarter of the annual regional average
Devices		
The supplier offers the possibility to purchase used devices.	0	Does not offer
	1	Offers

The supplier provides a warranty for used devices.	0	Does not provide
	1	Warranty is less than one year
	2	Warranty is one year or more
	3	Warranty is three years or more
The supplier provides long-term technical support and security updates for the operating system of the devices.	0	Support lasts less than five years
	1	Support lasts less than eight years
	2	Support lasts more than eight years
The supplier's maintenance operations and processes consider environmental sustainability.	0	Do not consider
	1	Consider at a basic level
	2	The avoidance of energy consumption is a fundamental principle of operations and processes
Spare parts and components for the supplier's devices are available for a long period.	0	Spare parts are available for less than five years
	1	Spare parts are available for less than eight years
	2	Spare parts are available for more than eight years
The supplier's devices are designed to be user-serviceable.	0	Self-maintenance is not possible
	1	The device can be serviced by the user
	2	The device can be serviced by the user, and third-party components can be used

The supplier's device installation process considers environmental sustainability.	0	Does not consider
	1	Considers at a basic level
	2	The process is designed with energy consumption avoidance as a key principle
The supplier has a defined take-back process for used devices.	0	No process
	1	New devices are refurbished once
	2	New devices are refurbished twice or have a lifespan of more than ten years
The supplier has defined the lifecycle of devices.	0	Not defined
	1	Lifecycle is defined
	2	Lifecycle is defined and optimized to reduce energy consumption and emissions
The supplier recycles electronic waste.	0	Does not recycle
	1	Electronic waste is recycled
	2	Electronic waste accumulation is minimized, and the remaining waste is recycled

Telecommunications

The energy consumption of telecommunications can be measured.	0	Energy consumption cannot be measured
	1	Energy consumption can be measured in some services
	2	Energy consumption can be measured in all services

The emissions of telecommunications can be measured.	0	Emissions cannot be measured
	1	Emissions can be measured in some services or some scopes
	2	Emissions can be measured in all services and all scopes
The supplier minimizes telecommunications usage.	0	Does not minimize
	1	Minimizes in some services
	2	Minimizes across all operations
The supplier's telecommunications solutions aim to avoid the use of wireless networks.	0	Does not avoid
	1	The use of wireless networks is not preferred
	2	Wireless networks are used only as a last resort

Administration

The supplier has an environmental management system	0	No environmental management system
	1	Environmental management system exists
	2	Certified or audited environmental management system exists
The supplier's environmental management system considers IT.	0	Not considered
	1	Considered at a general level
	2	Considered in detail

The supplier reports its environmental impacts.	0	No environmental report
	1	Environmental report exists
	2	Environmental report audited by an external party exists (Note: may create unnecessary differences between small and large companies)
The supplier calculates its carbon footprint. *The carbon footprint must be calculated using a widely accepted method.*	0	Not calculated within the past 18 months or calculation does not cover all scopes
	1	Calculated by the supplier itself
	2	Carbon footprint calculation performed or audited by an external party (Note: may create unnecessary differences between small and large companies)
The supplier actively minimizes its carbon footprint	0	Does not minimize
	1	Minimizes at a basic level
	2	Minimizes with clear goals and long-term commitment
The supplier has carbon footprint reduction targets.	0	No targets
	1	Basic-level targets
	2	Ambitious targets
		The definition of basic and ambitious levels should be specified in the request for proposal and must be relevant to the procurement.

The supplier provides staff guidance on IT-related responsibility.	0	No guidance
	1	General-level guidance
	2	Detailed guidance
The supplier has an ethical code of conduct.	0	No code of conduct
	1	General-level code of conduct
	2	Detailed code of conduct
The supplier reports internally on the environmental impact of IT.	0	Does not report
	1	Reports once a year
	2	Reports in detail and more than once a year
The environmental impact of the supplier's IT is audited.	0	Not audited
	1	Internally audited
	2	Audited by a third party or certified by a third party as a result of the audit
The supplier's IT environmental impact reporting has a sponsor in top management.	0	No sponsor
	1	Sponsor in top management
	2	Sponsor in top management, and impacts are reported more than once a year

11 Thank Yous

This guide is, in many ways, a natural continuation of my book Green Code and an extremely important tool for reducing energy consumption and emissions in the IT sector. Even just slowing down the growth of energy consumption and emissions would be a step in the right direction.

Companies and public organizations manage a significant portion of IT solutions, and virtually all consumer applications are developed by companies. Therefore, the change should begin with businesses.

The Green IT Maturity Model[142], which I developed together with Exove's CTO Kalle Varisvirta, served as the foundation for many of the solutions and procurement criteria presented in this book.

I would like to extend special thanks to the early readers of this book, who provided valuable insights and suggestions that significantly enriched the text. The reviewers of the Finnish version included Valohai's CTO Aarni Koskela, Rebl Group's Sustainability Specialist Meeri Nyberg, and Konsepto's CEO Mikko Paltamaa. Additionally, Exove's Growth Marketer Essi Rostedt and Rebl Group's Communications Manager Kati Iharanta proofread and refined the language of the text.

For the English language version, Exove's Principal Tech Lead Rihards Steinbergs, CivicActions' Open Standards & Practices Lead Mike Gifford, Torchbox' Senior Engineer Thibaud Colas, and Platform.sh' VP, Strategic Operations Jérôme Andrieux provided excellent commentary.

[142] exove.com/services/green-it-maturity-model/

Without your contributions, this book would be much narrower in scope and of lower quality overall. It goes without saying that any remaining errors are solely my own responsibility.

12 Feedback

I warmly welcome any feedback and new ideas for greener IT procurement. This topic is crucial both for the development of the IT sector and for slowing down climate change. Additionally, it is a deeply personal matter for me, which is why I am committed to improving the quality and impact of this guide.

If you feel that a particular topic was overlooked or not covered in enough depth, I would love to hear about it. Likewise, I appreciate new ideas, insights on overlooked aspects, or tips for making IT procurement more sustainable. I would also be grateful if you could report any errors you come across.

If you'd like to help improve this guide—or even just share your appreciation—please take a moment to fill out this short survey:

Fill out the survey

Thank you!