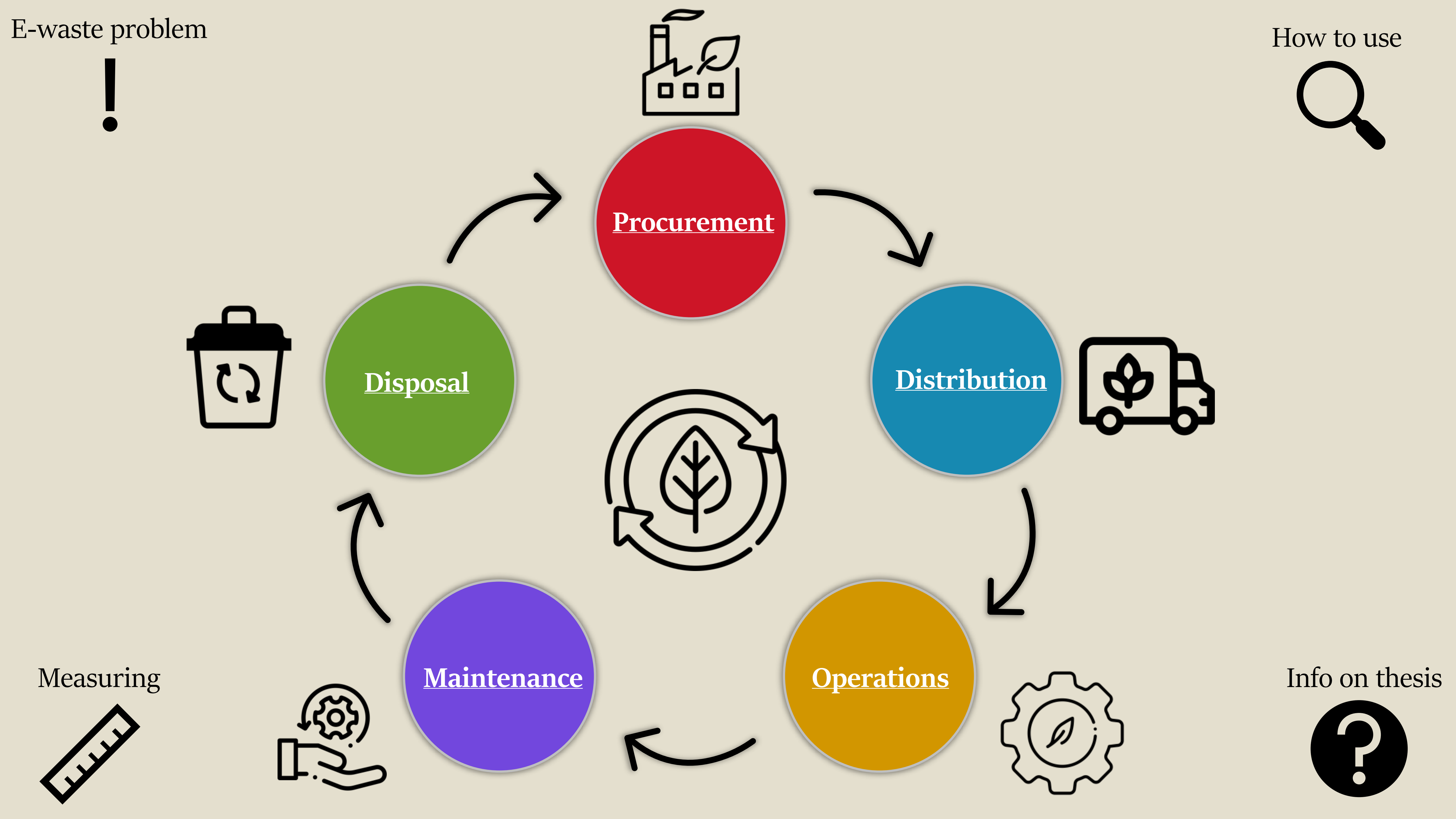
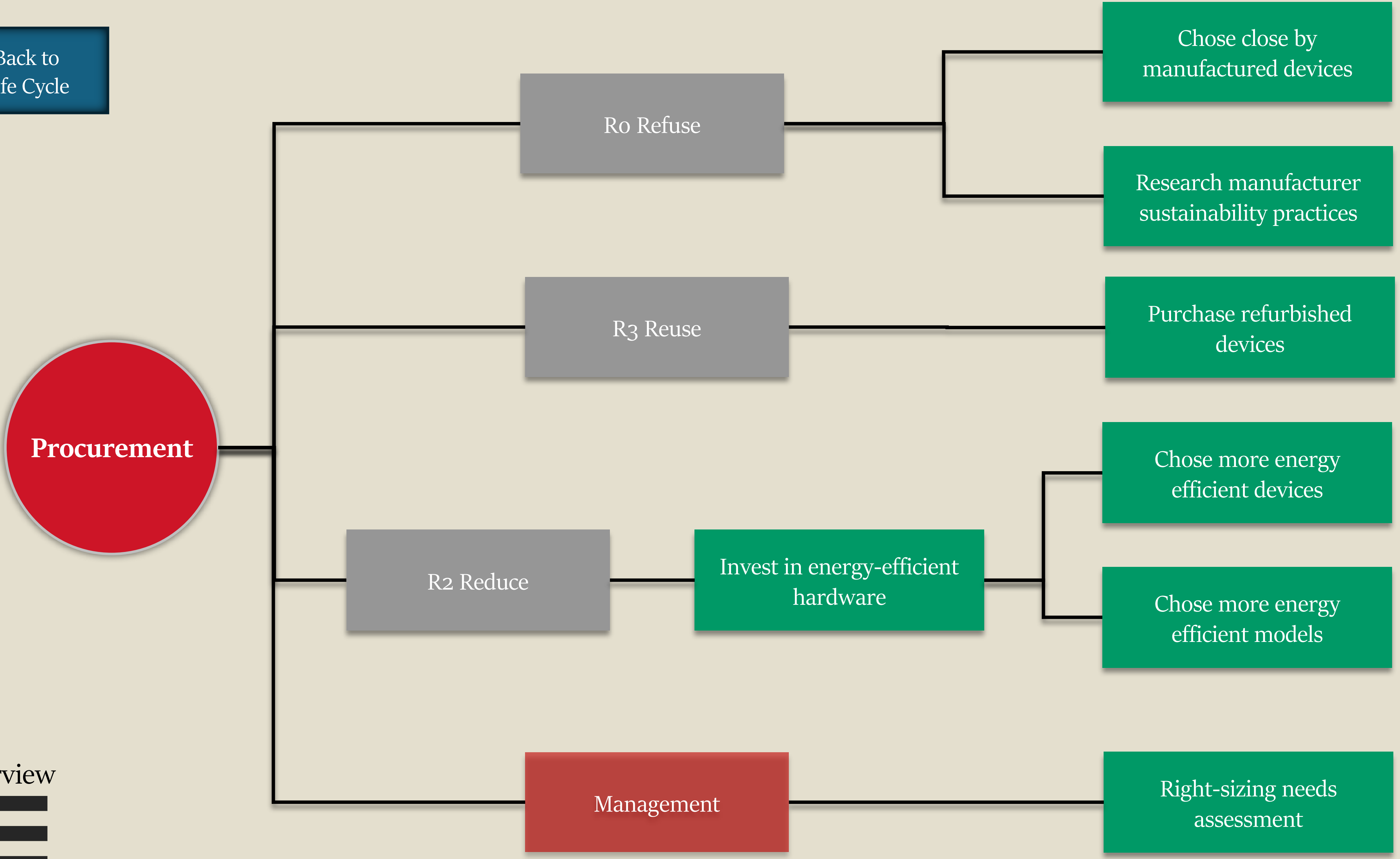
DSS


E-waste problem
How to use
Procurement
Distribution
Operations
Maintenance
Disposal
Measuring
Info on thesis

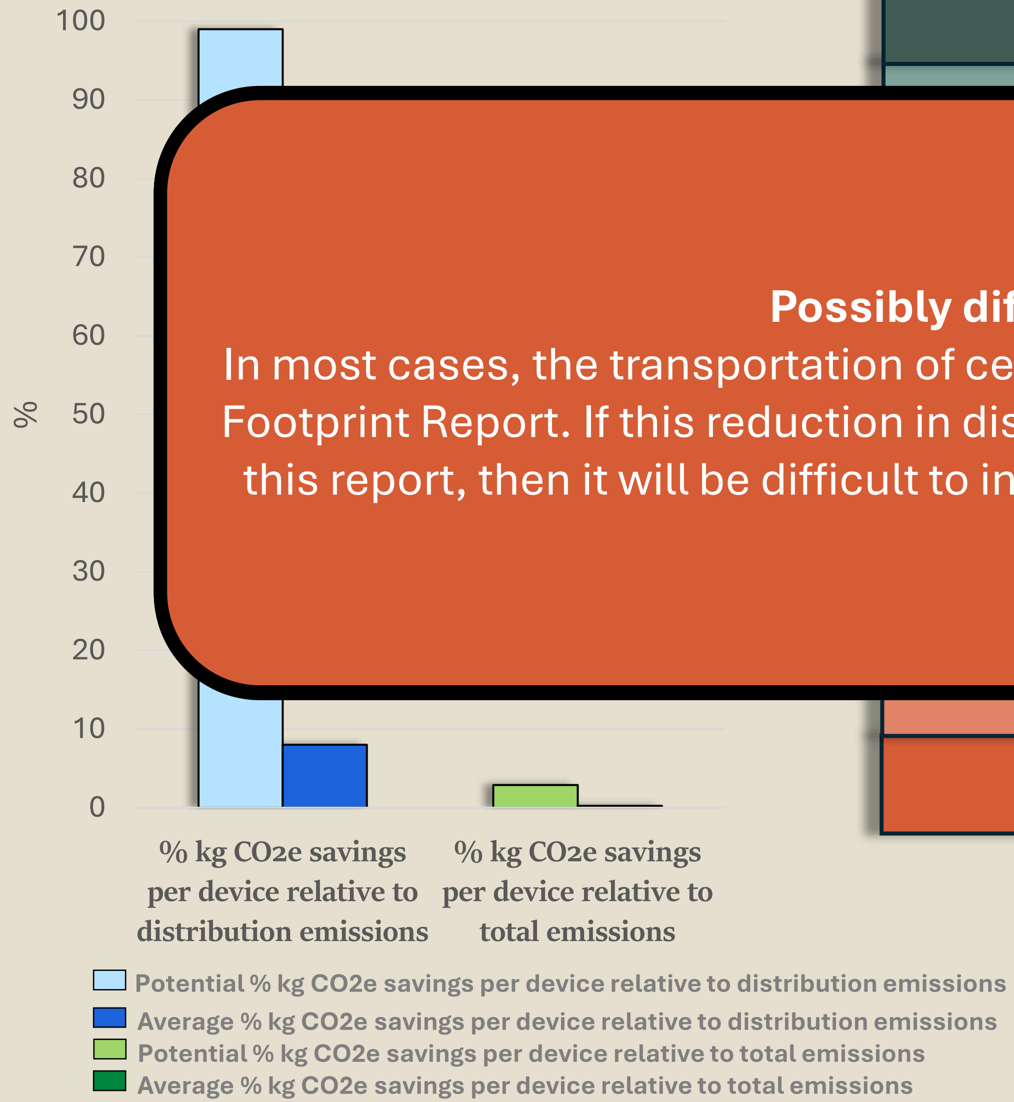
Back to
Life Cycle



Overview

Back to Procurement

Choose close by manufactured devices



Tools

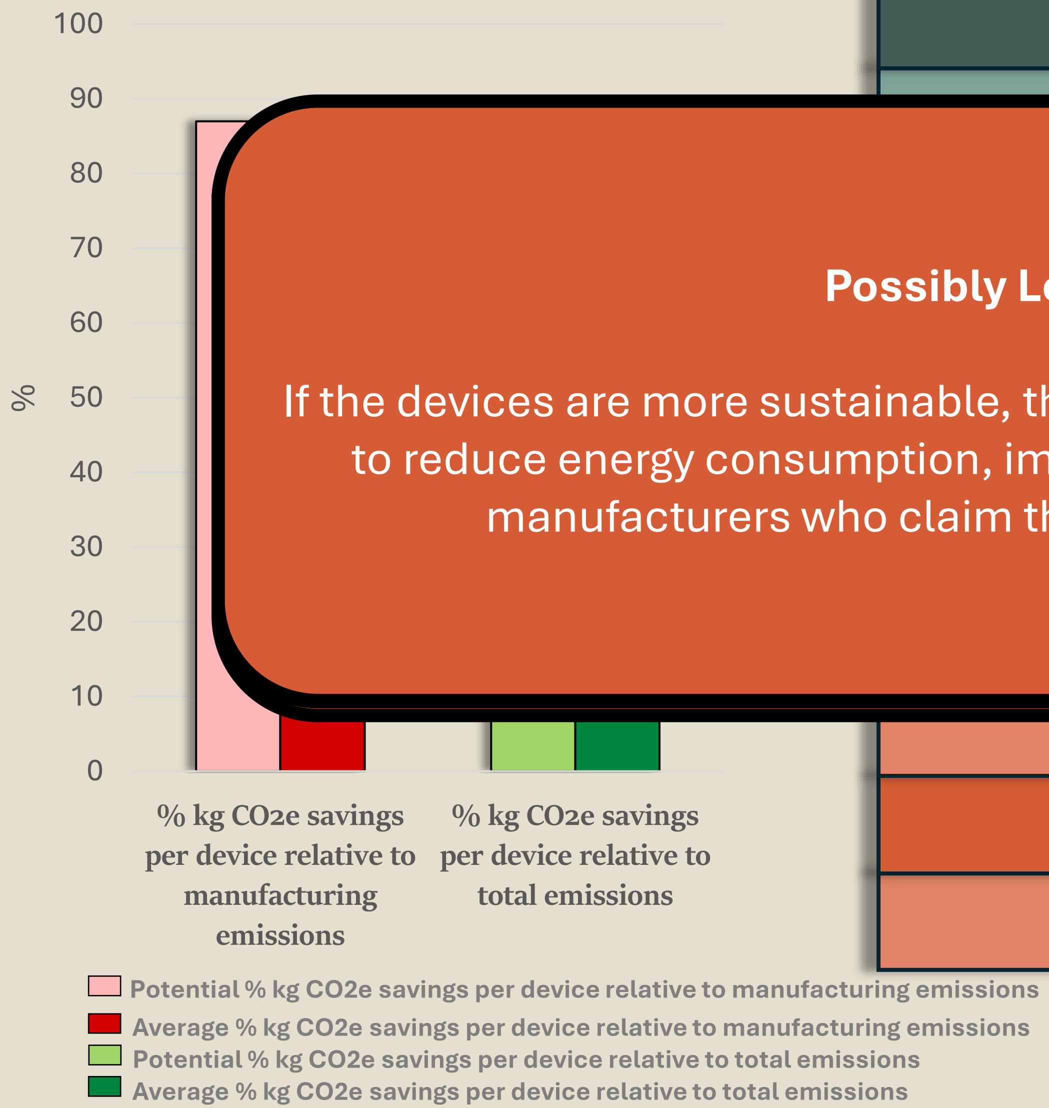
Possibly difficult to implement in CSRD

In most cases, the transportation of certain devices is already taken into account in the Carbon Footprint Report. If this reduction in distributions emissions is not already taken into account in this report, then it will be difficult to integrate the decrease in CO_2e emissions into the CSRD.

Time-consuming reporting

Back to Procurement

Research manufacturer sustainability practices



Tools

Time-consuming research

Higher Production Costs

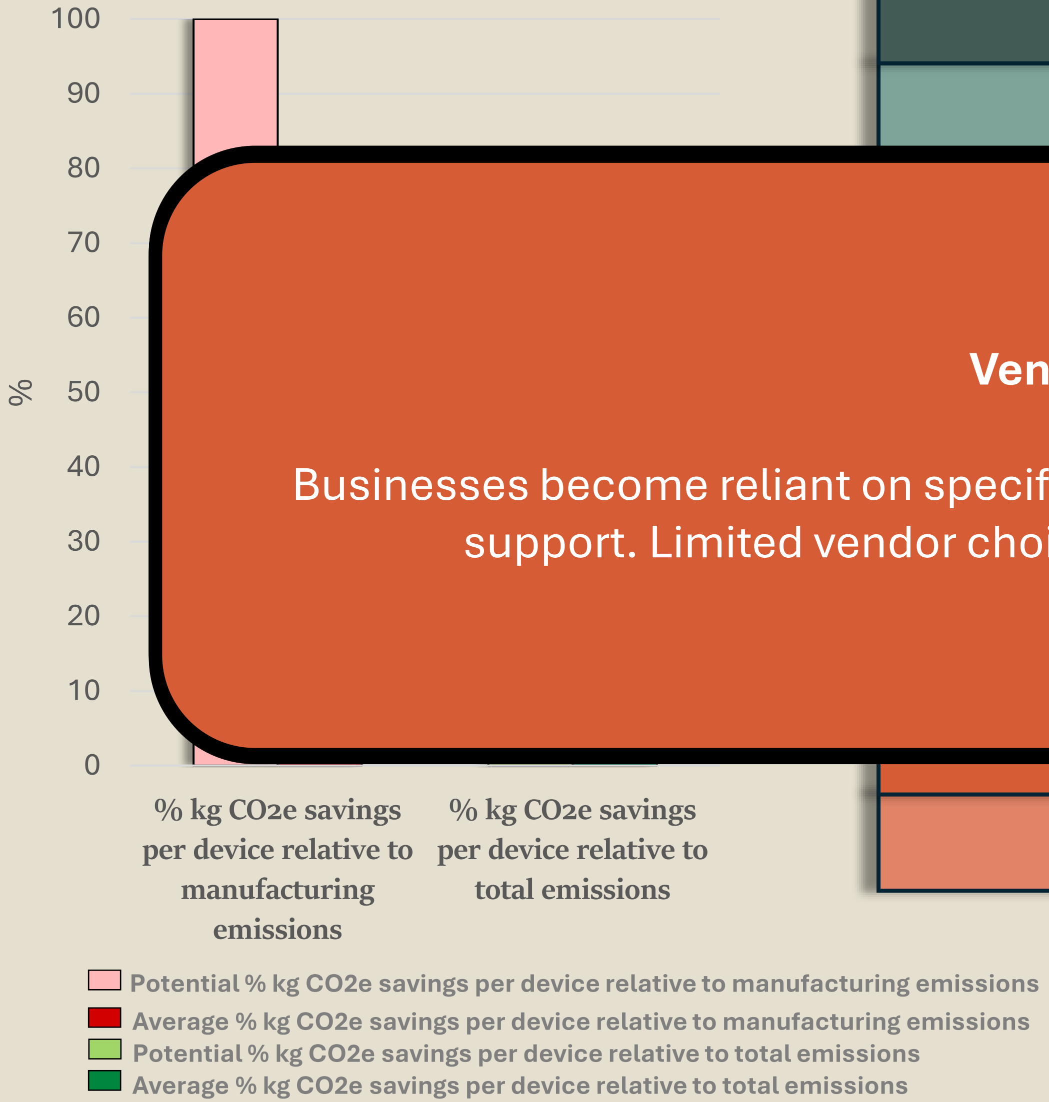
Possibly Less Efficient / Slower Devices

Possibly Less Efficient / Slower Devices

If the devices are more sustainable, they may have less powerful processors or slower memory to reduce energy consumption, impacting their speed and efficiency. However, there are manufacturers who claim that sustainability has no effect on performance.

Back to Procurement

Purchase refurbished devices



Tools

Digital Product Passports (DPP)

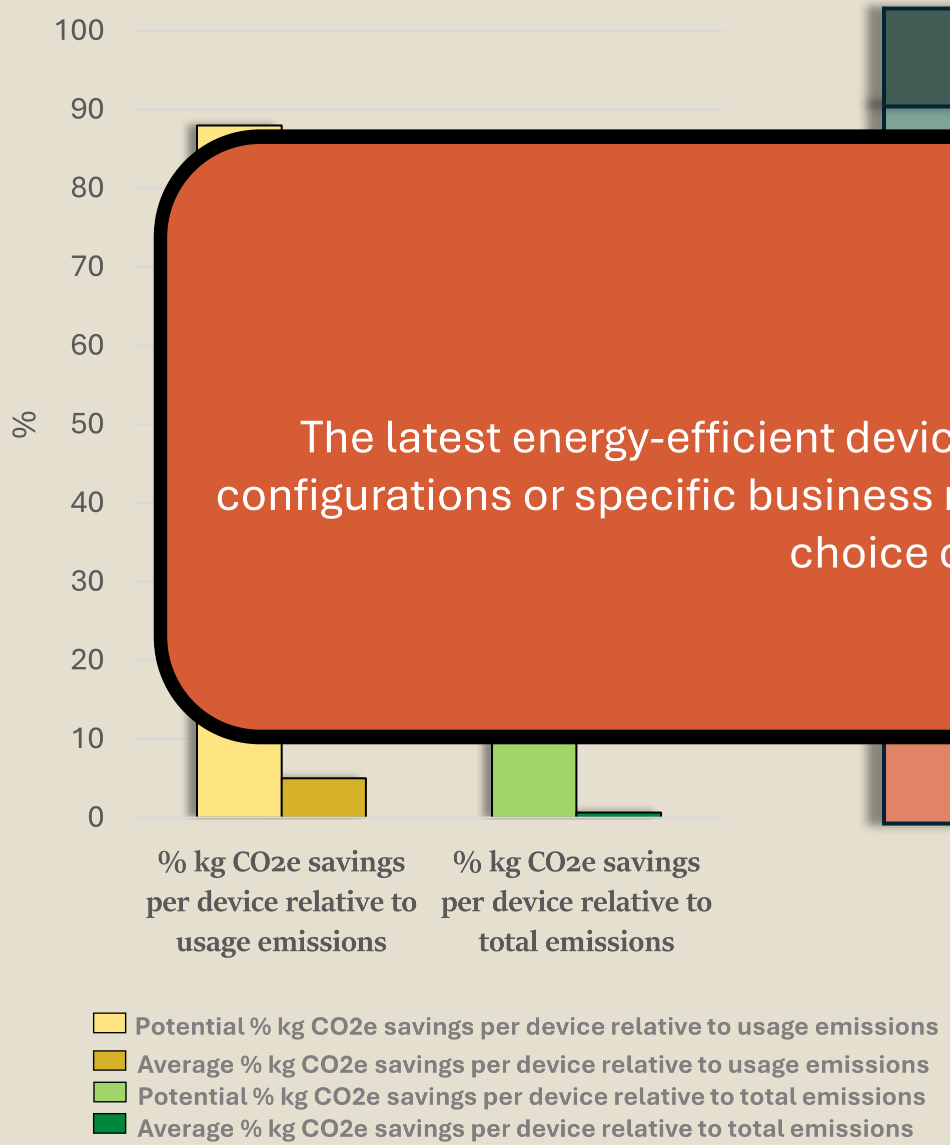
Vendor Dependence

Businesses become reliant on specific refurbishment vendors for hardware options and support. Limited vendor choices might restrict price negotiation power.

Vendor Dependence

Back to Procurement

Chose more energy efficient devices



Tools

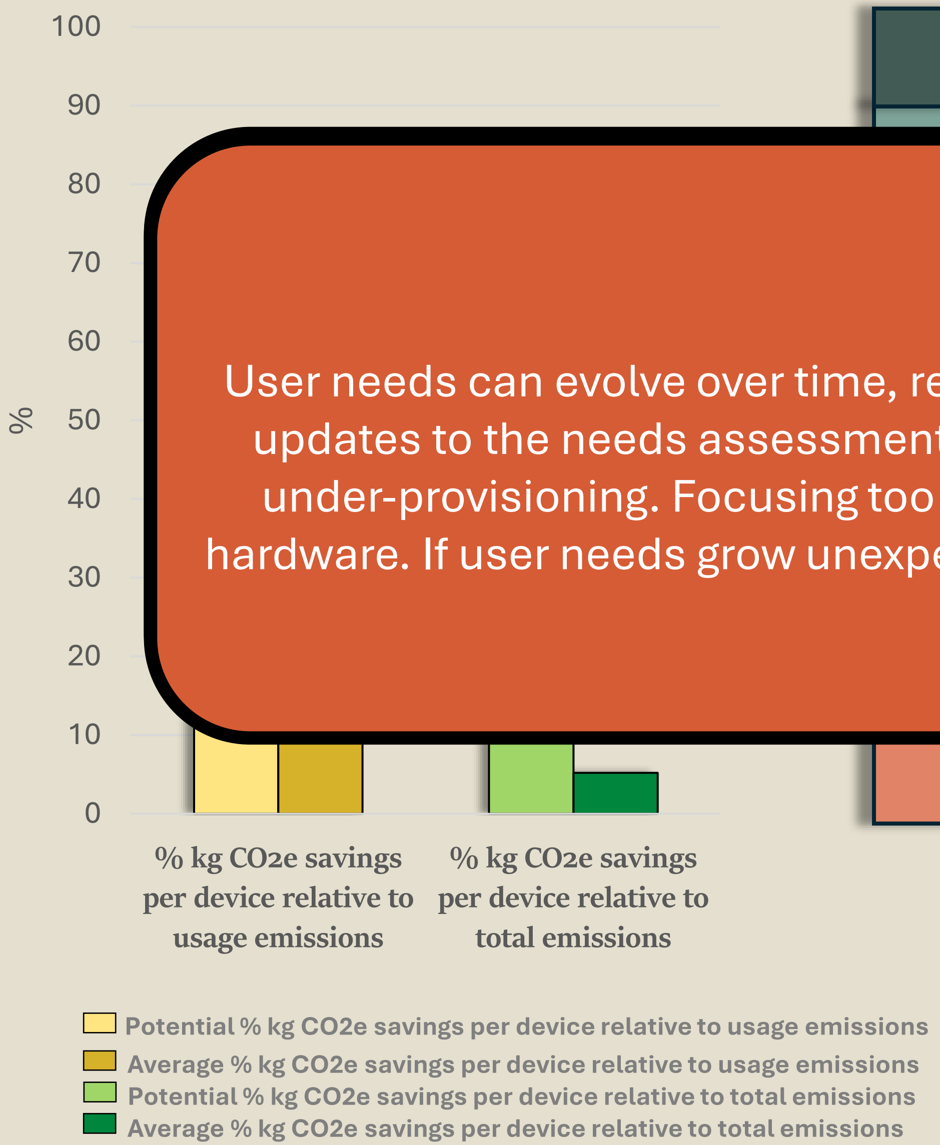
Limited Availability

The latest energy-efficient devices might have limited availability, especially for specific configurations or specific business needs. Businesses might face longer lead times or have less choice compared to traditional options.

Limited Availability

Back to Procurement

Chose more Energy Efficient Models



Tools

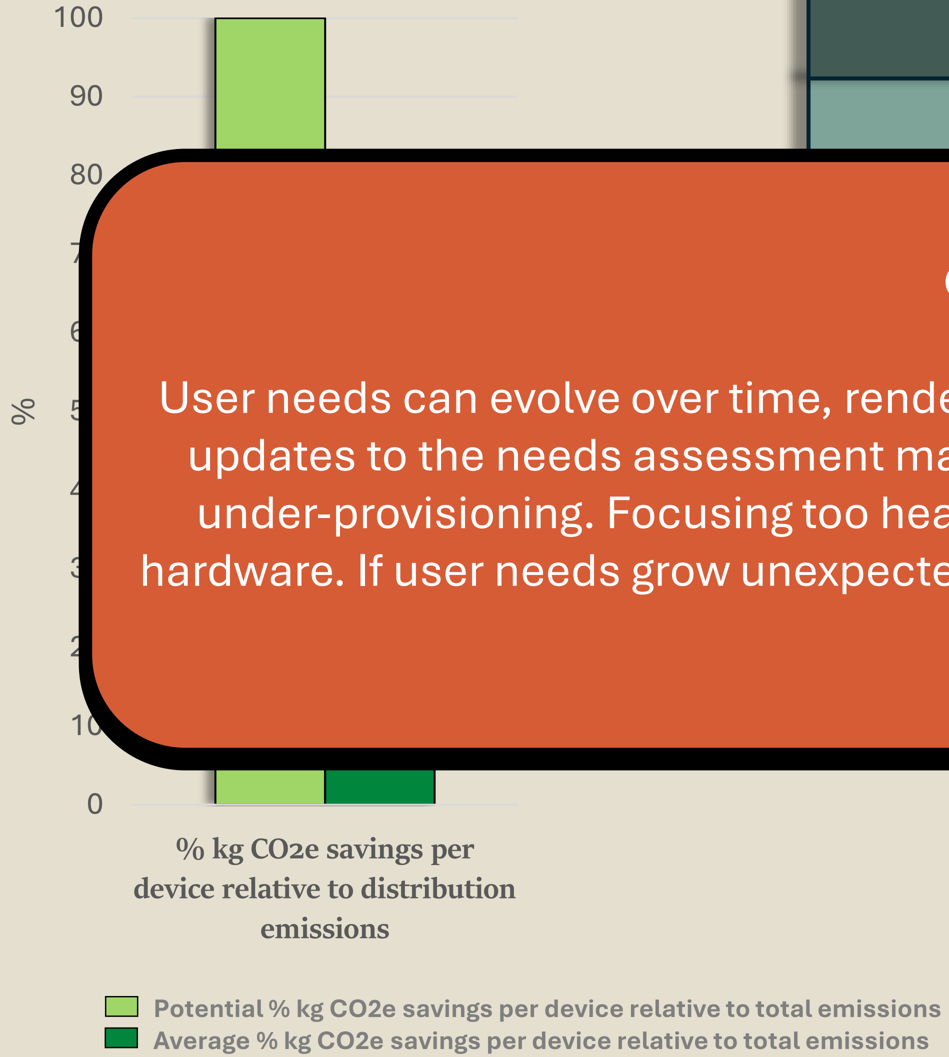
Changing Needs

Changing Needs

User needs can evolve over time, rendering initial assessments outdated. Regular reviews and updates to the needs assessment may be needed to ensure continued efficiency and avoid under-provisioning. Focusing too heavily on right-sizing could lead to under-provisioning of hardware. If user needs grow unexpectedly, performance bottlenecks and user frustration might emerge.

Back to Procurement

Right-sizing needs Assessment



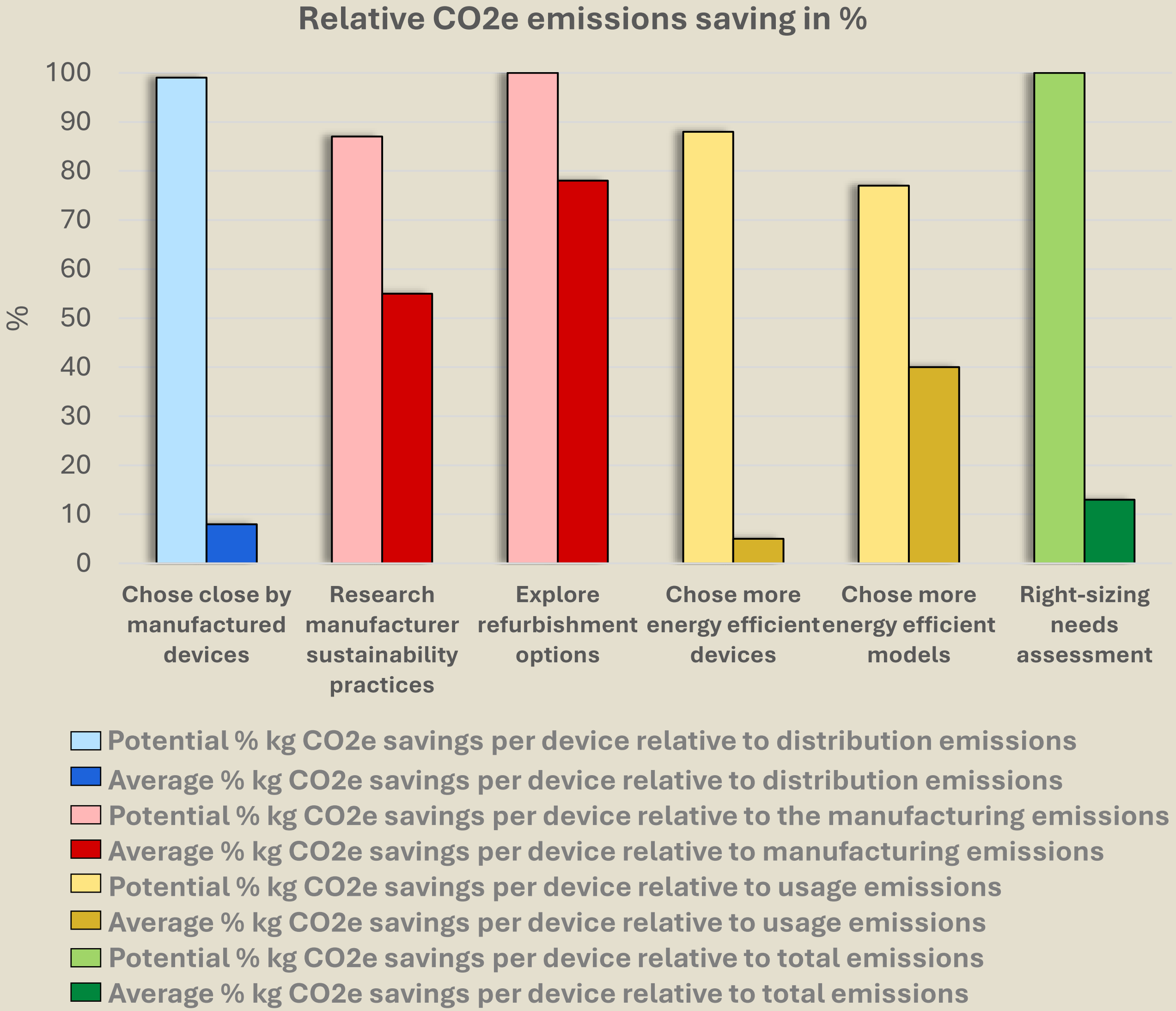
Tools
Life Cycle Assessment (LCA)

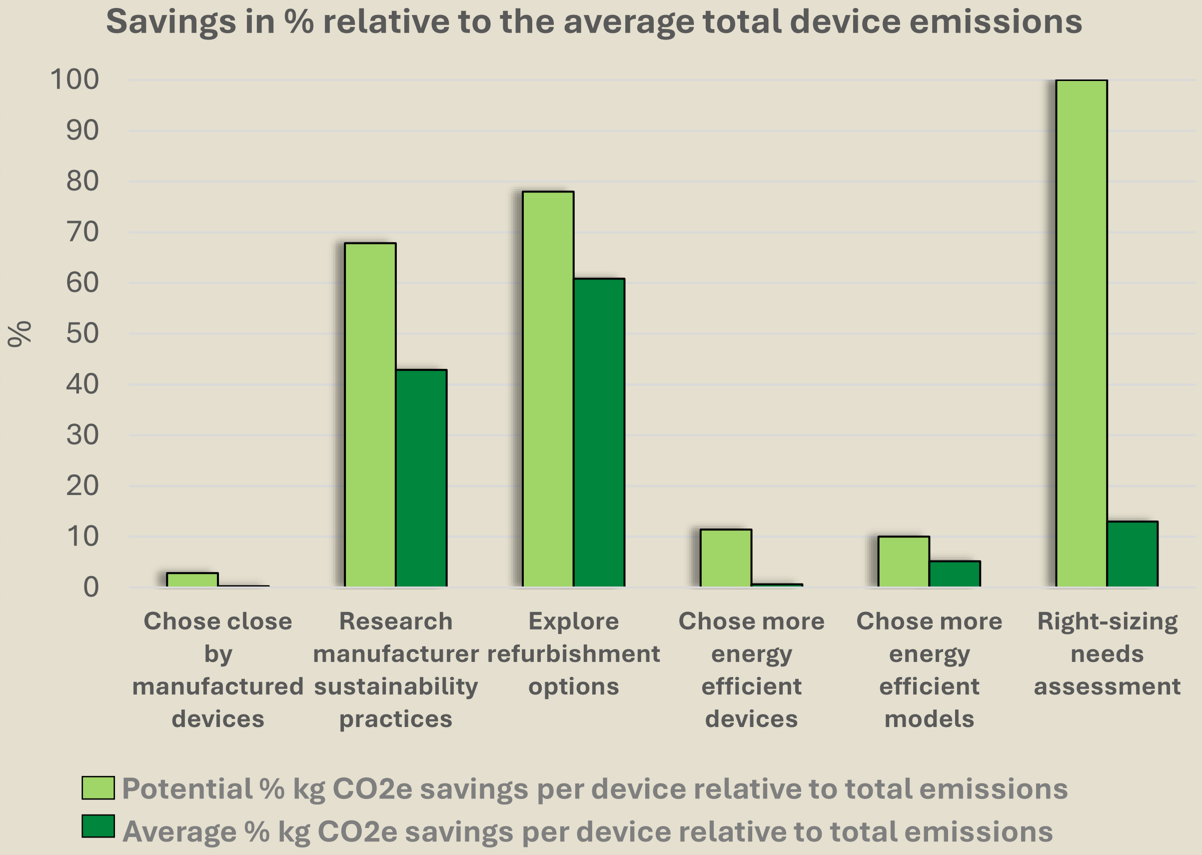
Changing Needs

User needs can evolve over time, rendering initial assessments outdated. Regular reviews and updates to the needs assessment may be needed to ensure continued efficiency and avoid under-provisioning. Focusing too heavily on right-sizing could lead to under-provisioning of hardware. If user needs grow unexpectedly, performance bottlenecks and user frustration might emerge.

Back to Procurement

Overview of effects of all possible improvements





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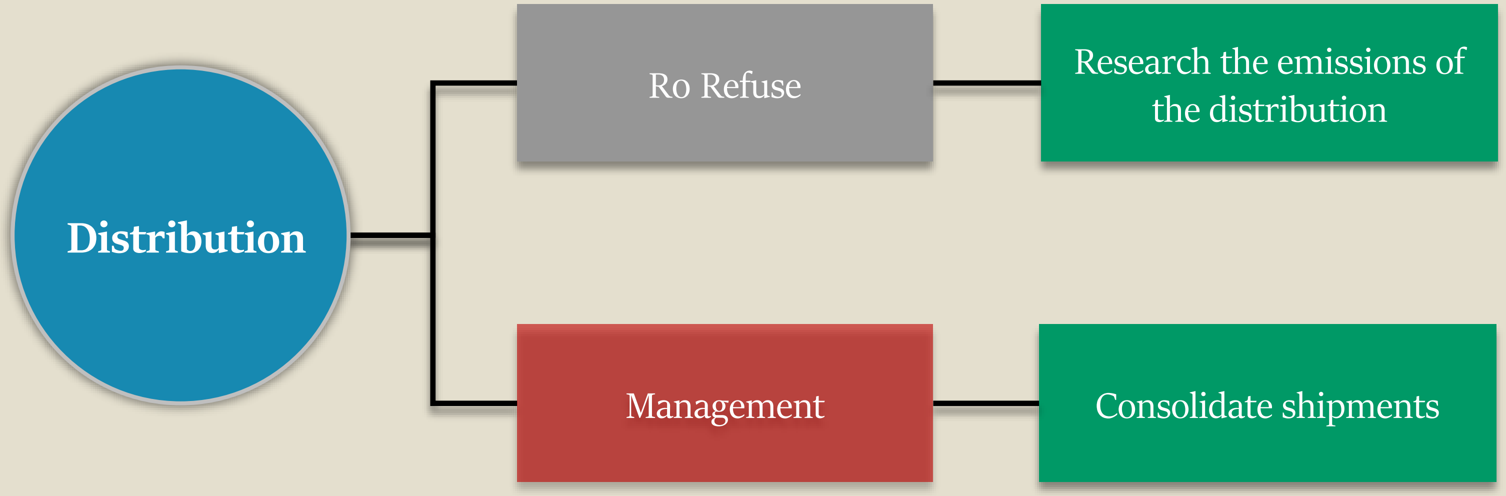
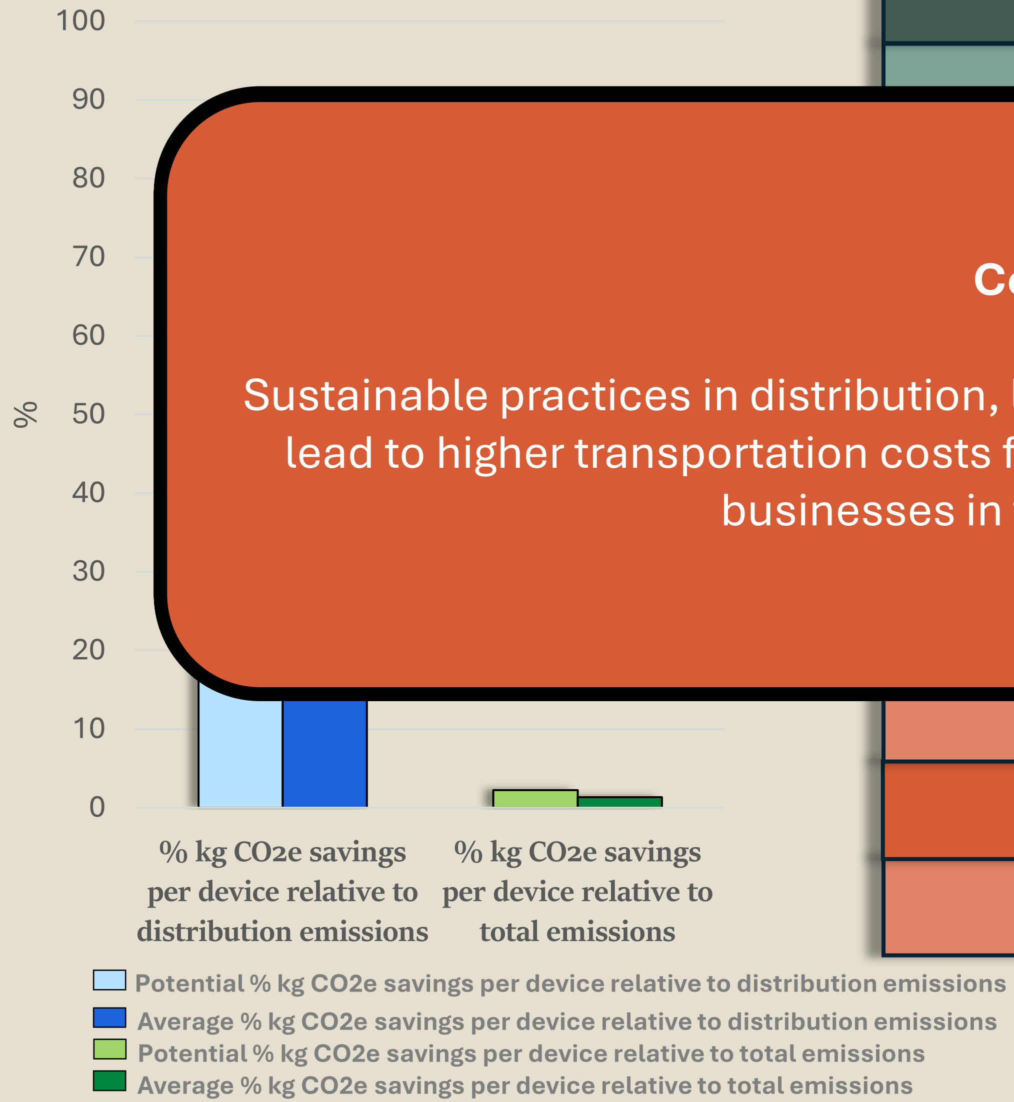


Overview

Back to Distribution

Research the emissions of the distribution



Tools
Carbon Footprint Report (CFR)

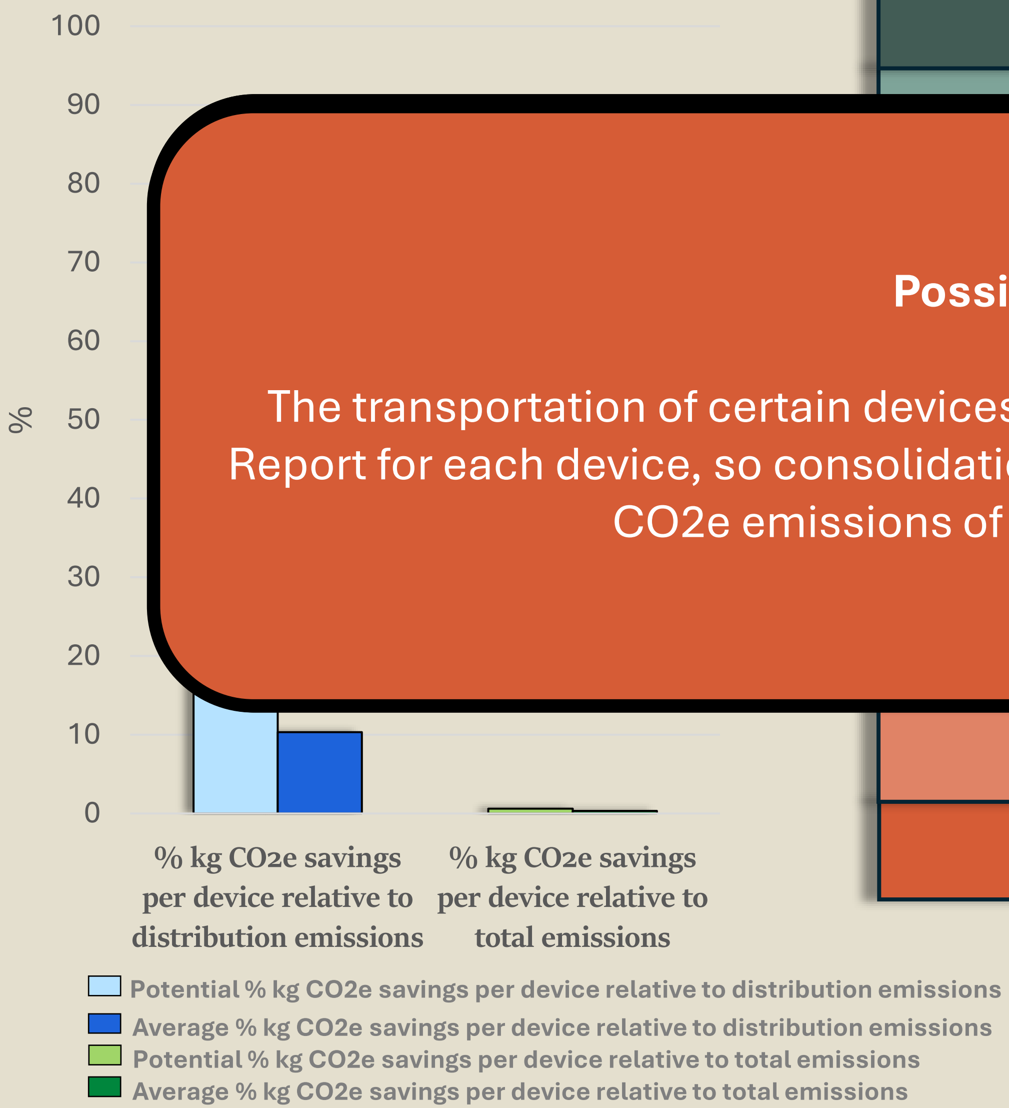
Cost Considerations

Sustainable practices in distribution, like using electric vehicles or recycled packaging, might lead to higher transportation costs for manufacturers. These costs could be passed on to businesses in the form of higher device prices.

Focus on Specific Metrics
Limited Control
Cost Considerations

Back to Distribution

Consolidate shipments



Possibly not viable in CSRD

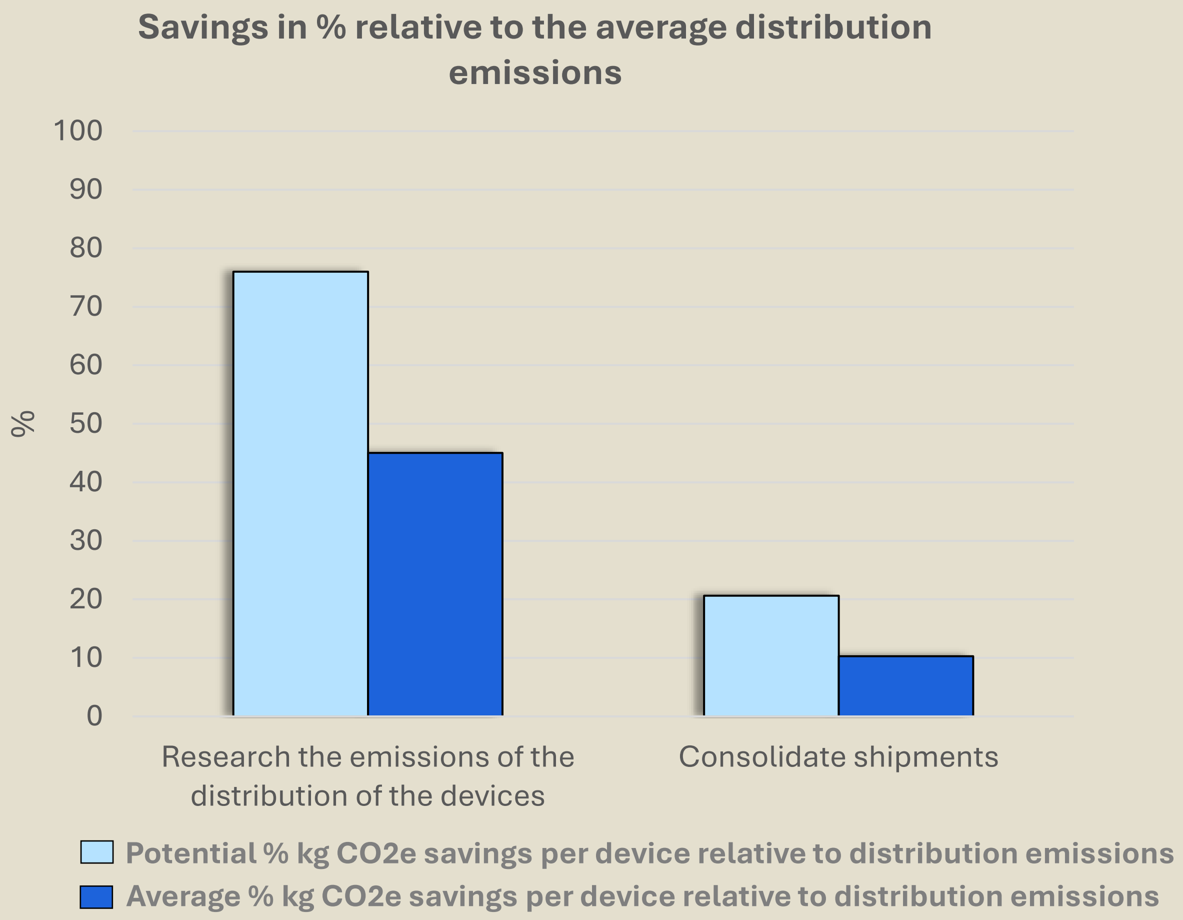
The transportation of certain devices is already taken into account in the Carbon Footprint Report for each device, so consolidation shipments is difficult to implement in the CSRD if the CO_2e emissions of the distribution is already integrated.

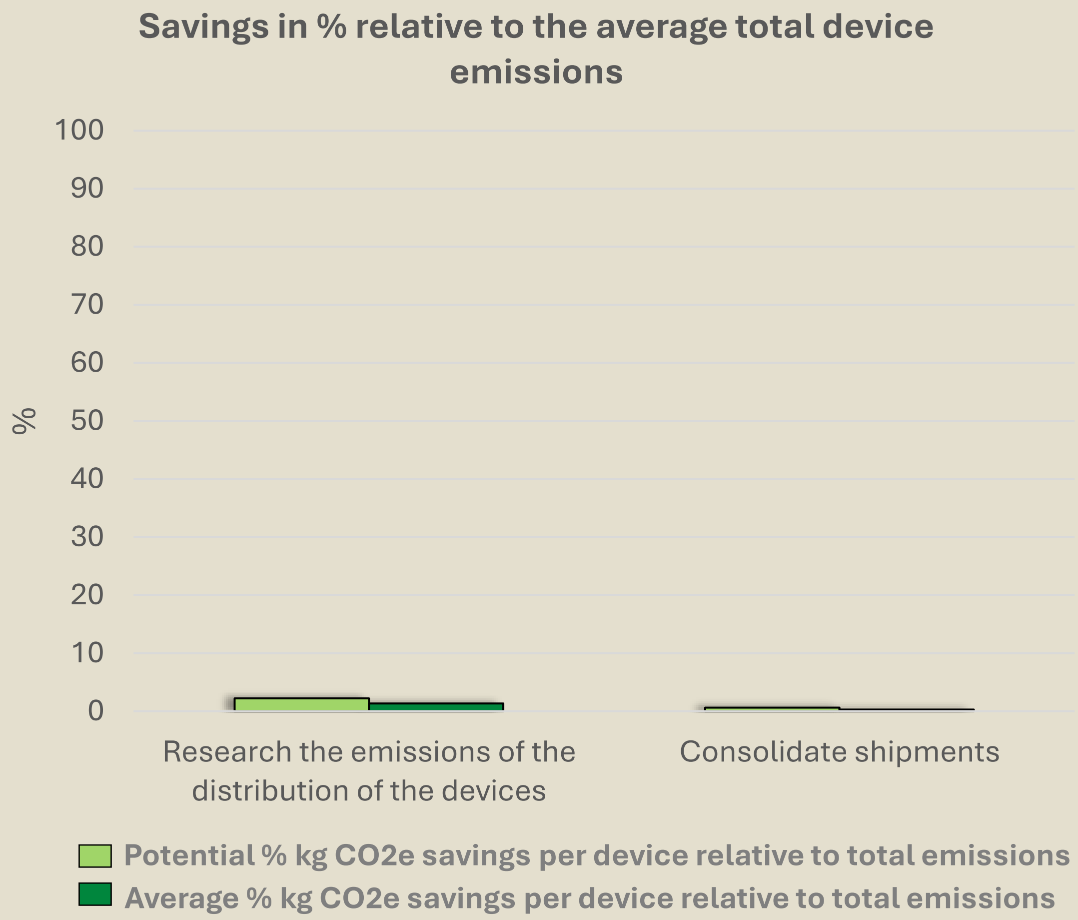
Tools
...t

Higher Storage Costs
Possibly not viable in CSRD

Back to Distribution

Overview of effects of all possible improvements





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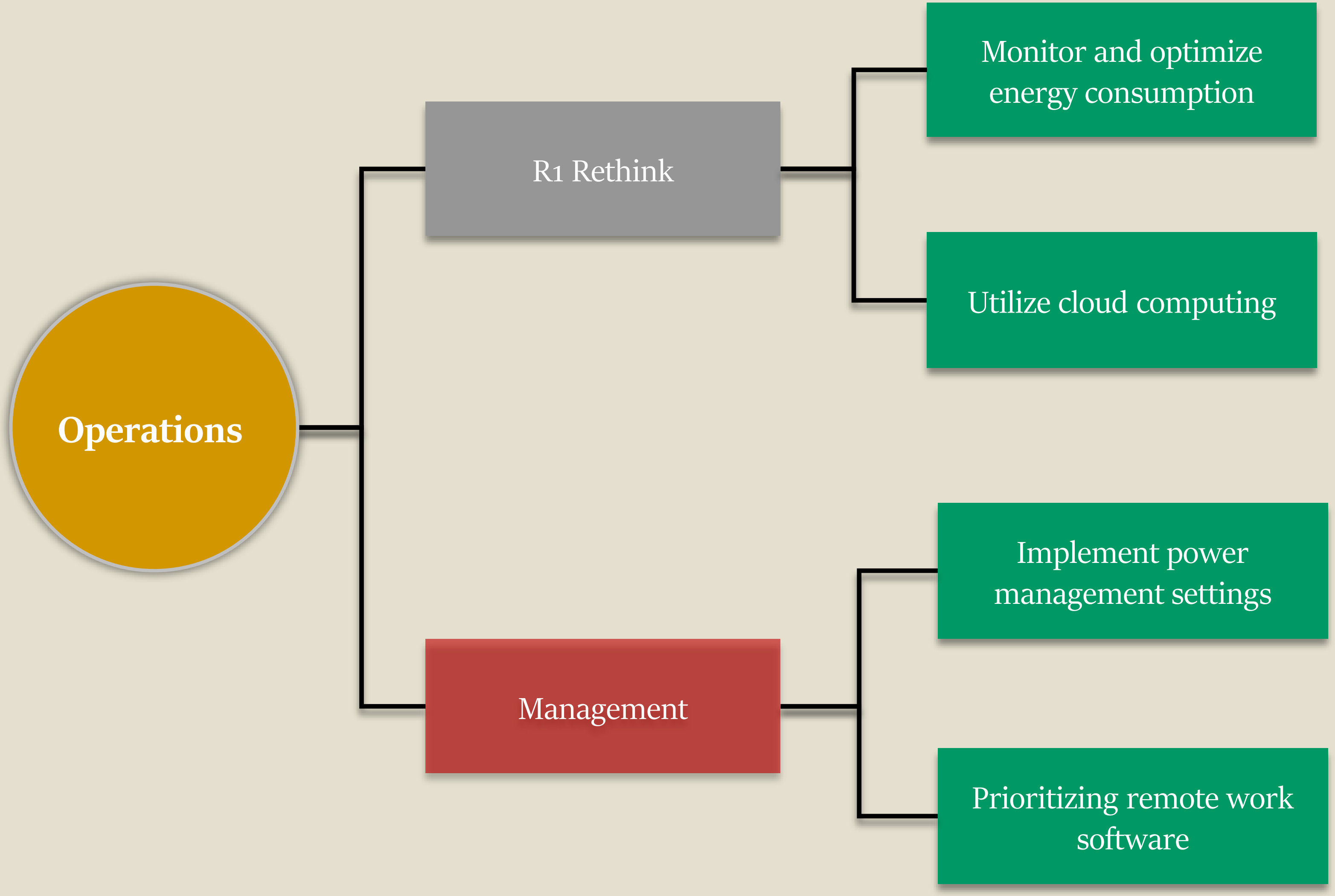
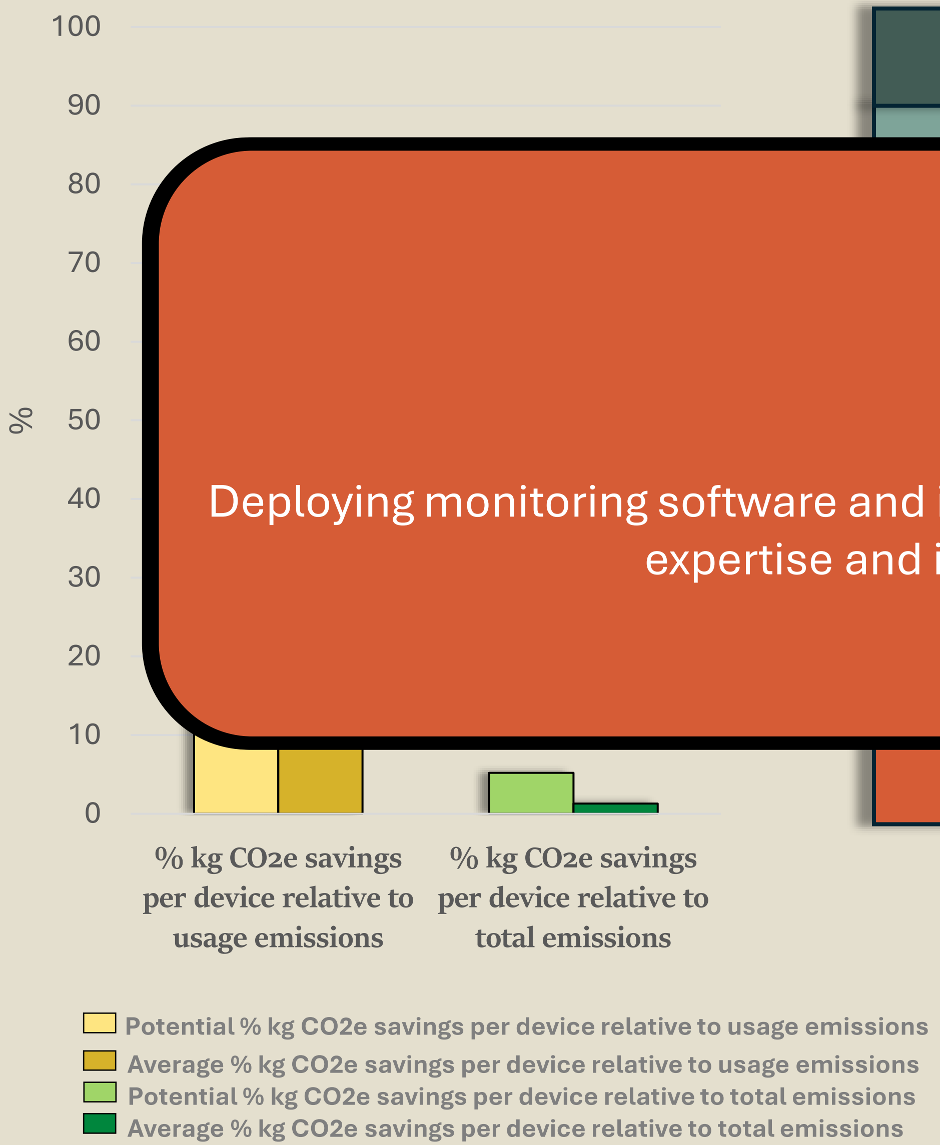


Overview

Back to Operations

Monitor and optimize energy consumption



Tools

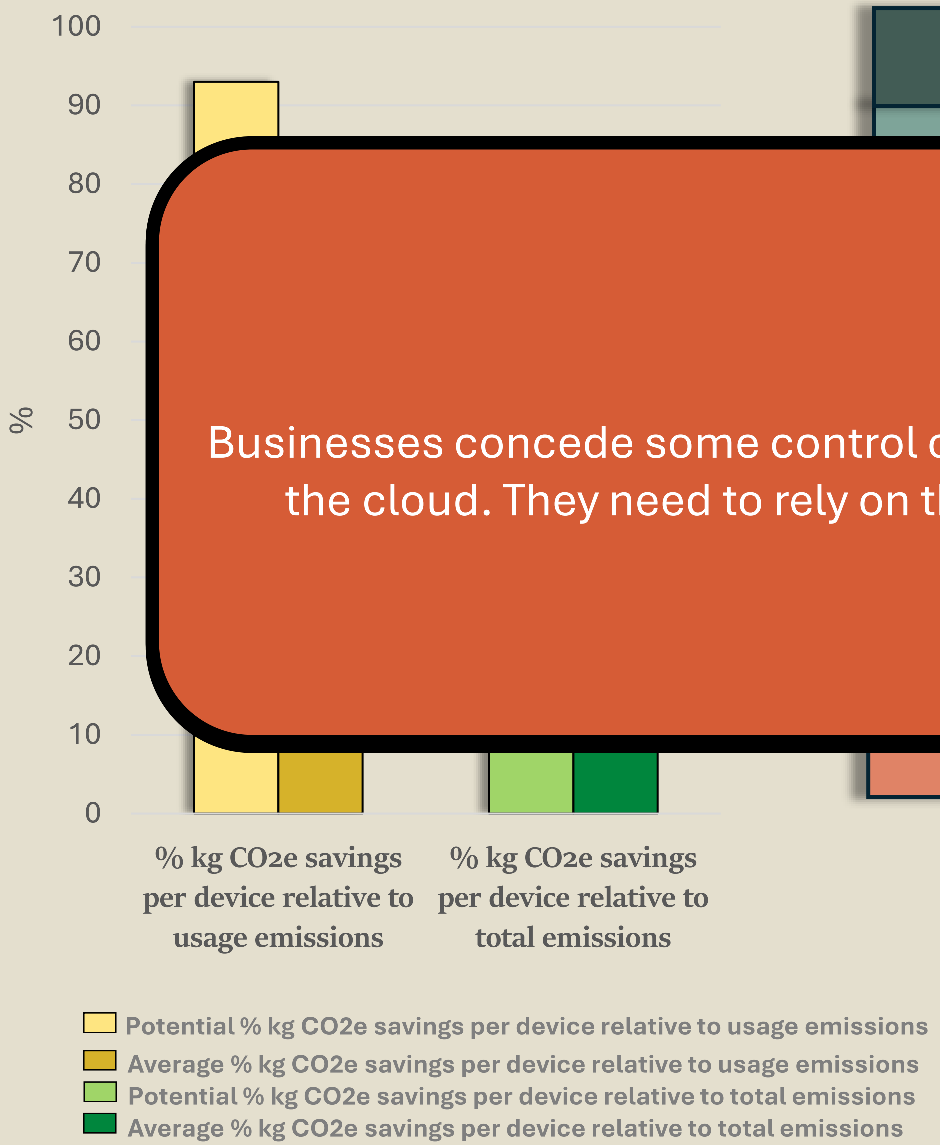
Implementation Costs

Deploying monitoring software and integrating it with existing IT systems might require technical expertise and incur additional implementation costs.

Implementation Costs

Back to Operations

Utilize Cloud Computing



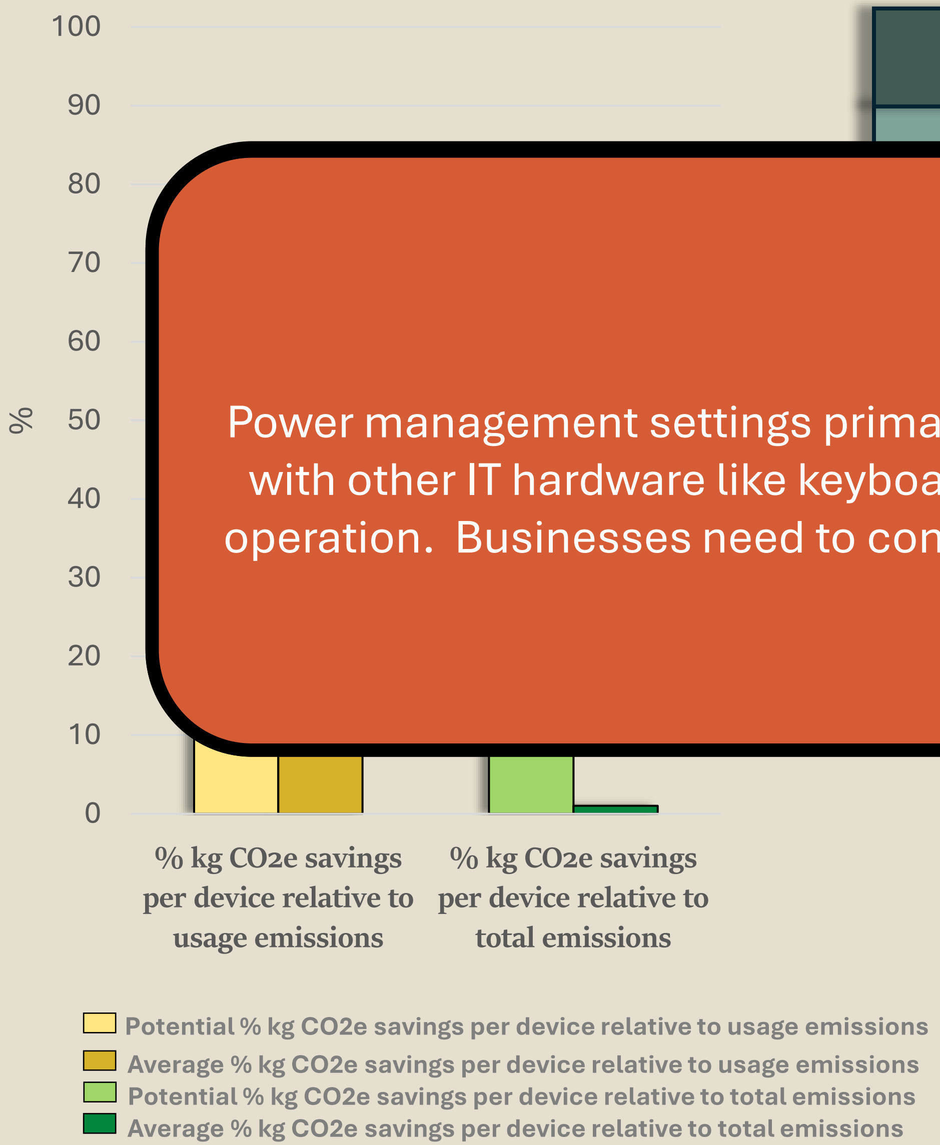
Tools

Limited Control

Businesses concede some control over IT infrastructure and data governance when migrating to the cloud. They need to rely on the cloud provider's uptime guarantees and data security practices.

Back to Operations

Implement Power Management Settings



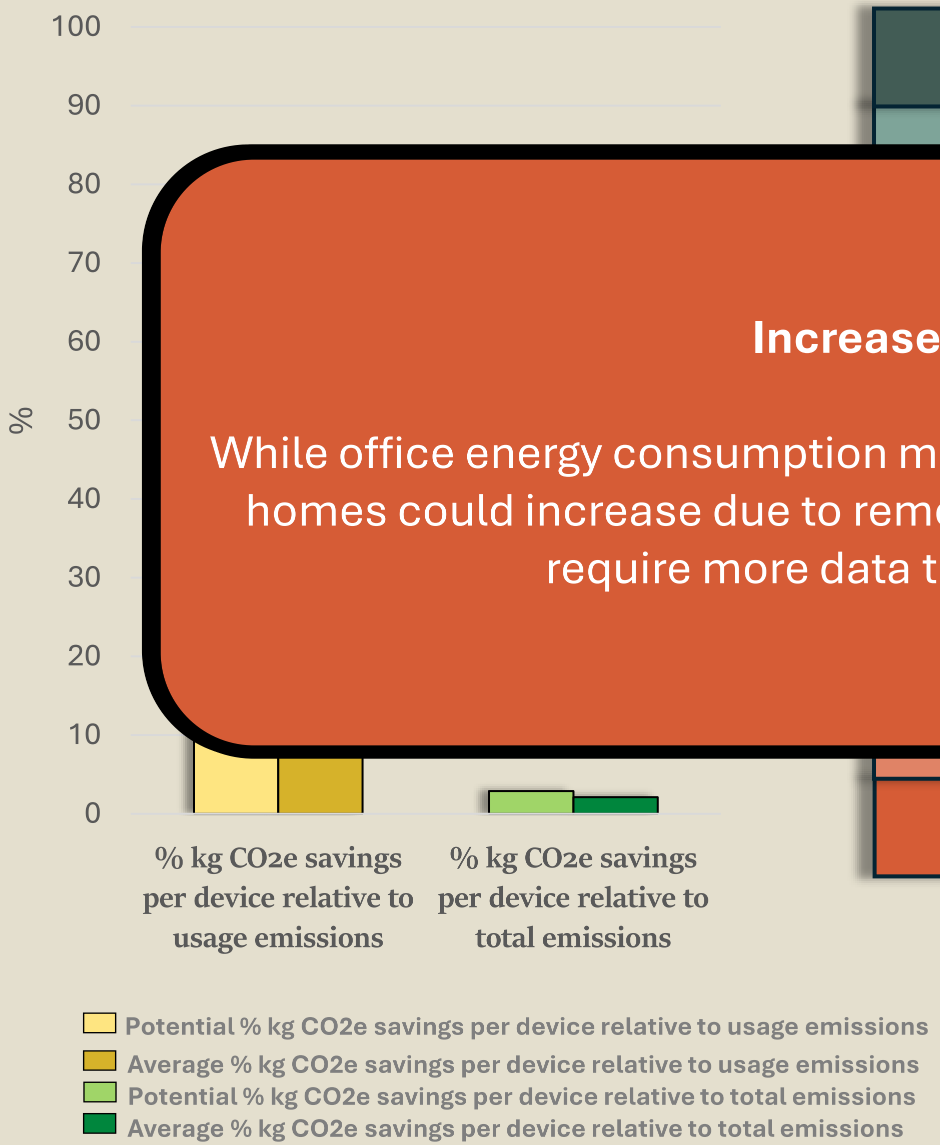
Tools

Limited Scope

Power management settings primarily target desktop computers and might not be as effective with other IT hardware like keyboards, computer mouses or printers that require continuous operation. Businesses need to consider comprehensive approaches beyond individual device settings.

Back to Operations

Prioritizing remote work



Tools

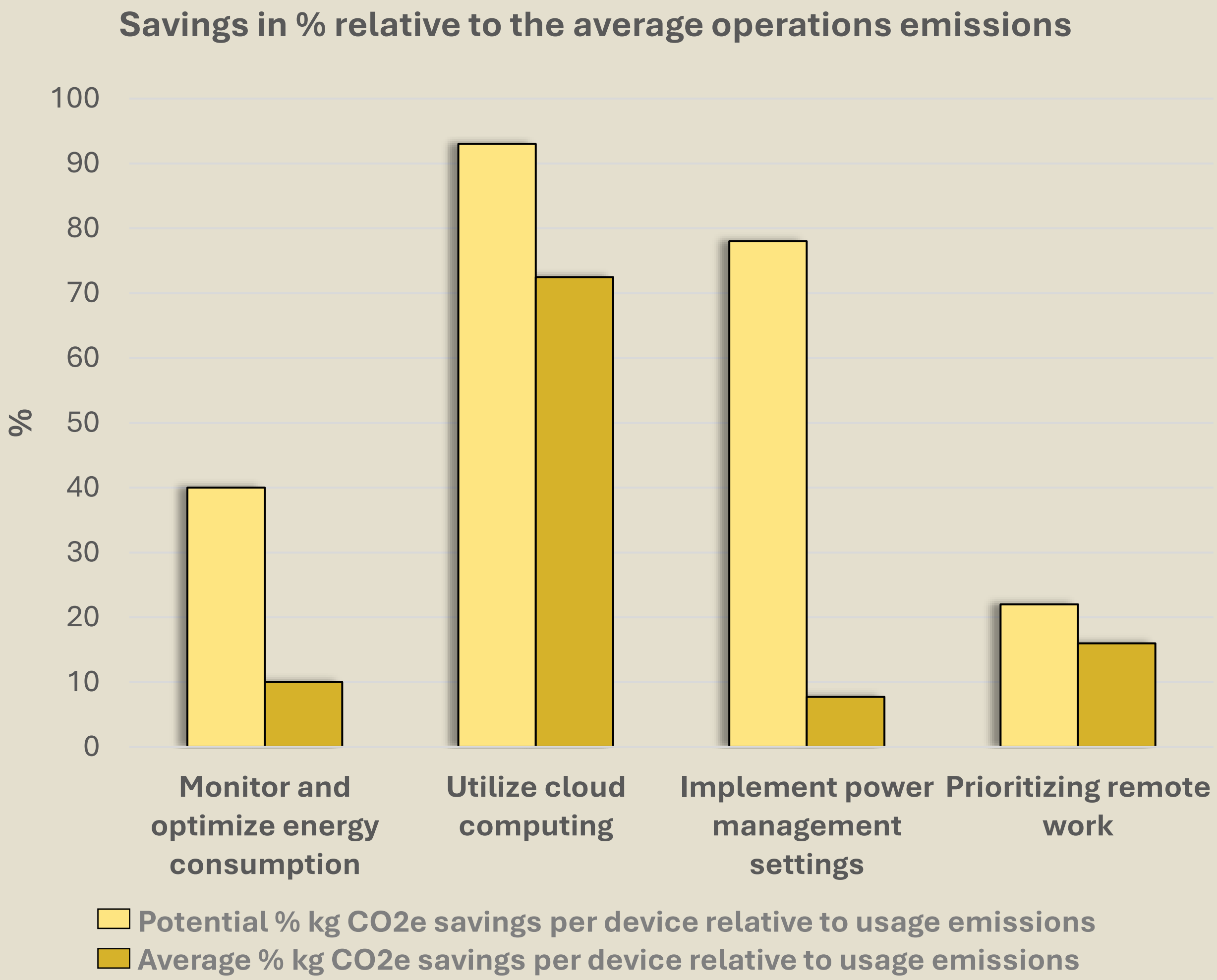
Increased Energy Consumption at Home

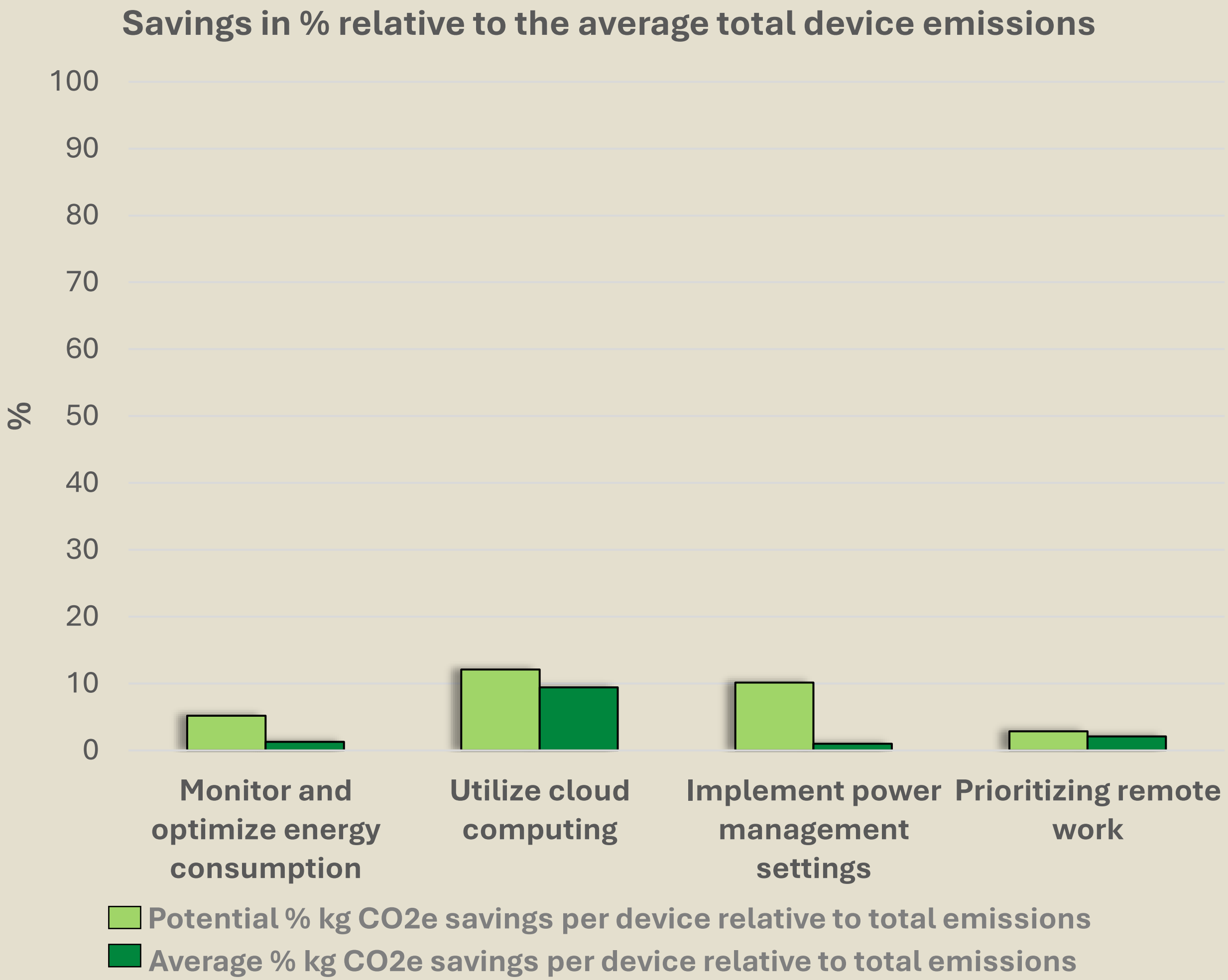
While office energy consumption might decrease, individual energy consumption at employees' homes could increase due to remote work activities. For example, high-definition video calls require more data transfer, leading to higher carbon emissions.

Increased Energy Consumption at Home

Back to Operations

Overview of effects of all possible improvements





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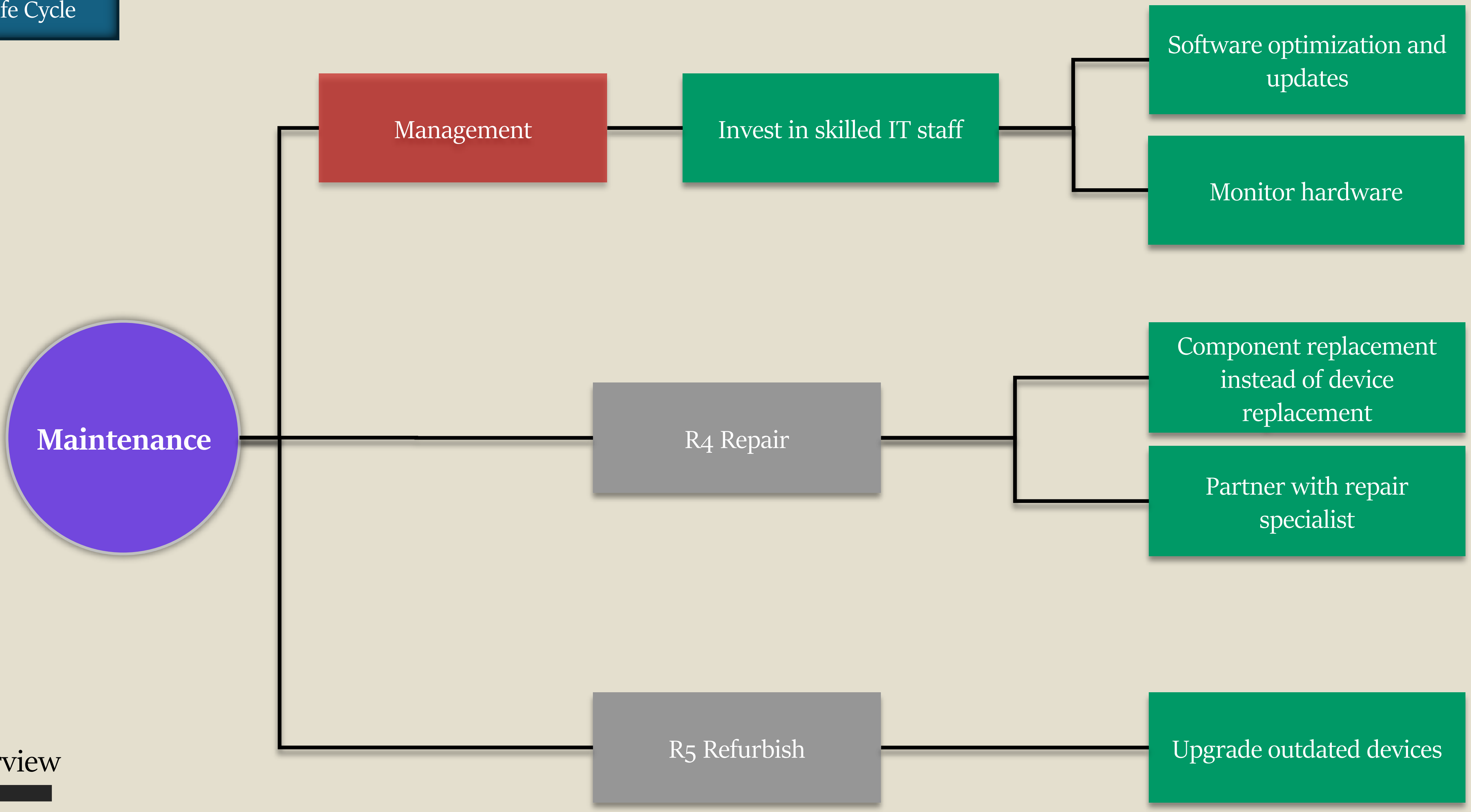
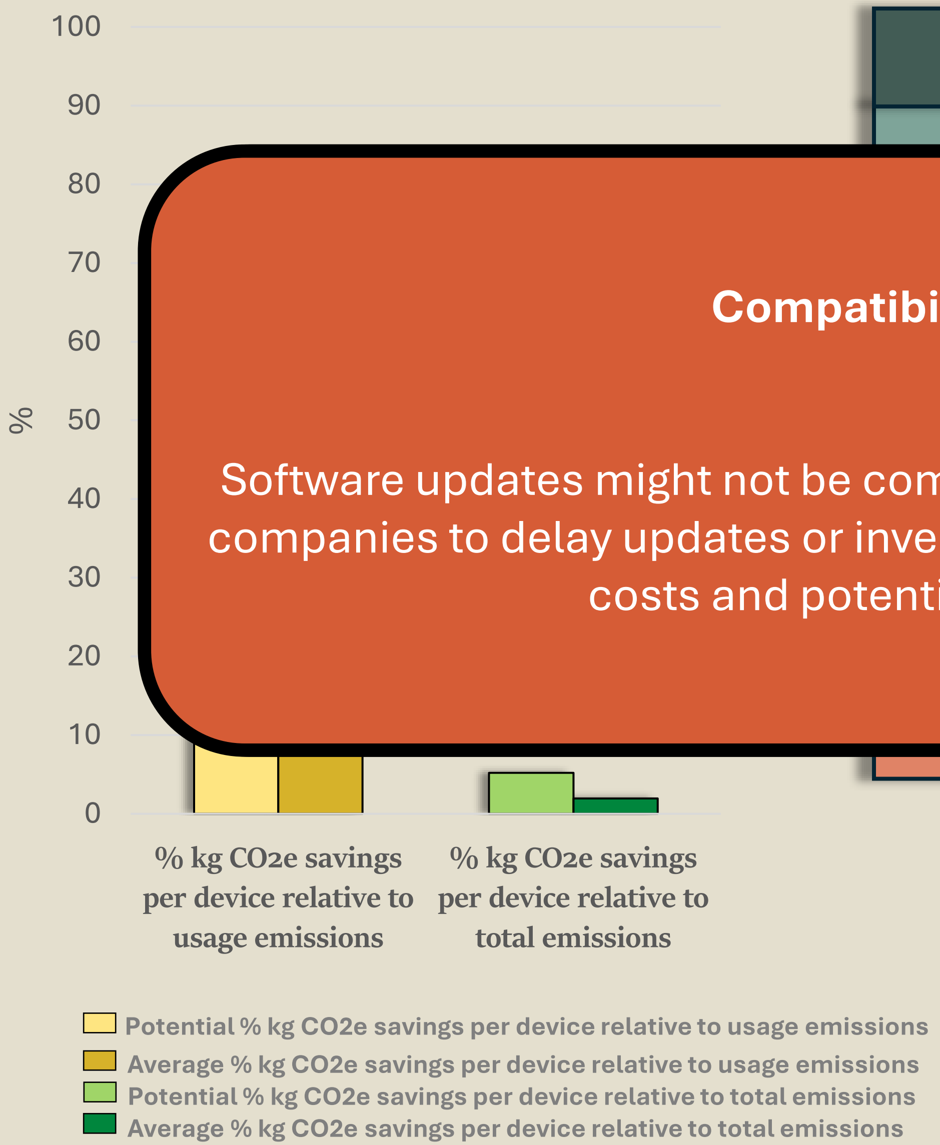


Overview

Back to Maintenance

Software optimization and updates



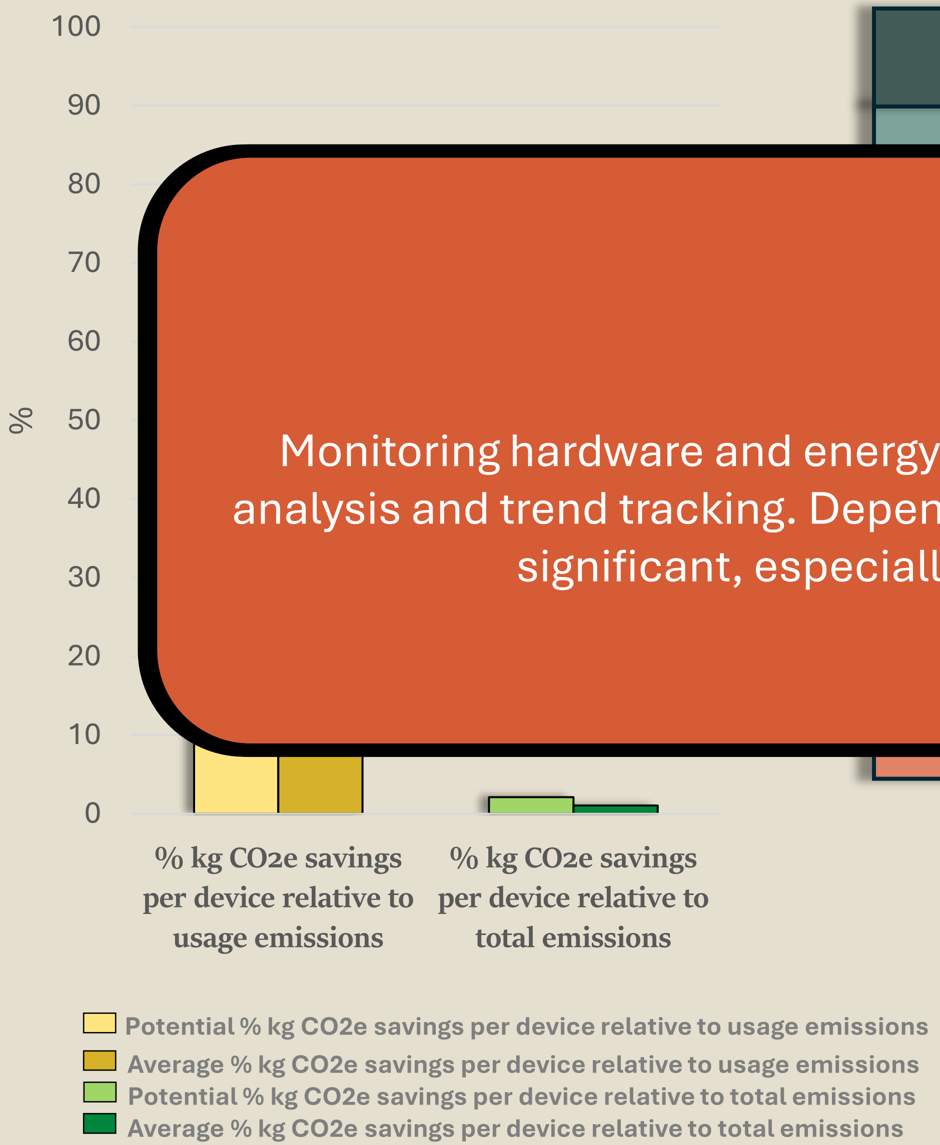
Tools

Compatibility Issues with Existing Software

Software updates might not be compatible with older business-critical applications, requiring companies to delay updates or invest in upgrades to these applications. This can lead to higher costs and potential delays in achieving optimal efficiency.

Back to Maintenance

Monitor Hardware Health



Tools

Data Storage Costs

Monitoring hardware and energy consumption generates data that needs to be stored for analysis and trend tracking. Depending on the volume of data collected, storage costs can be significant, especially if relying on cloud-based storage solutions.

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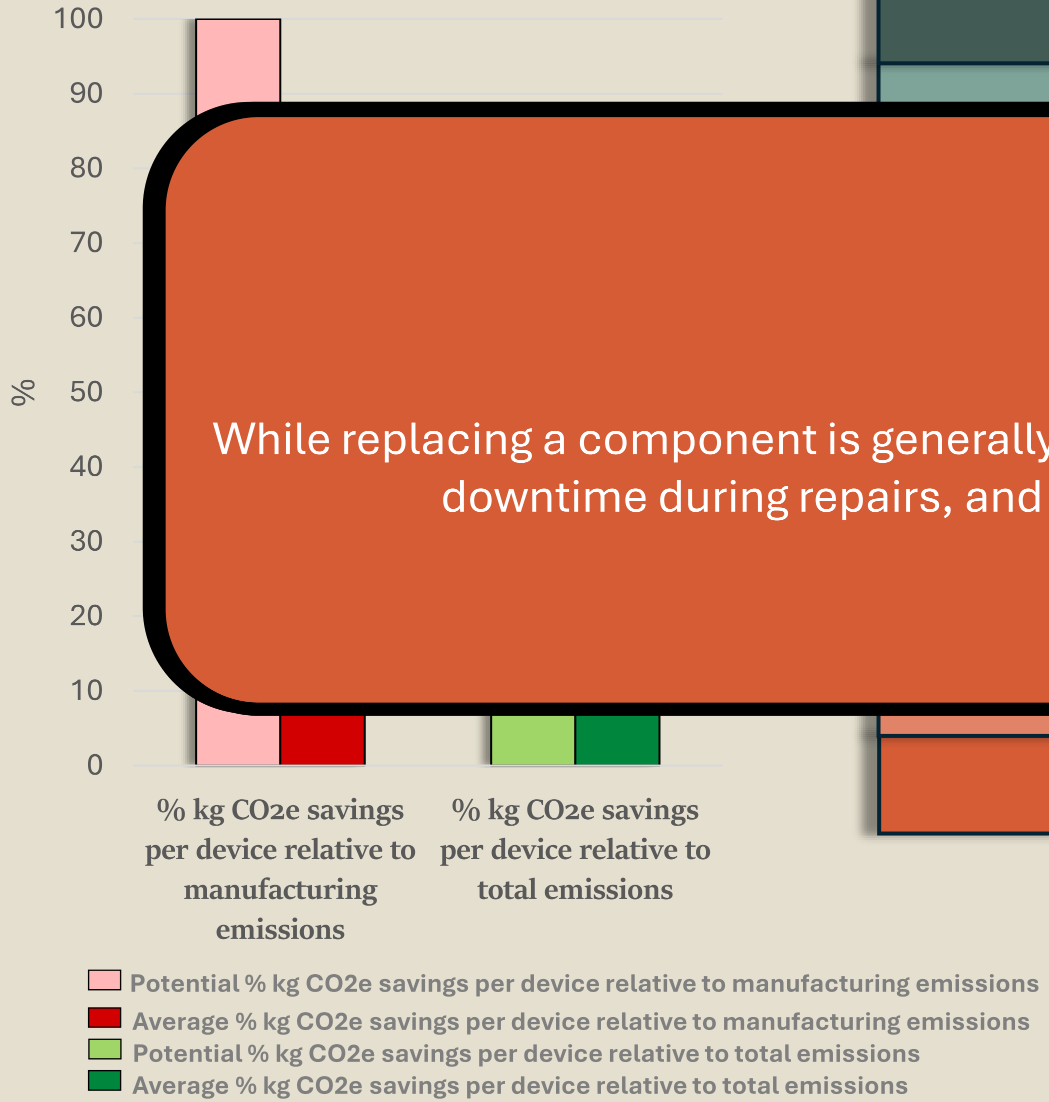
Component replacement instead of device replacement



Tools

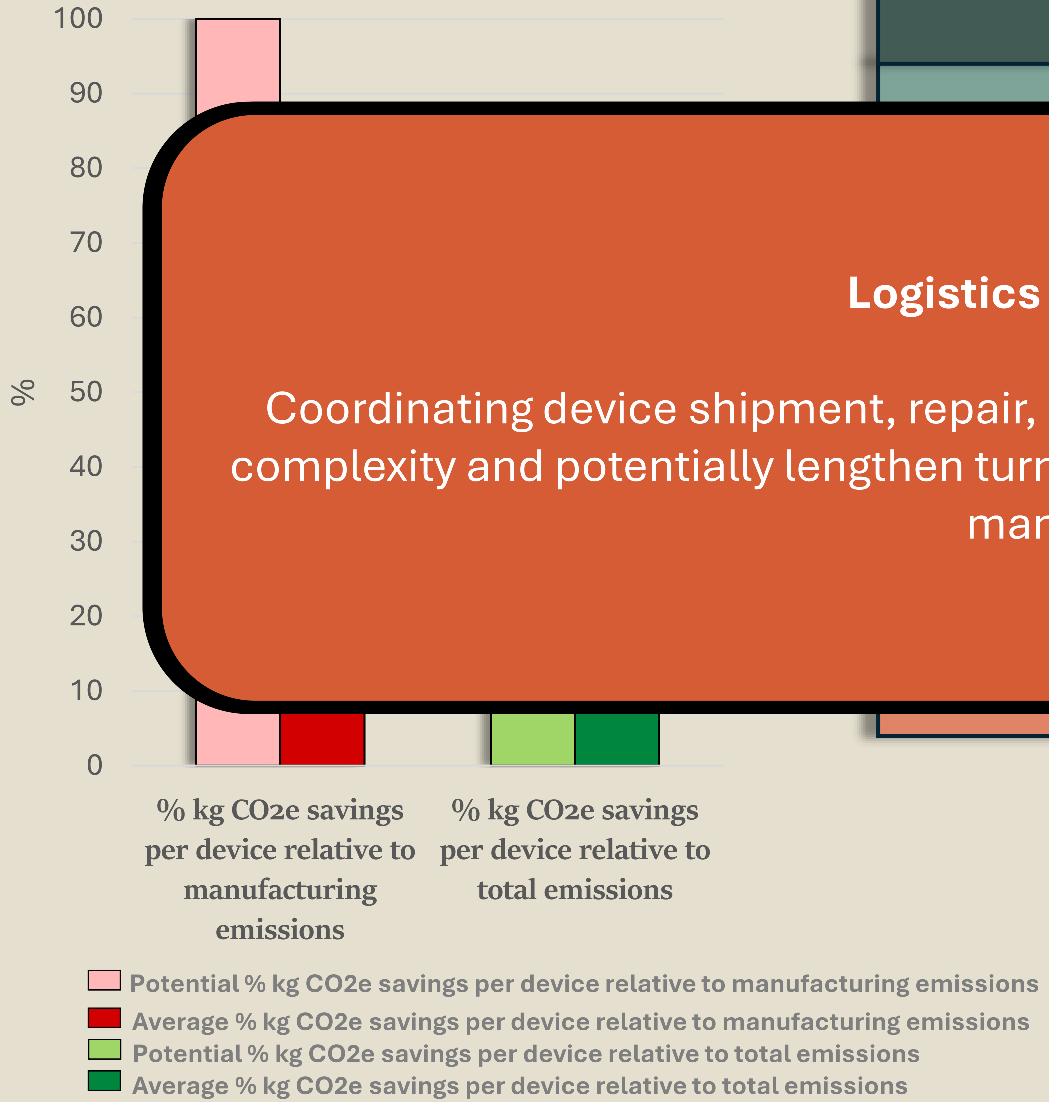
Hidden Costs

While replacing a component is generally cheaper than a new device, consider the cost of labor, downtime during repairs, and potential disposal fees for old components.

Hidden Costs

Back to Maintenance

Partner with repair specialist



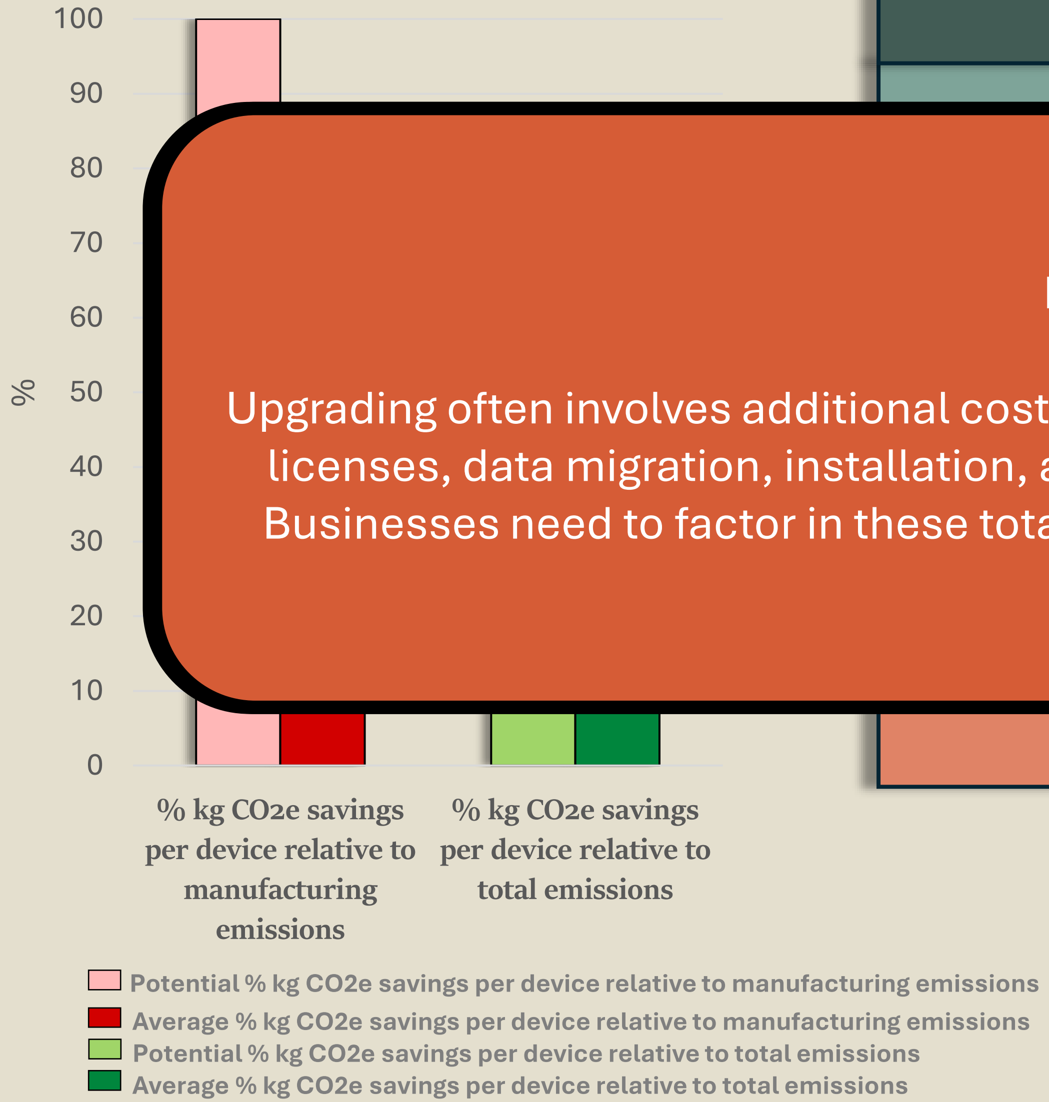
Tools

Logistics and Turnaround Times

Coordinating device shipment, repair, and return logistics with an external partner can add complexity and potentially lengthen turnaround times compared to in-house IT staff or on-site manufacturer repairs.

Back to Maintenance

Upgrade outdated devices



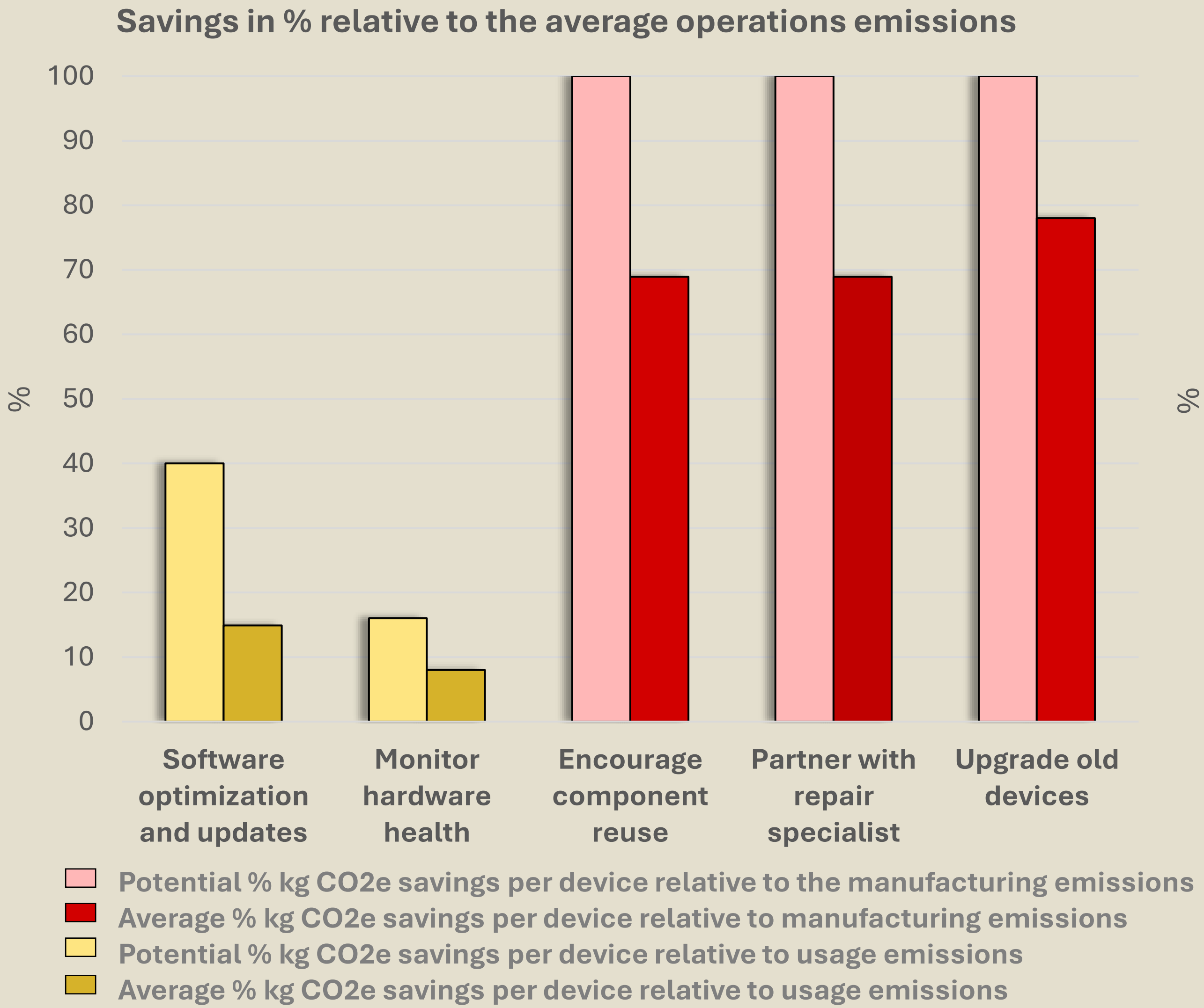
Tools
Hidden Costs

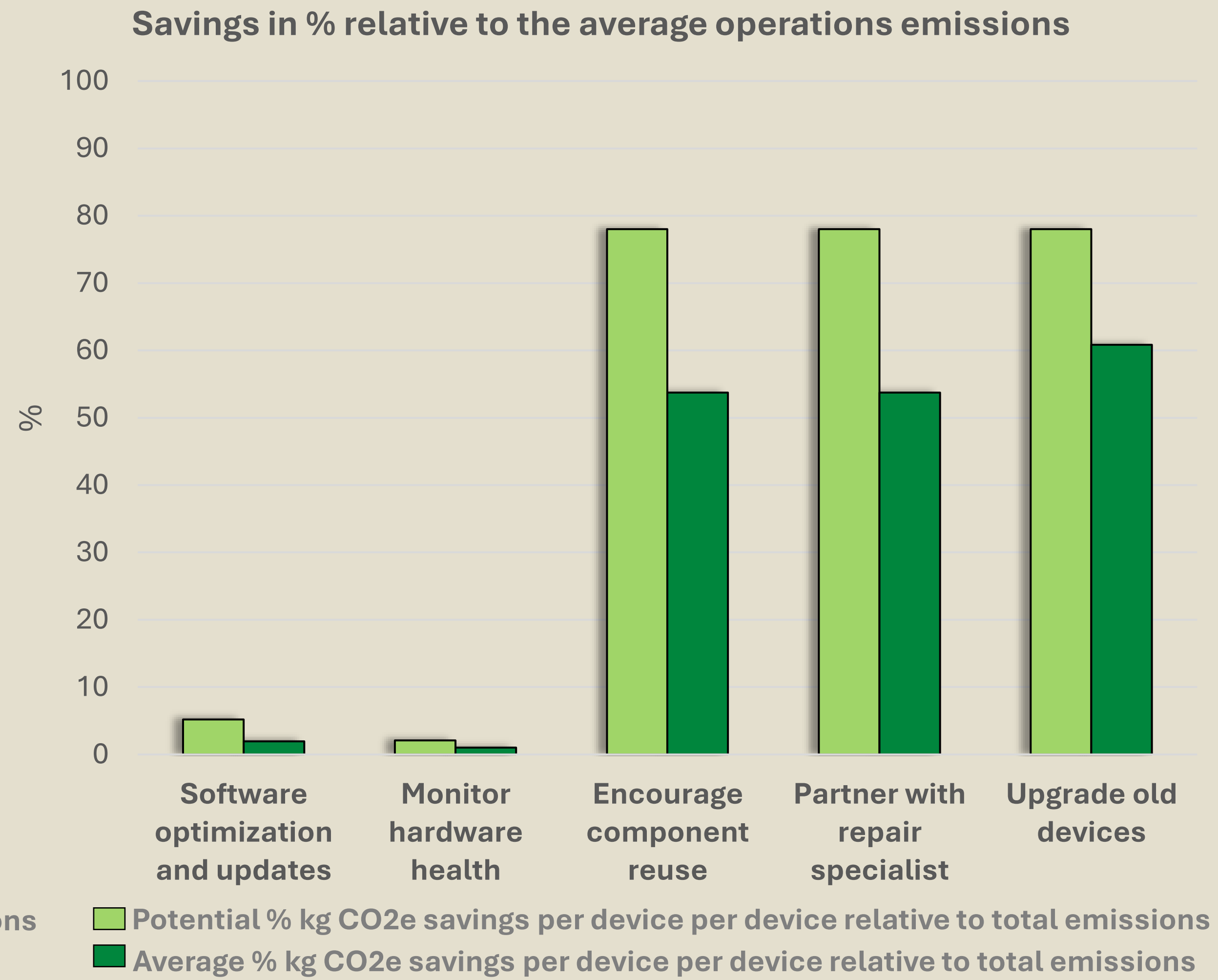
Hidden Costs

Upgrading often involves additional costs beyond the device itself. These can include software licenses, data migration, installation, and potential downtime during the upgrade process. Businesses need to factor in these total costs when evaluating the environmental benefits.

Back to Maintenance

Overview of effects of all possible improvements





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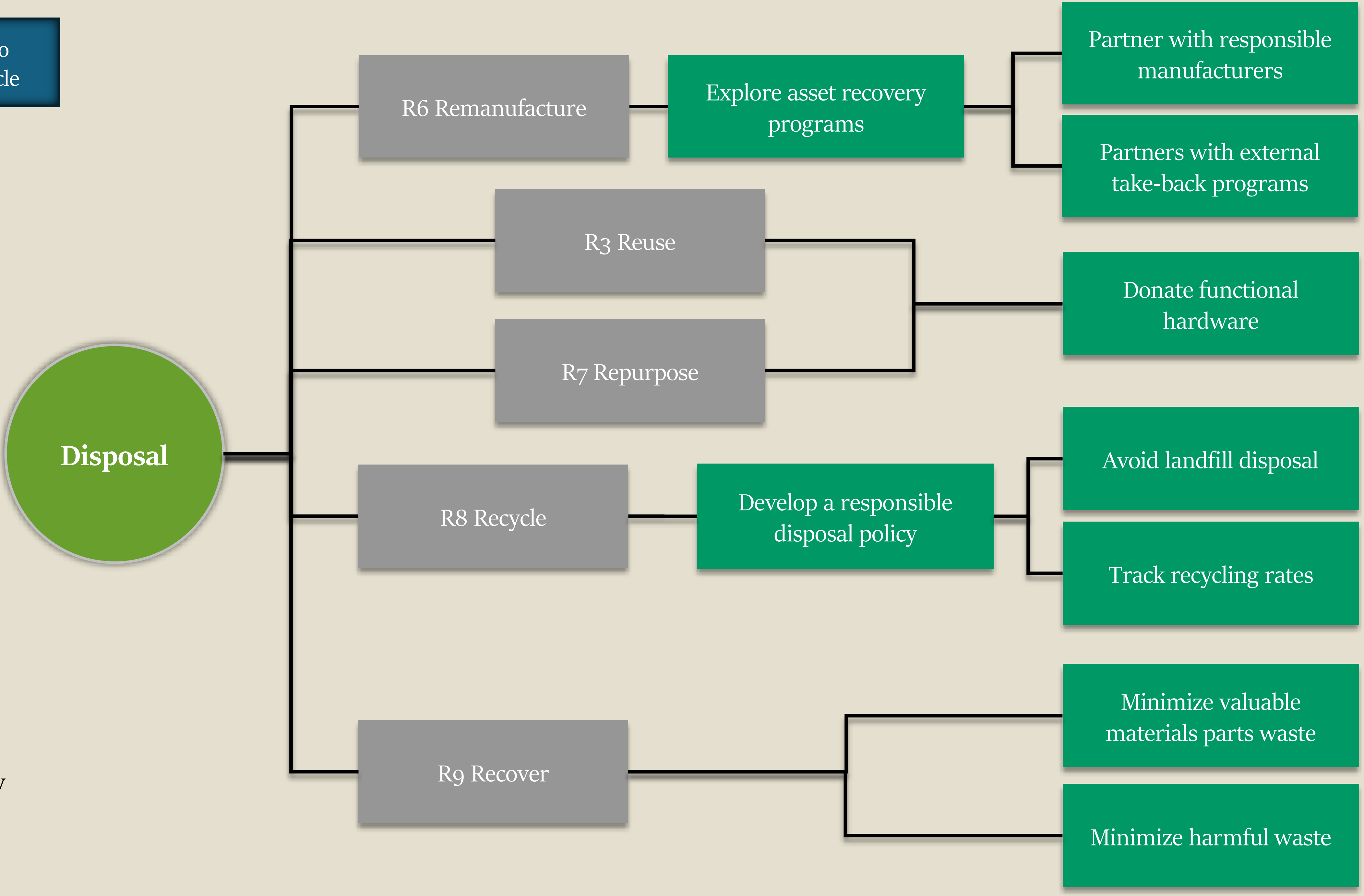
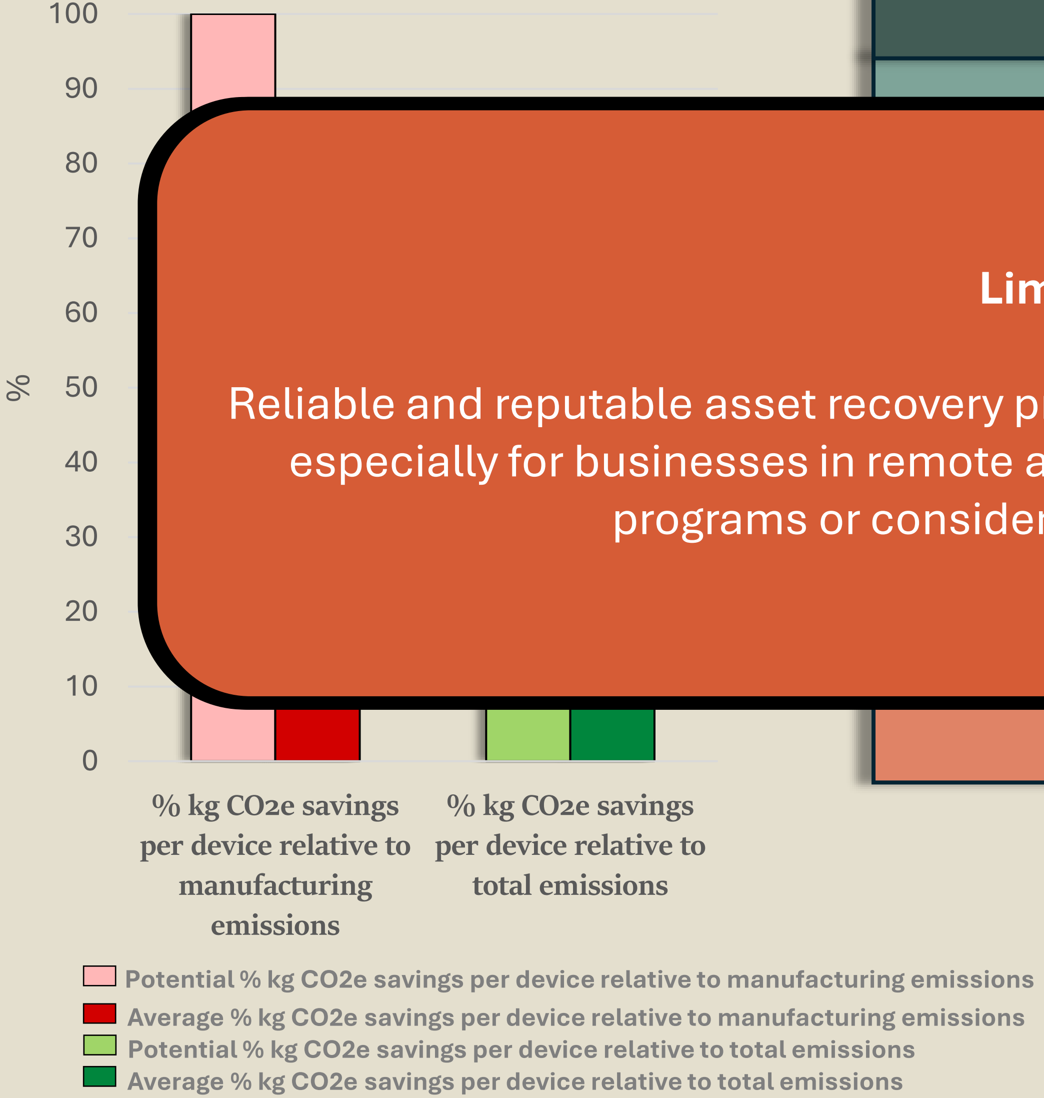


Overview

Back to Disposal

Explore IT asset recovery programs



Tools

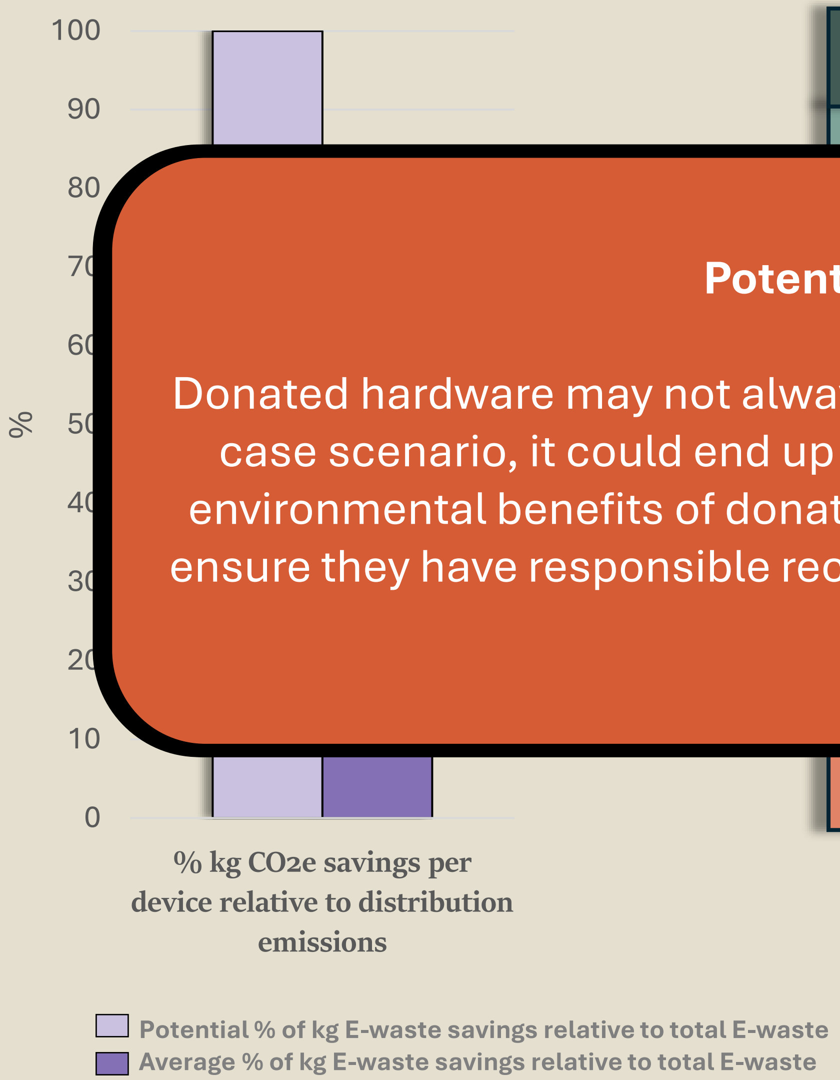
Limited Availability

Reliable and reputable asset recovery programs might not be readily available in all locations, especially for businesses in remote areas. Businesses might need to explore alternative programs or consider responsible self-disposal options.

Limited Availability

Back to Disposal

Donate Functional Hardware



Potential for Bypassing Proper Recycling

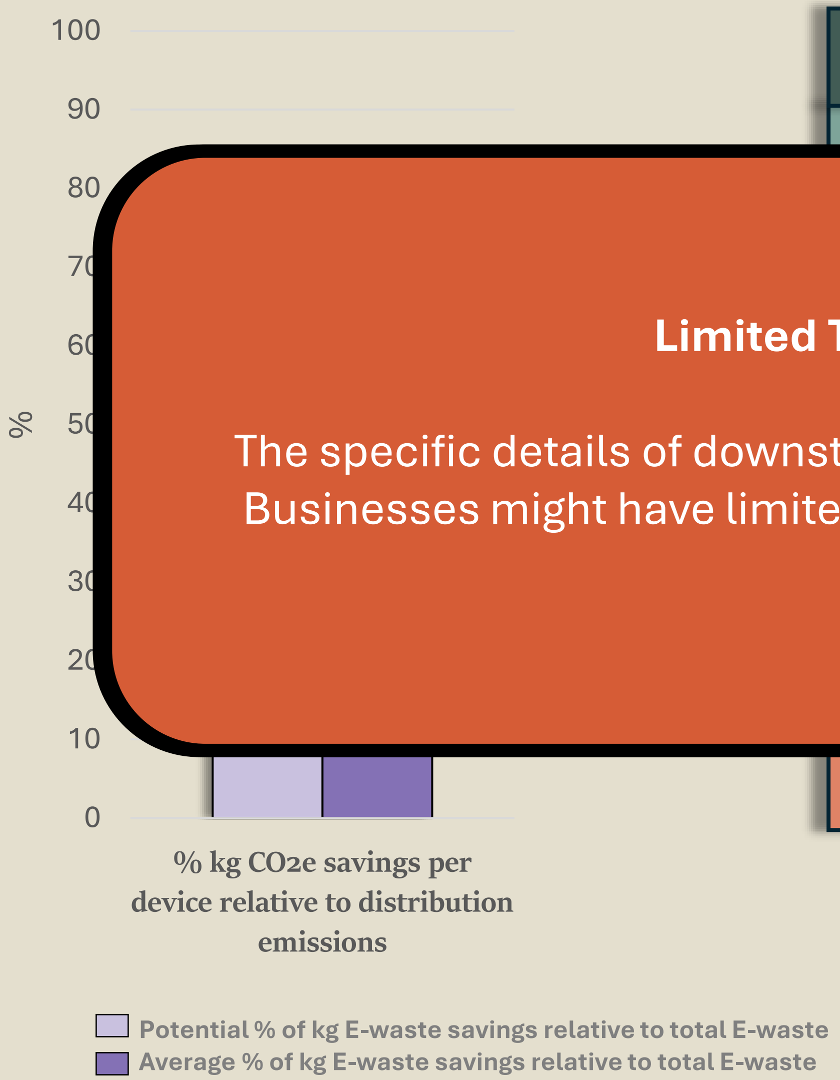
Donated hardware may not always be used for its intended purpose by recipients. In the worst-case scenario, it could end up improperly disposed of or recycled, potentially negating the environmental benefits of donation. Businesses need to carefully vet donation programs and ensure they have responsible recycling practices in place for equipment that cannot be utilized by recipients.

Tools

Potential for Bypassing Proper Recycling

Back to Disposal

Develop a Responsable Disposal Policy



Limited Transparency in Recycling Processes

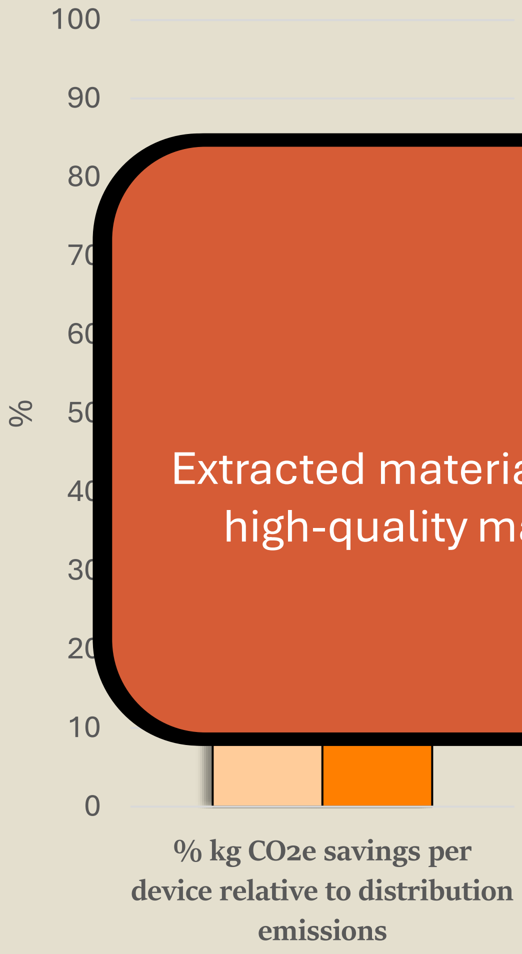
The specific details of downstream e-waste processing might not always be transparent. Businesses might have limited insight into the final destination and handling of recycled materials.

Tools

Limited Transparency in Recycling Processes

Back to Disposal

Minimize Valuable Materials parts waste



Potential % of kg valuable materials savings relative to total valuable materials
Potential % of kg valuable materials savings relative to total valuable materials

Tools

Purity of Recovered Material

Extracted materials might not be as pure as original materials, potentially limiting their reuse in high-quality manufacturing applications. Businesses need to consider the intended reuse applications of recovered materials.

Purity of Recovered Material

Back to Disposal

Minimize Harmful Waste

Tools
Waste Management Data

Potential for Misidentification or Mishandling

Accidental misidentification or mishandling of harmful waste can lead to serious environmental contamination and health risks. Businesses need to implement robust training procedures for personnel handling such waste.

Potential for Misidentification or Mishandling

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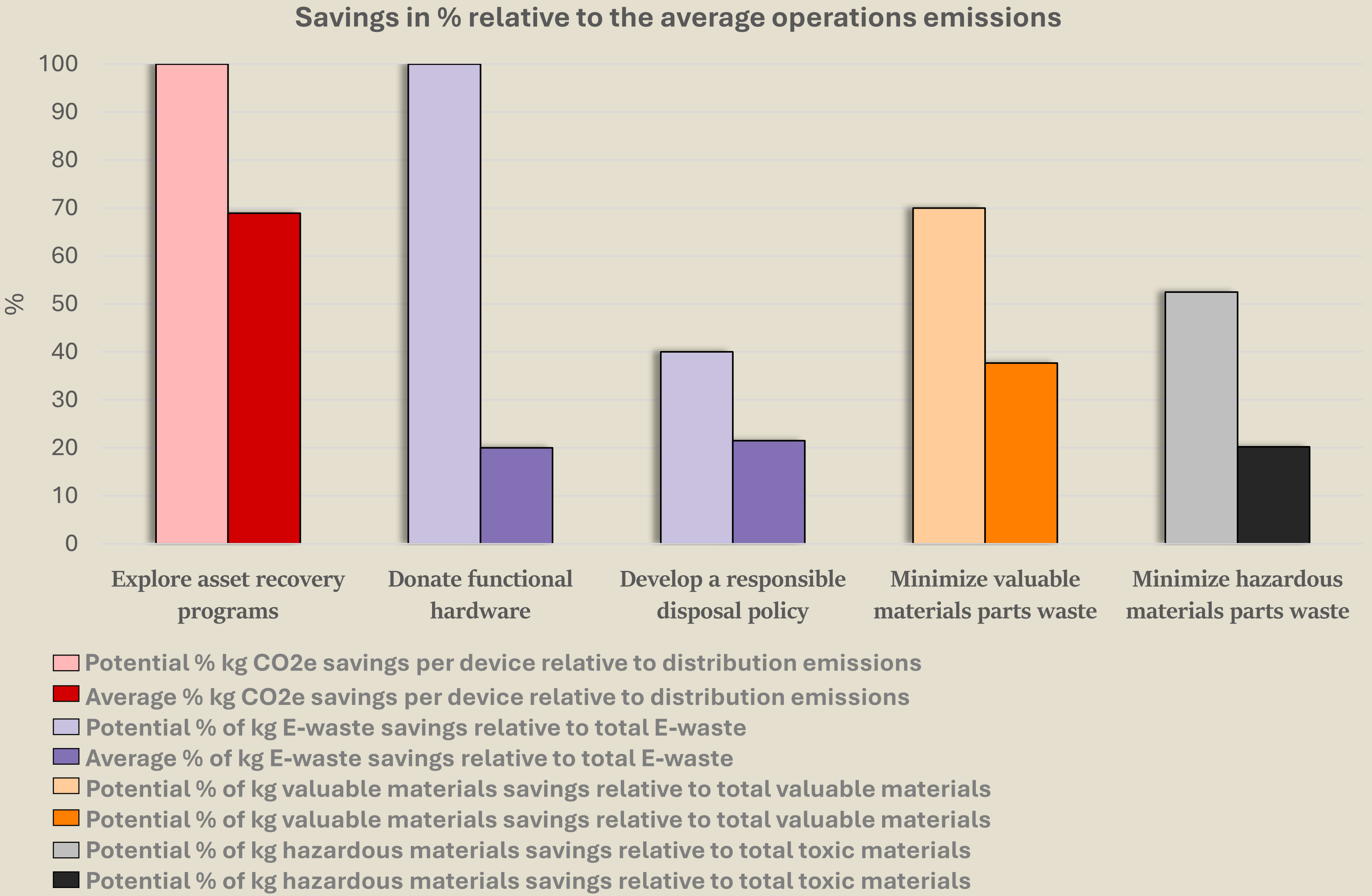
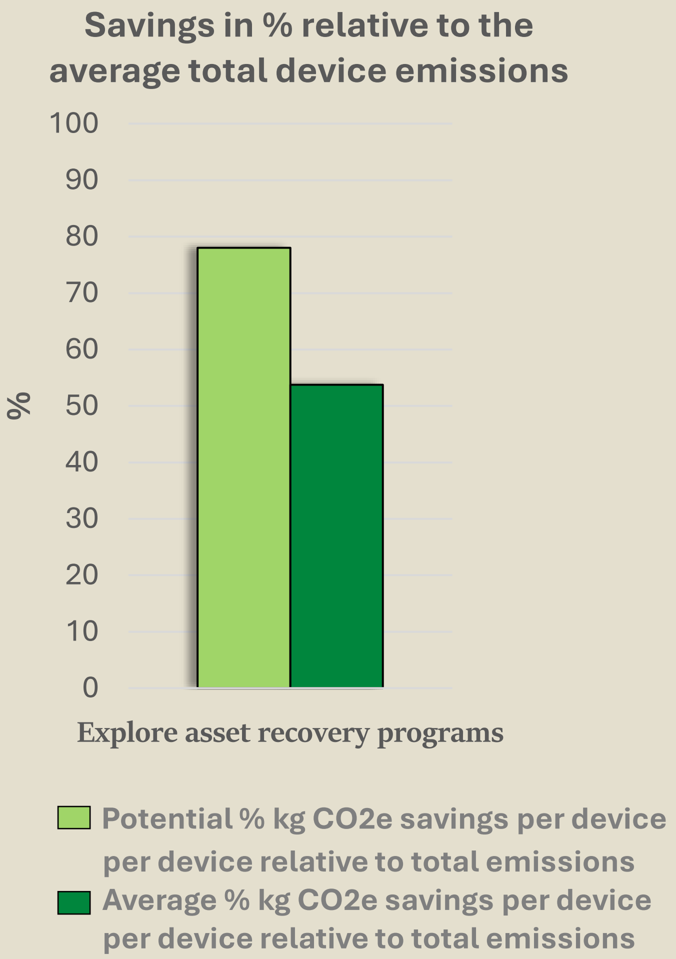
Overview of effects of all possible improvements





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Double Materiality Assessment (DMA)

The Double Materiality Assessment (DMA) is a component of the EU's Corporate Sustainability Reporting Directive (CSRD). It considers both the financial and sustainability materiality of a company's activities, considering their potential impact on the environment and society. Companies may use the DMA as a tool to define the scope of future ESG reports and reduce their environmental impact by identifying the most significant ESG topics across their entire value chain. The DMA is important for companies that want to demonstrate their commitment to sustainability and social responsibility and will be required to align their disclosures with the ESRS framework.

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Life Cycle Assessment (LCA)

Life Cycle Assessment (LCA) is a systems tool that assesses and improves the environmental performance of products by providing insights into the entire value chain. It is a helpful tool for reducing the environmental impact of IT hardware devices by providing a structured way to assess their impact through their entire lifecycle. By identifying environmental burdens associated with each stage of the lifecycle, companies can reduce their impact by optimizing their transportation methods, purchasing products with a lower carbon footprint, and incorporating End-of-Life design strategies. LCA allows companies to make informed decisions about IT hardware procurement and use, thereby contributing to a more sustainable future.

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Carbon Footprint Report (CFR)

The Carbon Footprint Report is a helpful tool in reducing the environmental impact of IT hardware devices by providing an accurate and specific understanding of the emissions caused by each process in the value chain. By identifying which processes have the highest emissions, companies can focus their efforts on reducing or optimizing those processes, such as purchasing IT hardware devices with a lower carbon footprint or optimizing their transportation methods. The report can also help companies identify areas where they can implement circular economy practices, such as recycling or refurbishing IT hardware devices at the end of their life cycle. By using the reports, companies can make informed decisions about their IT hardware procurement and use, thereby reducing their environmental impact.

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Emission factor

The emission factor is a tool that can help companies set a minimum standard for the environmental impact of their IT hardware procurement by using a standard emissions factor for devices purchased or E-waste which could not be recycled. It is particularly useful in situations where no carbon footprint report is available, and companies can track their progress over time and compare their emissions to industry benchmarks. However, it is important to note that this approach is less accurate and may not provide a complete understanding of the environmental impact of IT hardware devices. Therefore, it is recommended to only use this approach when a lack of data is available.

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Product Environmental Footprint (PEF)

The Product Environmental Footprint (PEF) is a helpful tool in reducing the environmental impact of IT hardware devices as it provides a comprehensive understanding of the environmental impact of a product throughout its lifecycle. By identifying which stages in the lifecycle of the IT hardware contribute most substantially to each environmental impact category, companies can focus their efforts on reducing or optimizing those stages, such as purchasing IT hardware devices with a lower carbon footprint or optimizing their transportation methods. The PEF method also encourages using recycled materials in new products, producing easier-to-disassemble products, and using recycled materials in production. By using the PEF method, companies can make informed decisions about their IT hardware procurement and use, thereby reducing their environmental impact.

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Organization Environmental Footprint (OEF)

The Organization Environmental Footprint (OEF) is a helpful tool in reducing the environmental impact of IT hardware devices as it measures the environmental impact of an organization. By identifying which areas of the organization have the highest environmental impact, companies can focus their efforts on reducing or optimizing those areas, such as implementing circular economy practices and reducing waste. The OEF method also provides valuable insights into the environmental impact of a company's supply chain, allowing companies to choose suppliers with a lower environmental impact. By using the OEF method, companies can make informed decisions about their overall environmental impact, including that of their IT hardware devices.

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Energy Star (Label)

The Energy Star label is a trusted, government-backed symbol for energy efficiency, helping consumers save money and protect the environment through energy-efficient products and practices. The label was established to reduce greenhouse gas emissions and other pollutants caused by the inefficient use of energy and make it easy for consumers to identify and purchase energy-efficient products that offer savings on energy bills without sacrificing performance, features, and comfort. For IT hardware devices, the Energy Star label can identify products such as monitors and computers that meet energy efficiency requirements, helping companies reduce their energy consumption and carbon footprint. By choosing products with the Energy Star label, companies can make informed decisions about their energy consumption, save money on energy bills, and contribute to a more sustainable future.

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EPEAT (Label)

The EPEAT label is a global ecolabel for electronics and technology products, managed by the Global Electronics Council. EPEAT measures the social and environmental impacts of products from extraction to end of life, and drives change at a global scale by measuring the sustainability of products. For companies, the EPEAT label can be a helpful tool in reducing the environmental impact of IT hardware devices by identifying products that meet sustainability criteria, including the reduction of carbon emissions and other environmental impacts throughout their lifecycle. By using products with the EPEAT label, companies can make informed decisions about their IT hardware procurement and use, reduce their environmental impact, and contribute to a more sustainable future. The EPEAT label can be a useful tool for large companies that are committed to sustainability and want to set an example for their employees and customers, encouraging them to prioritize environmentally friendly options.

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TCO Certified (Label)

The TCO Certified label is a sustainability certification for IT products that helps companies reduce the environmental impact of their hardware devices. The certification includes a comprehensive system of up-to-date criteria, independent verification, and a structured system for continuous improvement to drive real and lasting change. By choosing TCO Certified products, companies can ensure that the IT hardware devices they purchase meet strict environmental and social criteria that go beyond legislation and industry standards, including hazardous substances, circularity, socially responsible manufacturing, and environmentally responsible manufacturing. The certification process also includes mandatory and continuous independent verification, verifying compliance with all criteria by accredited experts. TCO Certified is a helpful tool for companies looking to reduce the environmental impact of their IT hardware devices and contribute to a more sustainable future.

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ESG benchmarking

ESG benchmarking is a tool that can help companies reduce the environmental impact of their IT hardware devices by comparing their environmental, social, and governance (ESG) performance against peers within their industry. By benchmarking their ESG performance, companies can identify areas for improvement and streamline operations, leading to reduced environmental impact. ESG benchmarking involves a systematic process of measuring and evaluating a company's environmental impact, social practices, and governance standards relative to its peers, offering context on performance, targets, and strategies. It gives companies accurate, comparable data that can demonstrate the value of their ESG program and attract socially responsible investors. By using ESG benchmarking, companies can evaluate their performance across different ESG criteria, set measurable targets for improvement, monitor their progress, and report their achievements to stakeholders. This can help companies improve their ESG ratings and rankings, identify gaps, and comply with regulations.

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Supply Chain Sustainable Performance Measurement

Supply Chain Sustainable Performance measurement is a tool used to evaluate the environmental impact of supply chains over a period, based on established principles of sustainable supply chain management. It can be helpful for companies trying to reduce the environmental impact of their IT hardware devices, as it uses economic sectors and evaluates their environmental impact at a sectoral level in specific countries as well as part of the global value chain. The tool calculates direct and indirect environmental effects, evaluates emissions and resource consumption intensities and footprints, and highlights the advantages of using a framework to account for all upstream supply chain environmental impacts throughout entire global supply chains. The tool also provides a measurement of environmental performance of key industries and an opportunity to assess technical and technological change during the investigated period. By using supply chain sustainable performance measurement, companies can identify areas for improvement and take steps to reduce their environmental impact throughout their supply chain.

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IT Incident management

IT incident management is a process that aims to restore normal service operations as quickly as possible and minimize business impact by diagnosing incidents and identifying their root causes. A new approach has been proposed to diagnose application incidents by effectively searching for relevant co-occurring and reoccurring incidents. This approach can be a helpful tool for companies to reduce the environmental impact of IT hardware devices by identifying and resolving incidents that may cause unnecessary energy consumption or waste.

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Waste Management Data

Waste management data refers to information about the composition of waste materials, including their physico-chemical properties, which can have a crucial impact on the environmental emissions associated with waste treatment, recycling, and disposal. This data can be used to identify the most sustainable solutions for reducing the environmental impact of IT hardware devices. However, waste composition data is often poorly justified and heavily reliant on secondary sources, which can result in high uncertainty. A Global Sensitivity Analysis (GSA) approach can be used to systematically assess the importance of waste composition data and identify critical chemical properties of waste that have an important contribution to the uncertainty. By including the effects of waste composition and justifying its uncertainty, waste management data can be a helpful tool for companies to reduce their environmental impact and contribute to a more sustainable future.

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Financial Reporting

Financial reporting is preparing and presenting financial information to stakeholders. It can help companies reduce the environmental impact of IT hardware devices by providing insights into costs associated with usage, maintenance, and disposal. Companies can identify opportunities to reduce waste and invest in sustainable IT hardware devices by tracking energy consumption costs and analyzing hardware options. Financial reporting can be a useful tool for companies to make informed decisions and adopt sustainable practices.

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Facilities Management

Facilities management (FM) is the practice of ensuring efficient building operation. Sustainable FM balances social, economic, and environmental impacts. By reducing energy, water, and waste, SFM can reduce the environmental impact of IT hardware devices and identify areas for investment in sustainable devices. The FM sector promotes policies and practices that source environmentally friendly products. The adoption of sustainability principles in FM requires collaborative partnerships that promote health, safety, and well-being practices.

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Energy Consumption Management

Energy consumption management of IT hardware is the measurement and monitoring of energy consumed during the use phase, which contributes to the environmental impact of the hardware. Companies can reduce the environmental impact of their IT hardware by measuring and managing energy consumption through the adoption of ICT impact measurement indicators (ICTIMIS). Companies prefer easy-to-measure and understand indicators related to energy consumption and efficiency, with clear connections to monetary consequences such as costs and savings. The easy collection of data, no or low influence on hardware performance, and easy-to-understand results are factors that influence the application of ICTIMIS in companies.

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Social Innovation Approach

The Social Innovation Approach is a type of innovation that aims to address sustainability challenges and targets social concerns directly. It focuses on social values, processes, and impacts, and complements established innovation typologies. It emphasizes social success factors, such as social systems and agency, rather than political and technological factors. By taking this approach, companies can reduce the environmental impact of their IT hardware by involving employees and stakeholders in the process, and implementing a circular economy model.

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Digital Product Passport (DPP)

The Digital Product Passport (DPP) is a tool that uses blockchain technology to collect and share detailed product data, focusing on sustainability, environmental impact, and recyclability. It improves traceability, supply chain transparency, and helps businesses comply with regulatory requirements. DPPs also engage consumers by providing accessible sustainability information, building trust, and promoting informed purchasing decisions. Overall, DPPs enable businesses to reduce their environmental footprint, contribute to a circular economy, and build stronger relationships with consumers and stakeholders through increased transparency and trust.

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General info on thesis

A Decision Support System for Sustainable IT Hardware Management in European Businesses

Strategies and Impacts of Regulatory Compliance and Environmental Improvements Across the IT Hardware Life Cycle

By

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in partial fulfilment of the requirements for the degree of
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in Engineering and Policy Analysis
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Research questions

Main research question:
What decision support system can support businesses in implementing or improving their sustainability management of IT hardware assets across each stage of their life cycle?

Sub Question 1:
How are European businesses affected by current and future regulations regarding the sustainable management of their IT hardware devices?

Sub Question 2:
What is the current e-waste problem and how can businesses influence and measure the sustainability of their IT hardware throughout its life cycle?

Sub Question 3:
Which improvements can businesses make in the different stages of the IT hardware life cycle to reduce their environmental impact and what tools can be used for this?

Sub Question 4:
What are the potential effects and dilemmas of these proposed improvements, and how can businesses address them?

Sub Question 5:
What decision support system can be set up to support companies in improving the sustainability of their IT hardware life cycle?

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Recommendations

Recommendations for utilizing the Decision Support System

Integrate the DSS into corporate sustainability strategies and IT management policies to systematically incorporate sustainability considerations across IT hardware life cycle stages.

Collaborate with stakeholders to optimize DSS implementation, ensuring alignment with company-specific contexts and sustainability goals.

Consider company-specific contexts when applying DSS recommendations to ensure alignment with sustainability goals and operational needs.

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European regulations regarding sustainability in businesses

The decision support system focuses on three key regulations: the European Green Deal, the Corporate Sustainability Reporting Directive (CSRD), and the proposed Corporate Sustainability Due Diligence Directive (CSDDD). These regulations are vital for European businesses because they push towards climate neutrality by 2050 and promote sustainable practices in IT hardware management.

The European Green Deal sets the vision for sustainability, including energy efficiency and circular economy practices. The CSRD requires large companies to report their environmental impacts starting in 2024. The CSDDD mandates businesses to identify and mitigate negative environmental impacts in their operations and supply chains. These regulations ensure compliance, drive innovation, and support responsible resource management in IT hardware practices.

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European Green Deal

The European Green Deal, launched by the European Commission in December 2019, is a comprehensive plan to achieve climate neutrality by 2050. It addresses various aspects such as climate, environment, energy, transport, industry, agriculture, and sustainable finance.

This Deal is crucial for the decision support system because it sets the sustainability framework that businesses must follow. By aligning with the principles of the Green Deal, the decision support system can guide companies in making environmentally responsible choices for managing their IT hardware, ensuring compliance with regulations, and contributing to broader climate goals.

Energy / Fit for 55

- EU Forest Strategy for 2030
- EU Chemicals Strategy for Sustainability
- Nature Restoration Law
- EU Biodiversity Strategy for 2030
- EU Strategy on Adaptation to Climate Change
- Right to Repair Directive
- Circular Economy Action Plan
- Clean Energy Initiatives
- Fit for 55 Package
- European Climate Law

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Corporate Sustainability Due Diligence Directive

The Corporate Sustainability Reporting Directive (CSRD), effective January 5, 2023, mandates large European companies to report on social and environmental impacts starting in 2024, with reports published in 2025. It applies to companies meeting at least two criteria: over 250 employees, more than 50 million euros in annual turnover, or over 25 million euros on the balance sheet. Small and medium-sized listed companies will start reporting in 2027. The directive requires reporting on various environmental aspects, such as Greenhouse Gas Emissions, Energy Consumption, and Waste Management. The diagram highlights the relevant aspects for IT hardware sustainability management in this research in **red**.

Risk and … for s… environm…

Labor practices

H… R…

…s

Impact on people

Greenhouse Gas Emissions

Energy Consumption and Efficiency

Water Management

Biodiversity and Ecosystem Impact

Waste Management

Pollution and Emissions

Circular Economy Practices

Environment… Risks and Opportunitie…

Back to Regulations

Corporate Sustainability Due Diligence Directive

The Corporate Sustainability Due Diligence Directive (CSDDD) is a proposed EU regulation requiring large companies to identify and mitigate negative environmental impacts across their operations. Unlike the Corporate Sustainability Reporting Directive (CSRD), which focuses on reporting environmental impacts, the CSDDD mandates companies to take actionable steps to reduce these impacts.

The CSDDD is crucial for this decision support system as it compels businesses to make sustainable decisions actively. The system will guide companies in managing their IT hardware in a way that complies with the CSDDD, helping them reduce their environmental impact proactively. While the decision support system can already aid companies interested in sustainability, its full relevance will be realized once the CSDDD is implemented, shifting focus from merely reporting impacts to actively reducing them.

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Effects of Improper E-waste Disposal

Valuable and Hazardous Materials in E-waste

E-Waste of the Basic IT Hardware Devices

Emissions of the Basic IT Hardware Devices

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E-Waste problem

Effects of Improper E-waste Disposal

Understanding e-waste effects is critical due to environmental contamination from hazardous substances like lead and mercury, which harm soil and water. Improper disposal also threatens human health with risks of respiratory issues and neurological disorders. Moreover, e-waste depletes valuable resources like gold and copper, worsening global scarcity. Addressing these issues through sustainable practices is essential to mitigate pollution, protect health, conserve resources, and promote a circular economy.

Pollution

Disposal time

Toxic

Scarce materials

Not recycled

Fast growing

Not documented

Back to
E-Waste problem

Valuable Materials in E-waste

Hazardous Materials in E-waste

Back to E-Waste problem

Hazardous Materials in E-waste

Devices / Materials	Television	Mo	Webcam
Plastic			
Lead			
Mercury			
Arsenic			
Cadmium			
Brominated Flame Retardants			

This page shows the hazardous materials which can be found in each of the basic IT hardware devices. Understanding what hazardous materials are found in these basic IT hardware devices is important to get an idea of which devices are even more important to recycle than others. Additionally, this knowledge promotes the importance of separating materials when recycling, as proper separation ensures that hazardous substances are handled safely, and valuable materials are efficiently recovered.

The **green** areas show that the material is likely to be found in the devices. The **orange** shows that the material can be found in the devices but that is very much depends on the specific type and version of the device. The **red** area indicates that the material is not likely to be found in the device.

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E-Waste problem

Valuable Materials in E-waste

This page shows the valuable and scarce materials which can be found in each of the basic IT hardware devices. The resources which are extracted from earth are finite, but some resources are much rarer than others. For many electronic devices, materials are used which will cease to exist in the future when not recycled. By understanding this we can reduce the need for further mining and its associated environmental impact, preserving the planet for future use.

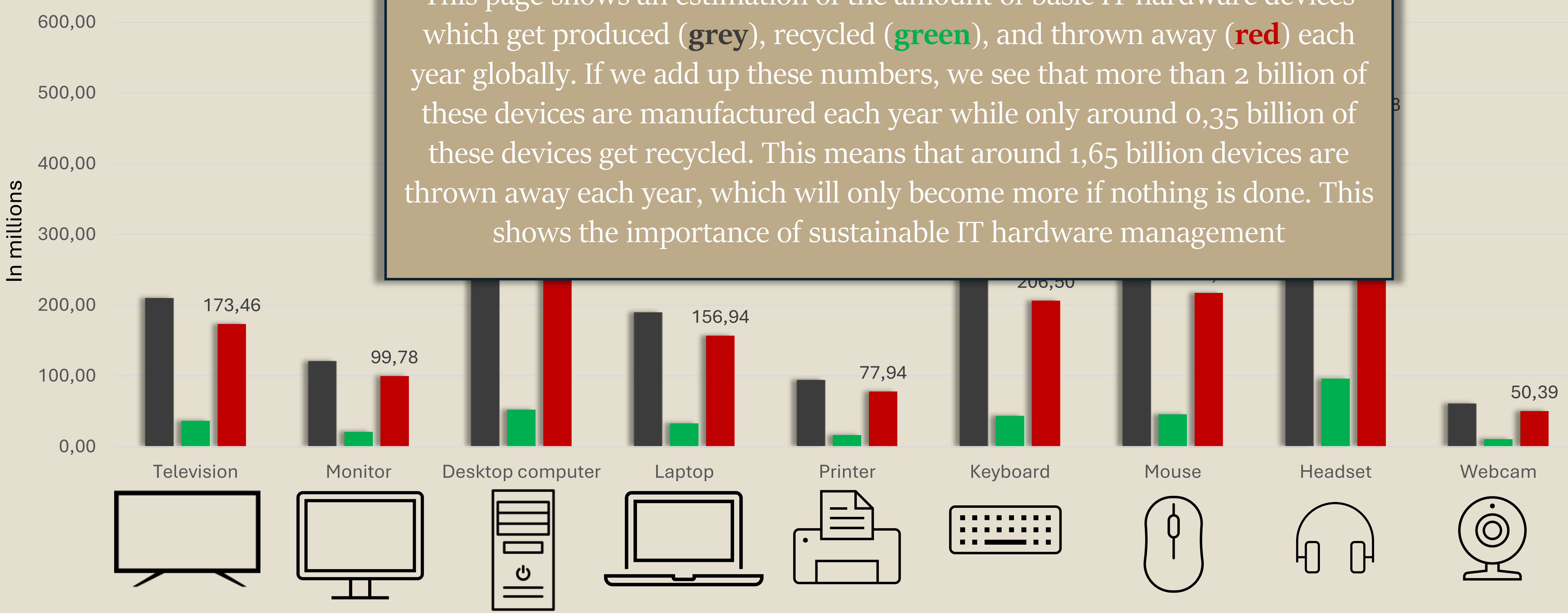
The **green** areas show that the material is likely to be found in the devices. The **orange** shows that the material can be found in the devices but that is very much depends on the specific type and version of the device. The **red** area indicates that the material is not likely to be found in the device.

Devices / Materials	Television	Mo	Webcam
REEs			
Indium			
Gallium			
Tantalum			
Cobalt			
Lithium			
Gold			

Back to
E-Waste problem

E-Waste of the Basic IT hardware Devices

This page shows an estimation of the amount of basic IT hardware devices which get produced (**grey**), recycled (**green**), and thrown away (**red**) each year globally. If we add up these numbers, we see that more than 2 billion of these devices are manufactured each year while only around 0,35 billion of these devices get recycled. This means that around 1,65 billion devices are thrown away each year, which will only become more if nothing is done. This shows the importance of sustainable IT hardware management



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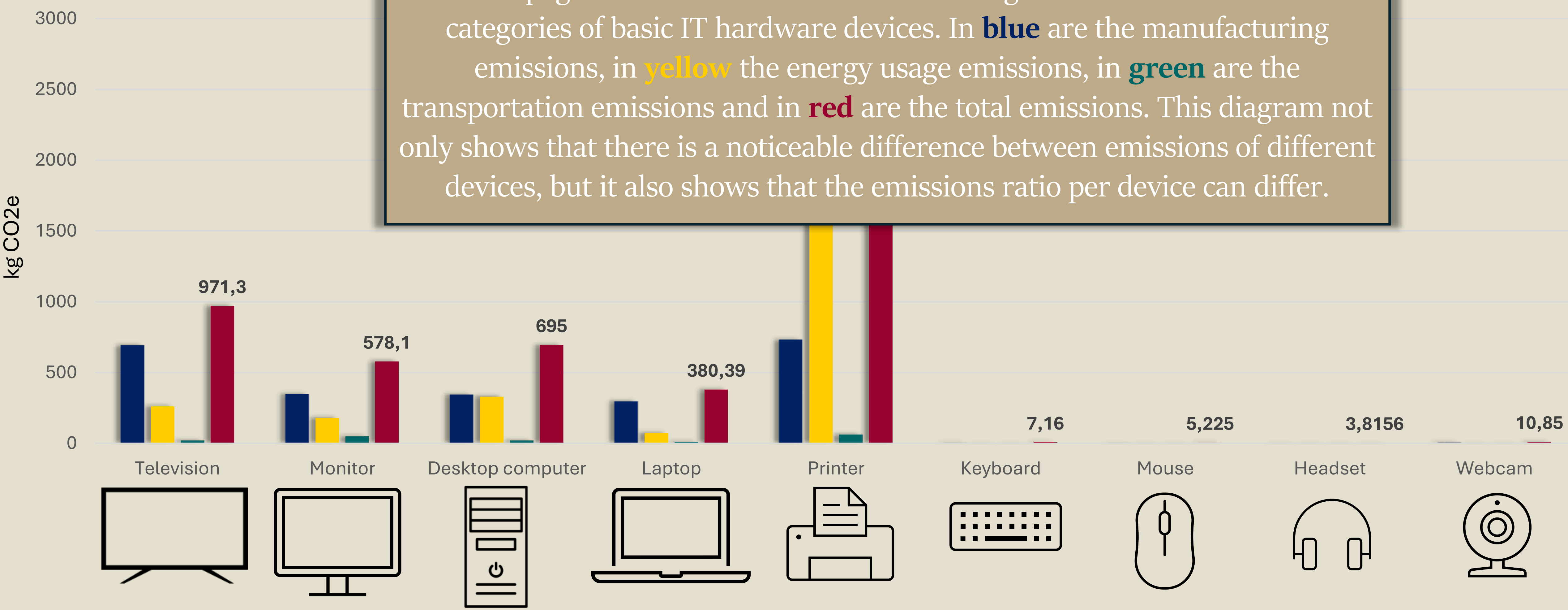
E-Waste problem

Emissions of the Basic IT hardware Devices

This page shows an estimation of the average emissions in different categories of basic IT hardware devices. In **blue** are the manufacturing emissions, in **yellow** the energy usage emissions, in **green** are the transportation emissions and in **red** are the total emissions. This diagram not only shows that there is a noticeable difference between emissions of different devices, but it also shows that the emissions ratio per device can differ.



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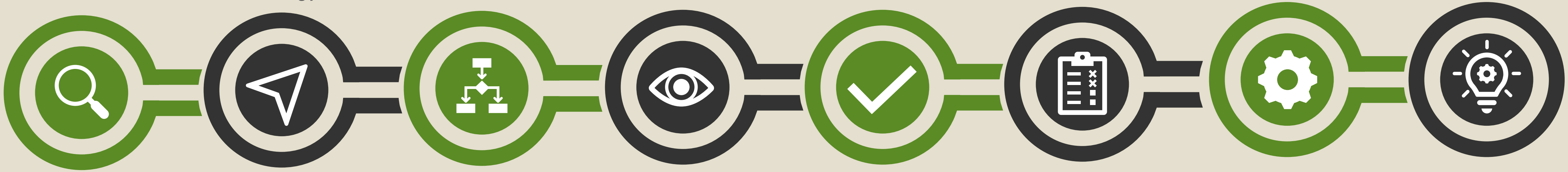
How to use the DSS



Identify Emissions

Find where emissions are highest in IT hardware processes—manufacturing, transportation, usage, or disposal. This pinpoints areas needing the most environmental focus.

Locate the Life Cycle Stage

Determine which stage (procurement, distribution, operations, maintenance, disposal) generates the most emissions. Target interventions accordingly.

Access the Relevant Stage

Navigate to the corresponding stage in the DSS for tailored solutions to specific challenges and emission sources.

Review Improvement Effects

Check how potential improvements can reduce environmental impact at each stage. Prioritize actions with the biggest benefits.

Select Applicable Improvements

Choose feasible improvements based on cost-effectiveness and emission reduction potential for your company's context.

Consider Dilemmas

Explore the dilemmas linked to implementing improvements to mitigate risks and ensure smooth transitions.

Explore Implementation Tools

Explore the different tools which can help with the implementation for the potential improvements

Apply the Improvement

Implement chosen improvements, monitor progress, and adjust as needed to achieve lasting environmental benefits.

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9R Framework

R0 Refuse

se

R4

The 9R framework is a framework used to evaluate and improve sustainability practices, particularly in the context of the circular economy. It identifies nine strategies, know as the 9Rs. These strategies aim to transform a linear economy (where resources are used once and then discarded) into a circular economy (where resources are continually reused and recycled). The 9R framework is applied to this DSS to analyze the entire lifecycle of IT hardware in businesses, from procurement and distribution to operations, maintenance, and disposal. By linking the 9Rs to each lifecycle stage, the framework helps identify strategies to conserve resources and minimize environmental impact.

R8 Recycle

R7 Repurpose

R9 Recover

Back to Procurement

Back to Distribution

Back to Operations

Back to Maintenance

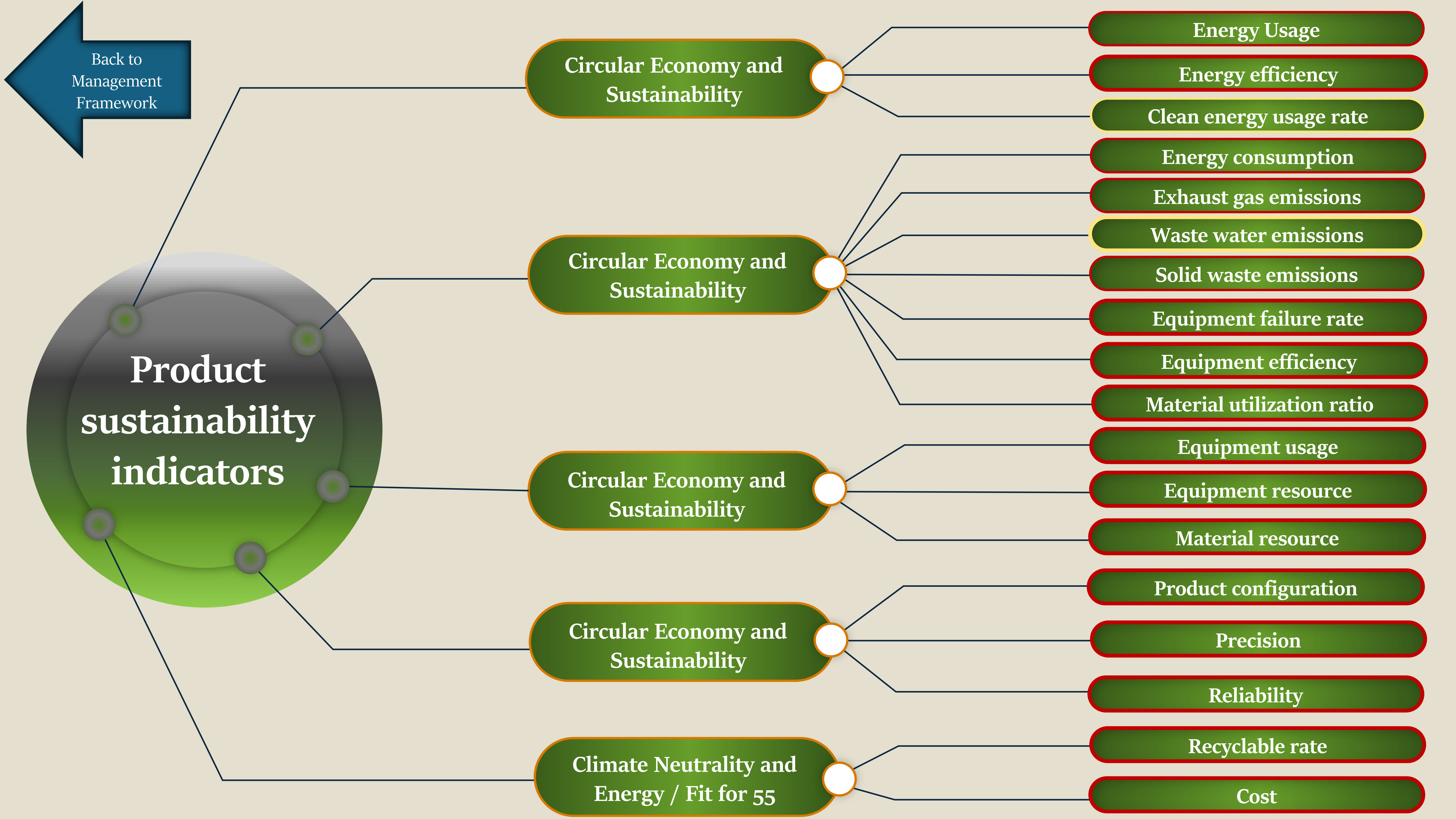
Management Framework

The management framework explained in the text is based on a journal by He, Luo, and Huang (2019), which assesses product sustainability throughout the product life cycle, emphasizing the business side of sustainable product management rather than focusing solely on product circularity like the 9R framework does. This journal introduces several product sustainability indicators, relevant to the IT hardware lifecycle, which consider factors that businesses must address when implementing sustainable solutions.

In contrast to the 9R framework, which focuses on the circular economy and post-use of equipment, this framework looks at sustainability from a business perspective. This is important for the DSS, as companies need sustainable solutions that do not conflict with cost and efficiency.

Product Sustainability Indicators

Indicators Categorized by the Stages of the Life Cycle



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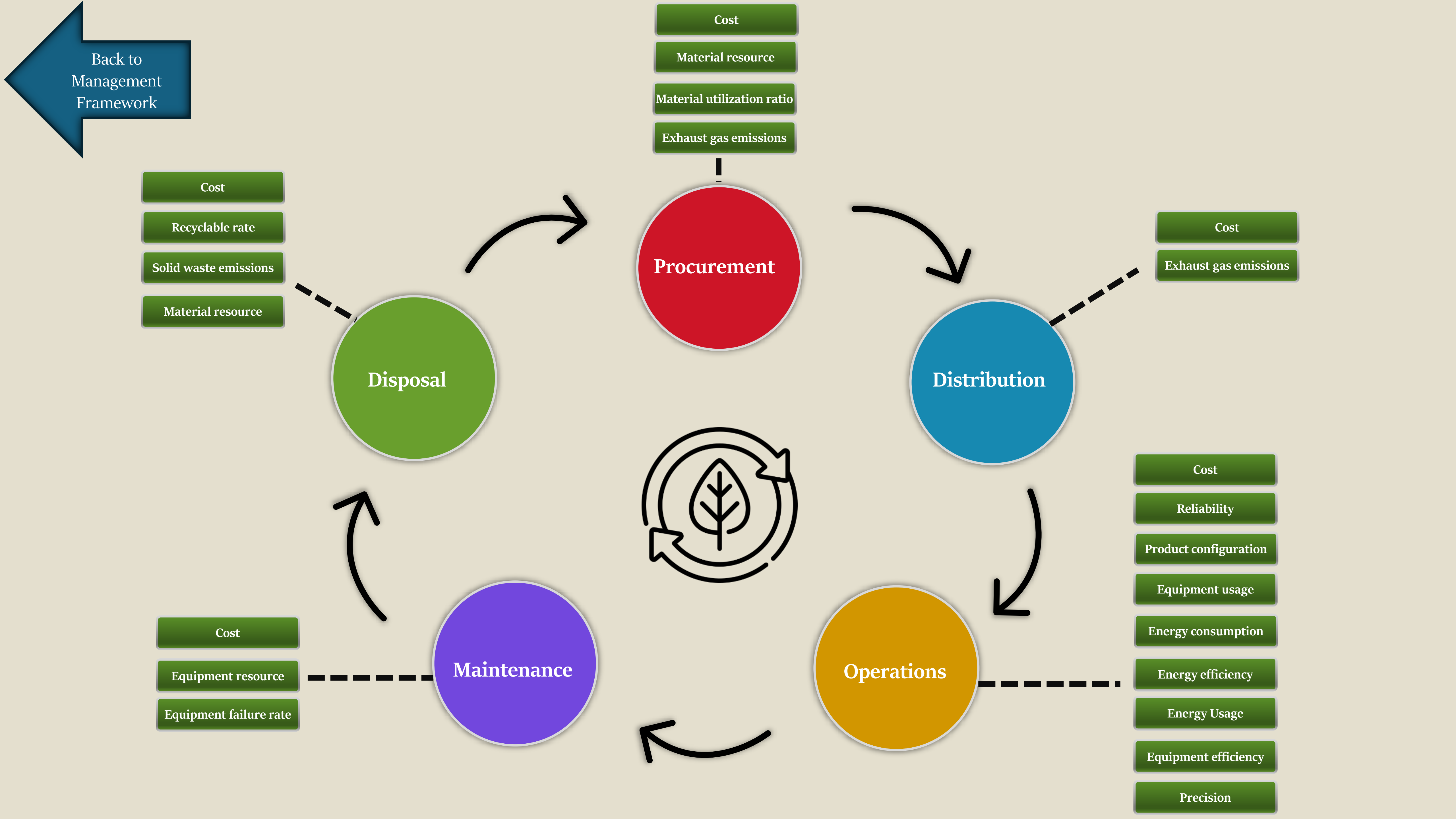
Product sustainability indicators
Circular Economy and Sustainability
Energy Usage
Energy efficiency
Clean energy usage rate
Circular Economy and Sustainability
Energy consumption
Exhaust gas emissions
Waste water emissions
Solid waste emissions
Equipment failure rate
Equipment efficiency
Material utilization ratio
Circular Economy and Sustainability
Equipment usage
Equipment resource
Material resource
Circular Economy and Sustainability
Product configuration
Precision
Reliability
Climate Neutrality and Energy / Fit for 55
Recyclable rate
Cost



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Cost
Material resource
Material utilization ratio
Exhaust gas emissions
Procurement
Cost
Exhaust gas emissions
Distribution
Cost
Reliability
Product configuration
Equipment usage
Energy consumption
Energy efficiency
Energy Usage
Equipment efficiency
Precision
Operations
Cost
Equipment resource
Equipment failure rate
Maintenance
Cost
Recyclable rate
Solid waste emissions
Material resource
Disposal

Back to
Life Cycle

Ways of Measuring and Reporting the
E ... are

E-waste, or electronic waste, refers to discarded electronic devices and components that are no longer in use. IT hardware, due to rapid technological advancements and obsolescence, contributes significantly to the growing global e-waste problem. Improper disposal of e-waste can lead to environmental pollution, as harmful chemicals and heavy metals, such as lead and mercury, can leach into the soil and water. Effective e-waste management involves proper recycling, refurbishing, and disposal practices, as well as designing products for longer lifespans, to reduce the environmental impact and mitigate the hazards associated with e-waste. This is why E-waste measurement can be essential. <u>Click here to go to the E-Waste Page</u>.

Greenhouse Gas Emissions

E-Waste

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Greenhouse Gas Emissions

Scopes and Categories explained

Scopes and Categories relevant to this research

HFCs

Greenhouse Gas (GHG) emissions are a critical metric for assessing the environmental impact of IT hardware. This measure accounts for the carbon dioxide (CO2) and other greenhouse gases released during the manufacturing, transportation, usage, and disposal of IT devices. The energy-intensive processes involved in producing semiconductors, circuit boards, and other components contribute significantly to GHG emissions. Additionally, the energy consumed during the operation of IT hardware, often sourced from fossil fuels, adds to its carbon footprint. Monitoring and reducing GHG emissions is crucial for mitigating climate change and promoting sustainable IT practices.

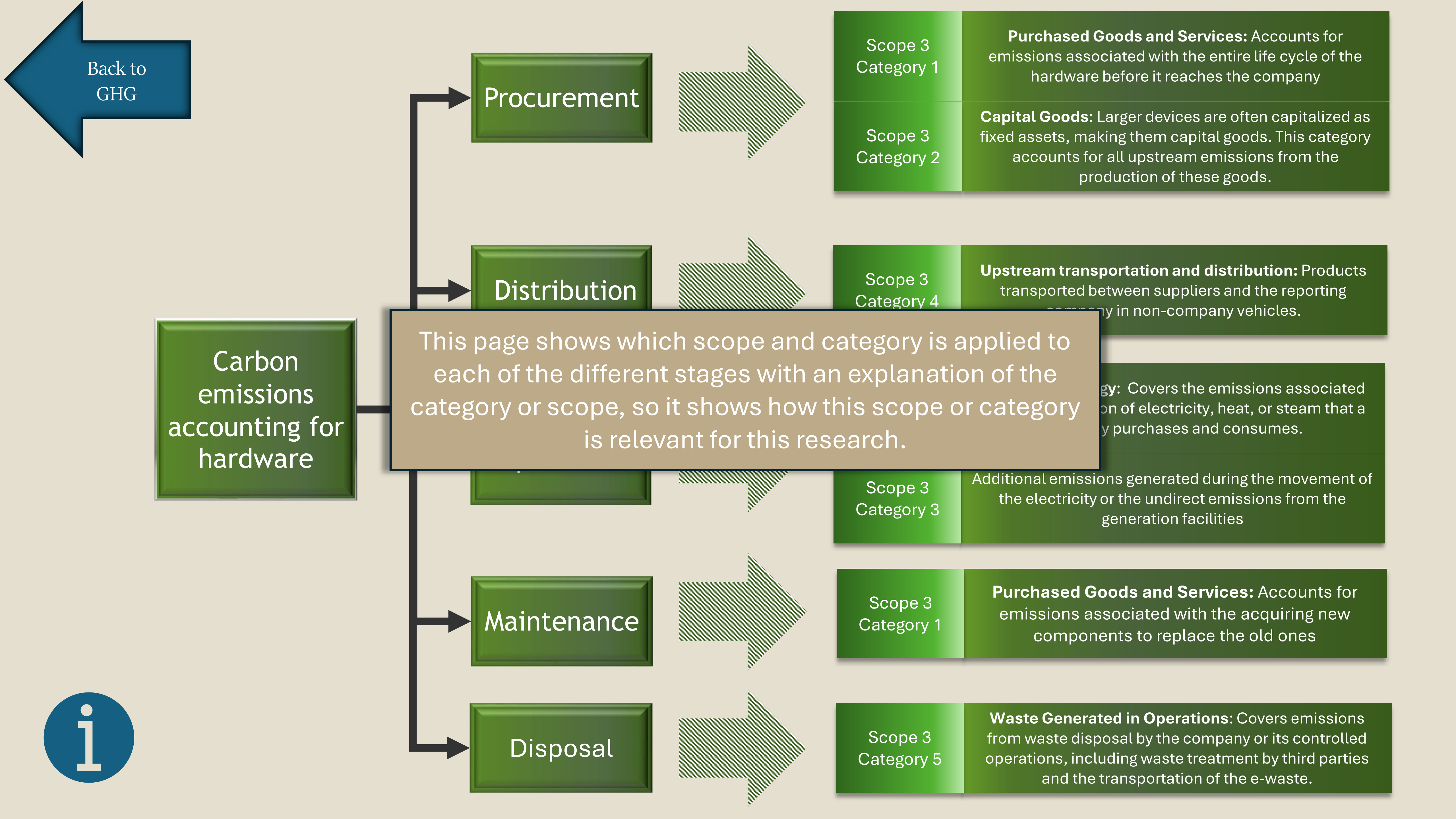
S… rolled by the organ… oilers or vehicles.

S… nergy, such as … on.

Sco… ontrolled by the organ… the production of … ste disposal.

The t… ir total emissions and … sidering all three scopes, organizations can develop more comprehensive strategies for managing their environmental impact and promoting sustainability.

Source: https://plana.earth/academy/what-are-scope-1-2-3-emissions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Carbon emissions accounting for hardware
Procurement
Distribution
Maintenance
Disposal
Scope 3 Category 1
Purchased Goods and Services: Accounts for emissions associated with the entire life cycle of the hardware before it reaches the company
Scope 3 Category 2
Capital Goods: Larger devices are often capitalized as fixed assets, making them capital goods. This category accounts for all upstream emissions from the production of these goods.
Scope 3 Category 4
Upstream transportation and distribution: Products transported between suppliers and the reporting
y in non-company vehicles.
This page shows which scope and category is applied to each of the different stages with an explanation of the category or scope, so it shows how this scope or category is relevant for this research.
gy: Covers the emissions associated
on of electricity, heat, or steam that a
y purchases and consumes.
Scope 3 Category 3
Additional emissions generated during the movement of the electricity or the undirect emissions from the generation facilities
Scope 3 Category 1
Purchased Goods and Services: Accounts for emissions associated with the acquiring new components to replace the old ones
Scope 3 Category 5
Waste Generated in Operations: Covers emissions from waste disposal by the company or its controlled operations, including waste treatment by third parties and the transportation of the e-waste.