ICTC's Sustainable ICT Guide for Technology Designers and Developers

1. Introduction

As a technology designer or developer, your organization has a unique ability to implement sustainability improvements across the ICT supply chain. It is said that over 80% of a product's environmental impacts are determined during its design.[i] While in reality this figure varies by product and industry, design *can* significantly alter what environmental impacts occur during later stages of the product life cycle, including raw material extraction, manufacturing, distribution, use, and end-of-life. By adopting environmental sustainability strategies like eco-design and by aligning your products and services with international standards and best practices for sustainable ICT, you can considerably reduce the environmental impacts that result from your ICT products and services.

Whether your organization is just beginning its sustainable ICT journey or looking for new ways to refine its approach, this guide can help your organization learn about environmentally sustainable ICT design and development. Each section includes a strategy that your organization can implement and a list of free and paid online resources to help you do so.

2. Understanding the Problem

Environmental Impacts of Technology

Understanding technology's environmental impact is a necessary first step to advancing sustainable ICT. Many ICT professionals don't see the environmental impact of their technology decisions because these impacts materialize in other parts of the ICT supply chain—for instance, mining, manufacturing, transport, and waste.

Research shows that ICT professionals are more likely to consider environmental impacts that they interact with directly versus those they don't see because they occur in other parts of the ICT supply chain. Learning about ICT's environmental impact is, therefore, an important first step in addressing the environmental impacts of ICT. In the subsections below, you can find information about the environmental impacts your organization may not be considering.

i) Energy Consumption

While ICT products and services can be a useful way to reduce energy use in other sectors, such as the buildings sector, ICT products and services also consume energy themselves.[ii] Studies from 2007 to 2010 estimated that the ICT sector accounts for 3.9% to 8% of total energy use[iii], and ICT's energy consumption is expected to increase even further going forward.[iv]

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Raw material extraction and manufacturing account for most of the energy consumed during the lifecycle of an ICT product. As an illustrative example, a two-gram memory chip consumes 73% of its lifetime energy during the mining, manufacturing, and production process.[v] This is because mining and manufacturing involve energy-intensive activities like blasting, crushing, smelting, heating and cooling, and air and water pumping.[vi] Though the energy intensity of manufacturing processes has improved over time, ICT devices require increasingly small, complex components, putting upward pressure on manufacturing-related energy consumption. For example, one study estimated smartphones consume 100 times more energy per gram of material than cars because of the complexity of the materials required to produce smartphones.[vii]

ICT infrastructure also consumes energy during its use phase (e.g., when being used by users), but not as significant of an amount as during manufacture. Networking and cloud infrastructure, for example, require a vast number of ICT devices and serve a very large number of users globally.

ii) Greenhouse Gas Emissions

ICT products and services can be used to reduce greenhouse gas (GHG) emissions in other sectors, such as agriculture, but they also produce significant GHG emissions themselves. ICTs are estimated to account for 1.8-3.9% of global GHG emissions, which is roughly equivalent to the global aviation sector, including both domestic and international travel and both passenger and freight.[viii] Going forward, GHG emissions from ICT products and services are expected to increase even further.[ix]

Raw material extraction and manufacturing account for most of the GHG emissions released by ICT products over their lifecycle. For instance, manufacturing a mobile phone generates five times more GHG emissions than are generated during the phone's use.[x] The amount of GHG emissions produced by ICT hardware over its lifecycle is highly related to the type of energy used. This is because fossil fuels emit far more GHGs than solar, wind, nuclear, or hydro.

iii) Water Consumption

Water consumption occurs in three main areas of the ICT supply chain: production (e.g., raw material extraction and manufacturing), data centre use, and energy use. Production, including raw material extraction and manufacturing, accounts for the largest proportion of ICT's water use.[xi] This is because producing ICT equipment and devices consumes substantial amounts of water, particularly in processes related to mining, cooling, and rinsing.[xii]

Data centres also use high volumes of water.[xiii] One study estimated that data centres with 15MW of IT capacity consume between 0.8 and 1.3 million litres per day.[xiv] Another study estimated that in 2014, in the United States alone, data centres consumed a collective 165

billion gallons of water.[xv] Data centres use water both directly to remove heat waste from ICT equipment to prevent overheating and indirectly by way of their energy use.

ICT products and services also consume water through their energy use. How much water is consumed during the lifecycle of an ICT device depends on what type of energy is used in raw material extraction, manufacturing, transport, and use.[xvi] Different sources of energy, such as coal, hydro, solar, and bioenergy, consume different amounts of water for the same energy output.

iv) Non-Renewable Resource Consumption

Digitalization, through the rapid adoption of ICT solutions, has escalated the global consumption of many non-renewable resources.[xvii] ICT hardware is produced using a long list of resources, including cobalt, copper, palladium, tantalum, germanium, silver, gold, indium, magnesium, gallium, iron, aluminum, platinum, and rare earths such as dysprosium and neodymium.[xviii] As the production of ICT hardware increases, so does global consumption of these minerals and metals.

Raw material extraction and manufacturing account for the vast majority (85%) of ICT's non-renewable resource consumption.[xix] This is partly because of the mined minerals and metals that are included in the final versions of ICT products and partly due to the water, land, and soil that are either used or contaminated during the mining process. In fact, one study estimated that the amount of materials used to produce ICT products is 50 to 250 times larger than the amount used directly in final products.[xx]

The design and end-of-life processing of ICT products are also linked to raw material extraction: when ICT hardware is not designed and disposed of in a way that facilitates recycling, it increases demand for raw material extraction to support the production of new equipment and devices.

v) Waste Creation

Waste is produced across the ICT lifecycle, but it is most significant in the raw material extraction, manufacturing, and end-of-life stages. Raw material extraction, or mining, generates waste gases, wastewater, radioactive waste, and mine tailings (mine tailings are the raw materials left over after target resources, such as tantalum, platinum, or rare earth elements have been removed).[xxi] In China, processing just one ton of rare earth elements results in 2000 tons of mine tailings and 1000 tons of wastewater filled with heavy metals and other environmentally degrading elements.[xxii]

Manufacturing processes also create waste in the form of defective products and unused byproducts. Eco-design and lean manufacturing processes can help reduce the amount of waste created during manufacturing.

When ICT products reach the end of their life, they become electronic waste, or "e-waste." E-waste has become a major contributor to global solid waste. Today, it is recognized as the fastest-growing waste stream.[xxiii] In 2019, the global economy produced about 53.6 metric tons (Mt) of e-waste, representing an average of 7.3kg per capita.[xxiv] By 2030, the global generation of e-waste is projected to grow to 74.7 Mt per year.[xxv] E-waste is challenging because the vast majority of it goes undocumented, with just 17.4% being reportedly collected and properly disposed of.[xxvi] E-waste also differs chemically and physically from regular waste, containing hazardous materials like lead, mercury, nickel, and cobalt, which require specialized methods of dismantling and disposal.[xxvii] Many factors are contributing to the growth of e-waste. The number of users and number of devices per user are increasing constantly. Many devices also have short lifespans due to the rapid cycle of innovation and a lack of hardware and software compatibility between old and new devices.[xxviii] Finally, repairing ICT devices is complex and repair options are often limited and expensive.[xxix]

Digital technologies also generate "digital waste," data that are stored and processed despite no longer being needed or used. Technology adopters create digital waste when they unnecessarily duplicate and retain files, store data in inefficient formats, perform unnecessary tasks or computations, collect redundant data, and run or maintain software applications they don't use. The data that digital technologies create and store has real-world impacts, including increased demand for ICT hardware, increased energy and water use, and, at times, increased GHG emissions.

vi) Soil, Water, and Air Pollution

Soil, water, and air pollution mainly occur in the resource extraction, manufacturing, and end-of-life stages of the ICT lifecycle. Raw material extraction results in waste gases, wastewater, radioactive waste, and mine tailings, which contain hazardous materials that commonly leak or leach into the natural environment, limiting plant growth and causing toxicity to plants, animals, and humans.[xxx] Raw material extraction negatively impacts every component of an ecosystem, including the water, soil, and air, as well as the plants, animals, and humans within and around it.[xxxi]

Many manufacturing processes pollute the environment to some degree via air and water pollution.[xxxii] In particular, ICT manufacturing involves the use of hazardous chemicals, substances, and elements, which, depending on the manufacturing facility and local oversight and regulations, may be released into surrounding air and water systems.[xxxiii]

Common methods for e-waste processing and disposal, such as landfilling, incineration, and dumping, negatively impact soil, water, and air.[xxxiv] E-waste is compacted and buried underground, often using liner systems to minimize the amount of toxins that leach into the surrounding environment.[xxxv] Still, toxic elements and pollutants leach from landfilling facilities. Incineration is used both to dispose of e-waste and to extract valuable components from e-

waste for recycling.[xxxvi] It creates hazardous fumes, dust, and ashes that contain pollutants and can contaminate nearby air, water, and soil.[xxxvii] Many studies identify high levels of pollutants and heavy metals in the soil surrounding different kinds of e-waste processing facilities.[xxxviii] Once in the soil, toxic chemicals from e-waste, such as carcinogens and neurotoxins, enter the water table, are taken up by plants and animals, and move their way through the food web to humans.[xxxix] While pollution is generally worse near informal versus formal processing sites, even well-regulated methods for e-waste recycling and disposal release contaminants into the natural environment.

3. Organizational Infrastructure

i) Environmental Sustainability Strategies

Environmental sustainability strategies help organizations set, track, and report on goals related to the environment. According to ICTC's research, organizations with an ESG or environmental sustainability strategy are twice as likely as those without to consider environmental impacts in their technology decisions: this is because environmental sustainability strategies are often integrated into many aspects of an organization, including organizational strategy, policies, decision-making infrastructure, goals, and performance metrics. Creating an environmental sustainability strategy is, therefore, an effective way to begin your organization's sustainable ICT journey.

While creating an environmental sustainability strategy for your organization, you will need to (1) perform an initial assessment, (2) develop your organization's environmental sustainability strategy, (3) adopt a reporting framework to report your environmental impact and progress on your environmental goals, and (4) ensure your strategy and reporting frameworks can be applied to ICT infrastructure, products, and services. In the below list, you'll find a variety of free online resources to help you self-assess your organization's approach to environmental strategy, develop an ESG or environmental strategy for your organization, and incorporate ICT into your organization's ESG and environmental strategies.

List of Resources:

Performing an Initial Assessment (tools to assess your organization's existing performance when it comes to environmental sustainability)

- Use this free online tool to self-assess your organization's environmental sustainability: Sustainability Advantage Basic Sustainability Assessment Tool
- Use this free online tool to self-assess your large, multi-location, multi-national organization's environmental sustainability: Sustainability Advantage Advanced Sustainability Assessment Tool

- Use this free online assessment to assess your organization's ESG performance: B Impact Assessment
- Use this paid online tool to self-assess where your organization can improve its environmental sustainability: Responsible Business Alliance Self-Assessment Questionnaire

Developing an ESG and Environmental Strategy (tools to help your organization develop an ESG or environmental strategy)

- Use this paid international standard to learn about common ESG terms and definitions and how to set ESG goals: ISO 26000 Guidance on Social Responsibility
- Use this free online tool to measure, manage, and improve your organization's impact on the environment: B Impact Assessment
- Use this free online document to explore examples of the types of actions your organization can take at different stages of your environmental journey: CDP Organizational Guide for Environmental Action
- Use this online tool to set, manage, and track organizational goals that are aligned with the sustainable development goals: SDG Action Manager
- Use this paid international standard to set up an "environmental management system" for your organization and help your organization manage and achieve its sustainability goals (note: this standard was developed for all industries, not just ICT): ISO 14001:2015
- Use this online tool to set an emissions reduction target in line with the Science Based Target Initiative's criteria: SBTi Set a Target

Reporting on your environmental impact and progress towards environmental goals (tools to help you develop and adopt a standardized reporting framework)

- Use this set of interconnected standards to measure and report on a broad range of environmental impacts and environmental sustainability initiative: Global Reporting Initiative (GRI) Standards
- Use this set of interconnected standards to measure and report on a select range of sustainability topics: Sustainability Accounting Standards Board (SASB) Standards
- Use this document to identify 21 core and 34 expanded metrics for ESG reporting: World Economic Forum – Towards Common Metrics and Consistent Reporting
- Use this document to to explore common reporting metrics related to climate change, forests, and water security: CDP Reporting Guidance Documents
- Use this set of international standards to measure and report on your GHG emissions in a standardized way: GHG Protocol Standards

- Use this document to get guidance on how to measure your organization's emissions—including both energy emissions and value chain emissions—and report on your GHG reductions progress: CDP Climate Disclosure Framework for SMEs

Accounting for ICT in ESG and Environmental Sustainability Strategies (tools to help your organization incorporate ICT into its existing strategies)

- Read this paid online textbook to learn how to design and execute a sustainable IT strategy: Sustainable IT Playbook for Technology Leaders
- Use this free online document to learn about the three-stage roadmap that your organization can use to accelerate its sustainable IT agenda: Capgemini's Roadmap for Sustainable IT Implementation
- Use these paid international standards to incorporate ICT products and services into your organization's existing environmental, social, and governance strategy (note this standard was developed specifically for ICT): SustainableIT ESG Standards

4. Enabling and Incentivizing Employees

i) Sustainable ICT Training

ICT professionals need the right knowledge, skills, and expertise to make environmentally sustainable technology decisions. In response to a survey conducted by ICTC in 2023, more than a quarter (27%) of ICT professionals indicated that they lacked the required knowledge, skills, and expertise to implement sustainable ICT practices. Meanwhile, just 15% of ICT professionals indicated that they had received training about sustainable ICT.

Many ICT professionals are never taught how to consider the environmental impact of their products or services nor how to distinguish sustainable from unsustainable design choices. One way your organization can improve the environmental impact of its products and services is by providing your technology designers and developers with sustainable ICT training. For example, you could train your employees on the relationship between ICT and sustainability, sustainable software engineering principles, international standards for sustainable ICT products and services, or how to calculate greenhouse gas emissions and other environmental impacts associated with their design choices.

In the list below, you'll find a variety of online courses, corporate training modules, handbooks, and guides on the topic of sustainable ICT:

List of Resources:

Sustainable ICT Training

- Take this free MOOC (massive open online course) to learn about the environmental impacts of digital technologies: MOOC on the Environmental Impacts of Digital Technologies
- Consult this free online handbook to learn how to implement green ICT: Green ICT Handbook: A Guide to Green ICT
- Read this paid online textbook to learn how to design and execute a sustainable IT strategy: Sustainable IT Playbook for Technology Leaders

Eco-Design Training for ICT

- Take this free online course to learn about the core principles of sustainable software engineering: Microsoft Training Course on the Principles of Sustainable Software Engineering
- Take this free online course to learn about what drives carbon emissions in software applications, what you can do to reduce the carbon emissions of your software, how to measure software emissions using the GHG Protocol or Software Carbon Intensity Specification, and the different types of corporate climate targets your organization can set in relation to software: Green Software Practitioner Training and Certification
- Take this free online course to learn about how to green data centres: ITU Greening Data Centres Online Course
- Take this paid online course to learn about design standards for sustainable ICT, conducting environmental assessments for ICT products and services, and more: International Federation of Global and Green ICT: Green IT Professional Training and Certification
- Read this paid online textbook to learn about sustainable IT infrastructure: SustainableIT Playbook for Technology Leaders
- Read this paid online textbook to learn about how to build faster, more carbon efficient websites: Designing for Sustainability
- Read this paid online textbook to lean about how to build, host, and operate code in a more environmentally sustainable way: Building Green Software
- Read this paid online textbook to lean about sustainable web design: Sustainable Web Design

Sustainable ICT Procurement Training

- Take this free online course to learn about circular and sustainable public procurement for ICTs: ITU Circular and Sustainable Public Procurement for ICTs Online Course

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- Take this low-cost online course to learn about sustainable procurement and how your organization can make more sustainable purchasing decisions: ECOCanada Sustainable Procurement: Purchasing the Future We Want
- Take one of these paid online courses to learn about sustainable procurement: Sustainable Procurement for Professionals (designed for procurement professionals) or Sustainable Procurement Essentials (designed for all professionals)

ii) Incentivizing Sustainable ICT

Building the right incentives into your organization's sustainable ICT strategy is an important part of making sure it achieves its desired goals. When surveyed, 68% of technology designers and developers indicate that they do not have clear incentives to make environmentally sustainable ICT decisions at work. Between privacy, security, accessibility, cost optimization, user experience, and environmental sustainability, ICT professionals have a lot of priorities to balance. Because of this, they need clear incentives to make environmentally sustainable technology decisions.

There are a number of ways your organization can build incentives into its sustainable ICT strategy. One example is incorporating sustainable ICT outcomes and key performance indicators in the annual goals that you set for your entire organization, specific teams, and individual employees. Similarly, your organization can incorporate sustainable ICT outcomes and key performance indicators into the decision-making structures that you use to award vendor contracts, provide employee feedback, determine bonuses or raises, and promote employees. Formally incorporating sustainable ICT outcomes and key performance indicators into these aspects of your organization signals to teams and individual employees that sustainable ICT is a high-level priority to your organization and ensures that teams and employees receive personal benefits for prioritizing environmental sustainability in their technology decisions.

Another way you can incentivize sustainable ICT decisions is by implementing internal "penalties" for the environmental impacts that individual teams, products, or service lines produce or by implementing internal "caps" on the environmental impacts that teams can generate and then assigning penalties when those limits are exceeded. One well-known example of this type of approach is Microsoft's internal "carbon fee," which Microsoft is using to reach its carbon emissions goals: in 2020, Microsoft began charging internal business groups fees for their scope 1, 2, and 3 carbon emissions and then using the funds generated to implement sustainability improvements across the organization.

List of Resources:

- Consult this free online handbook to learn how to incentivize sustainable ICT decisions: Green ICT Handbook: A Guide to Green ICT

- Consult this paid online textbook to learn how to engage employees in your organization's sustainable IT strategy: Sustainable IT Playbook for Technology Leaders
- Use these paid international standards to learn what key performance indicators you can incorporate into your organization's goals and decision-making structures (for example, see Governance: Culture of Sustainability (100)): SustainableIT ESG Standards
- Consult this free online resource to learn how to use internal carbon fees to incentivize environmentally sustainable IT decisions: How Microsoft is using an internal carbon fee to reach its carbon-negative goal

5. Eco-Design

As a technology designer or developer, one of the main things you can do to improve the environmental sustainability of your products and services is to engage in eco-design. Eco-design is an approach to product and service design that considers what negative environmental impacts might occur over a product or service's lifecycle and then seeks to reduce them. While eco-design was originally developed for all types of products and services, and not just ICT, organizations like ECMA International have developed free guidance documents to help you adapt environmental design considerations to the ICT sector.

This section explores three ways your organization can apply eco-design to the design and development of ICT products and services, including lifecycle assessment, aligning your product and service design with ecolabels, and aligning your product and service design with international standards for sustainable ICT.

i) Lifecycle Assessment

Lifecycle assessments (LCAs) are a tool used to determine the environmental impacts of ICT products or services over their lifecycle. LCAs are important because the environmental impacts that occur during different stages of the ICT lifecycle are interdependent: decisions made during design, raw material extraction, and manufacturing will also change what environmental impacts occur during later stages. Trying to improve environmental impacts in one stage of the supply chain may worsen impacts in another. For instance, hardware designed to be more energetically efficient in the use phase typically requires more energy during the manufacturing phase – negating efficiency gains.[xl] This is one of the many examples of why it is important to think about the environmental impacts of technologies from a lifecycle perspective.

LCAs can be used by ICT professionals for a variety of purposes. Technology designers and developers can use LCAs to estimate the future environmental impact of design decisions. Technology adopters can use LCAs to compare different versions of ICT products and services and identify the most sustainable choice. Environmental impact data from LCAs can also give companies the information they need to report the environmental impact of their products and

services to partners, clients, and investors, increasing transparency across the ICT supply chain. An LCA should take into account several metrics of environmental impact, such as impacts on biodiversity, water consumption, land use, and non-renewable resource extraction. This differs from a product carbon footprint (PCF) assessment, which only quantifies CO_2 equivalent emissions. While PCF assessments can add value, an LCA is more robust and can help mitigate negative implications beyond CO_2 equivalent emissions.

When conducting life cycle assessments, organizations should follow a standardized approach. This helps to ensure that the approach is robust and in line with best practices, and helps to ensure that life cycle assessments from different organizations are comparable. Organizations have a several international standards that they can choose from when selecting a methodology for their life cycle assessments. This includes the International Telecommunications Union's L.1410: Methodology for Environmental Life Cycle Assessment of ICT Goods, Networks, and Services[40]; ETSI's ES 2013 199: Methodology for Environmental Life Cycle Assessments of ICT Goods, Networks, and Services[41]; NegaOctet's Methodology for Measuring the Environmental Impact of Digital Services[42]; and the International Organization for Standardization's ISO 14044:2006: Life Cycle Assessment Requirements and Guidelines.[43] In addition to relying on standards, organizations can use existing datasets to acquire relevant data for their life cycle assessments. For example, the NegaOctet database provides environmental impact data for more than 1,500 pieces of ICT equipment and up to 30 impact categories.[44]

While LCAs were originally designed for tangible products like laptops and servers, several organizations are working to adapt LCAs to intangible digital products like websites and software applications. Sustainable ICT leader, Mightybytes, has explored the concept of a "digital life cycle assessment," which "applies the rigor of an LCA to digital products and services." Similarly, the Sustainable Digital Infrastructure Initiative is developing the concept of a "digital environmental footprint," which measures the total environmental impact of activities in the digital economy.[45] In the below list, you'll find a variety of free and paid resources to help you learn about LCAs in the context of ICT, familiarize yourself with international standards for LCA, and learn how to apply LCAs to not just physical hardware but also intangible digital products.

List of Resources:

International Standards and Tools for ICT Lifecycle Assessment

- Use these paid international standards to learn how to measure the environmental impacts of ICT: SustainableIT ESG Standards
- Use this free online standard to design your organization's approach to lifecycle assessment (note: this standard was designed for ICT goods, networks, and services): ETSI ES 203 199 V1.3.1

- Use these free online standards to learn about and design your organization's approach to lifecycle assessment (note: this standard was designed for ICT goods, networks, and services): ITU-T L.1400: Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies and ITU-T L.1410: Methodology for environmental LCAs of ICT goods, networks and services
- Use this paid online standard to design your organization's approach to lifecycle assessment (note: this standard was designed for all types of products and services, not just ICT): ISO 14044:2006
- Use this paid online database to obtain ready-to-use-data for your ICT lifecycle assessments: NegaOctet Database

International Standards and Tools for Product Carbon Footprints

- Take this free online course to learn about what drives carbon emissions in software applications, what you can do to reduce the carbon emissions of your software, how to measure software emissions using the GHG Protocol or Software Carbon Intensity Specification, and the different types of corporate climate targets your organization can set in relation to software: Green Software Practitioner Training and Certification
- Use this free online resource to calculate the greenhouse gas emissions associated with ICT products and services over their lifecycle: ICT Sector Guidance Built on the GHG Product Life Cycle Accounting and Reporting Standard
- Use this free online standard to learn about what methodologies you can use to evaluate the greenhouse gas emissions impact of ICT technologies in your organization: ITU-T L.1420: Methodology for energy consumption and greenhouse gas emissions impact assessment of information and communication technologies in organizations
- Use this paid online standard to learn about what methodologies you can use to evaluate the carbon footprint of electrical and electronic products: IEC TR 62725:2013

Applying Lifecycle Assessment to Intangible Digital Products

- Consult this free online resource to learn how to apply lifecycle thinking to intangible, digital products, such as data centre services, websites, and mobile apps: Mightybytes Understanding Digital Life Cycle Assessments
- Consult this free online video to learn how to apply lifecycle thinking to intangible, digital products: Creating a Digital Environmental Footprint: A Life Cycle Assessment Approach

Real-World Examples

- Consult this free online resource to see an example of lifecycle thinking in action: Ericsson Life Cycle Environmental Impacts of a Smartphone

- Consult this free online resource to see the ISO 14040:2006 standard applied to digital services: Digital Technologies in Europe: an environmental life cycle approach
- Consult this free online resource to see an example of product carbon footprints in action: Dell Product Carbon Footprints

ii) ICT Ecolabels

Environmental labels (or ecolabels for short) are an effective way to engage in eco-design. Ecolabels are labels or "marks" that companies like yours can place on their products and services to help buyers identify environmentally sustainable suppliers. Ecolabels are often administered by independent, third-party organizations. These independent organizations are responsible for verifying companies' adherence to environmental standards and then giving companies the right to use the associated ecolabel.

Importantly, not all ecolabels are created equal. ISO 14024:2018 is an internationally recognized standard that designates the highest-quality ecolabels, which are known as "Type I environmental labels." To become certified as a Type I environmental label, ecolabel managers must follow specific principles and procedures when defining product categories, choosing environmental criteria and standards, and assessing companies' compliance.

In the below list, you'll find a variety of free online resources to help you explore which ICT ecolabels are available and which of your competitor's ICT products already adhere to common ecolabels for ICT.

List of Resources:

ICT Ecolabels

- Use this free online resource to learn about the EPEAT ecolabel and the environmental criteria they use to certify electronic and technology products: EPEAT Criteria
- Use this free online resource to learn about the Energy Star ecolabel for energy efficiency (ICT devices with an Energy Star label are certified to be energetically efficient, using 20-40% less energy during the use phase than conventional models): Energy Star
- Use this free online resource to learn about the TCO Certified ecolabel and the environmental criteria they use to certify IT products: TCO Certified Criteria Overview
- Use this free online resource to learn about the ECOLOGO Certification and the lifecycle approach they use to measure and certify environmental sustainability: ECOLOGO
- Use this ecolabel repository to search for relevant ecolabels in 199 countries and 25 industry sectors: Ecolabel Index
- Use this standard to assess the quality of ecolabels and determine whether they are certified Type I environmental labels: ISO 14024:2018

Product Registries (tools to help you find ICT ecolabel-verified products)

- Use this free online tool to find products certified by the EPEAT ecolabel: EPEAT Registry of Products
- Use this free online tool to find IT products certified by the TCO Certified ecolabel: TCO Certified Product Finder

iii) Sustainable ICT Standards

Another way to implement eco-design is to align your organization's technology purchases with sustainable ICT standards. Sustainable ICT standards are developed by a variety of international standards-setting organizations, including the International Telecommunications Union (ITU), International Organization for Standardization (ISO), Institute of Electrical and Electronics Engineers (IEEE), International Electrotechnical Commission (IEC), European Telecommunications Standards Institute (ETSI), and ECMA International. Globally, more than 150 standards covering a vast number of topics have been developed for the ICT sector. Some examples of topics covered by sustainable ICT standards are:

- Eco-Design: ECMA 341 provides guidance on environmental design considerations for ICT and CE products
- Supply Chain Management: ITU-T L.1060 provides general principles for the green supply chain management of the ICT manufacturing industry
- Procurement: ITU-T L.1304 provides guidance on procurement criteria for sustainable data centres
- Green Data Centres: ITU-T L.1300 provides guidance on best practices for green data centres
- Web Sustainability: WSG 1.0 provides guidance on how to make websites and digital products more sustainable

Many sustainable ICT standards provide specific guidance on reducing the environmental impacts of ICT. Of the more than 150 sustainable ICT standards available, approximately half focus on energy efficiency, a quarter focus on reducing material waste, a fifth focus on reducing greenhouse gas emissions, a tenth focus on reducing hazardous chemical use and reducing air pollution, and a handful focus on reducing freshwater use and reducing land system change.

Energy Efficiency

Many sustainable ICT standards, including those published by ECMA and ETSI, provide guidance on how to measure energy consumption and energy efficiency in ICT products. Others, such as ISO 50001, provide guidance on how to track, manage, and improve energy efficiency over time. Still, others specify how to design ICT products according to good energy management practices, such as by using energy sources efficiently, building energy-saving modes into

components and devices, including mechanisms to reuse waste energy, making energy consumption and efficiency data available to partners and end-users, and using renewable energy sources when possible (see ETSI, ECMA, and ITU standards). Additionally, standards like ECMA 341 suggest taking a lifecycle approach so as to maximize energy efficiency across a product's lifecycle instead of just focusing on one phase at a time.

Reducing Material Waste (such as e-waste)

Sustainable ICT standards, including those published by ETSI, ITU, and ECMA, specify that ICT manufacturers should maximize their use of recycled and bio-based materials in products; share data with partners, end-users, and recycling centres about the recyclability of specific components and parts; and design products in a way that facilitates repair, reuse, and recycling later on, such as by reducing the number of materials per component or part, not using manufacturing processes that reduce recyclability, and making it easy to separate products into individual components and parts. Additionally, sustainable ICT standards ask ICT manufacturers to maintain robust repair and recycling programs so as to extend the lifecycle of ICT products and materials during their use stage, in turn reducing their environmental impact per year of use.

Reducing Greenhouse Gas Emissions

Several sustainable ICT standards provide guidance on how to evaluate the greenhouse gas emissions associated with ICT products and services. For example, IEC TR 62725:2013 provides users with guidance on the methodologies that they can use to evaluate the carbon footprint of electrical and electronic products over their lifecycles. Similarly, ICT Sector Guidance Built on the GHG Product Life Cycle Accounting and Reporting Standard provides guidance on how to calculate the greenhouse gas emissions associated with ICT products and services using the GHG Protocol Product Life Cycle Accounting and Reporting Standard.

Reducing Hazardous Substance Use

Sustainable ICT standards, such as ITU T REC L.1015, specific that ICT manufacturers should meet the substance restriction requirements laid out in the European Union Restriction of Hazardous Substances (RoHS) Directive; disclose substances of very high concern (SVHC) under the European Union Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) Regulation; and limit quantities of hazardous substances like chlorine and bromine, as well as heavy metals like lead, cadmium, mercury, and hexavalent chromium.

In the below list, you'll find a variety of free and paid resources to help you familiarize yourself with international standards for sustainable software engineering and sustainable ICT.

List of Resources:

- Take this paid online course to learn about design standards for sustainable ICT, conducting environmental assessments for ICT products and services, and more:

International Federation of Global and Green ICT: Green IT Professional Training and Certification

- Take this free online course to learn about the core principles of sustainable software engineering: Microsoft Training Course on the Principles of Sustainable Software Engineering
- Take this free online course to learn about how to green data centres: ITU Greening Data Centres Online Course

6. Working to Enable Change Across the ICT Supply Chain

i) Supply Chain Transparency

A lack of transparency across the supply chain prevents organizations like yours from trying to improve their ICT sustainability. Professionals who *try* to obtain data from ICT suppliers often report being unable to do so due to a lack of available data and trust. In response to a recent survey, for example, approximately 20% of respondents indicated that their suppliers are not transparent enough about the environmental impacts of their ICT products and services. Meanwhile, 17% indicated that they do not have enough visibility into their ICT supply chain.

This reality makes it important for organizations like yours to both disclose environmental sustainability data to your buyers and request environmental sustainability data from your suppliers more often. At present, technology suppliers report rarely (if ever) being asked by Canadian customers about the environmental sustainability of their ICT products and services, giving them little incentive to collect this data in the first place. The more organizations start requesting and disclosing environmental data, the more transparent the ICT supply chain will become.

When it comes to environmental sustainability data, there are a vast number of indicators that you could request or disclose. For example, you could request data from your suppliers about their contribution to climate change by asking for the CO_2 equivalent emissions associated with their products, services, or operations. Meanwhile, you could disclose your organization's contribution to water resource depletion by indicating the amount of water your products and services use in comparison with local water availability. While it might seem overwhelming to navigate all of the environmental impacts outlined in documents like ITU-T L.1410, the best thing your organization can do is start somewhere small. Once you've opened up dialogue with your buyers and suppliers, you can work together to focus and refine the environmental data you share.

There are a number of ways your organizations can disclose and request environmental data. This includes supplier questionnaires (e.g., basic questionnaires that you draft and provide to your buyers or to your suppliers to complete), formal environmental audits (e.g., lifecycle

assessments or other types of environmental audits that you contract environmental services professionals to conduct on your behalf), and environmental reporting platforms (e.g., paid platforms that you use to formally request and manage yours and your supplier's environmental data).

In the list below, you'll find a few examples of tools and services that you can use to disclose, request, and manage environmental data, as well as a list of documents that provide examples of environmental impact categories and data.

List of Resources:

Tools to Help You Request and Disclose Environmental Data

- Use this free online resource to see examples of what simple, high-level criteria you can ask ICT suppliers about and what language you can use: Green Economy Canada and HP RFX Guide
- Use this free online standard to see what types of environmental impact categories and indicators you can disclose and/or ask your suppliers about ITU-T L.1410: Methodology for environmental lifecycle assessments of information and communication technology goods, networks and services
- Contract an organization like this to conduct supply chain audits, lifecycle assessments, or other sustainability assessments on your behalf: Sedex Information Exchange
- Use a paid online platform like this to disclose, request, and manage environmental data: CDP Supply Chain

ii) Working with Users

Users can significantly influence the environmental sustainability of your organization's information and communications technologies, even when those technologies are designed to be sustainable by default. Through their everyday habits, users can shorten or lengthen the lifespan of your organization's technology devices, increase or decrease the amount of data storage and processing your organization needs, and ensure or negate proper end-of-life management for ICT hardware. Because of this, it's important for your organization to work with your technology users to implement best practices and reduce the environmental impact of their everyday technology-use habits. For example, you can provide your users with dynamic feedback about the environmental impact of their technology use, help your users configure devices and software programs to use less energy, water, or other resources, implement data and digital resource minimization principles, and recycle or dispose of ICT hardware responsibly. In the list below, you'll find a number of online resources that can help you work with users to reduce the environmental impact of their technology use.

List of Resources:

- Consult this free online guide for more information about how you can work with users to reduce the environmental impact of their technology use: Green ICT Handbook: A Guide to Green ICT
- Consult this free online standard for technical guidance on the type of information and guidance you can provide to users: ECMA 341: Environmental Design Considerations for ICT & CE Products
- Consult this free online standard for technical guidance on the type of information and guidance you can provide to users: W3C Sustainable Web Guidelines
- Consult this paid online textbook to learn how to incorporate users into your sustainable IT strategy: Sustainable IT Playbook for Technology Leaders

iii) Repairing ICT Devices

ICT devices have short lifespans and require a lot of resources to be used for only a few years.[xli] Prolonging the life of an ICT device is environmentally sustainable because it delays the need to manufacture a replacement device, thereby limiting environmental impacts from the manufacturing stage and reducing demand for new raw material extraction.[xlii] From a lifecycle perspective, prolonging the life of an ICT device also reduces the environmental impact of that device *per* year of use: if a laptop is used for five years instead of three, then the environmental impacts that occur during its production and manufacturing can be spread over five years, too.

Apart from designing durable hardware that is built to withstand falls, spillages, and extreme temperatures and helping users take good care of their ICT devices, one of the main ways your organization can prolong the life of ICT devices is by maintaining robust repair and refurbishing programs. It is unlikely that many of your customers will have the resources or ability to repair or refurbish technology devices internally; because of this, it's important for your organization to maximize the number of replaceable components in your devices and maintain robust warranty and repair programs.

In this list below, you'll find a variety of free and paid resources with more information about extending the life of ICT devices.

List of Resources:

- Consult this free online standard to learn about environmentally sustainable design practices for device longevity: ECMA 341: Environmental Design Considerations for ICT & CE Products
- Consult this free online resource to learn about environmentally sustainable design practices that extend product lifespans: TCO Certified Environmental Criteria
- Consult this free online guide to learn about repairing and prolonging the life of ICT devices: Green ICT Handbook: A Guide to Green ICT

- Consult this paid online textbook to learn about repairing and prolonging the life of ICT devices: Sustainable IT Playbook for Technology Leaders

Recycling ICT Devices, Components, and Materials

When ICT products reach the end of their life, they become electronic waste, or "e-waste," which has become a major contributor to global solid waste. Reportedly, just 17.4% of global e-waste is properly collected and disposed of.[xliii] E-waste differs chemically and physically from regular waste, containing hazardous materials like lead, mercury, nickel, and cobalt, which require specialized methods to dismantle and dispose of.

As a technology designer or developer, your organization can limit the environmental impacts of e-waste by designing your products in line with sustainable ICT standards and best practices for device recyclability and by maintaining robust recycling programs. For example, standards published by ETSI, ITU, and ECMA specify that ICT manufacturers should maximize the use of recyclable and bio-based materials in their products; share data with partners, end-users, and recycling centres about how to remove data from ICT devices and about the recyclability of specific components and parts; and design products in a way that facilitates repair, reuse, and recycling later on, such as by reducing the number of materials per component or part, not using manufacturing processes that reduce recyclability, and making it easy to separate products into individual components and parts. As mentioned by Niklas Sundberg in his Sustainable IT Playbook for Technology Leaders, a good starting point for your design and development team is to develop a "circularity strategy." Among other things, this could include guiding principles for your design team, specific targets, such as the number of years you want your devices to last, the percentage of recycled (versus raw) materials you want to use in your devices, and which hazardous substances you want to avoid.

Your organization can also reduce the environmental impacts of e-waste by helping your employees properly dispose of and/or recycle ICT devices. If your suppliers do not maintain internal recycling programs, you should direct your employees to recycle their ICT devices properly at their closest electronic products recycling centre. In most Canadian provinces, electronics recycling is managed by an organization called the Electronics Products Recycling Association, which operates regulated electronics recycling programs for individuals and businesses across Canada.

List of Resources:

- Visit this online resource to find out where across Canada your employees can recycle ICT devices: Recycle My Electronics
- Consult this free online standard to learn about environmentally sustainable design practices for device recyclability: ECMA 341: Environmental Design Considerations for ICT & CE Products

- Consult this free online standard to learn about environmentally sustainable design practices for device recyclability: ITU-T L.1060: General principles for the green supply chain management of information and communication technology manufacturing industry
- Consult this free online standard to learn about eco-design practices for device recyclability: ECMA 341: Environmental Design Considerations for ICT & CE Products
- Consult this paid online textbook to learn how to incorporate circularity principles into your organization's ICT device management practices: Sustainable IT Playbook for Technology Leaders

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