ICTC POLICY BRIEF

# ADVANCING ENVIRONMENTALLY SUSTAINABLE ICT IN CANADA

ICTC CTIC

Research by

ICTC CTIC
Information and Communications Technology Council
Conseil des technologies de l'information et des communications

In partnership with

CONSEIL DE GOUVERNANCE NUMÉRIQUE
DIGITAL GOVERNANCE COUNCIL

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# Preface

The Information and Communications Technology Council (ICTC) is a not-for-profit, national centre of expertise for strengthening Canada's digital advantage in a global economy. Through trusted research, practical policy advice, and creative capacity-building programs, ICTC fosters globally competitive Canadian industries enabled by innovative and diverse digital talent. In partnership with an expansive network of industry leaders, academic partners, and policymakers from across Canada, ICTC has empowered a robust and inclusive digital economy for over 25 years.

The Digital Governance Council is a member-driven organization that acts as a cross-sector-neutral convener for Canada's executive leaders to identify, prioritize, and act on digital governance opportunities and challenges. The organization leads an Executive Forum for Council members, sets technology governance standards through the Digital Governance Standards Institute and certifies the compliance of Canadian organizations in the management of the effective and efficient use of digital technologies.

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The opinions and interpretations in this publication are those of the authors and do not necessarily reflect those of the Government of Canada.

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# Foreword

**Over the past two years, The Information and Communications Technology Council (ICTC) and the Digital Governance Council (DGC) have been working to advance environmental sustainability in Canada's information and communications technology (ICT) sector:**

In February 2022, ICTC and DGC forged a partnership to advance the objectives of DGC's Sustainable IT Pledge, the first-ever commitment by Canadian organizations to cut rapidly rising emissions from digital technologies.

In December 2022, ICTC partnered with DGC to conduct a knowledge synthesis of global standards for environmentally sustainable ICT. Over the following eight months, ICTC conducted two adjacent knowledge syntheses: one about the environmental impacts of ICT and another about global policy responses to these impacts. ICTC also conducted a series of key informant interviews with global ICT sustainability experts to identify best practices for advancing sustainable ICT and Canadian ICT businesses to learn more about the state of environmental sustainability in the Canadian ICT sector.

In April 2023, ICTC partnered with DGC to hold a policy roundtable on advancing sustainable ICT in Canada. Roundtable participants discussed how they measure the environmental impacts of ICT, the current state of ICT sustainability in Canada's ICT sector and progress to date, ongoing challenges to accomplishing sustainable ICT, and potential responses to these challenges, such as standards and best practices for sustainable ICT development and procurement.

In May 2023, ICTC conducted a survey of 500 professionals from across Canada who, in their current role, are responsible for ICT procurement, ICT operations management, or ICT product and service development. The first of its kind in Canada, the survey benchmarked the state of sustainability in Canada's ICT ecosystem, including whether organizations are thinking about sustainability from an ICT perspective, how organizations are approaching sustainable ICT, and what challenges organizations face in advancing sustainable ICT.

**This policy brief details early findings from this work and outlines what steps need to be taken to advance environmentally sustainable ICT in Canada.**

The Background section provides a high-level overview of the environmental impacts that occur across the global ICT supply chain, including during raw materials extraction and processing, production and manufacturing, transportation, software and web design, technology use, recycling, and end-of-life disposal.

The Present State of ICT Sustainability section details the current state of ICT sustainability in Canada, drawing on findings from ICTC's sustainable ICT survey.

Finally, Challenges and Solutions to Sustainable ICT discusses what challenges organizations face in accomplishing sustainable ICT and considers what industry and policy solutions may be needed to advance sustainable ICT in Canada.

# Background

It is abundantly clear that our collective well-being and the health of the global economy rely on our ability to mitigate environmental harm. In response to a 2023 survey by the World Economic Forum, global leaders identified "failure to mitigate climate change" as the number one risk facing humanity in the next 10 years. This was followed by "failure of climate-change adaptation," "natural disasters and extreme weather events," and "biodiversity loss and ecosystem collapse."[1]

Of the 10 "planetary boundaries" that define a safe operating space for humanity (freshwater use, land system change, biodiversity, extinction, climate change, novel entities, stratospheric ozone depletion, atmospheric aerosol loading, ocean acidification, and biological flows), the Earth has already transgressed five and is dangerously close to transgressing three more.[2] Already, changes in the frequency and severity of extreme weather events are making large regions of the world unhabitable and are impacting agricultural production and business, industry, and supply chain resilience.

Of the planetary boundaries, climate change poses the most urgent threat to Canadians. Within the first eight months of 2023, Canada experienced 6,074 fires, burning approximately 4% of Canadian forests.[3] Higher instances of extreme forest fires are being driven by uncharacteristic droughts and record-breaking temperatures, themselves brought on by anthropogenic climate change.[4] Climate change is also amplifying the frequency and severity of heavy rainfall, extreme flooding, and hurricanes.[5] Already, climate change is drastically impacting Canada's security, critical infrastructure, and collective well-being.

Mitigating climate change will require an overall reduction in the flow of heat-trapping gases like carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) into the atmosphere.[6] By 2030, global greenhouse gas (GHG) emissions will need to be reduced by 45% (below 2010 levels) and by 2050, the world will need to have achieved its net zero target.[7] At the same time, other drivers of climate change and environmental degradation will need to be addressed, including pollution, land use change, biodiversity loss, and our overuse of finite resources. If these outcomes are not prioritized, we will be met with severe biophysical cascading effects, including reduced sea ice extent, rising sea levels, ocean acidification, and more extreme floods, droughts, and fires.

While high-emitting and material-intensive sectors will be at the forefront of sustainability gains[8] all sectors have a role to play—even ICT, which despite being perceived as having minimal impacts on the environment, contributes to global GHG emissions, raw material extraction, pollution, and more.

1 "The Global Risks Report 2023," 2023, World Economic Forum, https://www3.weforum.org/docs/WEF_Global_Risks_Report_2023.pdf

2 "Planetary Boundaries," 2021, Stockholm Resilience Centre, https://www.stockholmresilience.org/research/planetary-boundaries.html

3 "Wildfires in Canada have broken records for area burned, evacuations and cost, official says," July 2023, The Associated Press, https://abcnews.go.com/International/wireStory/wildfires-canada-broken-records-area-burned-evacuations-cost-100806230; "Forest fire centre declares 2023 worst year ever for Canadian wildfires," June 2023, The Canadian Press, https://www.theglobeandmail.com/canada/article-quebec-wildfire-smoke-causes-widespread-smog-warnings-grounds-some/; "Canadian wildfires fueled by climate change, study shows," August 2023, DW, https://www.dw.com/en/canadian-wildfires-fueled-by-climate-change-study-shows/a-66601298

4 Barnes, Claire, et al., "Climate change more than doubled the likelihood of extreme fire weather conditions in Eastern Canada," 2023, https://spiral.imperial.ac.uk/bitstream/10044/1/105981/17/scientific%20report%20-%20Canada%20wildfires.pdf

5 "Climate Change 2022," 2022, IPCC, https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/

6 "Responding to Climate Change," 2023, Global Climate Change Vital Signs of the Planet, https://climate.nasa.gov/solutions/adaptation-mitigation/

7 "Special Report: Global Warming of 15°C," 2018, IPCC, https://www.ipcc.ch/sr15/

8 E.g., Mining, oil and gas, transport, agriculture, and buildings and infrastructure. See: "Greenhouse gas emissions: drivers and impacts," 2023, Environment and Climate Change Canada, https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions-drivers-impacts.html

# The Environmental Impact of the ICT Sector

Information and communications technologies (ICTs) receive high recognition for their ability to improve other sectors' efficiency and productivity while decreasing GHG emissions and energy use.[9] Because of this, many argue that ICT has an overall benefit to the environment.[10] This may be true, but ICT's ability to reduce energy consumption and GHG emissions has not been fully realized.[11] In many cases today, ICT's environmental benefits are cancelled out by negative impacts along the ICT supply chain, such as during manufacturing, transport, use, and disposal.[12]

ICTs have also increased global energy consumption.[13] The United Nations Environment Programme (UNEP) reports that "if the Internet were a country, it would be the sixth largest electricity consumer on the planet," comprising 7% of global electricity consumption.[14] Moreover, 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.[15] Beyond its contribution to climate change, ICT's rapid growth and complex supply chain make it an ongoing contributor to raw material extraction, soil, water, air pollution, waste generation, and more; much of these byproducts are often unclear to the common consumer. In the figure below, we provide additional details about the environmental impacts that occur in each stage of the ICT supply chain.

9 Ajwang and Nambiro, "Climate change adaptation and mitigation using information and communication technology," 2022, International Journal of Computer Science Res. 6, 6, 1046-1063, https://www.researchgate.net/publication/362732924_Climate_Change_Adaptation_and_Mitigation_using_Information_and_Communication_Technology; "Data Centres and the Grid—Greening ICT in Europe," 2023, CERRE, https://cerre.eu/wp-content/uploads/2021/10/211013_CERRE_Report_Data-Centres-Greening-ICT_FINAL.pdf; Dandres, Thomas et al., "Consequences of future data centre deployment in Canada on electricity generation and environmental impacts," 2016, Journal of Industrial Ecology, https://doi.org/10.1111/jiec.12515; secondary sources as cited in Granit, Ian, "The Digital Divide: Effects on Distribution of Wealth and Resources and Climate Change," 2020, Undergraduate Journal of Politics, Policy, and Society, https://ujpps.com/index.php/ujpps/article/download/79/35

10 Ibid.

11 Reimsbach Kounatze, Christian, "Towards Green ICT Strategies," 2009, OECD Digital Economy Papers, http://dx.doi.org/10.1787/222431651031

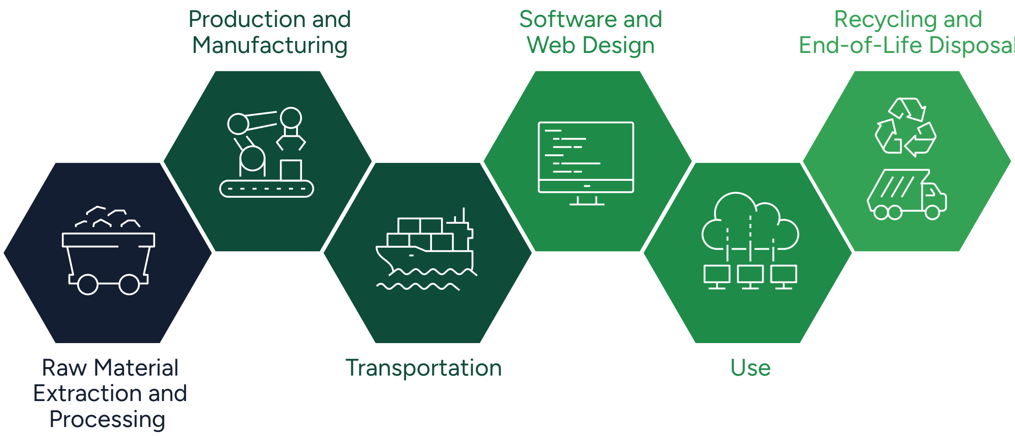
12 Hilty, Lorenz and Bieser, JCT, "Opportunities and risks of digitalization for climate protection in Switzerland," 2006, University of Switzerland, https://www.dora.lib4ri.ch/empa/islandora/object/empa%3A14982; Kopp, Thomas and Lange, Steffen, "The climate effect of digitalization in production and consumption of OECD countries," 2019, The University of Grottingen and the Institute for Ecological Economy Research, https://ceur-ws.org/Vol-2382/ICT4S2019_paper_3.pdf

13 Steffen Lange, Johanna Pohl, and Tilman Santarius, "Digitalization and energy consumption. Does ICT reduce energy demand?," 2020, Ecological Economics, http://www.santarius.de/wp-content/uploads/2020/08/Digitalization-and-energy-consumption-Ecological-Economics-LangePohlSantarius-2020.pdf

14 Schwarzer, Stefan and Peduzzi, Pascal, "Foresight Brief," 2021, UNEP, https://wedocs.unep.org/bitstream/handle/20.500.11822/37439/FB027.pdf

15 These estimates vary due to the fact that ICT emissions are challenging to measure: in part due to a lack of consistent data for CO2 emissions accounting, and in part due to the fact that ICTs transcend traditional sectoral boundaries, making it challenging to capture the their total share of emissions. See: Freitag, C. Et al., "The real climate and transformative impact of ICT" A critique of estimates, trends, and regulations," 2021, ScienceDirect, https://www.sciencedirect.com/science/article/pii/S2666389921001884#; Ritchie, Hannah, "Climate change and flying: what share of global CO2 emissions come from aviation?," 2020, Our World in Data, https://ourworldindata.org/co2-emissions-from-aviation; Schwarzer, Stefan and Peduzzi, Pascal, "Foresight Brief," 2021, UNEP, https://wedocs.unep.org/bitstream/handle/20.500.11822/37439/FB027.pdf

## ICT Supply Chain




## Raw Material Extraction and Processing

ICT hardware and equipment rely on large quantities of raw materials, including indium, lithium, tantalum, gallium, copper, silver, gold and rare earth elements.[16] While the environmental impacts of raw material extraction and processing depend on ore processing procedures, weak environmental regulations in this stage of the supply chain can lead to water depletion, aquatic and terrestrial contamination, increased toxicity for wildlife and human life, and other land-use changes impacting the vitality of the natural environment.[17] According to a study by the OECD, if demand for rare earth elements continues and current environmental management practices remain unchanged, by 2050, we will see a 200% to 300% increase in environmental impacts from resource extraction for ICTs.[18]

## Production and Manufacturing

The manufacturing of ICT products, such as computers, smartphones, and networking equipment, is the most energetically intensive phase of the ICT supply chain: approximately 80% of the energy that is consumed across the lifecycle of an ICT device is consumed during manufacturing.[19]

16 Duporte, Alexandre, “Environmental impacts of digitalization,” 2022, AEIDL, https://www.aeidl.eu/wp-content/uploads/2022/10/AEIDL-PolicyUnit-Environmental-impacts-of-digitalisation-AD-v4.pdf; Santarius, Tilman et al., “Digital sufficiency: conceptual considerations for ICTs on a finite planet,” 2022, Annals of Telecommunications, https://doi.org/10.1007/s12243-022-00914-x; Santarius, Tilman et al., “Digitalization and the decoupling debate,” 2022, Sustainability, https://doi.org/10.1007/s12243-022-00914-x; Tansel, Berrin, “From electronic consumer products to ewastes: global outlook, waste quantities, recycling challenges,” 2017, Environment International, https://www.sciencedirect.com/science/article/abs/pii/S0160412016305414; Wäger, Patrick et al., “The material basis of ICT,” 2015, ICT Innovations for Sustainability, https://link.springer.com/chapter/10.1007/978-3-319-09228-7_12;

17 ADEME (2018) as cited in Duporte, Alexandre, “Environmental impacts of digitalization,” 2022, AEIDL, https://www.aeidl.eu/wp-content/uploads/2022/10/AEIDL-PolicyUnit-Environmental-impacts-of-digitalisation-AD-v4.pdf; Liu, Ran et al., “Impacts of the Digital Transformation on the Environment and Sustainability, 2019, Oko-Institute EV, https://www.researchgate.net/publication/342039732_Impacts_of_the_digital_transformation_on_the_environment_and_sustainability

18 OECD, “Measuring the Relationship between ICT and the Environment,” 2019, OECD, https://www.oecd.org/sti/43539507.pdf

19 Lennerfors, Thomas Taro et al, “Sustainable ICT: A Critique from the Perspective of World Systems Theory,” 2014, ICT and Society, https://doi.org/10.1007/978-3-662-44208-1_6; Santarius, Tilman et al., “Digital sufficiency: conceptual considerations for ICTs on a finite planet,” 2022, Annals of Telecommunications, https://doi.org/10.1007/s12243-022-00914-x; Santarius, Tilman et al., “Digitalization and the decoupling debate,” 2022, Sustainability, https://doi.org/10.1007/s12243-022-00914-x; Hilty, Lorenz and Bieser, JCT, “Opportunities and risks of digitalization for climate protection in Switzerland,” 2006, University of Switzerland, https://www.dora.lib4ri.ch/empa/islandora/object/empa%3A14982

Reducing energy consumption across the ICT lifecycle is a complex task: often, designing hardware to be more energetically efficient during its use requires more energy to be consumed during manufacturing, negating overall reductions in energy use.[20] ICT manufacturing also relies on hazardous materials, which contribute to climate change, acidification, eutrophication, land use change, and eco and human toxicity.[21] Humans involved in ICT manufacturing are often exposed to carcinogenic chemicals and have elevated rates of cancer.[22] ICT manufacturing also relies on large quantities of water and is known to pollute nearby waterways.[23]

## Transportation

ICT inputs, parts, and finished products need to be transported between mining, processing, manufacturing, distribution, and end users. The ICT sector relies on a global supply chain of ICT inputs, components, and equipment, which are produced all over the world. Components are typically imported to separate plants for assembly before being shipped to retailers and transported to end users.[24] Long supply chains increase transportation needs, resulting in significant GHG emissions from energy consumption.[25]

## Software and Web Design

Software programs, web applications, and web infrastructure are built on top of ICT's physical hardware and networking infrastructure. Growing demand for complex software has increased software's energy consumption and GHG emissions.[26] As software applications become more powerful, for instance, through big data and AI, environmental impacts are expected to increase. Software is also implicated in an ongoing cycle of technological obsolescence: as more powerful hardware is introduced, software needs updating, increasing energy consumption.[27] Likewise, software updates often render ICT devices obsolete, contributing to e-waste and environmental toxicity.[28]

20 As cited in Williams, Eric, "Environmental effects of information and communications technologies," 2011, Nature, https://doi.org/10.1038/nature10682; Arunshanyan, Yevgenia et al., "Lessons learned – Review of LCAs for ICT products and services," 2014, Computers in Industry, https://doi.org/10.1016/j.compind.2013.10.003; Hischier, Roland et al., "Grey Energy and Environmental Impacts of ICT Hardware, 2015, "ICT Innovations for Sustainability, https://doi.org/10.1007/978-3-319-09228-7_10; Kern, Eva et al., "Processes for green and sustainable software engineering," 2015, Green in Software Engineering, https://link.springer.com/chapter/10.1007/978-3-319-08581-4_3; Liu, Ran et al., "Impacts of the Digital Transformation on the Environment and Sustainability, 2019, Oko-Institute EV, https://www.researchgate.net/publication/342039732_Impacts_of_the_digital_transformation_on_the_environment_and_sustainability; Luciervo, Frederica, "Big Data, Big Waste? A Reflection on the Environmental Sustainability of Big Data Initiatives," 2020, Science and Engineering Ethics, https://doi.org/10.1007/s11948-019-00171-7

21 Williams, Eric, "Environmental effects of information and communications technologies," 2011, Nature, https://doi.org/10.1038/nature10682

22 Ibid

23 Berkhout, Frans and Hertin, Julia, "De-materialising and re-materialising: digital technologies and the environment," 2004, Futures, https://doi.org/10.1016/j.futures.2004.01.003; Bomhof, Freek et al., "Systematic Analysis of Rebound Effects for 'Greening by ICT' Initiatives," 2009, Communication and Strategies, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1659725; Liu, Ran et al., "Impacts of the Digital Transformation on the Environment and Sustainability, 2019, Oko-Institute EV, https://www.researchgate.net/publication/342039732_Impacts_of_the_digital_transformation_on_the_environment_and_sustainability; Arunshanyan, Yevgenia et al., "Lessons learned – Review of LCAs for ICT products and services," 2014, Computers in Industry, https://doi.org/10.1016/j.compind.2013.10.003; Smith, Lucy et al., "Life cycle assessment and environmental profile evaluations of high volumetric efficiency capacitors," 2018, Applied Energy, https://www.researchgate.net/publication/324259198_Life_cycle_assessment_and_environmental_profile_evaluations_of_high_volumetric_efficiency_capacitors

24 Chowdhury, Adib Kabir and Veeramani, Shanmugam, "Information technology: Impacts on environment and sustainable development," 2015, Pertanika Journal of Science and Technology, https://www.researchgate.net/publication/273130988_Information_Technology_Impacts_on_Environment_and_Sustainable_Development; Schischke, Karsten et al., "Life cycle energy analysis of PCs—Environmental consequences of lifetime extension through reuse," 2003, Research Gate, https://www.researchgate.net/publication/268435652_Life_cycle_energy_analysis_of_PCs-Environmental_consequences_of_lifetime_extension_through_reuse; as cited in Viana, Luciano Rodrigues et al., "Sending fewer emails will not save the planet! An approach to make environmental impacts of ICT tangible for Canadian end users," 2022, Sustainable Production and Consumption, https://doi.org/10.1016/j.spc.2022.09.025

25 Ibid.

26 Lago, Patricia et al., "The service greenery-integrating sustainability in service-oriented software," 2010, International Workshop on Software Research and Climate Change, https://research.vu.nl/en/publications/the-service-greenery-integrating-sustainability-in-service-orient; Raghu, Shruti, "Study of Sustainability in Software Engineering," 2015, CSE Department, Hindu College of Engineering, https://files.ifi.uzh.ch/hilty/t/Literature_by_RQs/RQ%20120/2015_Raghu_Study_of_Sustainability_in_Software_%20Engineering.pdf

27 Kern, Eva et al., "Processes for green and sustainable software engineering," 2015, Green in Software Engineering, https://link.springer.com/chapter/10.1007/978-3-319-08581-4_3

28 Forge, Simon, "Powering down: remedies for unsustainable ICT," 2007, Foresight, https://www.proquest.com/docview/224194572; Raghu, Shruti, "Study of Sustainability in Software Engineering," 2015, CSE Department, Hindu College of Engineering, https://files.ifi.uzh.ch/hilty/t/Literature_by_RQs/RQ%20120/2015_Raghu_Study_of_Sustainability_in_Software_%20Engineering.pdf

## Use

Environmental impacts during ICT product and service use primarily relate to energy consumption and GHG emissions.[29] Using ICT devices, particularly when streaming videos, consumes energy locally, which can, in turn, emit GHGs; however, most of the environmental impacts that occur during ICT use stem from data centres.[30] Data centres are essentially the backbone of cloud services, which have increased significantly due to the proliferation of data storage as a service, compute as a service, and software as a service business models, as well as the growth of AI.[31] While the cloud is often viewed as "light, transparent, and energy efficient," it can have significant environmental impacts, particularly when data centres do not manage heat or water effectively or are powered by fossil fuels.[32] Other environmental impacts arise from cryptocurrency mining[33] and wireless networks.[34] Emissions from ICT use are expected to grow as the adoption and use of digital devices, software, and data centres increase.[35]

## Recycling and End-of-Life Disposal

At the end of their lifecycle, ICT hardware and devices need to be recycled or disposed of. Unfortunately, digital devices are the most produced and discarded products, resulting in large amounts of physical waste.[36] The UNEP reports that "in 2019, a record 53.6 million metric tonnes of e-waste were produced, the equivalent weight of 125,000 Boeing 747 jumbo jets [and] more than all of the commercial aircraft ever created."[37] Today, e-waste is the world's fastest-growing waste stream.[38]

29 Appiah-Otoo, Isaac et al., "The impact of information and communication technology (ICT) on carbon dioxide emissions: Evidence from heterogeneous ICT countries," 2022, Energy & Environment, https://doi.org/10.1177/0958305X221118877; Belkhir, Lotfi and Elemeligi, Ahmed, "Assessing ICT global emissions footprint: Trends to 2040 & recommendations," 2018, Journal of Cleaner Production, https://doi.org/10.1016/j.jclepro.2017.12.239; Hischier, Roland et al., "Grey Energy and Environmental Impacts of ICT Hardware, 2015, "ICT Innovations for Sustainability, https://doi.org/10.1007/978-3-319-09228-7_10; Viana, Luciano Rodrigues et al., "Sending fewer emails will not save the planet! An approach to make environmental impacts of ICT tangible for Canadian end users," 2022, Sustainable Production and Consumption, https://doi.org/10.1016/j.spc.2022.09.025

30 Arunshanyan, Yevgenia et al., "Lessons learned – Review of LCAs for ICT products and services," 2014, Computers in Industry, https://doi.org/10.1016/j.compind.2013.10.003; "Data Centres and the Grid—Greening ICT in Europe," 2023, CERRE, https://cerre.eu/wp-content/uploads/2021/10/211013_CERRE_Report_Data-Centres-Greening-ICT_FINAL.pdf; as cited in Dandres, Thomas et al., "Consequences of Future Data Center Deployment in Canada on Electricity Generation and Environmental Impacts," 2017, Journal of Industrial Ecology, https://doi.org/10.1111/jiec.12515; Kelly, Tim and Adolph, Martin, "ITU-T initiatives on climate change," 2008, IEEE Communications Magazine, https://doi.org/10.1109/MCOM.2008.4644127

31 Brevini, Bendetta, "Black boxes, not green: Mythologizing artificial intelligence and omitting the environment," 2020, Big Data & Society, https://doi.org/10.1177/2053951720935141; Ojala, Tuuli et al., "The ICT sector, climate and the environment : Interim report of the working group preparing a climate and environmental strategy for the ICT sector in Finland," 2020, Ministry of Transportation and Communications, https://julkaisut.valtioneuvosto.fi/handle/10024/162473

32 Luciervo, Frederica, "Big Data, Big Waste? A Reflection on the Environmental Sustainability of Big Data Initiatives," 2020, Science and Engineering Ethics, https://doi.org/10.1007/s11948-019-00171-7; "Mix énergétique, intensité carbone et Datacenters : la géographie des électrons," 2023, Datacampus, https://datacampus.fr/2022/05/16/mix-energetique-intensite-carbone-et-datacenters-la-geographie-des-electrons/

33 As cited in Badea, Liana and Mungie-Pupăzan, Mariana Claudia, "The economic and environmental impact of bitcoin," 2021, IEEE, https://www.researchgate.net/publication/350361329_The_Economic_and_Environmental_Impact_of_Bitcoin; as cited in in Monserrate, Steven Gonzalez., "MIT Case Studies in Social and Ethical Responsibilities of Computing," 2022, MIT Case Studies in Social and Ethical Responsibilities of Computing, https://doi.org/10.21428/2c646de5.031d4553

34 "Data Centres and the Grid—Greening ICT in Europe," 2023, CERRE, https://cerre.eu/wp-content/uploads/2021/10/211013_CERRE_Report_Data-Centres-Greening-ICT_FINAL.pdf; Malmodin, Jens et al., "Greenhouse Gas Emissions and Operational Electricity Use in the ICT and Entertainment & Media Sectors," 2010, Journal of Industrial Ecology, https://kth.diva-portal.org/smash/record.jsf?pid=diva2%3A315388&dswid=-8077

35 Chen, Sibo, "The Materialist Circuits and the Quest for Environmental Justice in ICT's Global Expansion," 2016, TripleC, https://doi.org/10.31269/triplec.v14i1.695; Duporte, Alexandre, "Environmental impacts of digitalization," 2022, AEIDL, https://www.aeidl.eu/wp-content/uploads/2022/10/AEIDL-PolicyUnit-Environmental-impacts-of-digitalisation-AD-v4.pdf; International Telecommunication Union, "Toolkit on environmental sustainability in the ICT sector," 2012, ITU, https://www.itu.int/ITU-T/climatechange/ess/index.html; Forge, Simon, "Powering down: remedies for unsustainable ICT," 2007, Foresight, https://www.proquest.com/docview/224194572

36 Sibo Chen, "The Materialist Circuits and the Quest for Environmental Justice in ICT's Global Expansion," 2016, TripleC, https://doi.org/10.31269/triplec.v14i1.695https://doi.org/10.31269/triplec.v14i1.695; Asif Khan and Wu Ximei, "Digital Economy and Environmental Sustainability: Do Information Communication and Technology (ICT) and Economic Complexity Matter?," 2022, International Journal of Environmental Research and Public Health, 19(19), https://doi.org/10.3390/ijerph191912301

37 Schwarzer, Stefan and Peduzzi, Pascal, "Foresight Brief," 2021, UNEP, https://wedocs.unep.org/bitstream/handle/20.500.11822/37439/FB027.pdf

38 Ibid.

E-waste differs chemically and physically from regular waste as it contains hazardous materials and requires specialized methods for dismantling and disposal.[39] Due to its complexity, e-waste is rarely disposed of properly. Instead, e-waste is often incinerated, left in landfills[40], and sometimes dumped into the ocean[41], releasing hazardous fumes and toxic chemicals that can bioaccumulate across aquatic and terrestrial ecosystems.[42] Contaminants of particular concern include lead, mercury, nickel, and cobalt.[43]

With such an extensive supply chain and such a short lifecycle, it is unsurprising that ICT technologies are not yet sustainable. While important enablers of future innovative climate solutions, today, ICTs contribute to GHG emissions, ecological footprints, environmental degradation, and ecotoxicity.[44] Improving environmental sustainability across the ICT supply chain is critical[45] to mitigating climate change and other environmental harms while enabling climate innovation.[46]

39 Robinson, Brett H., "E-waste: An assessment of global production and environmental impacts," 2009, Science of The Total Environment, https://www.sciencedirect.com/science/article/abs/pii/S0048969709009073

40 Forti, Vanessa et al., "The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential," 2020, United Nations University, United Nations Institute for Training and Research, International Telecommunication Union, and International Solid Waste Association, https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf

41 Haque, Nawshad et al., "Rare earth elements: Overview of mining, mineralogy, uses, sustainability and environmental impact," 2014, Resources, https://www.mdpi.com/2079-9276/3/4/614

42 Forti, Vanessa et al., "The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential," 2020, United Nations University, United Nations Institute for Training and Research, International Telecommunication Union, and International Solid Waste Association, https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf

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# The Present State of ICT Sustainability in Canada

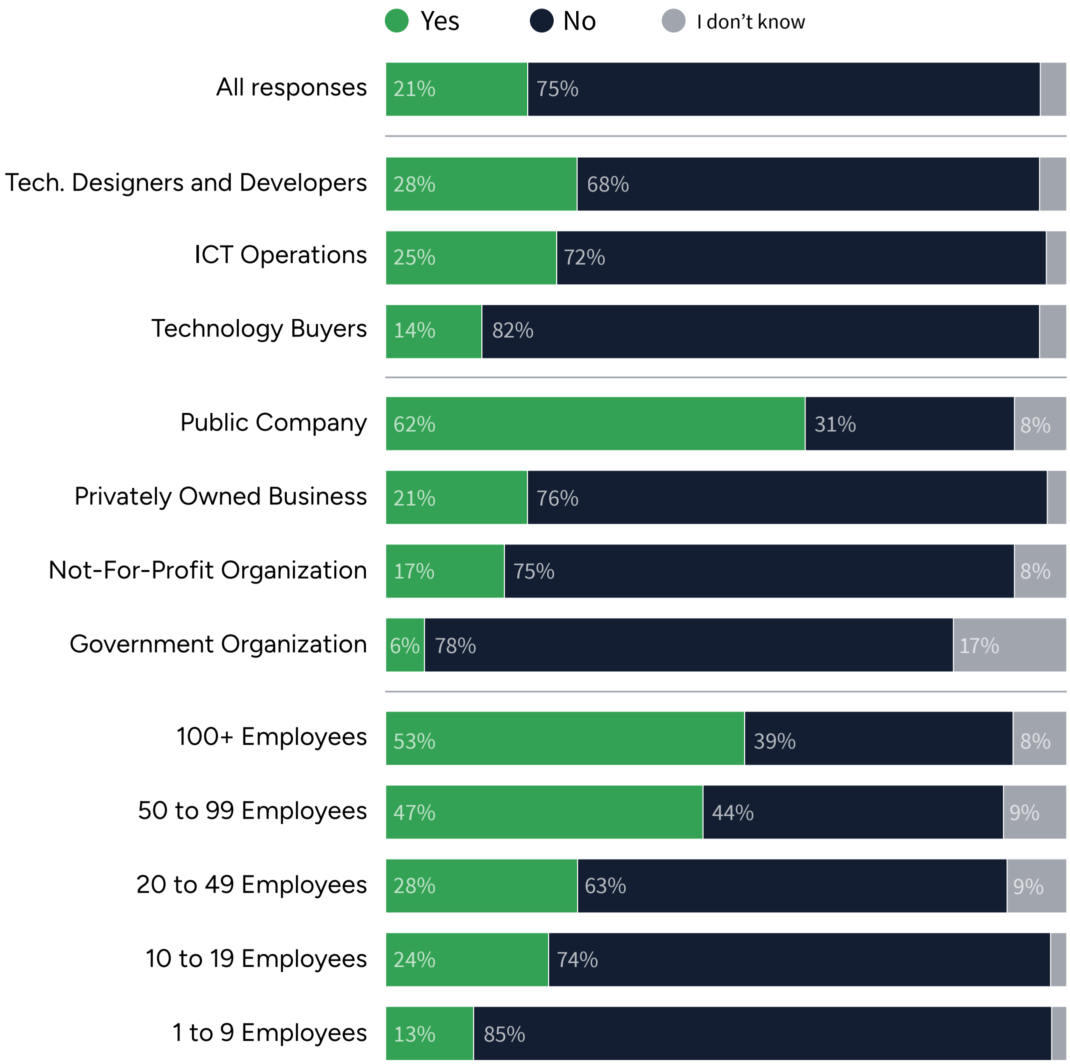
Despite the aforementioned harmful environmental impacts, most ICT stakeholders in Canada do not think of ICT from an environmental sustainability perspective—or if they do, their approach to sustainable ICT is not yet robust. While many organizations see technology as a way to achieve environmental gains—such as with clean tech—very few use tools like environmental management systems (EMS), lifecycle assessments (LCA), eco-design, or use sustainable procurement to design, build, buy, and manage ICT sustainably.

## ESG and Environmental Sustainability Strategies

ICTC's Canadian Survey on Sustainable ICT finds that only a small percentage of digital economy organizations have a general environmental, social, and governance (ESG) or environmental sustainability strategy, let alone one particular to ICT (see Figure 1). Very small organizations and startups are even less likely to have a general environmental sustainability strategy, as are government organizations and organizations that primarily engage in technology procurement, as opposed to technology design and development.

Comparatively, large companies are often better resourced, with the ability to spend time, human, and financial resources to align organizational strategies with emerging trends. Public companies are also subject to greater public scrutiny and specific legal and reporting requirements related to ESG. Moreover, organizations with internal technology developers, designers, and ICT operations managers tend to have more advanced corporate infrastructure than those who solely adopt technology.

FIGURE 1 Does your employer have a formal ESG or environmental sustainability strategy?

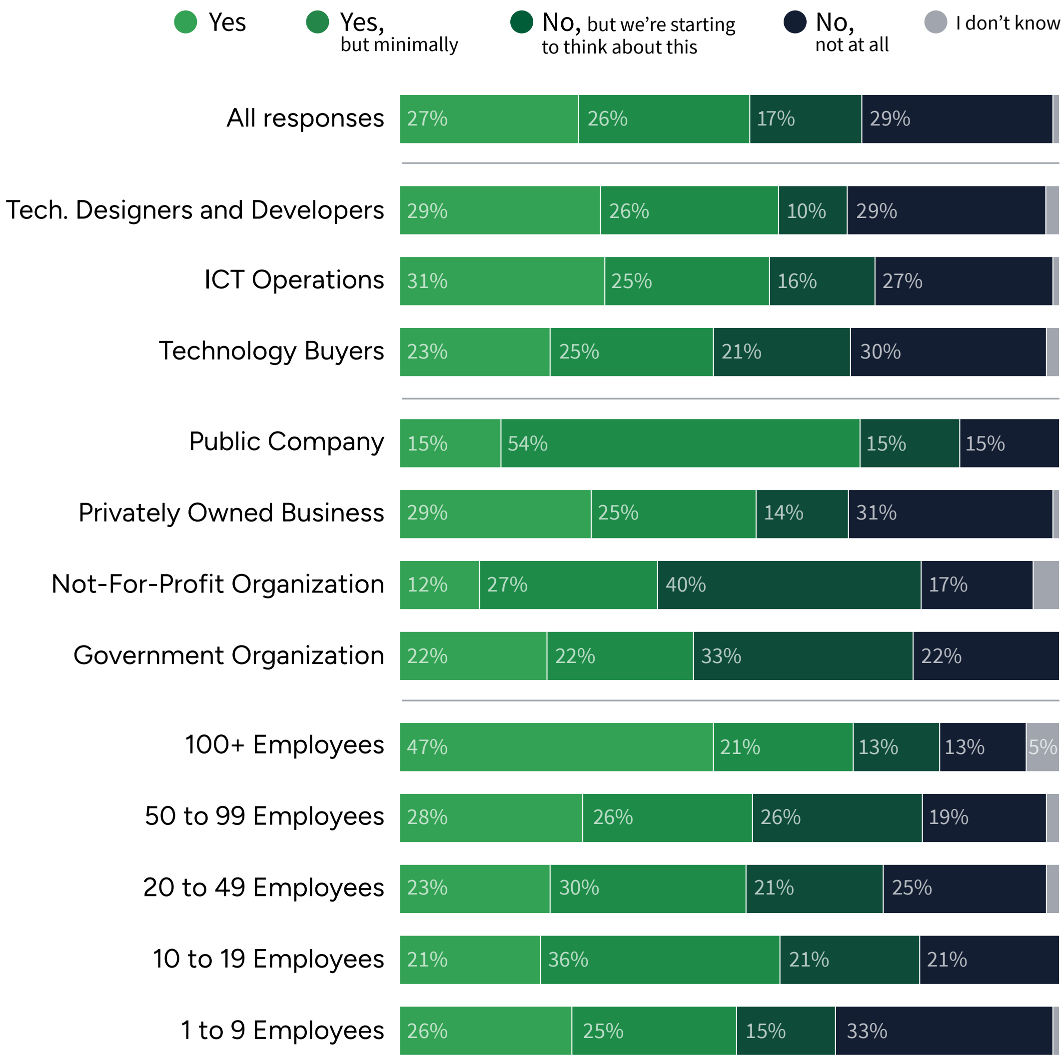



Data source: ICTC's Canadian Survey on Sustainable ICT

## Factoring Environmental Sustainability into ICT Decisions

While a significant portion of digital economy organizations now factor environmental impact and/or environmental sustainability into the way they design, develop, buy, or manage ICT, many of these organizations only do so minimally, while an even larger percentage do not do this at all (see Figure 2). As was the case for general ESG and environmental sustainability strategies, large organizations, public companies, and technology designers and developers were the most likely to factor environmental impact or environmental sustainability into how they design, develop, buy, or manage technology (see Figure 2).

**FIGURE 2** Does your employer factor environmental impact or environmental sustainability into how they design, develop, buy, or manage ICT?




Data source: ICTC's Canadian Survey on Sustainable ICT

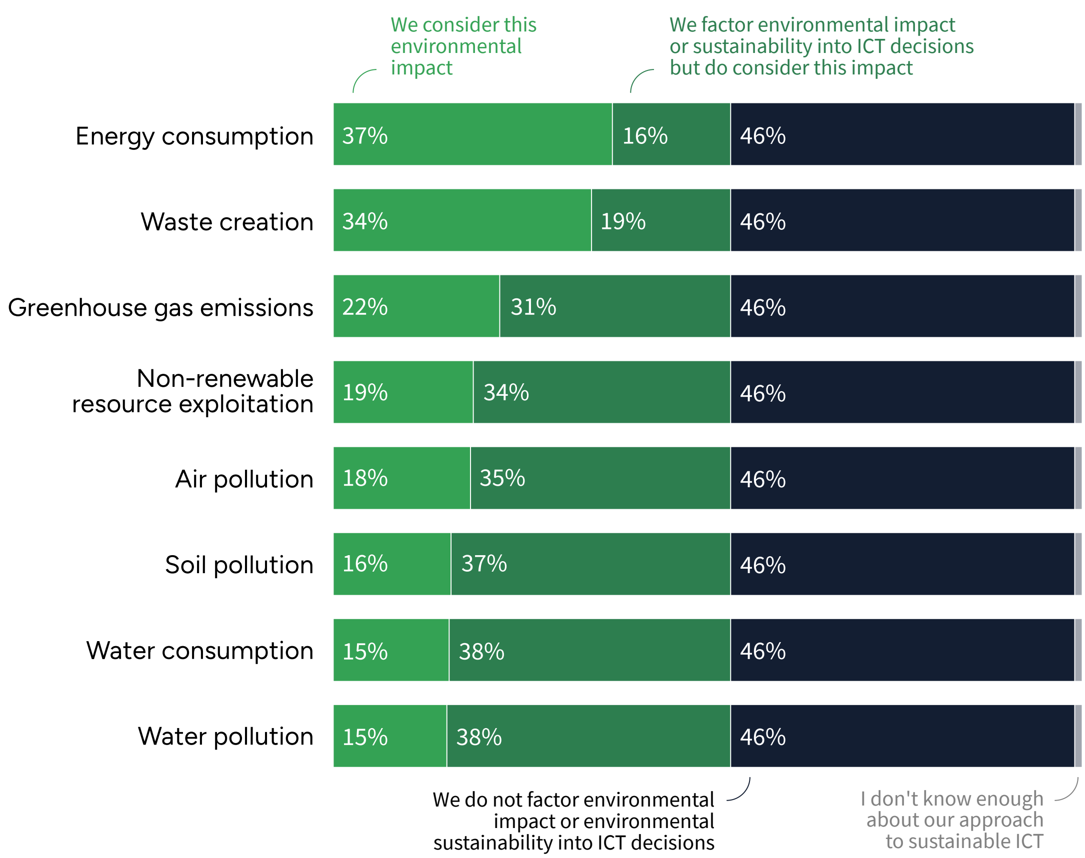
Even among organizations that *are* thinking about sustainable ICT, a large proportion have only started doing so recently. Among respondents whose employers are thinking about sustainable ICT, approximately 65% began doing so within the last five years, highlighting how recent of a trend this is.

Moreover, the subset of organizations that *are* thinking about ICT from a sustainability perspective is mainly focusing on energy consumption and physical waste generation rather than other types of environmental impacts (for example, GHG emissions, non-renewable resource exploitation, water consumption, and air, water, and soil pollution) (see Figure 3).

These findings suggest that organizations are more likely to consider environmental impacts that they interact with directly—such as through energy consumption and physical waste generation—than impacts that occur out of sight and tend to be at the very beginning and tail end of the ICT supply chain, such as soil, air, and water pollution.

Which environmental impacts organizations consider are also impacted by the size of the organization and their relationship to ICT (e.g., whether they are an ICT designer or developer, buyer, or operations manager). For instance, ICT buyers and operations managers are more likely than technology designers and developers to consider waste creation, likely because ICT buyers and operations managers are those who manage products at their end of life. Meanwhile, large organizations are exceptionally more likely to consider water consumption than smaller organizations, perhaps due to the weight given to water consumption in ESG.

**FIGURE 3** Which aspects of environmental impact or environmental sustainability does your employer consider?




Data source: ICTC's Canadian Survey on Sustainable ICT

## Approaches to ICT Sustainability

Approaches to ICT sustainability most commonly focus on physical waste generation (e.g., reusing and recycling ICT devices, having goals or programs to reduce waste generation) and energy consumption (e.g., having goals or programs to reduce energy use, monitoring the energy consumption of ICT devices) (see Figure 4). Alternatively, very few organizations align ICT design and procurement with things like ecolabels and sustainability standards despite these being readily available. Even fewer measure and report—or purchase from suppliers that measure and support—scope 1 (direct emissions from sources owned or controlled by the organization), scope 2 (emissions from purchased electricity, heat, or steam for organizational operations), or scope 3 (indirect emissions from sources not owned or controlled by the organization) GHG emissions.

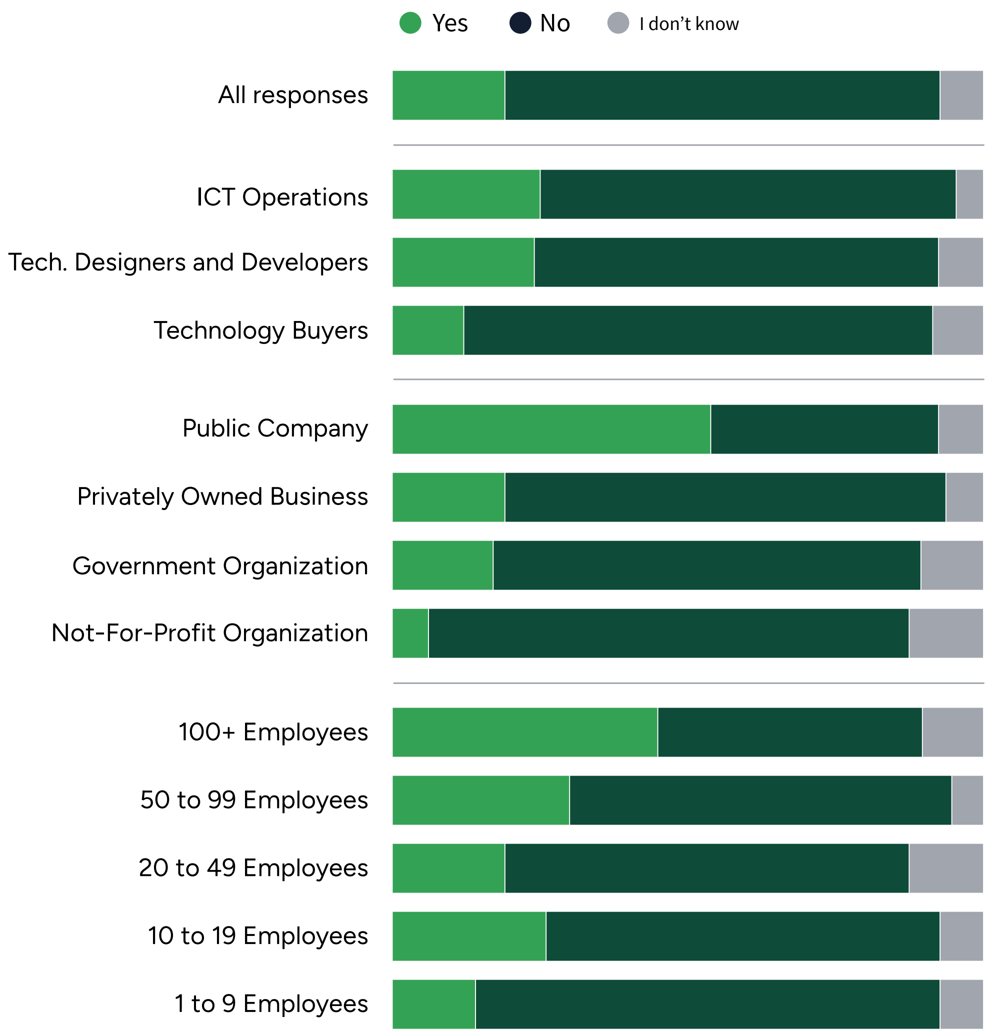
**FIGURE 4** Which of the following approaches, if any, does your organization use to limit or remove the environmental impacts of its ICT operations?


Data source: ICTC's Canadian Survey on Sustainable ICT

## Incentives for ICT Sustainability

Finally and importantly, most ICT professionals state that they lack clear incentives to make environmentally sustainable ICT decisions at work (see Figure 5). Once again, public and large companies appear to be the most advanced, while governments, not-for-profit organizations, and small organizations appear to be the least advanced. Employees at public and large companies were considerably more likely than their counterparts to report clear incentives.

**FIGURE 5** Which of the following approaches, if any, does your organization use to limit or remove the environmental impact of its ICT operations?




Data source: ICTC's Canadian Survey on Sustainable ICT

Overall, ICTC's research finds that despite various harmful environmental impacts associated with ICTs today, most ICT stakeholders are not yet fully considering the environmental impacts of ICT in their work—or if they are, their approach does not adequately consider the full range of environmental impacts or the full variety of possible approaches to sustainable ICT.

A confluence of factors makes it difficult for today's ICT stakeholders to adequately address ICT's environmental impact and advance Canada's progress toward a sustainable ICT ecosystem. Yet, many of these challenges pose opportunities for implementable and trackable interventions to drive positive change. Core sustainable ICT challenges and solutions are described next.

# Challenges and Solutions to Sustainable ICT

Qualitative research participants, roundtable participants, and survey respondents identified a variety of challenges that can make it difficult to implement sustainable ICT strategies, even when there is a will to do so. The most common four—awareness, organizational capacity, transparency, and market signals—are explored in this section. For each challenge, ICTC presents recommendations that Canadian stakeholders, including government, industry leaders, and academic institutions, can implement to help advance ICT sustainability in Canada.

## Challenge Limited Awareness

The first challenge the ICT ecosystem faces in implementing sustainable practices is simple yet very significant: many individuals responsible for technology development, procurement, and ICT decision-making do not possess a strong awareness of the environmental impacts of ICT, nor do they fully understand how to enhance ICT sustainability.

In response to ICTC's Canadian business survey, more than a quarter (27%) of respondents indicated lacking the required knowledge and expertise to make environmentally sustainable ICT decisions, while approximately 16% indicated lacking proper awareness of the environmental impact of ICT products and services. Similar sentiments were expressed by individuals interviewed for this study. As one technology developer noted: "We don't have any concrete information on the environmental consequences of software design decisions." Another developer had similar remarks: "I don't have clarity on how technologies impact the environment."

Because many ICT professionals are not completely aware of the environmental impacts of technology, it is unsurprising that most are simply not thinking about ICT sustainability to the extent needed to propel positive change. As noted by one research participant, an ICT operations manager responsible for technology procurement, "I'll be honest... it's never really been at the forefront of our minds."

Another interviewee responsible for technology procurement felt the same way, noting that the biggest barrier to sustainable ICT is a lack of awareness; as she explained, it had never occurred to her to factor environmental impact into procurement decisions.

Among qualitative research participants, small software companies and startups were especially unaware of their environmental impacts, as demonstrated by the following quotes:

> We are a very small company, so I think that our impact is pretty inconsequential.
>
> – CEO, Software Company

> We are a small startup, so we don't really need to establish any environmental regulations internally. Our activities mainly run in Google cloud, and the only hardware we have are laptops, so other than that, we have no real GHG emission footprint.
>
> – Procurement Officer, Software Company

> I have two AI companies. And in my opinion, [they do] not have too much of an environmental impact.... I mean, in general, you can say that the entire electronic economy is a sustainable economy relative to the petrochemical economy that came before it, right? There's no fossil fuel involved in what we do in the AI business... at least not directly. So, in that sense, you can say the entire business is environmentally friendly.
>
> – CEO, Software Company

A lack of awareness about the environmental impact of ICT has resulted in a lack of action toward improving the environmental sustainability of the ICT sector. This is especially true for ICT companies, who often do not physically see the environmental impact of their products, services, or operations. As noted in The Present State of ICT Sustainability in Canada section, organizations are more likely to consider environmental impacts that they directly interact with, such as energy consumption, as opposed to impacts that occur at the beginning or tail end of the ICT supply chain. For many ICT professionals, the environmental impacts that occur in other parts of the ICT supply chain are largely invisible. In sum, though not necessarily intentional, an "out of sight, out of mind" mentality fuels insufficient action on sustainable ICT.

## Solution Education and Knowledge Mobilization

To expand the use of sustainable ICT strategies, it will first be imperative to increase the ICT sector's knowledge of their environmental impact. Research participants and secondary literature state the importance of awareness campaigns in helping advance sustainable ICT.[47] Effective awareness campaigns will raise awareness of not just the environmental impacts that occur locally but those that occur across the ICT supply chain, including in other countries, which are even more likely to be "out of sight and out of mind."

47 Evangelista, Pietro and Hallikas, Jukka, "Exploring the influence of ICT on sustainability in supply management: Evidence and directions for research," 2022, Cleaner Logistics and Supply Chain, https://www.sciencedirect.com/science/article/pii/S277239092200024; International Telecommunication Union, "Toolkit on environmental sustainability in the ICT sector," 2012, ITU, https://www.itu.int/ITU-T/climatechange/ess/index.html; Santillán-Saldivar, Jair et al., "How recycling mitigates supply risks of critical raw materials: Extension of the geopolitical supply risk methodology applied to information and communication technologies in the European Union," 2021, Resources, Conservation & Recycling, https://doi.org/10.1016/j.resconrec.2020.105108

Equally important is including content about the environmental impacts of ICT in tech-focused programs at post-secondary institutions. Governments, post-secondary institutions, and industry are encouraged to use a combination of different channels and mediums to bring this message to as wide an audience as possible.

## Challenge Organizational Capacity

Many organizations that are aware of the environmental impacts of ICT still lack the capacity to make environmentally sustainable ICT decisions. In response to ICTC's survey, 37% of respondents indicated that they do not have enough time, capacity, or other resources to make environmentally sustainable technology decisions. Meanwhile, 27% indicated that they lack the required knowledge and expertise to make environmentally sustainable ICT decisions, while 13% indicated that they do not have the right organizational processes or policies in place. A lack of organizational capacity manifests in several ways. First, a lack of the required time and resources causes other goals or values to be ranked as "higher priority" than ICT sustainability. This is often the case for small startups, not-for-profits, and small or medium size enterprises, which are more likely to have limited resources to dedicate to sustainable ICT. Additionally, many organizations face a lack of skills and knowledge to adopt sustainable ICT strategies and organizational processes (to be discussed in the following sub-section).

ICT designers and developers, operations managers, and buyers face a long list of priorities. Technology must be designed efficiently, adhere to privacy and accessibility legislation, follow cybersecurity best practices, be easy to use, meet market needs, be cost effective, and more. Oftentimes, the long list of priorities involved in technology design, operations management, and procurement means that some outcomes need to be deprioritized.

In many cases, the cost of technology outweighs other specifications or asks. One research participant, a procurement officer, simplifies this reality, stating, "There is a fairly large emphasis on price, and I don't think we would be willing to pay more for technology that has environmental benefits." This is further amplified in a weakening economy. When the founder of a tech startup was asked what is higher on their priority list than sustainability, they quickly answered: "Being able to pay the bills and buy the things we need… It's all about survival. You need to be able to make money faster than you are spending it." Of course, it is difficult to blame organizations for prioritizing revenue and cost over sustainability, particularly when they are a business in startup or survival mode or an under-resourced public organization trying to meet their technology needs with limited funding.

Other interviewees noted that their business is already prioritizing other areas of environmental, social, and governance strategy, such as reducing transport-related emissions or trying to increase equity, diversity, and inclusion, leaving little to no room for ICT sustainability. One interviewee justified not thinking about an ICT sustainability policy because "[they] do social good in other areas." Similarly, interviewees from cleantech or clean-tech-adjacent companies often felt that because they build technological solutions to address environmental harm, it is less important for them to consider the environmental impact of their own solutions.

For example, one organization explained that they had recently adopted new sensors, enabling them to start monitoring their cellular towers remotely, in turn reducing scope 1 emissions associated with travel and in-person site inspections. That said, the interviewee did not state whether they had balanced these savings against possible increases to their scope 3 emissions, for instance, due to embodied environmental impacts in ICT hardware. ICT hardware has notoriously high scope 3 emissions, which can sometimes outweigh improvements in scope 1.[48]

Still, other interviewees explained that ICT-related emissions make up only a small percentage of their total GHG emissions and, as a result, felt they are not a priority. These organizations typically have greater GHG emissions from other practices like transportation or manufacturing. Importantly, all these organizations appear to be well-intentioned but simply prioritize other parts of the sustainability puzzle over direct ICT supply chain environmental impacts.

## Solution Clear Incentives

In terms of solutions, many interviewees noted that greater incentives (such as tax breaks or grants) would help them adopt sustainable ICT strategies. Interviewees noted that while there are many programs and tax incentives in Canada to help businesses adopt digital technologies, there is a dearth of similar incentives related to sustainable ICT (such as eco-design, lifecycle assessment, product carbon assessment, business model innovation, or other best practices). Going forward, it will be important for governments to shape and deploy sustainability-oriented ICT incentives to ensure compliance and spur positive change. Interviewees noted that tax incentives, grants, and subsidized consulting services are possible options.

## Challenge Knowledge and Skills

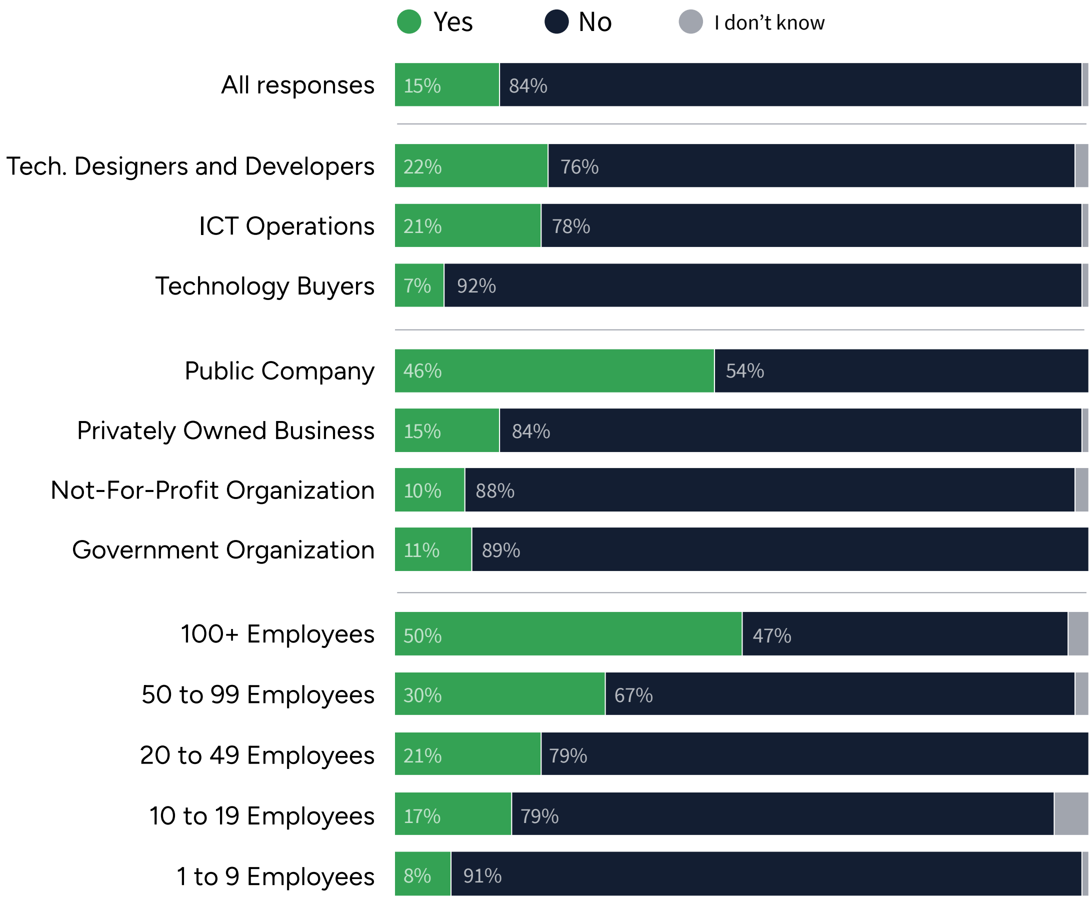
A shortage of environmentally sustainable ICT skills impacts organizational capacity to adopt sustainable ICT practices. Of the 500 respondents to ICTC's survey, 27% indicated that they lacked the required knowledge and expertise to implement sustainable ICT practices. Moreover, just 15% of all respondents had received sustainable ICT training, while 84% had not (see Figure 6). Individuals who worked for small (versus medium or large) companies were less likely to have received this type of training, as were those who worked for government organizations, not-for-profit organizations, and privately owned businesses (versus public companies), and those who held technology procurement roles (as opposed to technology design and development or operations management roles). Indeed, just 7% of technology buyers reported having received training on sustainable ICT.

Interviewees who were responsible for ICT procurement reiterated the above findings. One interviewee noted that most procurement professionals are "never taught" to consider the environmental impacts of their purchases and indicated that it is not uncommon for procurement professionals to be unaware of organizational sustainability goals or to lack the necessary skills or resources to identify a sustainable versus unsustainable supplier.

48 Sundberg, Niklas, "Sustainable IT Playbook for Technology Leaders," 2022, Packt Publishing Ltd, https://books.google.ca/books/about/Sustainable_IT_Playbook_for_Technology_L.html?id=ab-UEAAAQBAJ&source=kp_book_description&redir_esc=y

Procurement professionals can have a strong influence on the priorities of technology designers and developers, yet without the appropriate knowledge, training, and skills, their ability to do so is severely limited.

**FIGURE 6** Have you received training on environmentally sustainable ICT design and development, operations management, or procurement?




Data source: ICTC's Canadian Survey on Sustainable ICT

## Solution Training

Formal and more widely accessible training is needed to reduce the ICT sector's environmental sustainability skills gap. For technology buyers, training programs will need to focus on how to assess the sustainability of an ICT supplier, product, or service to make well-informed purchasing decisions. Countries such as France are leading in this area: the French government is requiring widespread sustainability training for procurement officers as part of recent updates to the French Public Procurement Code.[49] This highlights the importance of top-down policies. Another possible avenue for procurement training relates to ecolabels: while teaching all procurement officers how to conduct lifecycle assessments or product carbon footprints would be a substantial undertaking, training on how to identify trustworthy ecolabels and how to assess suppliers, products, and services using ecolabels could be an efficient way to achieve change.

49 Martor, Boris and Weiss, Raphael, "Strengthening the consideration of environmental and social aspects in French public procurement law," 2022, Bird & Bird, https://www.twobirds.com/en/insights/2022/france/strengthening-the-consideration-of-environmental-and-social-aspects-in-french-public-procurement-law

Beyond procurement, sustainable ICT training is needed for technology developers and designers, and ICT operations managers. According to the International Telecommunications Union's (ITU) Toolkit for Environmental Sustainability in the ICT Sector,[50] technology developers could benefit from a "Green Code of Ethics" that would help educate and guide designers in building environmentally and socially responsible technology. The ITU toolkit further explains that "a new wave of designers needs to build environmental intelligence into their core work."[51] This will require software and hardware developers to have a theoretical understanding of environmental science, climate change, and the impacts of technologies on the environment.[52] To ensure that the ICT sector's future talent pipeline is well-equipped, post-secondary institutions will need to incorporate aspects of environmental sustainability, such as lifecycle assessment, eco-design, and climate science, into engineering, computer science, and other technical programs. Finally, government and industry can collaborate to create more communication channels about sustainable ICT and mobilize standards and best practices. For example, interviewees in this study pointed to the success that the Government of the United Kingdom has had in sharing their own best practices and lessons learned via their website and social media.[53]

## Challenge Transparency

Limited transparency—including between organizations and across the ICT supply chain—prevents organizations from acting on ICT's environmental impact. Industry professionals who participated in ICTC's research reported a severe lack of standardized data about the environmental impact of ICT. Many had tried to obtain data from ICT manufacturers, suppliers, and service providers but, due to a lack of data and trust, were ultimately unable to do so. As a result, industry professionals are unable to determine if they are purchasing environmentally sustainable products and services. Moreover, ICT suppliers note being precluded from reporting upstream environmental impacts to their downstream clients. In a similar vein, proponents of sustainability state that they struggle to justify the value of ICT sustainability to their boards and executive teams. The combined effect of these challenges is an overall lack of transparency related to the sustainability of ICT products and services.

Similarly, in response to ICTC's business survey, approximately one-fifth (22%) of respondents indicated that their suppliers' environmental data is generally not standardized enough, making it difficult-to-compare suppliers. Meanwhile, 20% indicated that their suppliers are not transparent enough about the environmental impacts of their products and services, and 17% indicated that they do not have enough visibility into their supply chain. Notably, data-related barriers were more relevant for technology buyers and ICT operations managers versus technology designers and developers, suggesting information asymmetries between the suppliers and consumers of ICT.

50 International Telecommunication Union, "Toolkit on environmental sustainability in the ICT sector," 2012, ITU, https://www.itu.int/ITU-T/climatechange/ess/index.html

51 Ibid.

52 Ibid.

53 "UK Government Sustainable ICT," 2023, Government of the United Kingdom, https://sustainableict.blog.gov.uk/

While data and transparency barriers were less relevant for organizations with 100 employees or less, they were highly relevant for organizations with 100 employees or more. Considering that data and transparency barriers are more likely to be experienced by organizations already pursuing sustainable ICT, it is unsurprising that these types of barriers are less relevant for smaller organizations. As noted in the section The Present State of ICT Sustainability in Canada, smaller organizations are less likely to be thinking about ICT from a sustainability perspective in the first place, but as smaller organizations begin prioritizing sustainable ICT, the importance of data and transparency-related barriers will likely increase.

Making ICT supply chains more transparent is, therefore, crucial to enabling sustainable ICT. As one participant noted, “[The ICT sector] need[s] more information. We can’t just continue to estimate on the back of a napkin how much CO2e something has produced. There needs to be more detail, more accuracy.” Unfortunately, environmental data and reporting are not standardized across the ICT industry, making the limited data that is available less interoperable and more difficult to compare. Additionally, despite a subset of ICT sustainability leaders who are measuring and reporting their environmental impact, most ICT suppliers lack the incentive to do this.

## Solution Data and Reporting Standards

Research participants identified industry-wide data and reporting standards as an important way to enable sustainable ICT. While a variety of frameworks for environmental data and reporting exist,[54] there is limited consensus within the ICT industry as to which are the most suitable. As a result, some ICT businesses have decided to adopt existing standards, while others have opted to craft their own approach. Still, others have chosen to fill data gaps using more basic solutions, such as supplier questionnaires or audit sheets.[55] Commenting on this challenge, one roundtable participant shared how their company researched what sustainability metrics are used by global telecommunications companies and found that “there's no rhyme or reason—even for [an advanced sector like telecom], there is no standard reporting. No common definitions.”

54 For example, the Sustainable Digital Infrastructure Alliance has a methodology for assessing the digital environmental footprint of digital products and services and a list of metrics for assessing the sustainability of data centres. See: https://sdialliance.org/blog/software-lca-digital-environmental-footprint/ and https://knowledge.sdialliance.org/data-center-metrics. Type 1 ecolabels like EPEAT and TCO Certified have published detailed standards for assessing the environmental impact of ICT hardware, including computers and displays, imaging equipment, mobile phones, servers, and televisions, many of which are themselves based on standards published by accredited standards setting organizations like the IEEE, UL Standards, and the American National Standards Institute. See: https://www.epeat.net/about-epeat#accessing-epeat-criteria; https://tcocertified.com/summary-of-criteria-in-tco-certified/. The Sustainable Web Design Community Group host the Web Sustainability Guidelines. See: https://w3c.github.io/sustyweb/. The International Telecommunication Union provides a series of guidance documents for sustainable ICT, including for guidance for ICT businesses on setting GHG emissions reduction targets, assessing the energy consumption of ICT services, setting metrics for circular economy in the ICT sector, developing e-waste management systems, and engaging in ICT goods lifecycle management. See: https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=14084&lang=en. The European Institutes for Sustainable IT provide through their responsible digital toolbox a directory of tools for estimating the environmental impacts (e.g., carbon footprint, energy consumption, e-waste, etc.) of ICT products and services, including machine learning models, IT infrastructure, communications networks, and more. Many organizations report adapting ISO 14040:2006, ISO 14044:2006, and the GHG Protocol Corporate Accounting and Reporting Standard to the ICT sector. See: https://www.capgemini.com/be-en/wp-content/uploads/2021/07/Sustainable-IT_Report-2.pdf. Beyond, data and reporting standards, organizations like Boavizta provide APIs for calculating the embodied impacts of a physical server type and an AWS instance type. See: https://knowledge.sdialliance.org/digital-environmental-footprint/overview-tools-and-apis. The Green Web Foundation hosts an open-source JavaScript library that enables developers to estimate the emissions related to the use of their apps, websites, and software. See: https://www.thegreenwebfoundation.org/co2-js/. Hubblo, which is a design office for research entities like ADEME and MiNumEco, offers tools and consulting to automate and integrate environmental metrics into IT design and decision making. See: https://hubblo.org/

55 Santillán-Saldivar, Jair et al., “How recycling mitigates supply risks of critical raw materials: Extension of the geopolitical supply risk methodology applied to information and communication technologies in the European Union,” 2021, Resources, Conservation & Recycling, https://doi.org/10.1016/j.resconrec.2020.105108

Unfortunately, individualized approaches to environmental measurement and reporting have their downsides. In addition to generating non-standardized and difficult-to-compare data, individualized approaches can lead to questionnaire fatigue among suppliers, whereby suppliers are so inundated with data requests that they are unable to address all of them effectively or opt not to respond at all.[56] International leaders in sustainable ICT, therefore, encourage industry associations to develop a common set of metrics that apply broadly while encouraging ICT suppliers to make data available publicly.[57] Given that major ICT companies already require environmental data from their partners and suppliers as a condition of doing business, Canada's ICT sector is well positioned to begin standardizing these requirements.[58]

## Solution Data and Reporting Requirements

Beyond standardizing approaches to data collection and reporting, Canada will need to implement mandatory reporting requirements for ICT suppliers. Given that Canada is a small market with limited ability to impact the global ICT sector, the most suitable option is to work with international partners in the United States and Europe to establish harmonized reporting requirements for ICT. Within this framework, ICT industry stakeholders and policymakers should push to ensure scope 3 environmental impacts are included in reporting obligations because many of the ICT sector's environmental impacts (such as those embodied in ICT hardware via manufacturing processes or those stemming from leased infrastructure like data centres) occur within scope 3.[59] For companies like Microsoft, that percentage can be as high as 97%.[60] While regulatory agencies are already in the process of developing reporting obligations for public companies, including public technology companies, if scope 3 impacts are not included in reporting obligations, the impact of these reporting obligations on ICT sustainability will be limited.

Another consideration is the inclusion of both static and dynamic data in reporting requirements. As noted by the Sustainable Digital Infrastructure Alliance, environmental data pertaining to ICT products and services can be categorized under two headings. The first encompasses static data about the environmental impacts that are embodied in ICT hardware and infrastructure from material extraction and processing, manufacturing, and transportation. The second encompasses dynamic data about the environmental impacts that stem from ICT product and service use, such as energy and water consumption or GHG emissions from energy consumption.[61] While the former category addresses the opaque nature of the ICT supply chain, the latter is important given the proliferation of business models like "software as a service" and "ICT infrastructure as a service."

56 International Telecommunication Union, "Toolkit on environmental sustainability in the ICT sector," 2012, ITU, https://www.itu.int/ITU-T/climatechange/ess/index.html

57 Ibid.

58 Hsu, CW et al., "A multi-criteria decision-making approach for evaluating carbon performance of suppliers in the electronics industry," 2014, International Journal of Environmental Science and Technology, https://doi.org/10.1007/s13762-013-0265-5

59 Sundberg, Niklas, "Sustainable IT Playbook for Technology Leaders," 2022, Packt Publishing Ltd, https://books.google.ca/books/about/Sustainable_IT_Playbook_for_Technology_L.html?id=ab-UEAAAQBAJ&source=kp_book_description&redir_esc=y

60 "2022 Environmental Sustainability Report," 2022, Microsoft, https://www.microsoft.com/en-us/corporate-responsibility/sustainability/report

61 "Overview Tools & APIs," 2023, SDIA, https://knowledge.sdialliance.org/digital-environmental-footprint/overview-tools-and-apis

For ICT product and service users to engage in more sustainable consumption patterns, they first need accessible information about whether they are using ICT products and services sustainably and how to improve the sustainability of their product and service use if not.[62]

## Solution Research and Data

Finally, even without implementing reporting obligations, governments and industry can sponsor research to generate publicly accessible data about the environmental impacts of ICT. As noted by research participants, government organizations like Natural Resources Canada (NRCAN) own a swath of applied research infrastructure and would be capable of producing third-party datasets about the environmental impacts of ICT devices, software, and infrastructure—for instance, data relating to material consumption, material content, device weight, energy consumption, and energy efficiency. It is worth noting that in countries like France, Germany, Switzerland, and the Netherlands, government-sponsored research to generate publicly accessible data for sustainable ICT is the norm. Organizations like the Institutes for Sustainable IT and the Green Web Foundation have been engaging in this type of work for years.

## Challenge Market Signals

Market signals, such as demand signals and funding criteria, are a powerful way to influence company behaviour. Demand signals are used by customers to communicate demand for a certain type of product or service and, in turn, signal a market opportunity to suppliers. Customers can send demand signals through a variety of channels by including a clause or specification in a request-for-information (RFI) or request-for-proposal (RFP), by providing feedback through a market research firm or market survey, or by asking suppliers specific questions during the sales cycle. Funding criteria are meanwhile used by funders to influence company policies or behaviours. Often, grant providers and investors do this by writing specific requirements into funding criteria or agreements.

Market signals were often noted by roundtable and interview participants as important to advancing sustainable ICT. Additionally, in response to ICTC's business survey, 73% of respondents identified the potential for cost savings, improved revenue, and growth as a motivator for working with sustainable ICT; 30% of respondents (and an even larger percentage of just technology developers and designers) identified "pressure from customers" as a motivator; and nearly one-fifth (17%) identified "pressure from partners and suppliers."

62 Bull, Richard et al., "Integrating an ICT carbon calculator tool into procurement processes at de Montfort University: Lessons learned," 2013, Carbon Management, https://doi.org/10.4155/cmt.13.10; "ICT and energy efficiency: The case for manufacturing : recommendations of the consultation group," 2009, European Commission, https://op.europa.eu/en/publication-detail/-/publication/e4641795-25d4-11e9-8d04-01aa75ed71a1/language-en; Fritsch, Andreas and Betz, Stephanie, "Envisioning a community exemplar for sustainability in and by ICT," 2018, SCOPUS, https://doi.org/10.29007/65tz; Hao, Yu et al., "The role of information and communication technology on green total factor energy efficiency: Does environmental regulation work?," 2022, Business Strategy and the Environment, https://doi.org/10.1002/bse.2901; Subburaj, Srikanth, "Green IT: Sustainability by aligning business requirements with IT resource utilization," 2014, Masters of Computing, Federation University, https://researchonline.federation.edu.au/vital/access/services/Download/vital:7510/SOURCE1; Werland, Stefan et al., "Policy Instruments for Environmental Innovations: The example of resource use in ICT products,"2010, Berlin Conference on Human Dimensions of Global Environmental Change, https://doi.org/10.17169/refubium-22195; Chakir, Aziza et al., "A decisional smart approach for the adoption of the IT green," 2021, Environment, Development & Sustainability, https://doi.org/10.1007/s10668-020-00999-1; International Telecommunication Union, "Toolkit on environmental sustainability in the ICT sector," 2012, ITU, https://www.itu.int/ITU-T/climatechange/ess/index.html

Unfortunately, environmental sustainability criteria are not included in most ICT market signals at present. Technology companies interviewed for this study report that they are rarely, if ever, asked by customers and investors about the environmental sustainability of their products and services—unless they are a cleantech company, and even in that case, the questions usually pertain to how ICT can help advance sustainability outcomes as opposed to how they approach building ICT sustainably. As for public procurement, though some governments are in the process of designing a new approach, most governments and MASH-sector (Municipalities, Academic institutions, School boards, and the Health Authority) organizations do not include sustainable ICT requirements in their RFIs, RFPs, and supplier contracts. Beyond this, most organizations that receive government grants are not subject to ICT sustainability audits.

While industry stakeholders stress the potential for technology buyers and ICT investors to generate a focus on sustainability, for a variety of reasons, this potential is not being met. For one, a lack of awareness about the environmental impacts of technology prevents buyers and investors from recognizing the importance of ICT sustainability. Second, a lack of environmental sustainability knowledge and skills, combined with a lack of standardized environmental data, prevents buyers and investors from including impactful criteria in RFIs, RFPs, funding agreements, and supplier contracts. Finally, a lack of time and financial resources prevents many purchasing teams from prioritizing the development of this knowledge, skills, and criteria.

## Solution Environmental Sustainability Criteria

Going forward, it will be crucial for technology buyers and investors to send better signals to technology developers and designers. This means including environmental criteria in technology RFIs, RFPs, supplier contracts, and funding agreements. While many participants felt it was important for technology buyers to act quickly, avoid perfectionism, and "just do something," other participants warned that Canada is a small market with limited ability to influence international supply chains. If individual technology buyers and investors develop their own approach, they risk not having enough buying power to influence supply chain actors or sending too many different signals for suppliers to accommodate.

While some research participants said it is important for individual actors to move quickly and begin sending market signals to ICT suppliers, other research participants noted that action must come from Canadian governments and industry. More specifically, industry and governments are advised to help technology buyers pool their purchasing power by adopting standardized criteria for sustainable ICT, whether that be existing standards, a new set of Canadian standards aligned with international approaches, or ICT ecolabels, like TCO Certified or EPEAT.

# Conclusion

Insufficient regulations and a lack of awareness at varying levels of the ICT supply chain have resulted in water depletion, aquatic and terrestrial contamination, increased toxicity for wildlife and human life, and other land use changes impacting the vitality of the natural environment. On top of this, ICT manufacturing and use make up a growing share of global GHG emissions, contributing to anthropogenic climate change. Despite a breadth of harmful environmental impacts, most ICT stakeholders in Canada are not thinking about ICT from an environmental sustainability perspective, and if they are, their approach to sustainable ICT is not yet robust.

While some ICT stakeholders simply do not see environmental sustainability as a priority, many others face challenges that deter them from being able to prioritize sustainable ICT (in its design, procurement, and operations management). For one, a lack of awareness about technology's environmental impacts prevents technology stakeholders from recognizing the importance of sustainable ICT. But even when organizations are aware, a lack of data, knowledge, and skills prevents them from delivering sustainable ICT outcomes effectively. At the same time, many organizations lack the resources to develop new data, knowledge, and skills. When technology buyers and investors are prevented from including environmental criteria in contracts and agreements, technology designers and developers are inadvertently "nudged" to deprioritize sustainable ICT.

Without industry-wide coordination and government support, it is unlikely that the ICT sector will prioritize sustainability fast enough to minimize environmental harm. Without action, the ICT supply chain will continue to generate adverse environmental impacts in Canada and abroad, including during raw material extraction and processing, ICT manufacturing, transport, use, software development, recycling, and end-of-life disposal.

Luckily, governments and industry have a range of tools at their disposal to influence ICT stakeholders and encourage environmentally sustainable ICT: namely, programs to build awareness about the environmental impacts of ICT; capacity-building programs for organizational skills development, knowledge, and processes; initiatives to increase supply chain transparency, including data and reporting standards, data and reporting requirements, and government-sponsored research and data; and finally, initiatives to improve the use of environmental sustainability criteria in procurement and funding agreements.