Digital Technologies and Environmental Change

An Emerging Global Issues Brief

15 August 2016

Discarded electronics waste (e-waste) in Agbogbloshie, Ghana

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Executive Summary

A large body of research demonstrates that building, implementing and using digital technologies can result in unintended social, economic, political and environmental consequences. This policy brief focuses on the latter set of consequences; it provides a short overview of how digital technologies affect environmental change through their production, use and disposal/recycling. The carbon footprint, ecosystem degradation, and resource depletion associated with these processes have reached a critical point and demand action on a global scale. As the brief explains, these issues carry many unique implications for Global Affairs Canada (GAC), its projects, policies and broader practices.

The author of this brief recommends that Global Affairs Canada:

- acknowledge that their digital technology projects have real and measurable environmental costs.
- commit to deepening their knowledge of the complications, challenges and consequences of building, implementing and using digital technologies.
- examine how its existing international projects manage their digital technology procurement and electronics waste.
- apply Canada's 'Policy on Green Procurement' to all of GAC's future international projects, as well as their procurement of digital services.
- adopt a mechanism—in partnership with expert academics or the Canadian Environmental Assessment Agency—for assessing how GAC technology-related projects (e.g. 'ICT4D' and 'open data' projects) increase the long-term demand for energy, data and additional digital devices.
- fund sufficient clean energy projects to offset increased electricity demand associated with GAC projects, especially in developing countries.
- fund international research related to e-waste, energy demand, electronics recycling and ethical resource extraction, especially in developing countries.
- re-consider tensions between 'science, technology and innovation' vs. 'climate change' policy priorities within GAC's and the GoC's organisational structures.
- explore partnerships with Canadian and international non-state actors who are working in the domains of 'green computing' and ICT4S.
- partner with other federal departments and agencies to address issues of climate change with a whole-of-government

The issues in this brief are 'wicked problems', which means they are incredibly complex and have few clear or easy solutions. But that complexity won't resolve itself; Global Affairs Canada and the Government of Canada have a unique and exciting opportunity to drastically rethink the links between their energy, environment, digital and international policies and projects. Let's seize that opportunity.

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Introduction

Digital technologies have become fundamental to everyday life. They have made it easier to share personal, professional, and business information across time and physical space. They have helped raise millions of people out of poverty. They facilitate the movement of air, sea, space, and land traffic. And they often underpin clean energy technologies. With such ubiquity and so many positive uses, digital technologies will likely continue to play an important role in the future of global development. However, a growing chorus of technologists, academics and non-profit organisations have been raising concerns about digital technologies and the companies who make them.

Research has demonstrated that building, implementing and using digital technologies can result in serious social, economic, political, health, and environmental consequences. Many of these consequences are interconnected, and relate to where, how, when, why, by whom and for what purposes our digital devices and services are made and used. Academics and journalists have documented concerns about digital technologies and tech companies reducing cultural diversity, oversimplifying complex social problems (e.g. inequality), and introducing a new form of 'digital' colonialism. In the past two decades, research has directly linked digital devices—and the materials that make up and support them—to significant global ecosystem degradation, including soil and water contamination, natural resource depletion, and the production of increasingly high carbon footprints. These environmental issues often contribute to 'knock-on' effects, including health, food, water, economic and political insecurity, which occur primarily in developing countries.

Left to Right: a tin mine in the DRC; computer assembly line; e-waste in Ghana.

The following policy brief offers some insights into how Global Affairs Canada (GAC) and its policymakers might approach this complex set of issues. The brief describes the environmental effects of digital technologies by focusing on three phases in their lifecycle: production, use, and disposal/recycling. Each phase carries a unique set of implications for Earth's environmental systems, as well as for GAC, its policies, practices and projects. Before discussing those implications, the brief describes how governments and businesses around the world are currently responding to the environmental costs of digital technologies. Based on those examples, the brief offers a list of preliminary policy recommendations. However, the list—like the brief—is not meant to be exhaustive. The brief offers an overview for policymakers with the hopes that they will have additional ideas about how and where to intervene. The appendices include a list of non-state actors with whom GAC may wish to partner on future projects, and a 'design fiction' that the ministry may use to stimulate further discussion.

Methods

This policy brief presents a synthesis of the findings from a multi-stage multidisciplinary literature review. The literature review focused on recent [i.e. in the past 10 years] publications in academic databases and journals that present policy, management, computer science, and environmental sciences research, including: GreenFile, JSTOR, Environment and Planning, Nature, and the ACM's Digital Library. A fragment of that literature review is included in footnotes throughout the brief. The author used several environmental assessment and management concepts to guide her literature review, including: cradle-to-grave or 'life-cycle' assessment, the circular economy, and the Earth's biophysical limits[1]. Life-cycle assessment is an established technique for thinking about and assessing the environmental footprint(s) of objects from their creation to their disposal and recycling. The circular economy concept considers the wider economic and material flows that could be—or are—associated with 'no waste' and 'no pollution' projects. The concept of the Earth's biophysical limits was introduced by a world-renowned multidisciplinary group of Earth-systems and environmental scientists. It is an internationally recognised and accepted framework for understanding how the Earth's biophysical systems are interconnected, and how human actions influence those systems.

These concepts were selected to guide the literature review because they are widely accepted and applied within many political, business and academic settings. Moreover, each concept offered a complementary lens through which to explore how digital technologies affect environmental change.

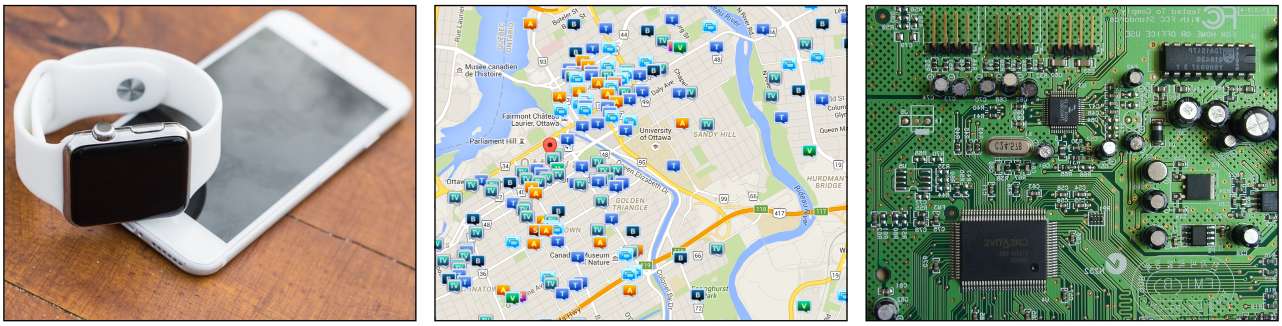
Environmental Effects of Digital Technologies

The environmental effects of digital technologies occur at every stage of a device's life, via its hardware and software. Hardware is the very tangible part of a digital technology; you can see hardware and hold it. Examples of hardware include cellular

[1] Rockström et al. 2009. "A safe operating space for humanity." doi: 10.1038/461472a

telephones, laptops, tablets, monitors, Internet routers, 'smart' watches, printers, air quality sensors, bluetooth chips, hearing aids, animatronic prosthetic limbs, and heart monitors, along with thousands of other products and pieces. Hardware is often made from a combination of electronic components, such as batteries, capacitors, switches, resistors and semiconductors, as well as additional plastics, chemicals and metals that facilitate information sharing between those components.

Software is less tangible; it is the set of programs and applications ("apps"), libraries and files that allow hardware to share information and function as a complete device. Examples of software include operating systems (e.g. Microsoft Windows, Apple's OS X and iOS, Android, Ubuntu, Linux), word processing or spreadsheet programs and files (e.g. MS Word, Excel, Pages, Google Docs), email clients and services (e.g. Outlook, Gmail, Yahoo), social media websites and mobile apps (e.g. Facebook, Twitter, Vine), social media posts (e.g.. tweets, pictures, shared stories), Internet browsers (e.g. Firefox, Chrome, Internet Explorer), traffic management systems, and digital mapping tools, among others.



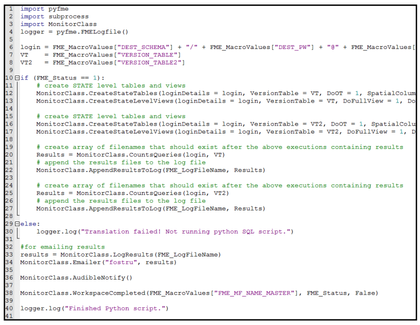
Left to Right: a 'smart watch' and smartphone; Ottawa's digital crime map; a motherboard.

Software and hardware are co-dependent; the type of hardware in a device dictates the type of software that the device needs, and the type of software on a device influences how hardware components are used. Hardware and software affect the environment in interconnected ways during their production, use, and at the end of their lives, when they are being recycled or discarded.

Production of digital technologies

Consumer demand, advancements in technology, and industry-led design decisions (e.g. planned obsolescence) drive the production of hardware and software. Each production process unfolds distinctly, and has measurable effects on the environment.

Software production occurs in homes, universities, and businesses around the world. Much like software itself, the environmental effects of producing software are often considered less tangible and measurable than those of its counterpart, hardware. But the electricity, transportation, office spaces, and office supplies used while producing software



all carry environmental costs that *should* contribute to calculations of the overall 'embodied impact'[2] of a digital technology.

Hardware production affects the environment at different stages. Some professionals claim that the hardware design process (e.g. conceiving of a product, creating product wireframes, prototyping a device, etc.) is the beginning of those effects, whereas others claim that the resource extraction and device manufacturing processes mark the beginning. Regardless of which comes first, very little information is publicly available about hardware design processes. As a result, attempting to measure and assess the environmental impact of hardware design is difficult. In contrast, the natural resource extraction and hardware manufacturing processes are highly documented, and have attracted a great deal of attention from academics, journalists, the private sector and governments alike.

Every digital device is made of a unique combination of natural resources, including: gold, platinum, palladium, tungsten, cobalt, neodymium, terbium, petroleum, and lithium, among others. The embodied impact of extracting and producing these resources varies significantly between mining companies, mining sites, and resources[3], due to the diverse legal and policy frameworks in place around the world. Numerous reports indicate that mining operations have caused serious ecosystem degradation, including in several of GAC's 'countries of focus' and 'partner countries' (e.g. Mozambique, Bolivia, and the Democratic Republic of Congo [DRC]). For example, in the DRC—where rare minerals and metals extracted for digital technologies have been labeled 'conflict resources'—several mining sites have collapsed, had chemical spills, or been abandoned. These events led to water pollution, soil contamination, and air quality degradation, as well as the serious harm of workers. Although no digital technology companies run these mining operations, their businesses directly supports these mines. Mining operations supply hardware manufacturers with the raw materials they need to create the final digital technology products that we use.

Hardware manufacturing carries its own set of environmental costs, which also vary significantly based on the manufacturing company, the location(s) of its facilities, and the product(s) it makes. Some manufacturing facilities use large amounts of freshwater to

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[2] 'embodied impact' is a term used to describe the total environmental impact of sourcing, transporting, processing, and manufacturing a material, product or service.

[3] some resource-specific 'embodied impact' estimates and calculations are publicly available online. For example, The European Union's *Science for Environment Policy* published "The environmental impact of gold production." http://ec.europa.eu/environment/integration/research/newsalert/pdf/302na5_en.pdf

create their products, while others dump wastewater from the manufacturing process into rivers. This has been a serious issue in China, where estimates suggest that between 25 and 60 million acres of arable land is currently contaminated with heavy metals from electronics manufacturing. Similarly, several hardware manufacturing facilities in Japan and India have been accused of air, water, heat and noise pollution. Whilst the electronics industry has faced some pressure to clean up their supply chains, these global industries have proven to be incredibly complex operations for intervention.

Using digital technologies

When we use our digital technologies, we affect the environment in several ways. We contribute to the amount of carbon dioxide (CO_2) in the atmosphere through our increased demand for electricity, which we need to power our personal and workplace devices, as well as the support infrastructure we have created for our technologies (e.g. the Internet, data centres, satellites). We change the shape and nature of physical spaces by installing devices and support infrastructure (e.g. internet cables, wifi routers in parks, water quality sensors in our waterways, satellites in space, etc.) in places that previously had other uses. We also alter how, where, and when we engage with the environment when we follow apps that tell us where to travel, what to see and do, where to eat, etc.

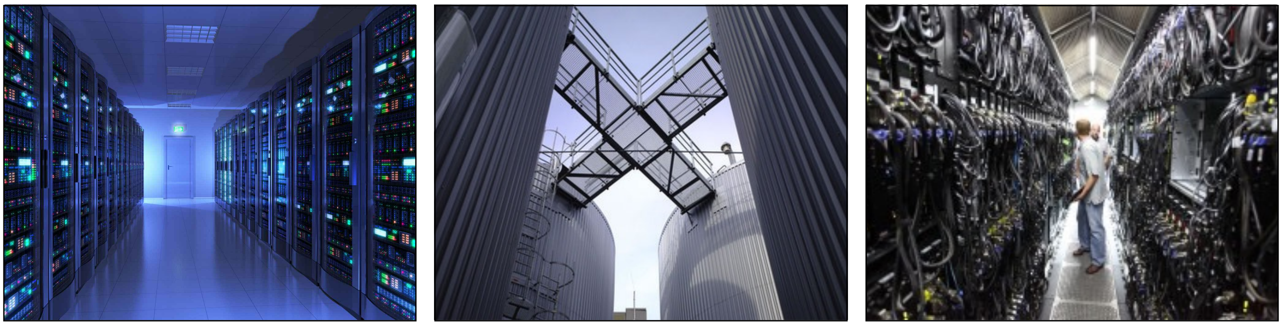
Whilst renewable energy sources are becoming increasingly popular and available, 67% of electricity globally continues to be generated from fossil fuels[4]. Some of that electricity powers our at-home and at-work digital technologies, as well as our internationally distributed data centres. Data centres are the backbone of the Internet; they are the physical places where we store much of our digital information (e.g. our tweets, Facebook posts, online photos, emails, documents in 'the cloud', and our 'digitised' personal data) and our digital services (e.g. Netflix, YouTube, Flickr, etc.). Data centres are almost always 'on', which is a large part of why global data centres currently have an annual carbon footprint that is equal to, if not greater than, that of the airline industry.

Experts predict that the demand for and from data centres is likely to triple in the coming decade. Some of that increased demand will come from our personal choices; a UK study showed that residents spent an average of 9.9 hours online during a typical week in 2005, and over 20 hours per week online by 2014[5]. We currently install more apps on our phones than previously, and we often have more Internet-connected 'smart' devices in our homes, too. Although many of these latter 'smart' devices come with

[4] OECD Factbook 2015-2016, Energy and Transportation - Electricity Generation

[5] Hazas et al. 2016. "Are there limits to growth in data traffic?" doi:10.1145/2926676.2926690

promises of increased home energy efficiency, recent research from the UK and Australia suggests that these devices actually *increase* energy and data centre demand[6]. This increase stems from the higher overall number of Internet-connected products in the home, as well as from the automated software updates and communications that run in the background of an application. These automated updates are hidden data and energy costs, which highlight how personal choices are not the only influence on increased demand.



Left to Right: a data centre 'stack'; Germany's LEED-certified data centre; behind a 'stack'.

The technology industry, and its design decisions, currently drive—and will continue to drive—much of the increased demand for data centres. Their continued push for more Internet-connected devices and services in our homes, workplaces, and urban spaces (see: "Internet of Things" [IoT] projects and global 'smart city' projects led by IBM, Siemens and Cisco), as well as 'abundant' access to the Internet (Facebook's *Internet.org* project; Google's Project Lune), have direct implications for the scale and volume of data centres needed to support such projects. The short-term gains from these projects—which often offer promises of economic growth, improved service delivery, or 'innovation'—might not outweigh their long-term social and environmental consequences. Professor Ian Bitterlin, one of the UK's leading experts on data centres, recently explained that "even if the [data centre] industry were able to shift to 100 per cent renewable electricity, the volume of energy they would need would put intolerable pressure on the world's power systems"[7]. In addition to their energy demands, data centres often require immense volumes of water for their cooling systems[8]. These issues have led some experts to call for self-imposed limits on Internet usage and speeds, while others have simply wondered how to deal with this complex issue[5]. Few clear solutions have emerged.

Our use of digital technologies also affects the environment in other ways. We change the shape and nature of physical spaces by installing devices and support

[6] Y. Strengers et al. 2016. "The hidden energy cost of smart homes". theconversation.com

[7] In conversation with The Independent.

[8] M. Hogen. 2015. "Data flows and water woes: The Utah Data Centre" doi: 10.1177/2053951715592429

infrastructure around the world. For example, Internet cables, like telephone cables, now traverse our oceans and have attracted the attention of sharks[9], among other marine wildlife. Traffic monitoring sensors are being installed in our roadways, a process that often requires significant retrofitting of those roadways. Satellites contribute to our growing 'space waste' problem. We also alter how, where, and when we engage with the environment every time we follow the 'most efficient' directions provided by mapping algorithms, or when we eat at the same set of restaurants recommended by Yelp and TripAdvisor, or when we adjust our homes furnishing so that they are more popular on airBnB. These processes have measurable effects on the environment, but few studies have explored those effects. They are currently considered 'emerging concerns', which are primarily being discussed by journalists[10] and in books[11].

Recycling or disposing of digital technologies

At the end of their lifecycles, digital technologies have demonstrable effects on the environment. If recycled appropriately, we can recover 35000 pounds of copper, 772 pounds of silver, 75 pounds of gold, and 33 pounds of palladium from just one million mobiles phone. But appropriate recycling facilities are not always in place. Until recently, many discarded and 'recycled' electronics from developed countries (including Canada, the United States of America, and members of the E.U.) ended up in informal e-waste 'dumping grounds'. These dumping grounds have historically been located in many countries around the world, but the largest sites developed in India, China, and Agbogbloshie, Ghana. Few descriptions of the dumping grounds are more vivid than this:

> *"In Agbogbloshie, seven- to twenty-five-year-old boys smash stones and simple tools against TVs and PCs to get to the metals, especially copper. They will earn approximately $2.50 per day. Most of them, hoping for a better future, left their families from the poor northern and upper west regions of Ghana for this kind of work. Injuries like burns, untreated wounds, lung problems, eye damage, and back problems go hand in hand with chronic nausea, anorexia, debilitating headaches and respiratory problems. Almost everyone suffers from insomnia. Smoke and invisible toxins (especially cadmium) harm the careless*

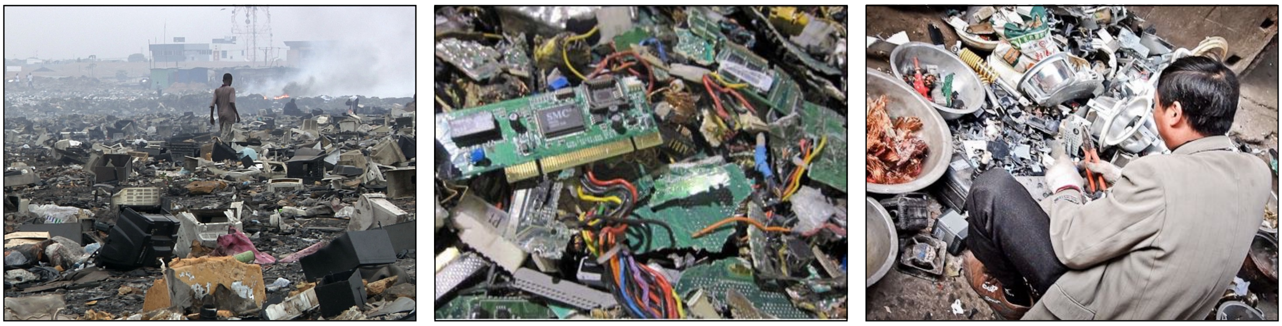
[9] W. Oremus. 2014. "The Global Internet is being attacked by sharks, Google Confirms". Slate.com

[10] K. Chayka. 2016. "Welcome to AirSpace: How Silicon Valley helps spread the same sterile aesthetic across the world."

[11] A. Greenfield. 2013. "Against the smart city (the city is here for you to use)."

workers because they often don't know about the risks and walk around in flimsy footwear like flip-flops. Most of them die from cancer while in their 20s.'[12]

Similar stories and descriptions have been written about dumping grounds in India and China. The pollution from these sites continues to harm workers, and has also proven to be the source of soil and water contamination in regions nearby. Considering that e-waste remains the fastest growing waste stream globally, these dumping grounds and their contamination of local ecosystems is a serious concern. As a result, these issues have gained international attention, and their financial, environmental, and national-security related implications have been discussed at lengths.



Left to Right: e-waste in Ghana; assorted e-waste; e-waste processing in China

Many developed countries—including Canada and members of the European Union—have implemented stringent waste electrical and electronic equipment (WEEE) legislation, and have developed environmentally sensitive recycling systems in their home territories to help tackle the problem. However, very few environmentally sensitive e-waste recycling facilities have been set up in developing countries, nor have many developing countries passed much WEEE legislation. As a result, only ~30% of global e-waste is processed in formal recycling systems. The rest ends up in landfills, is illegally exported and unaccounted for, or is processed through other means, including at these informal dumping grounds[13].

Current Responses from Governments and Industry

Many organisations remain unaware of, or ambivalent towards, the environmental effects of digital technologies. However, there have been some encouraging international responses to the broad set of challenges outlined in this brief.

[12] K. McElvaney. 2014. "In Pictures: Ghana's e-waste magnet." Aljazeera.com

[13] J. Lepawsky. 2014. "Changing geography of global trade in electronic discards" doi: 10.1111/geoj.12077

Governmental responses

Several governments have responded by developing 'green electronics' procurement systems, data centre carbon taxes, as well as e-waste regulations, policies, and management systems. For example, the European Union has adopted two pieces of legislation to deal with e-waste: the Directive on waste electrical and electronic equipment (WEEE Directive) and the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive). The WEEE Directive allows consumers to return their WEEE free of charge, which has encouraged more consumers to recycle and/or re-use WEEE. The RoHS Directive restricts the use of hazardous substances in electrical and electronic equipment by requiring heavy metals such as lead, mercury, cadmium, and hexavalent chromium and flame retardants such as polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE) to be substituted by safer alternatives.

The United Kingdom, like many European Union Member States, has adopted those regulations, but has found that they are not yet fully effective at preventing e-waste from being illegally shipped overseas. In late 2015, the UK's Environment Agency fined the directors of Daniels Recycling £130 000 for illegally exporting 187 tonnes of hazardous e-waste to six African countries[14], and additional reports of British and European e-waste arriving in dumping grounds abroad persist. Notwithstanding these minor issues, the United Kingdom continues to take steps towards eliminating illegal e-waste.

The United Kingdom has also taken some steps towards addressing the carbon costs of the data centre industry. Data centres have been subject to the United Kingdom's Climate Change Levy (CCL) since 2001, when the CCL launched as an incentive for UK businesses to increase energy efficiency and reduce carbon emissions. In 2014, the UK government released a Climate Change Agreement (CCA) that offered data centres a reduction in, or exemption from, some of the carbon taxes if they agreed to meet specific efficiency targets. TechUK's initial report[15] on the agreement provides insights into the successes and failures of the CCA, including why some data centre facilities failed to meet their reduction targets. Overall, the CCA has proven to be modestly effective thus far, and may prove to be a model for other countries.

In the United States of America (USA), e-waste regulations and policies remain sparse and uncoordinated. As a result, the USA remains one of the largest suppliers of e-waste to global electronics dumping grounds. However, the Government of the USA has

[14] UK Environment Agency. 2015. "Married couple and company must pay £130,000 for waste crime."

[15] Tech UK. 2014. "Climate Change Agreement (CCA) for Data Centres." techuk.org

made progress in other areas related to the environmental effects of digital technologies; the Obama Administration recently tucked several environmental reporting mechanisms into the Dodd-Frank Act[16]. For example, businesses based in the USA who make use of minerals and materials from the DRC must now prove that their materials are conflict-free. The Dodd-Frank Act also included regulations targeting mining safety, and oil and gas industry corruption. Long before those regulatory changes were implemented, George W. Bush issued an Executive Order (13423) that required all US Federal agencies to use the Electronic Product Environmental Assessment Tool (EPEAT)[17] when procuring digital technologies. EPEAT is a tool that offers third-party assessments of and environmental product ratings for electronic devices. It faced some criticism for 'greenwashing' its ratings of products in 2012, but it otherwise remains a popular tool internationally.

The EPEAT rating system. Products must meet all of EPEAT's basic criteria to qualify.

Within Canada, the regulation of e-waste has been largely handed to provincial and municipal authorities; every province has different e-waste legislation, and most municipalities have access to vastly different e-waste processing facilities. Dr. Josh Lepawsky, an internationally renowned e-waste researcher based at Memorial University, believes there is space for Canada to adopt a nation-wide regulatory framework for managing e-waste[18]. No such framework appears to exist at this point in time.

On the procurement side, the Government of Canada has a long-established *Policy on Green Procurement*, which encourages the "integration of environmental performance considerations into the procurement process including planning, acquisition, use and disposal"[19]. This policy recently earned the GoC an award through EPEAT and the Green Electronics Council. However, the policy does not extend to projects run internationally

[16] J. Smith et al. 2012. "Dodd-Frank and the environment: from the belly of the Trojan horse."

[17] More information here: http://www.epeat.net/

[18] N. Mortillaro. 2015. "Electronic waste is piling up. Here's why you should care." globalnews.ca

[19] http://www.tpsgc-pwgsc.gc.ca/ecologisation-greening/achats-procurement/politique-policy-eng.html

by departments and ministries within the Government of Canada, including those run by Global Affairs Canada. Nor does the procurement policy apply to the procurement of digital services. This leaves international projects—particularly those in developing countries—open to acquiring non-EPEAT certified products, producing unobserved energy demand, and generating e-waste that might end up in global dumping grounds.

Private and non-profit organisational responses

Hundreds of established and emerging non-profit and for-profit organisations have addressed issues related to conflict minerals, electronics manufacturing, and e-waste. Several notable, established international environmental and human rights non-profits also produce reports and assessments that examine and communicate the environmental and societal effects of digital technologies. For example, Greenpeace publishes regular 'Green Gadgets' and 'Click Clean' reports, which explore the environmental costs of digital devices and services. Friends of the Earth are involved in several e-waste advocacy projects. The Restart Project runs electronics repair workshops around the world, and publishes regular e-waste and electronics consumption updates on their blog. Fairphone continues working to produce the world's 'fairest' mobile phone. By 'fair', they refer to having established their own conflict-free supply chain, in which they pay all of their workers 'fair' wages, and they have made their devices easily repairable.

A few major digital technology companies have also responded to some of the issues highlighted in this brief. For example, Apple has been a long-time champion of environmentally friendly digital technologies. It releases a range of environmental reports, including an annual 'environmental responsibility report' and individual 'product environmental reports'. These reports are widely considered to be the most comprehensive and open reports offered by any digital technology company. They describe the carbon footprints of Apple's business operations and products, as well as Apple's future directions related to environmental sustainability.

Microsoft maintains a section on its website that describes its environmental sustainability projects. In 2012, Microsoft launched an internal carbon pricing program and a related carbon fee investment fund that have encouraged departments to track the financial value of their emissions. The program has been considered a success; Microsoft now claims its business is carbon neutral, and that the internal carbon pricing program has resulted in $10 million in annual energy savings. The program also allowed the company to purchase 14 billion kilowatt hours of 'green power', and reduce its CO_2 emissions by 9.5 million metric tons.

Google also has a reputation as a 'green' technology company. It claims to have been carbon neutral since 2007[20]. They have invested in renewable energy sources on their corporate campuses, and in local clean energy production sites near their offices and data centres. Their data centres are currently amongst the most efficient globally, and Google claims to invest in the renewable energy sector beyond what its business consumes.

Despite these promising actions by some large technology companies, most have made little progress on the issues outlined in this brief. Moreover, many technology companies remain focused on their immediate business bottom lines; few appear concerned with the additional energy and infrastructure demands that their products and businesses generate. As noted in Greenpeace's recent Green Gadget report, "despite reductions in emissions per device, the industry's overall energy footprint continues to rise and, on the whole, companies have failed to adequately address this urgent and growing issue."[21]

Policy Implications and Recommendations

Global Affairs Canada, like many organisations and governmental departments, is in the difficult position of needing to balance the promise(s) of digital technologies with their very real costs. With so much complexity involved in the production, use, and disposal of digital technologies, policymakers might feel uneasy about selecting how, when and where to begin addressing this set of issues. Their sense of unease might be further compounded by the reality that research is rarely able to keep up-to-date with the rapidly changing digital technology market. Moreover, to date, few—if any—governments have attempted to integrate all of the environmental issues associated with digital technologies into broader 'systems thinking' projects about climate change. Most of the aforementioned issues have been tackled individually, if at all.

This brief has summarised a large body of contemporary research in the hopes that it will inspire GAC policymakers to drastically rethink the links between their energy, environmental, digital and international policies and projects. Based on the research, there appear to be many opportunities for Global Affairs Canada to adjust its business practices, projects, and policies. The following list of policy recommendations offer some ideas about opportunities to intervene in this complex space. However, the author believes that internal GAC policymakers are much better poised to set appropriate policy and research priorities in response to the issues outlined in this brief.

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[20] Google Green. https://www.google.com/green/

[21] Greenpeace. 2014. "Green Gadgets: Designing the Future. The path to greener electronics"

List of policy recommendations

The author of this brief recommends that Global Affairs Canada:

- acknowledge that their digital technology projects have real and measurable environmental costs
- commit to deepening their knowledge of the complications, challenges and consequences of building, implementing and using digital technologies (as noted, research has highlighted social, economic, political, and health concerns, which were not addressed in this brief).
- examine how its existing international projects manage their digital technology procurement and electronics waste.
- apply Canada's 'Policy on Green Procurement' to all of GAC's future international projects, as well as their procurement of digital services.
- adopt a mechanism—in partnership with expert academics or the Canadian Environmental Assessment Agency—for assessing how GAC technology-related projects (e.g. 'ICT4D' and 'open data' projects) increase the long-term demand for energy, data and additional digital devices.
- fund sufficient clean energy projects to offset increased electricity demand associated with GAC projects, especially in developing countries.
- fund international research related to e-waste, energy demand, electronics recycling and ethical resource extraction, especially in developing countries.
- re-consider tensions between 'science, technology and innovation' vs. 'climate change' policy priorities within GAC's and the GoC's organisational structures.
- explore partnerships with Canadian and international non-state actors who are working in the domains of 'green computing' and 'information and communication technologies for sustainability' (ICT4S).
- partner with other federal departments and agencies to address these issues with a whole-of-government approach

Appendix A: Non-state actors (potential partners)

This list of international non-state actors is not—and cannot be—exhaustive. It offers ten organisations that Global Affairs Canada may wish to partner with in future projects.

- **Green Electronics Council**
  Portland, Oregon (USA)
  http://greenelectronicscouncil.org/
  The Green Electronics Council is a 501c(4) non-profit that seeks to achieve a world in which only sustainable electronics are designed, manufactured, bought, used and recycled. Founded initially to manage EPEAT, the definitive global rating system for greener electronics, GEC advocates for sustainable electronics worldwide.
- **FairPhone**
  Amsterdam, The Netherlands
  https://www.fairphone.com/
  Fairphone is a social enterprise that is building a movement for fairer electronics. They have worked extensively to establish a conflict-free supply chain, better working conditions in their manufacturing facilities, and a more easily repairable mobile phone.
- **Agbogbloshie Makerspace Platform**
  Agbogbloshie, Ghana
  https://qamp.net/project/
  The Agbogbloshie Makerspace Platform (AMP) is a transnational youth-driven project to promote technology repair and development ecosystems in Africa. They are a unique space that works with people at the Agbogbloshie electronics dumping ground.
- **Basel Action Network**
  Seattle, Washington (USA)
  http://www.ban.org/
  The Basel Action Network works to champion global environmental health and justice by tackling issues related to e-waste and end-of-life ships. They work in countries such as China, the Phillipines, India and elsewhere. They produce interrelated strategies for policy, marketing solutions, and public engagement related to e-waste.
- **Plataforma Regional de Residuos Electrónicos en Latinoamérica y el Caribe (RELAC)**
  Santiago, Chile
  http://www.residuoselectronicos.net/
  Plataforma RELAC is a non-profit organisation focusing on e-waste issues in Latin America and the Caribbean, sponsored by IDRC-CRDI and launched by researchers at SUR Corporación de Estudios Sociales y Educación.

- **Centre for Environment and Development for the Arab Region and Europe (CEDARE)**
  Cairo, Egypt
  http://web.cedare.org/
  CEDARE is an international non-profit that works with partners throughout MENA on issues related to sustainable development, including e-waste.
- **WaSTE (Waste and Science, Technology & Environment)**
  St. John's, Newfoundland
  https://wastests.org
  WaSTE is an interdisciplinary research hub that explores the social, material and environmental implications of waste. Josh Lepawsky and Max Liboiron are two of the notable researchers associated with this hub.
- **The DEMAND Centre**
  Lancaster University, UK
  http://www.demand.ac.uk/
  The DEMAND Centre is a multidisciplinary research institute dedicated to exploring the social, institutional, and infrastructural complexities of energy demand. Elizabeth Shove, Gordon Walker, Mike Hazas, and Janine Morley produce very relevant work.
- **The European Commission's Science for Environment Policy project**
  University of the West of England (UWE), UK
  http://ec.europa.eu/environment/integration/research/newsalert/
  The Science for Environment Policy project, which is part of the Science Communication Unit at UWE, writes and publishes the European Commission's free news and information service. They may have already published reports of interest to GAC.
- **Association for Computing Machinery (ACM) Sustainable HCI Community**
  Internationally distributed; Chaired by Dr. Chris Preist of Bristol University
  http://www.sigchi.org/communities/hci-sustainability
  This is a community of researchers who explore issues of sustainability and computing—critically reflecting on the possibilities and implications of our design and use of interactive technologies.

Appendix B: Design Fiction

A 'design fiction' is a speculative research tool that is meant to seize public attention, affect the future thinking of its audience, and provoke the audience to share a message. Design fictions take many forms, and have been used to explore topics related to sustainability, drone activities, the future of education, and the future of food production, among other issues.

The following 'design fiction' (included on the subsequent page) imagines what could happen if Global Affairs Canada pursued some of the policy recommendations listed above. It is presented using a familiar format (ie. the Government of Canada's "news release" layout) and is meant as a thought experiment for the author and readers of this brief[22].

After reading the design fiction, readers should ask themselves: what would Global Affairs Canada need to do to turn this fictional announcement into reality? Should we pursue those changes? If so, what steps should we start taking now?

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[22] The text for this design fiction was directly inspired by recent announcements posted to Global Affairs Canada's news archive.

News Release

Global Affairs Canada Affaires mondiales Canada

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Ministers Dion, McKenna, Bains, and Foote announce carbon neutral digital innovation portfolio

January 16, 2018 - Ottawa, Ontario - Global Affairs Canada

The Honourable Stéphane Dion, Minister of Foreign Affairs, the Honourable Catherine McKenna, Minister of Environment and Climate Change, the Honourable Judy M. Foote, Minister of Public Services and Procurement, and the Honourable Navdeep Singh Bains, Minister of Innovation, Science and Economic Development, today announced that the government is taking action to address the environmental effects of its digital equipment, services and innovation portfolio.

The Government of Canada recognizes that the environmental effects of digital technologies have significant implications for Canada's economic, social, international and environmental interests, and has allocated up to $85 million over three years in the 2018 Budget to enable Canada to invest in 'green electronics', electronics waste (e-waste) recycling, and carbon offsets for its digital tools and services.

Of this, $40.5 million will be allocated to Foreign Affairs Canada to support carbon offsetting and e-waste recycling projects in three of its partner countries: Bolivia, Nigeria, and Sri Lanka. $20.5 million will be allocated to Environment and Climate Change Canada to invest in Canadian carbon offsetting projects. The remaining funds will be used to purchase green technologies, establish new partnerships across ministries, and work with organisations that can support research, training, and capacity building within Canada and abroad.

Quotes

> "Canada is acting on the priority concerns identified by electronics waste and international data centre experts, as well as environmental scientists. We will continue to work with national and international stakeholders to reduce the environmental effects of our digital portfolio—for the benefit of residents in Canada and abroad."
>
> *- Stéphane Dion, Minister of Foreign Affairs*

> "Science is at the core of our work, helping us to ensure a clean, safe and sustainable environment for Canadians. Together with our global partners, we are taking action to protect our air and soil quality, and restore global ecosystem health."
>
> *- Catherine McKenna, Minister of Environment and Climate Change*

> "Today marks a significant step forward toward ensuring that we can balance our . I especially want to commend the efforts of the many stakeholders and organizations that are committed to ensuring that specific actions will take place to protect these waters for future generations."
>
> *- Navdeep Singh Bains, Minister of Innovation, Science and Economic Development*

> "Extending our *Policy on Green Procurement* to our international projects has been a long-term goal. This announcement and its investments will allow Canada to reduce its carbon footprint and support environmentally sustainable projects at home and abroad. We look forward to working with our colleagues and other science agencies to address other areas of concern related to our procurement of devices and services."
>
> *- Judy M. Foote, Minister of Public Services and Procurement*

Quick facts

- Canada's digital footprint continues to grow, increasing the energy demand nationally at an unprecented pace.
- The global carbon emissions from digital technologies have tripled in the past decade, now exceeding that of the airline industry.
- Only ~30% of global electronics waste (e-waste) is processed in formal recycling systems. The rest ends up in landfills or is processed at informal e-waste dumping grounds, which have proven to be sources of soil and water contamination.

Related products

- Backgrounder - Environmental effects of digital technologies

Associated links

- Canada's Way Forward on Climate Change
- Canada's *Policy on Green Procurement*
- Green Electronics Council - E-waste and e-recycling
- DEMAND Centre - What is demand?

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