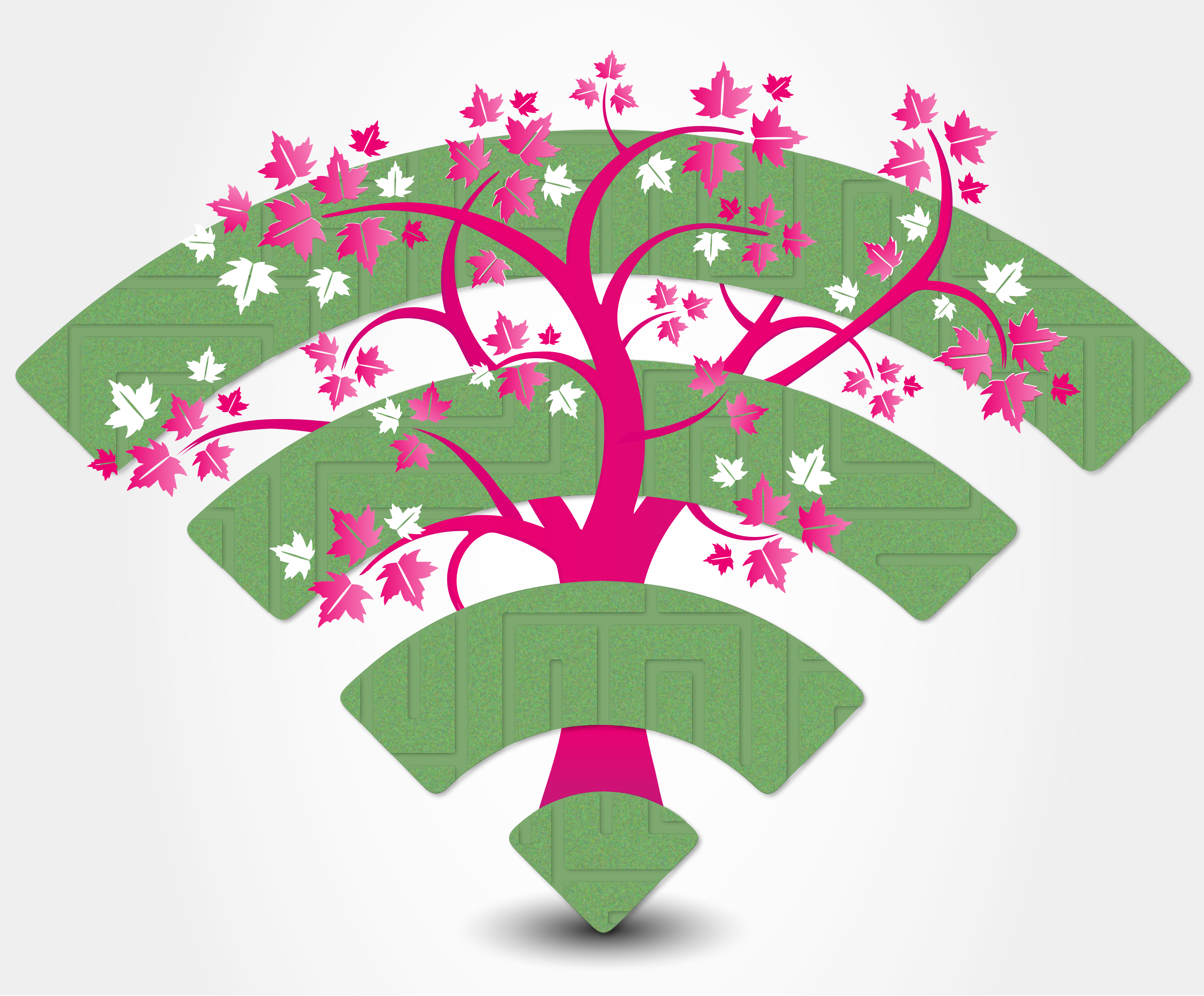
Clean Connection:

How Digitization Can Support Canada's Path to Net-Zero

Nour Abdelaal, Adams Aghimien, André Côté | June 2023



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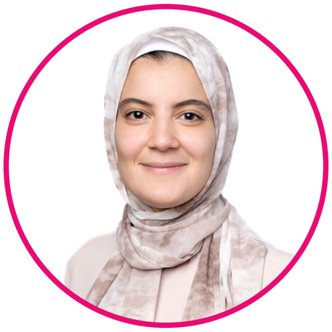

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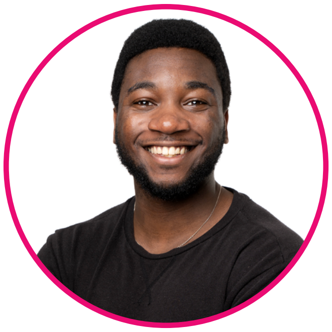

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Executive Summary

Canada's pursuit of a net-zero future is occurring amidst the rapid and transformative digitization of the country's economy and society. Enabled by innovations in information and communications technology (ICT), digitization is impacting everything from industrial production, supply chains, and business services to internet-enabled "smart" mobility, energy, and household devices. The intersections between digital transformation and progress towards climate goals are numerous and important for Canadian policy, business, and civil society decision-makers. Yet the interactions of digital policies with emissions reductions efforts are not yet well understood.

Estimates suggest that digitization in Canadian businesses and homes could reduce greenhouse gas (GHG) emissions by approximately 15 to 20 percent.

Digital technologies have significant potential to support national decarbonization and aid the transition to a net-zero future. For instance, estimates suggest that digitization in Canadian businesses and homes could reduce greenhouse gas (GHG) emissions by approximately 15 to 20 percent[1] [2] [3]. This would occur through efficiency gains from digital innovations such as smart monitoring, Mobility as a Service (MaaS), and remote work, to name just a few opportunities. Some estimates suggest that incorporating ICT solutions could save 10 times the carbon emissions that they generate in deploying them.[4]

Still, there are critical uncertainties when considering the potential impacts of digitization in enabling Canada's net-zero trajectory. Primary among them is policymakers, industry, and Canadians' ability to make choices that are more energy efficient, and the ability to meet the growth in electricity demand used to power the mobile networks, data storage, connected services, and other facets of Canada's digitization, including the increasing adoption of IoT and energy-intensive AI technologies.

An additional consideration is the alignment of digital-divide and climate-justice priorities, linking initiatives to expand digital connectivity and adoption for vulnerable and under-connected groups with Canada's climate goals. For example, increased connectivity in rural areas and Indigenous communities, where emissions per capita are relatively higher than in urban areas, could help reduce GHG emissions. Increased digital adoption for older adults would expand access to e-health and virtual services, which could also minimize transportation needs.

One conclusion is clear: Canada needs more evidence-based analysis and a multi-stakeholder agenda at the intersection of climate and digital policy to identify the right digital solutions that can enable greater efficiencies in energy use and reduction in overall carbon emissions.

Through a survey of 17 organizations across various sectors from agriculture and electricity to banking and real estate, and a roundtable featuring 15 representatives from cross-sectoral stakeholders, this White Paper amalgamates perspectives on the role of connectivity and digitization in helping Canada reach net-zero. As a first step, the research and stakeholder input to this paper revealed some important opportunities for action for industry and policy-makers:

The recommendations are categorized by first, second and third-order effects of ICT's impact on GHG emissions. First-order effects refer to the direct impact of the ICT sector (its production and use) on the environment, estimated at about 2-4% of total emissions. Second-order effects refer to the indirect impact of ICT on the environment through changes in broader production processes, products and distribution systems of other industries, such as technology solutions that make manufacturing and supply chains cleaner. Finally, third-order effects refer to ICT's indirect impact on the environment through changes in lifestyles and value systems in society, such as the shift to remote work.[5]

A) Reduce first-order effects of ICT's contribution to greenhouse gases:

1. ICT sector to develop and enforce industry standards to achieve net-zero in its operations.

2. Government to support the transition to a resilient and emissions-free electricity grid as a key enabler for greater digitization.

B) Enable second-order effects of ICT effecting changes in production, processes, products and distribution systems:

3. Government to assess opportunities to align digital with climate policies, including a climate impact lens for digital policies and performance measures, to maximize the potential for emissions reduction.

4. Government and industry to work together to support public and private investment in developing and deploying resilient telecommunication networks to ensure all Canadians maintain connectivity in the face of climate disruptions and expand equitable adoption of emission-reducing technologies across Canada by closing the digital divide through affordable 5G and fixed wireline in rural Canada, including through the effective release and use of spectrum.

5. Government to create incentives for digital adoption for small to medium sized businesses where the incorporation of technology is proven to enable emissions reductions, such as smart monitoring and sustainable agriculture practices.

6. Government to establish new and strengthen existing funding mechanisms to provide sustainable support for development, commercialization and deployment of open-source technology and software solutions aimed at climate change mitigation.

7. Government to clarify procurement policies to ensure they consider climate impacts and prioritize innovative Canadian companies as a means to expand adoption of digital technology solutions that enable emissions reduction within public sector organizations and operations, while also de-risking the purchasing of proven solutions for other actors in the economy.

C) Monitor third-order effects of ICT's changes in lifestyles and value systems:

8. Government and industry to observe for "rebound effects," whereby improved connectivity can induce new, more energy-intensive demands that counterbalance energy savings, and include these effects in the government's monitoring and reporting of emission levels within the economy.

9. Industry and government to commission empirical research from academia and/or institutes to assess the emission-related impacts of hybrid and remote work arrangements to better inform employers and policy.

10. Industry and government to jointly launch a Federal-Provincial-Territorial process on Digital and Climate Policy, to include ongoing engagement with municipal governments, Indigenous organizations, and stakeholders, to build common understanding, create momentum and establish shared commitments across government, industry and civil society stakeholder groups around how digital policies can help Canada achieve its net-zero target.

2

Introduction

Digitization and expanded connectivity, coupled with the right policies, have the potential to support Canada's climate objectives for carbon emission reductions. Canada, among over 120 countries worldwide, has committed to a net-zero emissions target by 2050 and a 40 percent reduction by 2030.[6] In 2021, Canada strengthened its climate plan and released A Healthy Environment and a Healthy Economy, which builds on the 2017 Pan-Canadian Framework on Clean Growth and Climate Change, outlining its plan to set and enforce emissions reduction targets through four main pillars: pricing carbon pollution, measures to further reduce emissions across the economy, measures to adapt to the impacts of climate change and build resilience, and actions to accelerate innovation, support clean technology, and create jobs.[7] Since then, Canada also enacted the Net-Zero Emissions Accountability Act, which enshrines into law the federal target to achieve net-zero by 2050 and sets enforcement mechanisms through legislative oversight to expand accountability and transparency in delivering on climate targets.[8]

Despite these efforts, Canada continues to lag in achieving its emission reduction goals. Canada has had nine climate plans since 1990 and has failed to achieve the targets set out in those plans.[9] A Canadian Centre for Policy Alternatives report finds that, from 2016 to 2019, Canada's emissions increased by 3.3 percent, far faster than the United States' 0.6 percent growth over that period.[10] [11] From 2020 to 2021, Canada's greenhouse gas (GHG) emissions increased by 1.8 percent,[12] well out of step with other G7 peer countries that successfully reduced GHG emissions by 4.4 percent to 10.8 percent during the same period.[13] Canada's failure to meet its reduction targets has led observers to become increasingly skeptical of Canada's ability to achieve its net-zero target by 2050.

Although Canada lags behind in achieving emissions reduction, there is significant potential for increased digitization and connectivity to support Canada's transition to net-zero. The Global Enabling Sustainability Initiative (GeSI) estimates that internet-enabled solutions could reduce greenhouse gas emissions by 16.5 percent.[14] Some estimates suggest that, by 2030, "smarter" systems could save 10 times the emissions that they generate, pointing to the potentially transformative effect of ICT on the energy-intensity of the economy.[15]

This future is possible as businesses and the economy continue to evolve, incorporating new innovations and pushing increased adoption of sustainable solutions to effectively reduce emissions in the long run. For example, 44 percent of CEOs in the United Nations Global Compact-Accenture CEO Sustainability Study see a net-zero future for their company in the next 10 years and 59 percent said they are developing low-carbon and renewable energy across their operations today.[16] Companies are also finding that their commitment to the climate aligns with their business model, making it financially attractive to invest in solutions to effectively reduce their emissions. Between 2013 and 2019, companies with consistently high environmental, social, and governance (ESG) performance achieved 4.7 times higher operating margins and lower volatility than low ESG performers over the same period.[17]

Objectives, Scope and Methodology

This White Paper explores the intersection of climate and connectivity, offering a preliminary analysis of how digital transformation and the adoption of new technologies could also support GHG reductions and a net-zero future. It also seeks to uncover perspectives from Canadian industries and companies that are thinking about how they might engage digital technology to achieve their net-zero goals. To date, much of the work in this space has been focused on specific industries with high levels of emissions (e.g., agriculture, mining, transportation). However, this has missed the big-picture conditions that will be required to underpin advancements in energy efficient innovations, including 5G+ connectivity and digitization. In the emergent space of digital climate policy, this seeks to spur an important cross-sector discussion among Canadian policy, business, and civil society decision-makers, in a moment when Canada's pursuit of a net-zero future is occurring amidst the rapid and transformative digitization of the country's economy and society.

This paper relies on secondary research and collates data from a review of existing publications on electronic databases. This includes searching for and identifying relevant literature from sources such as legal and policy frameworks from peer jurisdictions and international organizations, and media reports, federal and provincial government reports, briefs, memoranda, and websites. The paper is also informed by views and perspectives gathered from a diverse range of stakeholders in Canada. Through an open-ended questionnaire and a one-day policy workshop held on May 24, 2023, cross-sectoral representatives from participating organizations were surveyed for their impressions and insights.

This paper seeks to spur an important cross-sectoral discussion among Canadian policy, business and civil society decision-makers, in a moment when Canada's pursuit of a net-zero future is occurring amidst the rapid and transformative digitization of the country's economy and society.

Context-setting and Key Terms

An important starting point in considering the intersection of climate and connectivity is applying a general methodological frame to how the telecommunications and ICTs can impact the environment, The scholars Lorenz M. Hilty and Bernard Aebischer, in their book chapter ICT for Sustainability: An Emerging Research Field, offer a useful three-level analytical model:

1. First-order effects are "the direct environmental effects of the production and use of ICTs";[18]

2. Second-order effects are "the indirect environmental impacts through [the ICT impact on] the change of production, processes, products, and distribution systems";[19] and

3. Third-order effects are "the indirect environmental impacts through [the ICT] impacts on lifestyles and value systems."[20]

Researchers have added to this categorization of order effects another dimension that distinguishes between the positive and negative effects of ICT — what they call, "ICT as part of the problem or ICT as part of the solution."[21]

Studies have found that the digital and ICT sector directly contributes only two to four percent of emissions.[22] In terms of energy consumption, estimates show that powering digital devices (computers and smartphones) and the supporting infrastructures (communications networks and data centres) consumed about five percent of global electricity use in 2012,"[23] and recent estimates range from four to six percent as of 2020.[24] Direct contribution to emissions from the digital sector outlines the emissions generated and energy used to produce and operate ICT technology and would be categorized as "ICT as part of the problem". While direct contribution to emissions from ICT is low relative to other industries, estimates show that the ICT sector and the incorporation of digital solutions can create up to a 20 percent reduction of total global GHG emissions, mainly through indirect upstream and downstream effects.[25] [26]

This indirect impact consists of both second- and third-order effects where efficiency gains from technology solutions could make manufacturing/supply chain cleaner (second-order) and enable changes in lifestyle such as remote work (third-order). These positive impacts could be categorized as "ICT as part of the solution".

The concept of "order effects" offers a lens for categorizing the pathways of influence that telecommunication and ICT solutions are having or could have on climate goals and emissions reductions. Internet of Things (IoT) solutions — which refers to how connected devices and software, with sensory and processing abilities, can connect and share data with other devices and systems over the internet or a communication network to increase operational efficiency — offers wide-reaching impacts on processes that connect various aspects of our increasingly digitized economy. Understanding the complexity of emission sources and how digital solutions can transform the ICT industry, including transforming the general ecosystem of industries that support it as well as the industries that it supports, is key to instituting the right policies to maximize emissions reduction.[27]

Incorporating digital solutions to support a net-zero transition is not a linear solution: instead, it requires prioritizing the reciprocal and intertwined nature of the relationship between the ICT industry and all other industries and our lifestyles. The digital decade has presented the world with dual challenges: the green transition and the digital transition. These interconnected hurdles highlight the opportunity to build a cutting-edge, sustainable economy in Canada. Termed the twin pillars, these challenges are co-dependent: constructing a sustainable future demands increased automation and digitization, and at the same time increased efficiency and the elimination of excess waste.[28]

3

Digital Applications that could Enable Progress Towards Net-Zero

There is widespread consensus that achieving climate objectives and meeting net-zero targets will depend to a significant extent on green technological innovation and adoption.[29] [30] [31] This requires strong and resilient digital infrastructure networks, and transition to digital applications that bring about greater efficiency, and in turn, reductions in emissions. Efforts should also be focused in areas of highest potential for emissions reductions, which vary by region and sector in Canada. For instance, according to Statistics Canada, the highest GHG-emitting industry is oil and gas extraction, "responsible for 22.4 percent of Canada's total GHG emissions in 2020".[32] Yet, the crop and animal production industry accounted for the largest share of total GHG emissions in Manitoba (37.2 percent) and Saskatchewan (24.4 percent).[33] Households are also a major source in all regions, accounting for nearly one-fifth (17.5 percent) of Canada's total GHG emissions in 2020,[34] and the largest source in Ontario and Quebec at nearly 30 percent of total emissions.[35]

This section presents a selection of examples of digitization trends or innovations in ICT with the potential to support decarbonization.

5G+ Connectivity

Research has shown that new and emerging wireless technologies such as 5G have the potential to reduce greenhouse gas emissions and contribute positively to reducing climate change in Canada. Wireless carriers in Canada have taken steps to reduce their carbon footprint by "reducing energy consumption, switching to more efficient network equipment, and sourcing renewable energy where possible."[36] Despite efforts to reduce energy intensity in the running of wireless networks, increased consumer demand for mobile technologies in today's economy requires greater efficiencies to offset emissions increases from high consumer demand. Research by Accenture and the Canadian Telecommunications Association shows that 5G's greater network efficiency could offset these increases in consumption.[37] The study finds that a "general 5G cell site" transmits data using only 8 to 15 percent of the energy it would take for a 4G cell site.[38]

5G's ability to maximize energy efficiency comes from its ability to use antennas and spectrum to minimize interference, increase capacity per cell with wider bandwidth, and incorporate power-saving features to reduce base station power consumption.[39]

Therefore, the industry estimates that energy consumption from 5G does not grow substantially even if traffic data increases: 5G could possibly carry up to a hundred times more traffic while reducing its power consumption.[40]

Although greater connectivity could increase overall traffic demand, and, in turn, energy consumption, efficiency gains from 5G are greater than the increase in demand.[41] Accenture's study estimates that 5G will support a thousand-fold traffic increase in the next 10 years, while the full network's energy consumption will be half the current levels.[42] The researchers stipulate that 5G will enable up to a 10 MtCO2e equivalent reduction from Canadian wireless carriers between 2020 and 2030, compared to emissions without 5G.[43] Major telecommunications companies have committed to net-zero and securing fully non-emitting power (that is, the generation of power from sources and using processes that do not directly release any GHGs),[44] supported by the fact that 83 percent of Canada's electricity is currently non-emitting.[45] It remains the fact that in order to power the technology innovations of the future, Canada's grid will have to remain both clean and efficient to extract the amount of energy needed to fuel wide-ranging, systemic changes in digitization across the economy and society.

In terms of indirect (second- and third-order) effects, 5G will also enable reductions from other industries. The adoption of 5G has been estimated to contribute up to 20 percent in additional emissions reductions than wireless technologies' current estimated contribution, with mobile technologies having the potential to address 23 percent of Canada's total 2030 emission reduction target by 2025.[46] Accenture estimates that 70 percent of this additional abatement will come from incorporating 5G in use cases such as smart working, living and health, smart transportation, and smart buildings.[47]

The Global Enabling Sustainability Initiative (GeSI) study highlights that mobile technology can enable the reduction of emissions by supporting greater energy efficiency and increased digitization in 10 specific categories: 1) connected agriculture, 2) connected buildings, 3) connected cities, 4) connected energy, 5) connected health, 6) connected industry, 7) connected living, 8) connected transportation, 9) connected working and 10) physical-to-digital.

Smart Monitoring

"Smart" grids and digital meters, including smart home monitoring tools, can also enable greater emissions monitoring and therefore improve reductions in GHG emissions by increasing consumer knowledge and consciousness around their energy consumption.[48] Smart grids, with sensors and software, provide real-time information for quick responses to power issues and offer more predictability around usage and pricing.[49] Home automation technologies can help optimize environmental performance through energy management systems.[50] New environmental regulations have stimulated the growth of pollution monitoring and control technologies. When linked to telecommunications networks for the transmission of information, these systems can monitor conditions at a series of remote sites as emissions occur in real time.[51]

Researchers explain that "new smart metering technologies can now link utility [usage information] to the customer's meter through telephone or radio-based communication systems."[52] With information about the cost of services, customers can be encouraged to manage and reduce levels of water and energy consumption. A 2019 study found that one-third of the world's CO2 emissions were from household energy consumption.[53] However, outlining the promise of smart homes, another study based in Finland concluded that home automation could save 13 percent of home emissions.[54] By providing accurate, real-time data that enables informed energy consumption decisions and accurately outlines usage patterns, smart meters could help provide the information needed to deliver and sustain a transition to smart grids and a connected society.

The transition to net-zero buildings is also another way to reduce emissions in the construction and building sectors. Buildings accounted for 12 percent of Canada's direct GHG emissions in 2019 and over 85 percent of buildings sector emissions come from space and water heating, due to the use of fossil fuel equipment, such as natural gas furnaces, and extra energy demand for heating and cooling.[55] Through retrofitting existing infrastructure or ensuring new developments are designed with sustainability and green technology in mind, developers can significantly reduce the emissions and energy use of residential and commercial buildings by installing new, more energy efficient technology. For example, low-carbon heating and cooling systems (such as heat pumps and energy efficient air conditioning) as well as the adoption of a "smart buildings" system – a technology and service that allows the tracking, monitoring and reduction of energy use–are ways in which developers can achieve net-zero emissions buildings.[56] [57] The transition to sustainability design in building and construction will require developers to incorporate green technology throughout the planning and implementation process–a transition that has faced some resistance from developers due to the increased short-term cost of incorporating new technologies and lack of clarity on measuring the full value of climate-related innovations in building management that can be captured in the longer term.

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Mobility as a Service

Mobility as a Service (MaaS) refers to "the integration of various forms of transport services into a single mobility service accessible on demand."[58] MaaS is an alternative to the private use of a vehicle—it provides a single application that provides mobility options available to customers through a single payment channel. Canada's transportation sector is the second-largest contributor to overall GHG emissions and according to data from the most recent National Inventory Report (2021) cited in the federal government's Road to 2030 for Canada's Economy report, emissions from transportation were 186 megatons (Mt) in 2019, accounting for 25 percent of total emissions in Canada.[59] Researchers emphasize that MaaS can help reduce emissions, congestion, air pollution, and excess consumption of space.[60] [61] A 2022 study based in Amsterdam modelled travel activities in the city and created conservative, balanced and optimistic estimates showing that various bundles of MaaS technologies could reduce emission levels by 3 to 4 percent, 14 to 19 percent, and 43 to 54 percent respectively.[62]

MaaS has been considered a part of "smart mobility"—defined by Francini et al. as "the result of a planning process that makes use of technological supports in the simulation, use and monitoring phases of individual and shared transport systems to guarantee safety standards, functionality and sustainability."[63] [64] The implementation of MaaS requires the use of "integrated ICTs, sustainable transport and logistics systems" to reduce traffic, expand flexible mobility and provide commuters with real-time access to transport options.[65] MaaS combines various shared mobility solutions (such as car sharing, bike sharing, etc.) and public transport options together in a single interface where users can book tickets and complete payments as an alternative to private vehicles.[66] To create a well-integrated MaaS application system that optimizes route choices and packages of transport options (e.g., a shared electric vehicle, then shared bike, to reach a destination) on a single-platform interface will require greater degrees of connectivity between individual smartphones, public transport systems, and traffic data.[67]

Canada's transportation sector is the second-largest contributor to overall GHG emissions [...]

Remote Work

The transition to remote or hybrid work presents new opportunities to decrease emissions in the long run. During the COVID-19 pandemic, companies swiftly adopted work-from-home policies in response to lockdown measures, prompting renewed interest in the possibility and potential of remote work.[68] Likely due in part to these work-from-home policies, carbon emissions were down by 20 percent in April 2020 at the start of the pandemic compared to April 2019, and seven percent year-over-year due to the use of digital telecommunications to conduct work.[69] Enroute to a more digitized world, remote and hybrid opportunities allow for companies to expand their networks globally, without the expense and inefficiency of travel and, generally, with greater ease.[70]

While industries continue to explore the right balance between in-person and remote work, for many researchers have stipulated that telework could be one of the greatest avenues through which ICT can help minimize emissions significantly. Estimates from the International Energy Agency find that "transport has the highest reliance on fossil fuels of any sector and accounted for 37 percent of CO2 emissions in 2021."[71] Further estimates show that even if only 10 percent of the workforce in the EU adopted hybrid work, 22 million tons of CO2 will be saved in a year; and if 30 million people in the US transitioned to hybrid work, at least 75 to 100 Mt CO2e of GHG emissions will have been saved by 2030.[72] Moreover, estimates also show that if video conferencing replaces only 20 percent of travel in the EU, 22.3 million tons of CO2 will be saved.[73]

Agricultural Sector

According to Statistics Canada, 10 percent of Canada's GHG emissions are from crop and livestock production.[74] Digital adoption of technology solutions can reduce emissions from the agriculture sector. One study found that "through a combination of innovations in digital agriculture, crop and microbial genetics and electrification…71 percent of reduction in GHG emissions from row crop agriculture is possible within the next 15 years."[75] For example, the GHG nitrous oxide (N2O or N) is "produced mostly from excess available nitrogen in soils" stemming from "excess fertilizer application."[76] Technologies that optimize and deliver fertilizer guidance focus on providing the right amount of fertilizer, at the right rate, time, place and way (5 Rs approach) using N-demand forecasting and digital agriculture and agronomic modeling. Using high-resolution geospatial monitoring systems, crop simulation models can better predict and plan responses to fertilizer inputs based on soil, weather, terrain and crop demand to achieve the optimal use of fertilizer and minimize excess application. A US-based study in 2020 found that N fertilizer application based on forecasting of these technologies can reduce "N application by 36 percent for a 23 percent emission reduction."

Moreover, new technologies have developed advanced agriculture management devices to monitor for and filter out methane emissions. Drones can also support sustainable agriculture by using GPS and geographic information systems to reduce waste and transportation emissions. These examples are referred to as Climate Smart Agriculture (CSA) technologies, an integrated approach to agriculture that uses technology to transform systems toward green and climate resilient practices. One study applying CSA technology to rice cultivation estimates that these technologies reduced GHG emissions compared to normal practices between 7 and 23 percent and achieved economic benefit between 42 and 129 percent.[77]

Survey participants were asked what they thought the role of digital infrastructure and connectivity is in reaching net-zero GHG emissions.
Here's what we heard:

- Data collection and analytics to monitor emissions, using new technologies like AI and open source, interoperable blockchain.
- Remote work to reduce travel.
- Business-related digital infrastructure to support net-zero including: switching to cloud service providers with carbon-neutral data centres and relying on decentralized local micro grids.
- Adoption of digital tools and services to reduce emissions and increase energy efficiency in operations and production (e.g., mining, manufacturing, vehicles).
- Vehicle-to-infrastructure communication for optimization of routes and vehicle performance/data collection.
- Livestock management, precision agriculture, and new Canadian/partner satellites to improve mapping and geo-positioning capabilities in the agricultural sector.

4

Uncertainties in the Potential Impact of Connectivity on Climate Goals

The previous examples of what a smart, net-zero future could be in Canada require individuals, businesses, governments and households to be connected to the internet and communication networks to use the digital technology solutions required to bring about a net-zero reality. Representatives in the roundtable highlighted that Canada currently does not have the sufficient network capacity and infrastructure to accommodate the level of digitization that is imaged or needed for a net-zero future. Expanding connectivity and creating resilient networks is one common thread, underlying the infrastructure from which these advancements in energy efficiency can be realized.

However, expanding connectivity and digitization, while at the same time ensuring absolute or total energy demand and consumption is reduced, is not an easy feat: many complex, and often conflicting, forces could impact overall levels of energy consumption in our quest to transition to a smart, clean future.

The Energy Intensiveness of the Choices We Make

The transition to a net-zero future that relies on better connectivity is fraught with challenges. This move will require industry, community, government, and individuals to make choices and trade-offs that effectively weigh technologies' efficiency potential against their up-front cost and energy intensiveness. For example, when thinking about the infrastructural design of our technological future, policymakers and industry must consider how new mobile communication networks, which promote greater reach, faster speeds and allow individuals to stay connected through greater distances, could actually be more energy intensive than other connectivity choices. For example, mobile networks use greater energy to transmit data than fixed networks.[78] Bento asserts that the energy required by mobile phone infrastructures "is ten times higher than the direct consumption of the handsets," creating a "sizable impact on energy demand."[79]

The majority of the energy used by the internet is consumed in "the transmission and access networks delivering the internet" and "has been estimated to be approximately 0.5 percent of typical national consumption," with rates likely to rise as traffic levels continue to increase with digitization and more people getting connected.[80] In one study, researchers find that optical-access networks — a type of fibre-to-the-premise installation in which a single fibre from the backbone access network feeds one or more clusters of customers — is the most energy-efficient option of available access technologies, including wireless networks.[81] The researchers conclude that "wireless technologies will continue to consume at least 10 times more power than wired technologies when providing comparable access rates and traffic volumes."[82]

Despite these challenges, our technological infrastructure will likely continue to prioritize a mobile-first future as the industry projects continued growth. A study by Ericsson found 70 percent growth in total global mobile data traffic between 2016 and 2017, and forecast a compound annual growth rate of 42 percent through to 2022—an eight-fold increase compared to 2016.[83] In addition, data traffic to smartphones, including that sent over Wi-fi networks, is forecast to exceed the overall traffic from personal computers by 2021, accounting for 39 percent of overall internet traffic, compared to PCs at 28 percent, TVs at 19 percent, and tablets at eight percent, further fueling a mobile-first future.[84] Analysts also predicted that the number of connected devices will grow from 2.3 per person in 2016 to 3.5 in 2021, further escalating energy consumption from mobile access.[85] With greater growth of internet traffic, total internet energy consumption is estimated to grow by 60 percent from 2020 to 2030, and access network energy consumption is estimated to triple.[86]

While reliance on smartphones and mobile access is critical in a connected smart society, policymakers and industry need to monitor the energy intensity trade-offs and marginal efficiencies lost or gained when considering infrastructure development options to better understand technology's overall impact on total energy consumption and emissions. A key uncertainty underpinning this consideration is the GHG-intensity of the electricity used by digital technologies, and the ability of Canada's energy systems to deliver sufficient renewable and net-zero electricity into the future as demand grows.

With greater growth of internet traffic, total internet energy consumption is estimated to grow by 60 percent from 2020 to 2030, and access network energy consumption is estimated to triple

Reduction Estimates Are Not Easily Determined

Projections around reductions in emissions from increased connectivity and digitization are based on predictions that attempt to model human behavior, which could be vulnerable to error. It is difficult to achieve accuracy in GHG reductions estimates because prediction models must take into consideration a range of human factors that could have opposing effects on the total level of emissions.[87] Researchers have highlighted that forecasting uncertainty may still be evident in research that links lifestyle changes and indirect impacts on the environment resulting from greater connectivity and digitization based on assumptions about behavior.[88] [89] [90] Predictions that assume increased connectivity and digitization tools will result in more individuals choosing to work remotely, or installing smart home monitoring devices to encourage energy efficient choices, will require the general infrastructure of society to transition to green-first delivery models and a level of climate consciousness that can all together enable these lifestyle changes. Moreover, business practices and operations will need to transition in parallel to enable a green future. These behaviours are difficult to guarantee without a change in society's underlying value systems, including climate-threatening lifestyles such as overconsumption and materialism.

For example, some research into whether digitization will impact travel patterns finds "little evidence of anticipated, direct substitutions between travel and online accessibility" and instead "more complex and debated effects emerging over time."[91] Researchers have debated the "net balance of additions and savings to carbon emissions and energy consumption"[92] [93] from digital technologies, and debates in estimations continue to loom large. A better understanding of how lifestyle and daily habits change, parallelled with the proliferation of devices, technologies, and online services that continuously impact these patterns of behavior, is the foundation upon which policies and initiatives linking digital and climate goals should depend.

5

Aligning Digital Divide and Climate Justice Priorities

Facilitating large-scale technology adoption and connectivity to enable significant reductions in emissions will require ensuring that all individuals are connected to the internet and have the digital tools to be able to participate in a net-zero economy. Although nearly all Canadian residents (99 percent) live in areas with the infrastructure to connect to a basic internet service at home, 5.3 percent of households in Canada still do not have home internet service, and 15.5 percent do not have an internet connection service at the CRTC's 50 megabits per second (Mbps) (megabits per second) download speed target.[94]

Gaps in connectivity are the highest among rural households, Indigenous communities, low-income individuals and older adults. Almost half of households in rural and remote areas (41 percent) and more than half of First Nations reserves (57 percent) cannot connect to the internet at CRTC's 50/10 Mbps speed target.[95] Moreover, half of Toronto's low-income households (52 percent) report internet download speeds below the 50 Mbps target.[96] Older adults and people with disabilities have also consistently reported lower home internet use and speeds across Canada and within urban centres.[97] [98] Enabling a transition to a clean economy requires increasing digital adoption across all sectors, particularly for under-connected and vulnerable groups. A just climate transition requires that all people in Canada can benefit from the income and environmental gains realized from improved energy efficiency.

Moreover, expanding connectivity to rural areas and connecting those still left behind can help Canada achieve a net-zero future faster. Researchers point out that most fundamental green technologies that are "enabled by broadband require wide-area and ideally universal and mobile coverage" to effectively support large-scale infrastructural advancements such as the deployment of smart grids, smart transportation, autonomous vehicles, precision agriculture, and water conservation.[99]

In addition, energy efficiency gains can be better realized by connecting those in rural areas, who, without sufficient access to the internet or new digital solutions, use more energy than those in urban areas with better connectivity. According to the OECD, "rural regions have the highest emissions per capita, often driven by the lack of deployed sustainable alternatives and the demands of metropolitan areas for power generation, mineral extraction and agricultural production."[100] Moreover, "average emissions per capita in OECD countries in 2018 were three times higher in remote rural regions (26.3 tons of CO_2 per capita) compared to large metropolitan regions (9.3 tons of CO_2 per capita)" and "remote regions, home of about eight percent of the OECD population contributed to 17 percent of total GHG in the OECD in 2018."[101] The economic transformation needed for a net-zero future will require ensuring that gaps in digital adoption and rural connectivity are closed, particularly to support the transition of transport and production where emissions are highest.

Rural areas where agricultural practices and use of carbon-emitting vehicles for long transportation times still loom large, could experience a challenging transition to a net-zero future, as legacy systems and practices are upended. Building and supporting local climate policies in rural areas is pivotal to accelerate a "just transition," and to ensure the long-term effectiveness of these policies. Understanding that the climate transition may impact some communities more than others adds an important socioeconomic dimension to climate policy. Policies that do not take local impacts into consideration could undermine the social and political support needed to incorporate digital technologies and achieve a net-zero future.[102]

Rural and under-connected areas also require capacity-building initiatives to ensure administrators and governance can operate with the right knowledge, ability, skills, and funds to effectively manage transitional operations and implement measures to mitigate climate change in the long run. This will also require expanding digital literacy skills and technology know-how to local communities to enable local ownership and control of emerging technologies. The principle of "just transition" requires empowering rural areas and under-connected groups to develop transition strategies that address their unique digital challenges, and creating an enabling environment through expanded knowledge, institutional capacity, responsible governance, digital infrastructure, and funding.

Enabling a transition to a clean economy requires increasing digital adoption across all sectors, particularly for under-connected and vulnerable groups.

6

Takeaways for Industry Leaders and Policymakers

Emerging from the research scan and cross-sector stakeholder input, this section briefly surveys the current state of "digital climate" public policy in Canada, and outlines a set of recommendations and mobilization opportunities for advancing digital climate action in Canada.

Current "Digital Climate" Public Policies in Canada

There are currently no policies in Canada that explicitly outline or acknowledge the role digital and connectivity policies can play in shaping our climate objectives and meeting emission goals. Although the federal government and other governments have introduced some important programs at the intersection of climate and connectivity, the approach lacks a concerted effort to maximize the potential for digitization to support a faster transition to a net-zero economy in Canada. For example, Canada does not currently have the network capacity and infrastructure to accommodate all of the digital solutions and applications that may be necessary in the net-zero transition.

An example is the federal government's Smart Cities Challenge, launched in 2017 as a pan-Canadian competition adopting a smart cities approach to expand innovation and quality of life through data and connected technology initiatives.[103] In the latest federal budget, the government launched a new round of the Smart Cities challenge, focused on using connected technologies and data to improve climate resiliency.[104] Moreover, the 2023 federal budget outlines over $60 billion over the next 10 years for Clean Electricity Investment Tax Credits, which provide businesses from 15 percent to 40 percent refundable credit for eligible investments in technologies that support the development of clean electricity and manufacturing products or materials, as well as equipment for carbon capture and geothermal energy systems.[105]

There are currently no policies in Canada that explicitly outline or acknowledge the role digital and connectivity policies can play in shaping our climate objectives and meeting emission goals.

Significant public policy and investment is also focused on digitizing energy systems. An example is the Smart Grid Program, facilitated by Natural Resources Canada, to accelerate the development of smart grids that modernize the delivery of electricity and increase hosting capacity of renewable generation. The program allocated $100 million over five years for the demonstration and deployment of projects across Canada, fostering an environment conducive to driving the country towards a more sustainable and resilient energy future.[106] Canada has achieved significant progress in introducing smart grids, with 82 percent adoption nationally, attributed to a synergy of industry and governmental backing.[107] However, reaching 100 percent adoption remains challenging, primarily due to Canada's decentralized electricity regulation, led at the provincial level, which has made national coordination challenging.[108] Other programs focus on adoption of digital technology across the economy. To further incentivize digital adoption in industry, the federal government launched the Canada Digital Adoption Program (CDAP) in 2022 to help Canadian small- and medium-sized business to incorporate digital tools by accessing two forms of funding: micro-grants of up to $2,400 to help pay for costs related to adopting digital technologies, and grants to help pay for the services of a digital advisor, who can support with the development of a digital adoption plan, with the opportunity to secure zero-interest loans of up to $100,000 from the Business Development Bank of Canada to help implement those plans. Yet, uptake of CDAP has been very low to date.

Survey participants were asked what they thought is still needed to achieve net-zero. Here's what we heard:

- Tools for investing in and transparently financing renewable energy projects.
- Enabling marketplace for trading carbon credits.
- Accelerating discovery of new clean energy materials using AI to search spaces.
- Strong mobilization of R&D technologies to the commercialization stage to be incorporated as digital solutions in industry (e.g., direct reduced iron for steelmaking or reduced electrolytic hydrogen for chemical manufacturing).

Policy and Mobilization Opportunities

A) Reduce first-order effects of ICT's contribution to GHGs:

1. Meet industry standards for the ICT sector to achieve net-zero in its operations.

2. Support the transition to an emission-free electricity grid as a key enabler for greater digitization.

Reducing the Greenhouse Gas Impact of ICT

The telecommunications industry has a pivotal role to play in catalyzing society's transition to a net-zero future. The development of evidence-based, implementable industry standards will underscore the urgency of addressing this issue and set a benchmark that encourages environment-conscious decision making at executive and operation levels. It will also signal to other industries a clearer path towards reducing emissions, by providing digital infrastructure that can be easily integrated within a variety of businesses across multiple sectors of the economy.

The Global System for Mobile Communications Association (GSMA) took the first steps in achieving an industry standard and collective agreement on reducing emissions, establishing energy consumption targets and achieving a net-zero future. In 2019, these companies established a goal to transform the mobile industry and achieve net-zero carbon emissions by 2050.[109] A key component of this strategy involves climate disclosures. In 2020, comprehensive guidelines were issued detailing how operators could align with GSMA's carbon emissions objectives.[110] By April 2021, operators representing at least 50 percent of global mobile connections and 65 percent of industry revenues had pledged to adhere to science-based emissions reduction targets.[111]

The GSMA has also established a task force to aid operators in enhancing energy efficiency across networks and buildings, increasing access to and use of renewable energy, collaborating with suppliers on climate action, improving mobile device sustainability, and employing mobile connectivity to decrease carbon emissions through intelligent technologies.[112]

A key enabler of this goal will be a clean electricity grid, as energy demand grows to power mobile networks, data storage, connected services, and other facets of Canada's digitization. Canada has set a goal for Clean Electricity Regulations that achieve a net-zero grid by 2035. While Canada starts from a strong position of 82 percent of electricity coming from renewable sources, closing the remaining gap while maintaining affordability as demand increases will be critical. ICT can also play a significant role in supporting the development of a clean electricity grid through the incorporation of smart grids and more efficient energy-extracting technologies.

The telecommunications industry has a pivotal role to play in catalyzing society's transition to a net-zero future.

These ICT-enabled solutions to the grid can generate more efficient renewable power and also better integrate the grid with smart monitoring devices that can, for example, manage demand by smoothing out demand peaks from electric vehicle charging.

B) Enable second-order effects of ICT effecting changes in production, processes, products and distribution systems:

3. Government to assess opportunities to align digital with climate policies, including a climate impact lens for digital policies and performance measures, to maximize the potential for emissions reduction.

4. Government and industry to work together to support public and private investment in developing and deploying resilient telecommunication networks to ensure all Canadians maintain connectivity in the face of climate disruptions and expand equitable adoption of emission-reducing technologies across Canada by closing the digital divide through affordable 5G and fixed wireline in rural Canada, including through the effective release and use of spectrum.

5. Government to create incentives for digital adoption for small to medium sized businesses where the incorporation of technology is proven to enable emissions reductions, such as smart monitoring and sustainable agriculture practices.

6. Government to establish new and strengthen existing funding mechanisms to provide sustainable support for development, commercialization and deployment of open-source technology and software solutions aimed at climate change mitigation.

7. Government to clarify procurement policies to ensure they consider climate impacts and prioritize innovative Canadian companies as a means to expand adoption of digital technology solutions that enable emissions reduction within public sector organizations and operations, while also de-risking the purchasing of proven solutions for other actors in the economy.

Enabling the Digital Infrastructure for Net-Zero and Increasing Digital Adoption

While challenges and costs arise when building out networks and infrastructure to support greater connectivity, a net-zero future still requires continuous innovation and expansion of energy efficient communication networks to enable transitions to clean production and transportation within energy intensive sectors of our economy. This will require driving network and 5G deployment and investment to expand rural connectivity by maximizing the deployment of affordable 5G spectrum and fixed wireline in rural Canada and supporting climate and "smart" initiatives across the economy that require high-quality, reliable connectivity, particularly within GHG-intensive industries. As network and connectivity innovations expand, a transition to net-zero will also require encouraging digital adoption and buy-in among consumers, businesses and governments to enable more efficient operational processes.

Powering a fully connected smart city that can achieve net-zero emissions requires the expansion of resilient communication networks and infrastructure. A resilient network refers to the physical infrastructure that powers digital technologies, provides high-quality services with minimal disruption and the ability to safeguard against unpredictable impacts, system failures, or challenges to normal operation. Particularly in the context of climate change, the impacts of climate-related natural disasters add a further impetus to establish resilient networks that can continue to operate under harsher conditions. Resilient network infrastructure should also be universally available to allow all individuals to equally participate in society and access services, responsive to requests and user demands in an efficient manner, and scalable to adapt to a growing amount of traffic and a constantly changing digital environment.[113] This requires government and industry to work together to ensure affordable 5G and fixed wireline access across Canada, including through the effective release and use of spectrum, further investment in rural and Northern connectivity, increased competition, and subsidized services for lower-income communities.

The potential for digital solutions to positively impact climate goals also depends on industries' ability to adopt technologies that can reduce emissions. A survey of Canadian firms conducted by the Bank of Canada in 2018 found that Canadian businesses show a higher level of adoption of cloud computing and e-commerce and low rates for 3-D printing and artificial intelligence (AI).[114] Moreover, large firms show higher rates of adoption than small firms.[115]

Despite some progress in digitization within larger firms, barriers to digital adoption remain for many businesses in Canada. A report by the Ontario Chamber of Commerce further illuminates the main challenges to incorporating technology for small to medium enterprises (SMEs) in Ontario. Firstly, small employers with smaller margins and limited access to external capital, particularly within the current high-inflation environment, do not have the capital resources to sufficiently invest in digitization.[116] In addition to resource limitations, the report also outlines gaps in digital skills for employees, highlighting that "attracting and retaining workers with digital literacy can be particularly challenging for small businesses in a tight labour market."[117] Lastly, the report outlines that "fast, affordable and reliable broadband connectivity" is the "fundamental prerequisite for businesses of any size to access digital resources and talent."[118]

These challenges are compounded when small businesses cannot incorporate the data analytics and AI solutions that can enable better monitoring of emissions and a deeper understanding of process inefficiencies that, if addressed, could help reduce energy use and carbon emissions. A survey of business and technology leaders conducted by KPMG in 2022 found that "overall adoption of AI among Canadian organizations is less than half of that in the US, with only 35 percent of Canadian businesses saying they currently use AI in their operations versus 72 percent in the US."[119] Canadian SMEs find it especially difficult to quickly adopt new AI solutions as they require precise data collection and management strategies for algorithms to produce accurate results.

Open-source software solutions are one way to provide organizations access to data analytics capabilities to provide better insight into emissions and energy use. Yet, open-source software often provides incomplete or fragmented solutions that small organizations, without the knowledge, expertise, or time, may find it difficult to piece together different data projects and code to address their unique business challenges. One example is the Open Radio Access Network (Open RAN), a critical network technology that connects users—including communications service providers—to mobile networks over radio waves. Open RAN provides open-source solutions that allow for interoperability and flexibility in the operation of mobile networks, a concept that can also be applied to other sectors of the economy that could benefit from greater efficiencies through better technology integration.

To further fuel advancements toward a net-zero future, the government can directly invest or create incentives, such as tax credits, when emissions reductions are enabled through digital adoption, such as smart monitoring and sustainable agriculture practices. For example, the federal government provides a number of tax credits for businesses looking to adopt clean technology. The Clean Electricity Investment Tax Credit provides a 15 percent refundable credit for "investments in technologies that are required in the generation and storage of clean electricity and its transmission between provinces and territories." The Clean Technology Manufacturing Investment Tax Credit covers 30 percent of costs in "new machinery and equipment used to manufacture or process clean technologies and extract, process or recycle critical minerals."[120] Incentives generated by the government could make it more affordable for SMEs to adopt cleaner technologies by offsetting some of the upfront costs of purchasing devices, software or other supporting digital systems.

The government can also further take the lead in expanding digital adoption through procurement to stimulate demand for clean technology. A report by the Smart Prosperity Institute highlights the bottlenecks challenging government procurement of clean technology, namely that early-stage companies working on clean innovations may be perceived as riskier than other technologies, thereby disincentivizing risk-averse procurement approaches from adopting innovative solutions from cleantech startups, which in Canada continue to struggle to transition from pilot stage to commercialization.[121] According to the report, in 2016, federal spending on cleantech procurement was about 3.7 percent of total government spending in Canada—a number deemed insufficient by Canada's Economic Strategy Table, which recommended increasing cleantech procurement spending to five percent of total government spending by 2025.[122]

Survey participants were asked what they thought are still barriers to digital adoption in Canada. Here's what we heard:

- Gaps in rural connectivity.
- Cost as a barrier to incorporating digital solutions for small-to-medium sized enterprises.
- Cybersecurity risks.
- Not fully understanding ROI for digital technology and adoption (perceived economic risk: cost too high or return on investment too low).
- Workforce expertise to operationalize and fully capture value from technology adoption.

C) Monitor third-order effects of ICT's changes in lifestyles and value systems:

8. Government and industry to observe for "rebound effects," whereby improved connectivity can induce new, more energy-intensive demands that counterbalance energy savings, and include these effects in the government's monitoring and reporting of emissions levels within the economy.

9. Industry and government to commission empirical research from academia and/or institutes to assess the emission-related impacts of hybrid and remote work arrangements to better inform employers and policy.

10. Industry and government to jointly launch a federal-provincial-territorial process on digital and climate policy. Include ongoing engagement with municipal governments, Indigenous organizations, and stakeholders, to build common understanding, create momentum and establish shared commitments across government, industry and civil society stakeholder groups and find alignment on how digital policies can help Canada achieve its net-zero target.

Monitoring for Rebound Effects to produce Effective Emission Reduction Policies and Convening over this Shared Agenda

"Rebound effects" refers to the notion that improved digital and internet connectivity have the potential to induce "new, more energy-intensive forms of digital demand that could counterbalance energy savings."[123] For example, bandwidth demands for telecommunication networks "have increased at unprecedented levels…growing annually at an average rate of 50 to 60 percent and exceeding 100 percent growth during some years."[124] Particularly during and coming out of the pandemic, the transition to online delivery of most services, and the proliferation of web-based applications have accelerated the digitization of many aspects of everyday life. As the number of connected devices and level of data traffic continues to increase, the processing and storage power needed to keep these systems running will also need to grow significantly.

Some researchers argue that growth in some ICT uses is currently unsustainable.[125] For example, studies suggest that smart home technologies may actually be associated with increases in energy consumption, both directly (to run the new technologies and incorporate their use to existing consumption patterns) and indirectly, such as through increases in lighting and heating.[126] [127] Data centres for cloud storage pose another challenge. According to an Accenture study, "the number of large-scale data centres is increasing by 14 percent each year."[128] As a result of this continuous growth, global data centre electricity use is now nearly equivalent to the annual consumption of the country of Spain (one percent of global consumption).[129] This has increased the level of GHG emissions: global emissions from cloud computing were found to "range from 2.5 percent to 3.7 percent of all GHG emissions [as of 2019], thereby exceeding emissions from commercial flights (about 2.4 percent) and other existential activities that fuel the global economy" such as shipping, rice cultivation, and food processing.[130] [131]

Emerging technologies, such as generative AI and cryptocurrency, also consume increasing amount of energy, contributing to GHG emissions. Analysis by the Cambridge Bitcoin Electricity Consumption Index finds that Bitcoin alone represents 0.65 percent of global electricity consumption, making it the twenty-seventh largest consumer of electricity on the planet as of 2021.[132] The advancement of generative AI technology inherently requires the development of larger models with greater amounts of training data to increase performance, thereby requiring increasing levels of computational power and, in turn, potential for emissions. A study by the University of Massachusetts Amherst conducted in 2019 found that the carbon footprint of training several common large AI language models "produced more than 626,000 pounds of carbon dioxide equivalent—nearly five times the lifetime emissions of the average American car (and that includes manufacture of the car itself)."[133]

As Canada grapples with a net-zero society, a deeper understanding of the impacts of the technologies and lifestyle of the future is critical to understanding the overall impact of digital adoption on climate outcomes. For example, remote work that replaces a carbon-emitting transportation commute is undeniably a net benefit to a net-zero future. At the same time, employers will have to take into account a variety of considerations beyond GHG impacts in deciding their approaches to hybrid or remote work. And still, the availability of zero-emitting transit or electric vehicles could make such a trade-off less compelling over time.

Consequently, policies and initiatives to reduce emissions through ICT and expanded connectivity should become more holistic: a focus on the energy efficiency of digital infrastructures is not enough and should include the lifecycle GHG impacts of the change. For example, in one study, ICT applications that make freight transport more efficient were found to increase overall demand for transport (because transportation became faster and cheaper), whereas "utilizing the potential of ICT to dematerialize goods reduced the total demand for materials" and transport.[134] Understanding how marginal-efficiency gains impact total emission levels is a critical part of achieving a net-zero future in Canada.

Convening government, industry, and civil society in open and continuous dialogue is an important part of ensuring policies are well designed to effectively reduce overall emissions in the long term. This could take the form of a Federal-Provincial-Territorial Ministerial meeting with participation from relevant corporate and civil society groups. Developing a comprehensive policy framework is one way that government can take proactive measures in ensuring that society (individuals, private industry, and community) can maximize the positive effects of digitization, including increasing prosperity, fostering social justice, and improving efficiency, while minimizing its negative shortcomings, such as increases in absolute energy consumption due to rebound effects, or the exhaustion of valuable raw materials and energy during the design, development, manufacturing, and the use of these new technologies. The policy framework, and supporting ongoing consultations and dialogue between stakeholders, would also develop a shared, credible, and authoritative understanding of the potential of digital adoption in reducing emissions, detrimental costs of inaction and the urgency of meeting climate goals, which can further encourage clean technology uptake and climate conscious choices within all sectors of the economy.

While addressing the importance of digital policy in achieving net-zero on a national level is imperative, it is still critical to note the significant role of local initiatives and innovations in providing tailored solutions to specific community needs. Through greater open dialogue, local stakeholders could access greater resources to support their unique solutions and find a direct avenue through which to share their communities' unique digital and climate needs.

Emerging technologies, such as generative AI and cryptocurrency, also consume increasing amount of energy, contributing to GHG emissions.

7 Conclusion

Digital technologies have the potential to play a key role in improving energy efficiency and reducing GHG emissions. However, the adoption of digital technologies also poses some challenges and trade-offs that policymakers and industry leaders need to consider. The use of digital technologies can bring efficiency gains in energy consumption, but policymakers and industry leaders must be mindful of potential negative impacts such as increased energy consumption resulting from expanded connectivity and digital adoption. The government should consider linking Canada's climate and digital goals to better understand the role of resilient and energy-efficient communication networks, as well as the adoption of digital technologies across industries, in enabling a net-zero future.

Moreover, cross-sectoral dialogue could help illuminate climate-technology-equity trade-offs and establish industry standards on carbon emissions monitoring and management. Industry leaders in the digital and telecommunications sector have a key role to play in developing user-friendly and easily deployable digital solutions that effectively achieve net reductions in emissions and establishing the infrastructure needed to support Canada's path to net-zero. Other industries in the broader economic ecosystem should develop digitization strategies that successfully integrate digital solutions related to climate in all applicable aspects of business operations and enable employees and users to monitor, reduce and/or capture emissions effectively.

The use of digital technologies can bring efficiency gains in energy consumption, but policymakers and industry leaders must be mindful of potential negative impacts such as increased energy consumption resulting from expanded connectivity and digital adoption.

An evidence-informed approach to understanding overall impacts of technology adoption on the environment will enable government, businesses, and individuals to transition toward a net-zero future. The expansion of new innovations to enable a net-zero future will require policies—from both government and industry leaders—that can accurately discern levels of absolute change in energy consumption in the long run. This will depend on achieving a balance between "data demand growth versus the continuation of efficiency improvements"[135] in the infrastructure and supporting technologies needed to help the functioning of these innovations. The potential of digitization to support Canada's net-zero future is indeed promising; industry, policymakers, businesses and households all have a key role to play in ensuring the right digital solutions are well-integrated in our economy and lifestyles to achieve maximum reductions in overall emissions in the long term.

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