THE WIRELESS CRISIS

INCREASING DIGITIZATION WHILE REDUCING EMISSIONS

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CHALLENGE LANDSCAPE

The Current State of Green G

The climate crisis will impact everyone in the world to varying degrees. In the report *Our Common Future*, the term 'sustainable development' is offered to describe the way economies may flourish without posing a negative effect to future generations' wellbeing (Brundtland, 1987).

With the proliferation of the Internet since its public release 30 years ago, the information communication technologies (ICT) industry has greatly expanded. Approximately 3.6% of global emissions are caused by the ICT industry with communications network technologies—including wireline and wireless infrastructure—allowing broadband access for internetworking contributing approximately 24% of 3.6% emissions (Belkhir & Elmeligi, 2018). The mobile industry accounts for 220 million tonnes of carbon dioxide equivalent (CO_2e),[1] roughly 0.4% of global emissions (GSMA, 2021b).

Since the 2015 Paris Agreement on climate action was signed and ratified, countries have been tasked with reducing emissions to become 'net zero.' This includes a mass decarbonization of each industry, including wireless telecommunications. The push to decarbonize wireless infrastructure is referred to as 'Green G' (Next G Alliance, 2022a).

At the end of 2021, monthly mobile network traffic increased 40% globally, reaching 108 Exabytes[2] (EB) of monthly data (Ericsson, 2022). This sharp increase is driven by the proliferation of wireless subscriptions and connected devices, and the speed upgrades that coincide with fifth generation (5G) networks. Increased mobile network traffic is associated with an increase in greenhouse gas (GHG) emissions as wireless operators use more electricity to meet the demands of a growing network. Although the mobile industry's carbon footprint is relatively low, sustained cost pressure related to energy consumption, commitments to decarbonize, and anticipated mobile network traffic increases that coincide with the migration to 5G, have made energy efficiency a priority for network operators (GSMA, 2021a). 5G has been developed with the lens of environmental sustainability, where energy

[1] CO_2e is a metric in environmental analysis whereby all GHGs are converted into their 'carbon equivalents' for a same metric comparison of emissions impact.

[2] Equal to 1 billion gigabytes (GB).

efficiency has been a central consideration throughout the development, deployment, and potential use values of 5G networks (Williams et al., 2022).

State of Canadian Wireless Providers

Over the last decade, Canada's 'Big Three' wireless operators, Bell, Rogers, and TELUS, have each made inroads in reducing their carbon footprints. From 2020 to 2021,[3] Bell and Rogers reduced their total GHG emissions by 5.1% and 4.7%, respectively (BCE, 2022; Rogers, 2022). TELUS had a slight increase of 0.1% in total GHG emissions, but overall has reduced GHG emissions by 41% when compared to 2010 levels (TELUS, 2022).

The "Big Three" have accomplished GHG reductions by integrating energy saving technologies into their mobile networks. TELUS has entered into a virtual power purchase agreement (VPPA) in Alberta with the renewable energy developer, Elemental Energy, financing "Brook's Solar Project," setting 49,000 solar panels along the Trans-Canada Highway (Bullfrog Power, 2019). Through a partnership with telecommunications equipment provider, Ericsson, Rogers has begun implementing technology that enables their network to be more energy efficient by turning off, or 'sleeping,' network elements during times of low traffic (Rogers, 2022). Bell, which currently owns and operates 12 off-grid renewable energy sites, has partnered with the Interdisciplinary Institute of Technological Innovation, the Université de Sherbrooke and the company Stace, to provide the environmentally sensitive La Vérendrye Wildlife Reserve with 16,000 kWh of solar energy (BCE, 2022). Although not an exhaustive account, these energy saving initiatives provide a snapshot of the various ways the 'Big Three' are minimizing their ecological footprints.

Defining 'Green G'

The multi-faceted, interrelated, and contextual nature of a Green G system makes it difficult to propose a precise and complete definition. Reinforcing this contention, much of the academic discourse only put forward partial definitions, choosing to focus on one dimension of Green G rather than proposing whole network assessments. To address this limitation in defining the parameters of Green G, it is necessary to deconstruct the Green G ecosystem into its composite parts: operational and embodied efficiency (direct effects) and, rebound and enablement effects (indirect effects). Operational efficiency refers to a set of technologies and strategies that enable mobile

[3] Latest available data.

network operators to manage massive capacity increases while remaining at 'similar or lower power consumption' (Buzzi et al., 2016). These technologies and strategies include resource allocation, network planning and deployment, and energy harvesting (Buzzi et al., 2016). While operational efficiency is a necessary condition of Green G networks, it is not a sufficient condition. Any operational gains must be understood in relation to trade-offs in embodied consumption. Embodied consumption includes any energy used in acquiring raw materials, manufacturing devices, and installing equipment, as well as the energy used in maintaining, repairing, and replacing this equipment throughout its lifecycle (Williams et al., 2022).

Direct effects are generally easier to quantify, whereas an assessment of indirect effects requires a more speculative approach. Bieser and Hilty (2019) outline what exactly constitutes an assessment of indirect effects:

> "The process of identifying the environmental consequences of an ICT solution's capacity to change existing consumption and production patterns, taking into account the interrelated socio-economic, cultural, and human-health impacts, both beneficial and adverse, with the aim of informing decision-makers or the general public and mitigate unfavorable or promote favorable environmental consequences." (Bieser & Hilty, 2019, p. 2).

Indirect effects can be further separated into rebound effects and enablement effects. Rebound effects "occur when efficiency improvements lead to greater demand for the same product (direct) or other (indirect) products or services" (Williams et al., 2022, p. 11). In other words, a compounding effect occurs through greater digital usage from a growing digital sector, which limits any green initiatives (Williams et al., 2022). Lastly, enablement effects refer to the capacity for ICTs to produce energy savings in similar business product and offering lines[4] (Williams et al., 2022). Enablement effects of mobile communications are said to outweigh emissions by 10 times (GSMA, 2019).

Against this backdrop, we propose this definition:

> "*Green G refers to an interconnected set of energy saving technologies, strategies, and renewable energy resources that, after accounting for the potential impact of embodied energy or indirect effects, generate*

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[4] Also referred to as 'vertical sectors.'

energy efficiency gains operationally, or by enabling efficiency gains in vertical sectors, that outweigh or offset the energy consumed by the network."

Conflicting Values for Delivering Green G

Digitizing and Greening the Global Economy

Because wireless infrastructure uses energy in each component of its operations, this creates conflicting values when mass digitization is underway across countries like Canada. Governments and inter-governmental organizations identify the global future as 'green' and 'digital' noting this as the 'twin transition' (BEREC, 2022, 2023; OECD, 2022a, 2022b). This is a 'twin transition' as it is argued that these green and digital go hand-in-hand and are not separate policy entities. Proponents of the twin transition identify that the digitization of the economy will reduce emissions from teleworking reducing transportation emissions, and an increase in smart energy efficient electric grids (Ortega-Gras et al., 2021). Opponents express concern that digital has a growing environmental footprint (Ensmenger, 2018). With digital's environmental impact, the policy push for 'green' and 'digital' may result in stagnation of one. Greening would likely be limited given greater digitization efforts across public and private sectors as the world recovers from the COVID-19 pandemic; which emphasized countries' digital adoptions in this time (Taylor et al., 2021).

Achieving Universal Connectivity

As one of many impacts of the pandemic, it incentivized governments to invest in broadband infrastructure to connect citizens at a rapid pace (Ali, 2023). However, as scholars note, developing broadband infrastructure to each household and business—known as universal connectivity—should not exacerbate the climate crisis and each of these sustainable development goals ought to be achieved without limiting the success of another (Osoro & Oughton, 2022). In other words, universal connectivity should not increase emissions and exacerbate the climate crisis with instead, all sustainability goals working in harmony.

Canada has created broadband funding programs at provincial and federal levels of government and across agencies with the goal of universal connectivity by 2030 (Government of Canada, 2023a). Where the *Canadian Environmental Assessment Act* requires all Government legislation and programs to undergo an environmental impact assessment to reflect and reassess the application of projects and programs based on environmental damages (Government of Canada, 2016), Canada does not have indicators for decarbonizing the telecommunications sector as a federally regulated industry, and instead leaves such to self-governance amongst private sector stakeholders.

Financial Impacts for Green G

There is a prevailing sentiment that green technology can generate clean, low-cost energy. This rhetoric often serves to obscure the massive upfront capital expenditure and the long-term operational expenditures it takes to build, operate, and maintain a Green G network (Al-Dunainawi et al., 2018). Garroussi et al. (2022) found, with current prices for solar equipment, it is not economically viable for cellular operators to retrofit their base stations for complete reliance on solar power. Canada's carbon tax, which is currently $50 per tonne of CO_2e, would have to increase 10 times to incentivize providers to retrofit base stations (Garroussi et al., 2022).

5G—the next generation of wireless being deployed across Canada—has the capacity to create economic growth in various high-GHG-producing vertical sectors, while simultaneously reducing their overall GHG emissions. In the agriculture sector, it is estimated that smart applications enabled by 5G can bring $2.7 to $3.5 billion in gross domestic product to Canada (Deetken Group, 2022). Alongside these economic projections, at full capacity, precision agriculture could reduce the use of fossil fuels by 16% and the use of water by 21% (Deetken Group, 2022). Implementing 5G technology in the energy sector could drive down oil and gas prices by 5% to 10% (Deetken Group, 2022). By automating drilling, it is anticipated that GHG emissions would be reduced by up to 10% (Deetken Group, 2022).

The Global Landscape

U.S.

U.S. wireless providers are part of industry alliances championing Green G. Industry leadership has been encouraged for innovating Green G networks (Behar, 2017). Canadian and U.S. companies are in a bilateral industry alliance with Green G as a central goal (Next G Alliance, 2022a, 2022b).

Europe

The Body of European Regulators for Electronic Communications (BEREC) identify the primary policy mechanism telecommunications regulators have for Green G is mandating infrastructure sharing policies. Sharing occurs when infrastructure owners lease the same facilities instead of duplicating per operator. Such policies include cell tower sharing for wireless operators and are noted as key to limiting environmental impacts in this sector from the government policy perspective (Godlovitch et al., 2021).

UK

Our research found the UK to have the most advanced coordinated twin transition with a whole of government approach. In the leadership of the Department for Environment, Food & Rural Affairs (Defra) in the Digital, Data and Technology Services (DDTS) initiative (Howes, 2022), the UK Government has created a National Data Strategy with a green focus (UK Government, 2021), a Technology Code of Practice 12 Point on Sustainability guide (Central Digital and Data Office, 2021), a Greening Government Commitments proposal (Depra, 2021), a Digital and Data roadmap (Central Digital and Data Office, 2022), and a procurement policy framework for green, digital systems (Government Commercial Function, 2021). Such whole of government approaches to technology, specifically in government procurement, are identified in the scholarly literature as a smart innovation strategy for achieving green goals (DeNardis, 2010).

Geopolitical Tensions in Wireless Network Equipment

We also note, each of the above countries, including Canada, have limited which telecommunications equipment providers may be purchased from by wireless operators to build a Green G network. Chinese Huawei and ZTE have been banned over geopolitical security tensions (Becker et al., 2022; Tunney & Raycraft, 2022). Arguments may include that this limit in wireless equipment vendors could stagnate competition and slow advances in Green G equipment, however, our analysis has not found this to be the case. Other network component manufacturers working on Green G solutions are permitted within these markets and should allow for a green transition for this sector.

SYSTEM MAPS

Stakeholder Map

By employing a system thinking approach, key relationships emerge between the various stakeholders that design, build, manage, facilitate, and benefit from, a Green G network. These stakeholder groups can be separated into three broad categories: network operators, technology vendors, and third-party partnerships.

Systems Loop

No Clear Green G Definition Results in No Indicators for Achievement

- Two areas for types of energy usage in a Green G network are demonstrated in direct and indirect effects which make up the full energy usage and opportunities for increasing energy efficiency within these pillars.

Big Three Stakeholder Map

- Canada's 'Big Three' providers who concentrate the wireless market are mapped with their sustainability initiatives and network equipment operators mapped.

Rebound Effects

- Network efficiency can lead to increases in data usage and increases in other emission producing activities as consumers use greater bandwidth technologies which use greater energy.

VPPAs

- The VPPA model is visually demonstrated noting the business model of wireless providers contributing to green electrical grids.

Industry Self-Regulation

- Map identifies the building blocks of Green G and the metrics for measuring environmental impact of Green G. Industry associations are central to success by creating innovation spaces for companies to engage in two-way dialogue regarding Green G efforts.

SOLUTIONS LANDSCAPE

Government Solutions

Canada's Sustainability Strategy

Canada considers two sustainable development frameworks: the United Nations 2030 Sustainable Development Goals (SDGs), which are the global goals each country is charged to achieve increasing global wellbeing and climate mitigation; and the Federal Sustainable Development Strategy (FSDS) which build further (Government of Canada, 2022, 2023b). Part of achieving the SDGs and FSDS is reducing government carbon footprints and legislating carbon pricing, however, such would need to increase tenfold to incentivize a Green G network (Garroussi et al., 2022).

Monitoring and Measuring Green G

Canada considers telecommunications infrastructure within achieving the SDGs, but does so within SDG 9: 'Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation,' and tracks this infrastructural development annually through the Canadian Radio-television and Telecommunications Commission (CRTC), Canada's communications regulator, who assess universal connectivity for the metric (CRTC, 2023a, 2023b). In addition to the CRTC regulating telecommunications development and infrastructure in Canada; Innovation, Science, and Economic Development (ISED) Canada is the federal government department in charge with the wireless industry (Shepherd et al., 2014). Their responsibility within wireless is to allocate radio-spectrum bands, the natural resources which carry data 'through the air.' As part of its innovation capacity, ISED also allocates funding and programs to incentivize green innovation and development within the Canadian economy. Such green innovation programs were recently strengthened within Canada's 2023 federal budget (Department of Finance Canada, 2023; Zimonjic, 2023). ISED also requires cell tower sharing to promote competition, which has the external environmental benefit from reduced duplicated facilities (ISED Canada, 2023).

Industry Solutions

In our research, we found industry associations as the most impactful arenas for the global wireless industry to experiment and fulfill future Green G. These associations allowed manufacturers, academic researchers, and even competitors to meet in shared spaces with the goal of achieving Green G (IDATE, 2023; Next G Alliance, 2023). Associations have been highly impactful in providing consumer-facing wireless service providers a means of learning how to decarbonize their infrastructure and meet with vendors experimenting with lower energy options, resulting in reduced environmental footprints. Such a forum for procurement purchasing and two-way dialogue for identifying goals in wireless equipment creates network benefits from participating wireless providers. However, not all providers are part of each industry association.

CONCLUSION

Key Insights on Green G

At present, the Government of Canada does not monitor, measure, or mandate a green telecommunications sector, which leave industry to self-govern. Where some critics may question this limitation in government oversight, the telecommunications industry has historically been tasked with their own leadership. This industry leadership fueled connecting homes, businesses, and public institutions which supercharged the proliferation of the Internet upon its public release (Clinton White House, 1993). In recent years, similar requests for industry leadership have sprung industry associations—such as the Canada-U.S. Next G Alliance—to consider leadership in Green G. Telecommunications, including wireless infrastructure and such component manufacturers, have historically been known for this sector's ability to quickly innovate when specified goals are outlined by government.

Lessons Learned & Concluding Thoughts on Mapping Green G

Approaching our research, we had thought that strict government policy would be the opportune framework for the wireless industry's shift to Green G. Instead, through using a systems thinking approach, we learned many of these Green G approaches were already occurring and are embedded into planned infrastructural development for 5G and future 6G by Canada's Big Three.

Working on this project has provided our team with a wider understanding of the future of Canada's digital infrastructure and the ways in which sectors are making inroads transitions to decarbonization. With digital as the largest market capitalization sector of the global economy and the proliferation of wirelessly connected devices, analyses of the wireless industry allow for a wider assessment of the environmental impacts of ICT on an infrastructure- opposed to user-hardware basis.