The wireless crisis: Increasing digitization while reducing emissions

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Abstract

Each sector of the economy, and those sectors' corresponding regulators, are working to identify opportunities for decarbonization in the face of the climate crisis. The telecommunications sector is in a unique position within decarbonization discourse as the green transition has been coupled with the digital transition, thereby making a green and digital twin transition. Not all countries' decarbonization policies are able to capture the telecommunications industry. This sector is not a significant emitter, directly, however through indirect effects of greater energy using technologies it has the capacity to enhance carbon emissions. This paper analyzes the wireless telecommunications sector's path to decarbonization and notes opportunities for both government stakeholders, and companies themselves, to take in the effort to battle the climate crisis.

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

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[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).

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

Wireless has become especially prominent within the green transition of telecommunications. With enhanced datafication of wearable technologies along with other Internet of Things devices using wireless, the wireless sector becomes a prominent space for discussing green initiatives in telecommunications, both within the industry and potential government regulations for a successful green transition. In this paper, we will argue for how to conceptualize Green G, models the sector can utilize for decarbonization, and potential avenues for regulators to help steer the wireless sector towards decarbonization.

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 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 (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[3]

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

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

A map visually demonstrating this definition, and the direct and indirect components can be seen below.

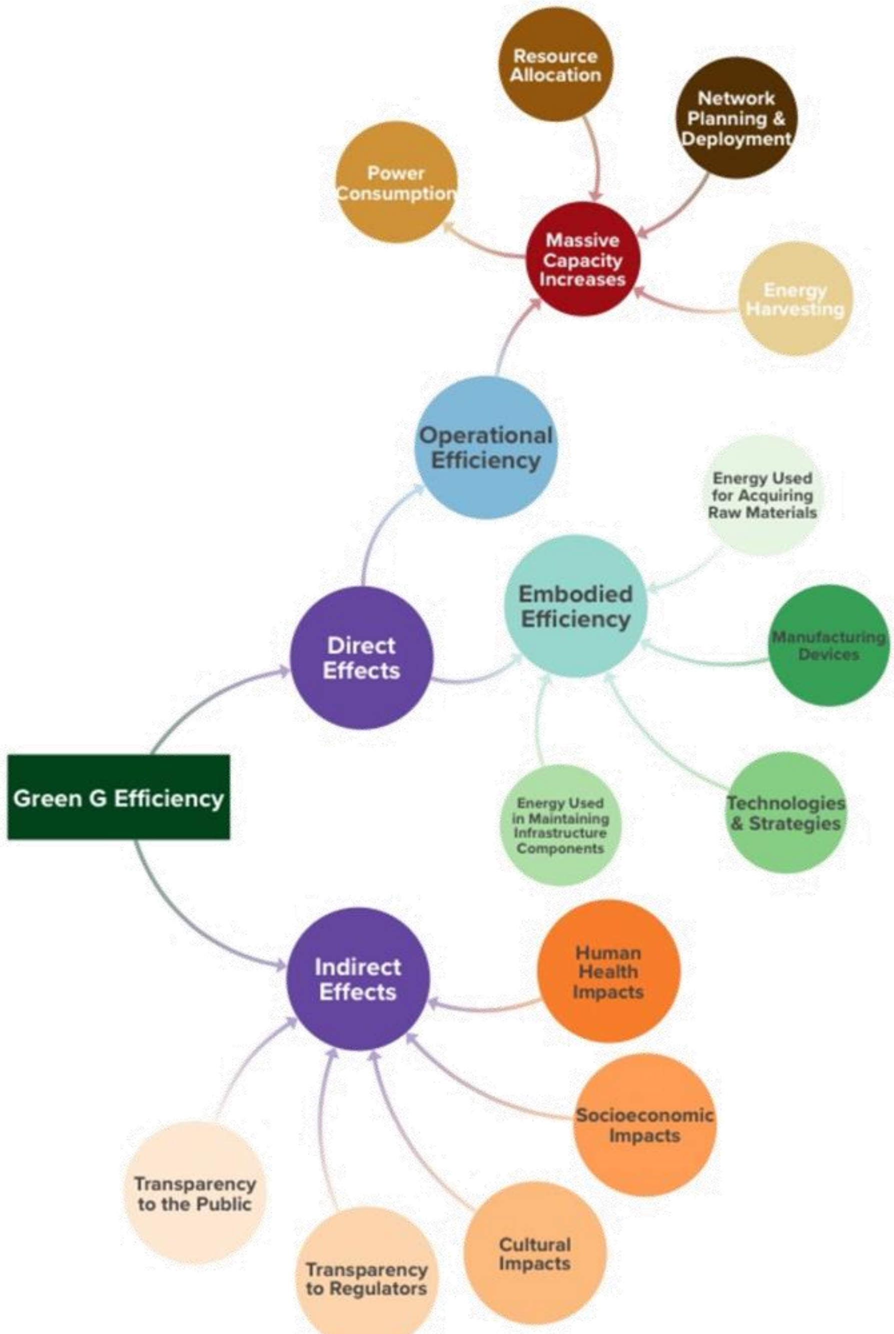

Figure 1: Systems map identifying a Green G definition. (Source: Authors)

Conflicting Values for Delivering Green G

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 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 by teleworking thereby 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).

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.

Many countries have broadband funding programs that are national, and provincial/state-level to achieve universal high-speed connectivity. Within these broadband funds, however, attention is not always paid to ensuring projects have a broad environmental impact assessment which will note the full range of carbon emissions which the project will have, as well as how many emissions the project will save. Policymakers and regulators therefore have an opportunity in their universal connectivity goals to request lifecycle assessments the project will have from a carbon footprint perspective, as well as require prospective internet service providers (ISPs) to identify expectations of whether the project will aid in climate action goals or detract from these.

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, for example, which is currently CAD$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 various countries in the Global North—has the capacity to create economic growth in various high-GHG-producing vertical sectors, while simultaneously reducing their overall GHG emissions. For example, 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 as a case study (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).

Examples of Green G Around the World

There are various examples of decarbonization in ICT initiatives. For example, American wireless providers are part of industry alliances championing Green G. Industry leadership has been encouraged for innovating Green G networks (Behar, 2017). Canadian and United States (U.S.) companies are in a bilateral industry alliance with Green G as a central goal, demonstrating international regional partnerships to achieve decarbonization at a continental level (Next G Alliance, 2022b). 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).

Our research found the United Kingdom (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, 2022), a Greening Government Commitments proposal (Department for Environment, Food & Rural Affairs, 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 policy goals (DeNardis, 2010).

Geopolitical Tensions in Wireless Network Equipment

Each of the above countries, as well as others, 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 by various countries (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. As well, for countries requiring past 4G infrastructure manufactured by Huawei and ZTE be removed, this increases electronic waste in telecommunications equipment, thereby enhancing indirect effects in the twin transition. Other network component manufacturers working on Green G solutions are permitted within these markets, which these companies as a sector would benefit from ensuring their technologies meet the highest standard of decarbonization efforts.

Solutions Landscape

In a complex system of telecommunications infrastructure, there will be various solutions presented to the sector and for regulators to consider. With a dynamic space filled with innovations new opportunities will emerge for decarbonization. We therefore turn our paper to noting broad recommendations as pillars in decarbonizing ahead of the green and digital twin transition.

Monitoring and Measuring Green G

Regulators would do well to require reporting of decarbonization by those they regulate. By requesting lifecycle analyses—especially as a provision of receiving broadband funds—regulators will have greater access to data to ensure that universal connectivity does not limit climate action goals. This reporting could be indexed by providers of certain annual revenue thresholds as not to limit new and smaller competitors. By having broad reporting, this will allow regulators to develop models in assessing smaller providers' potential carbon impact for certain funded telecommunications projects.

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.

Companies might also enter into virtual power purchase agreements (VPPA) with renewable energy developers. A systems map demonstrating VPPAs is shown below. As the diagram shows, the buyer will finance a renewable energy project with a renewable energy developer. The developer promises the builder a fixed rate for renewable energy. If the actual rate is below the fixed rate, the buyer makes up the difference. If the actual rate is above the fixed rate, the developer makes up the difference. Renewable energy will go into the power grid, where it is purchased by the buyer. The buyer receives renewable energy certificates which can be used to offset emissions.

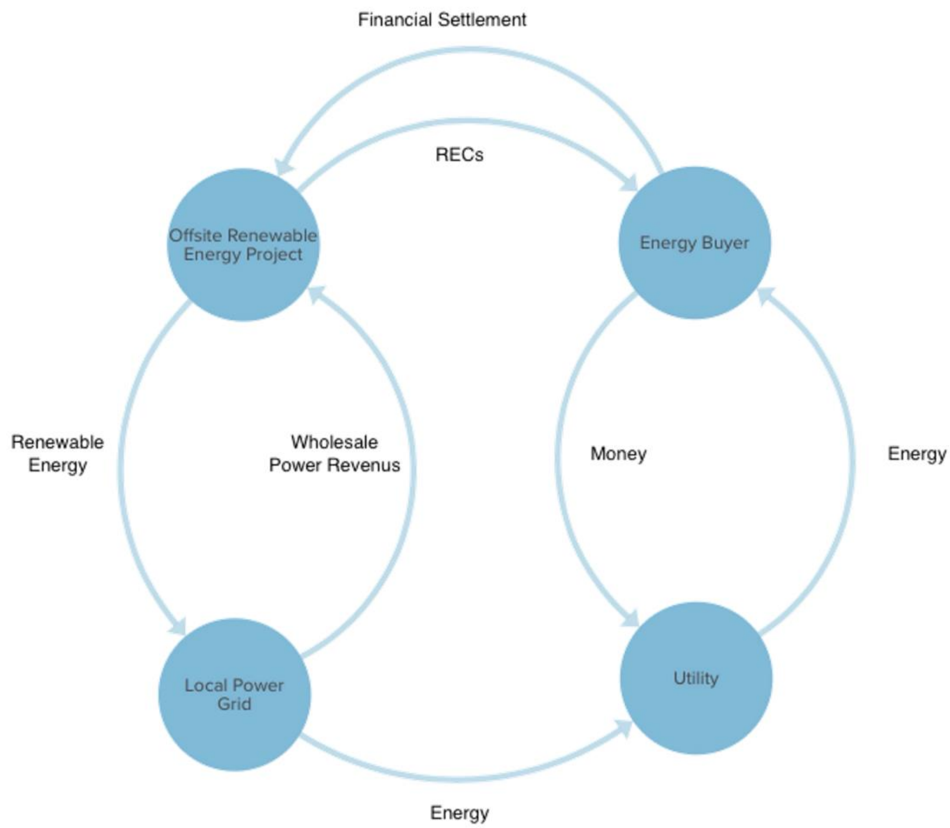

Figure 2: VPPA system map. (Source: Authors)

These VPPAs could include a telecommunications provider partnering with green power providers to build solar panels along highways where telecommunications lines also follow (Bullfrog Power, 2019). As well, ISPs might further partner with telecommunications equipment vendors to implement technology that enables their networks to be more energy efficient by turning off, or 'sleeping,' network elements during times of low traffic (Rogers, 2022). Companies might also purchase land for wildlife reserves and additional solar, wind, or hydraulic power to be generated from these lands to help with clean energy procurement (BCE, 2022). Although this is not an exhaustive account, these energy saving initiatives provide a snapshot of the various ways which the sector can minimize their ecological footprints.

Conclusion

There are various elements of the twin transition which this paper did not analyze specifically. Areas for future research include, for example, the ways in which 3G or 4G cellular plans which might come through ‘flanker brands’ or smaller providers can have higher GHG impacts due to older infrastructure not being as ‘clean’ as newer 5G plans. This could make those who would like to be more cost-conscious of their wireless telecommunications plans to have larger personal carbon footprints. As well, our report did not analyze the intricacies of wireline telecommunications. With the breadth of both sectors in wireline and wireless, we made the research decision to analyze one sector instead of both. Greater research to the wireline sector would be beneficial to analyze the impacts this infrastructure has on a warming planet.

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