



## Environment, Social and Governance (ESG) Impacts of 5G in Canada

Adapted from: The Socio-Economic Impacts of 5G

Deetken Insight was commissioned by TELUS to complete a comprehensive review of published research about 5G and its potential socio-economic impacts, with a particular focus on Canada. Access the full report including a bibliography here: <https://deetken.com/socio-economic-impacts-of-5g/>. We provide no opinion, attestation, or other form of assurance with respect to the completeness, accuracy, fair presentation, and findings from research of others that are presented in the report.

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## Key Takeaways

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- From an environmental perspective, many of the use cases of 5G reviewed for this report that promise commercial viability also reduce greenhouse gas emissions. 5G and the services it enables should be regarded as an important component in the portfolio of options available to reduce global warming. 5G and the services it enables could reduce Canada's GHG emissions by 20%. 5G-enabled technologies will also help feed a growing global population, advance sustainable agriculture, and improve waste management practices.
- From a social perspective, there are numerous use cases in the healthcare arena that stand to improve the effectiveness and efficiency of healthcare delivery. 5G technologies also support sustainable urbanization and offer possibilities to improve accessibility for traditionally disadvantaged populations, including those living in remote regions, older citizens, and those with disabilities.
- Reskilling the workforce to meet the demands of the digital economy will require a fundamental rethinking of current training and learning methodologies and support for impacted workers through this transition. Government in collaboration with industry has an important role to play to ensure that the right market structures and supports are in place to ensure that all demographics and regions benefit equitably from the opportunities enabled by 5G.
- 5G adoption may introduce new risks around cyber security and privacy protection. However, it also enables new capabilities that may mitigate these concerns such as network slicing and new, more secure encryption algorithms. Energy consumption has tended to increase with the introduction of previous network standards, such as from 3G to 4G. However, 5G itself is expected to reduce energy use on a per bit of data consumed basis by 85% to 90% from what 4G required. Building 5G with precision will facilitate the optimization of network performance on the new 5G frequencies while keeping capital and operating expenditures within reasonable levels. This means service providers will be able to limit energy consumption growth when introducing 5G.
- A further challenge is the increase in electronic waste that could occur as devices and sensors that utilize 5G networks become obsolete or non-functioning. Supporting the growth of e-waste recycling markets, finding new ways to divert e-waste from landfills, and reducing the toxicity of substances used in these devices are important steps for government, industry and stakeholders to undertake in partnership.

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This section of the report considers the non-economic impacts of 5G adoption. It is organized around the three ESG pillars (Environment, Social Governance) and outlines both the positive



benefits that arise with 5G adoption as well as new challenges that will need to be monitored and managed. The pillars can be summarized<sup>1</sup> as:

- Environment – conservation of the natural world
- Social – consideration of people and relationships
- Governance – standards of running a company

The ESG pillars provide the basis for establishing metrics for investors and analysts to assess companies on their environmental, social and governance practices while also considering financial returns. As a result of external pressure from governments, regulatory bodies and ESG agencies, as well as widespread realization of the benefits of ESG practices, ESG has advanced to the forefront of public and private organizations' agendas and is playing a crucial role in their strategic planning and risk management. Given the non-economic impacts of 5G adoption discussed in this section, 5G is a relevant factor that organizations should consider in their ESG programs.

A second, related organizing framework considered in this section is the United Nations Sustainable Development Goals (SDG). The SDGs are at the core of the U.N. 2030 Agenda for Sustainable Development, which provides a “shared blueprint for peace and prosperity for people and the planet, now and into the future.”<sup>2</sup> The SDGs comprise 17 goals with associated indicators and related targets. These are particularly relevant to governments and multilateral institutions in providing guidance about efforts to prioritize, monitor and manage their efforts to advance sustainable development. They are also relevant to businesses because they serve as a quasi-standard for defining ESG goals and metrics. A report by KPMG found that in 2018, 40% of the G250, the world's 250 largest firms, acknowledged the SDGs in their corporate reporting. Of those companies who acknowledged the SDGs, 39% also referenced them in their CEO and/or Chair's statement.<sup>3</sup>

Below is a summary of key non-economic impacts of 5G organized by ESG pillar. Related SDGs are also noted. This information draws on the findings in Section 5 and from other research. Refer to Section 5 for more detail about ESG impacts related to the 11 evaluated industry verticals.

## 5.1 Environment

**Many of the use cases for 5G have a corollary benefit in the form of GHG emissions reductions.**

According to the Intergovernmental Panel on Climate Change (IPCC), limiting global warming to the Paris Agreement target of 1.5°C by 2100 requires global net emissions to be reduced by approximately 43% (to 31 GtCO<sub>2</sub>) by 2030 (compared to 2019 emissions) and by approximately 84% (to 9 GtCO<sub>2</sub>) by 2050.<sup>4</sup> The mitigation pathways analyzed by the IPCC to achieve this target focus on institutional design, policy, finance, technological innovation and governance

<sup>1</sup> Definitions sourced from <https://www.cfainstitute.org/research/esg-investing>.

<sup>2</sup> Link to source: <https://sdgs.un.org/goals>.

<sup>3</sup> Link to source: <https://assets.kpmg/content/dam/kpmg/xx/pdf/2018/02/how-to-report-on-sdgs.pdf>.

<sup>4</sup> Link to source: [https://report.ipcc.ch/ar6wg3/pdf/IPCC\\_AR6\\_WGIII\\_FinalDraft\\_FullReport.pdf](https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf).

arrangements. In Canada, the Canadian Net-Zero Emissions Accountability Act preserves Canada's commitment to achieve net-zero emissions by 2050. The 2030 Emissions Reduction Plan, published by the Government of Canada in March 2022, maps out Canada's path to achieve its improved Paris Agreement target to cut emissions by 40% to 45% from 2005 levels by 2030. The plan includes contributions from various groups within Canada, including provinces, territories, First Nations, Canadian citizens, and the Net-Zero Advisory Body, on what is required to attain Canada's more ambitious climate target.<sup>5</sup>

According to the 2030 Emissions Reduction Plan, "economy-wide strategies to reduce emissions, like carbon pricing, clean fuels and reducing methane emissions, will enable Canada to reduce emissions in the most flexible and cost-effective way. They will also provide policy certainty to businesses and Canadians, allowing everyone to make more informed decisions as Canada's economy decarbonizes."<sup>6</sup> In addition, the Government of Canada is funding several programs across various sectors (buildings, electricity, heavy industry, oil and gas, transportation, agriculture and waste) to support their emissions reductions.<sup>7</sup>

Digital technologies can and will play a role in these objectives. Many 5G use cases have commercial viability because they reduce energy requirements; a corollary benefit is that GHG emissions are reduced to the extent the energy requirements are met by fossil fuels. According to a report by Ericsson, the adoption of digital solutions in energy, buildings, transport, travel, work, services and agriculture industries could reduce global GHG emissions by 7% to 15% by 2030.<sup>8</sup> Meanwhile, a study by Accenture finds that 5G-enabled mobile technologies in Canada will enable the abatement of up to 54 metric tonnes of carbon dioxide equivalent (MtCO<sub>2e</sub>). Smart working, living and health mobile technologies will drive approximately 29% of the abated carbon emissions, smart transport and cities will drive 24%, smart manufacturing 18%, smart buildings 16%, smart agriculture 7%, and smart energy 5%. Overall, research suggests 5G and the digital solutions they enable could reduce Canada's GHG emission by up to 20%.<sup>9</sup> Potential impacts of 5G solutions include:

1. **Traffic Congestion Management** – Vehicle platooning (i.e., groups of vehicles moving together), enabled by vehicle-to-vehicle (V2V) communication, can reduce air drag by 20% to 60%. It is estimated that this could reduce CO<sub>2</sub> emissions by 10% to 30%, depending on the platoon's composition and space between vehicle, among other factors.<sup>10</sup>

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<sup>5</sup> <https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html>.

<sup>6</sup> <https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030/sector-overview.html#sector1>.


<sup>7</sup> Ibid.

<sup>8</sup> Link to source: <https://www.ericsson.com/en/reports-and-papers/research-papers/exploring-the-effects-of-ict-solutions-on-ghg-emissions-in-2030>.

<sup>9</sup> Links to sources:

[https://www.farrpoint.com/uploads/store/mediaupload/492/file/Digital\\_Policy\\_and\\_Climate\\_Change\\_Report\\_FarrPoint\\_2022.pdf](https://www.farrpoint.com/uploads/store/mediaupload/492/file/Digital_Policy_and_Climate_Change_Report_FarrPoint_2022.pdf);  
[https://www.cwta.ca/wp-content/uploads/2020/10/5G\\_Role\\_In\\_Fight\\_Against\\_Climate\\_Change.pdf](https://www.cwta.ca/wp-content/uploads/2020/10/5G_Role_In_Fight_Against_Climate_Change.pdf).

<sup>10</sup> Link to source: [https://www.researchgate.net/profile/Imran-Reza/publication/351785569\\_Impacts\\_of\\_Autonomous\\_Vehicles\\_on\\_Greenhouse\\_Gas\\_Emissions-Positive\\_or\\_Negative/links/60aa8c12299bf1031fc4023e/Impacts-of-Autonomous-Vehicles-on-Greenhouse-Gas-Emissions-Positive-or-Negative.pdf](https://www.researchgate.net/profile/Imran-Reza/publication/351785569_Impacts_of_Autonomous_Vehicles_on_Greenhouse_Gas_Emissions-Positive_or_Negative/links/60aa8c12299bf1031fc4023e/Impacts-of-Autonomous-Vehicles-on-Greenhouse-Gas-Emissions-Positive-or-Negative.pdf).

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2. **Smart Public Transportation & Ride-Sharing** – Per person emissions for public transit are roughly 53% lower when compared to driving or ride hailing solo.<sup>11</sup> 5G will support the use of public transit by enabling minute-by-minute updates on the location of buses and trains and the number of available seats, thereby increasing passenger trust and utilization. Real-time schedules and updated timetables will help commuters plan their travel in advance, leading to more reliance on public transport. Transit operators will optimize bus inventory and enable dynamic bus routing, reducing idling. The more consistent driving patterns of automated trains could reduce energy consumption by 20%.<sup>12</sup>
  3. **Building Energy Management Systems and Smart Meters** – According to a 2022 report by Accenture, “heating, ventilation, and air conditioning (HVAC) account for one-third of a building’s energy use on average. ... 5G-enabled temperature and motion sensors can detect the temperature, air quality, and number of people using different spaces in a building to automatically adjust these factors in real-time to conserve energy. Similarly, Energy as a Service (EaaS) solutions are made possible with the enhanced network connectivity of 5G [and] can reduce electricity costs and thus emissions by up to 20% to 50%.”<sup>13</sup>
  4. **Asset Monitoring and Predictive Maintenance** – According to the same Accenture report, “real-time data about machines, or assets, and analytics of that data can improve productivity and thereby energy efficiency. For example, digital twins make it easier to monitor and operate assets remotely and avoid travel. ... Predictive maintenance enabled by 5G can also abate emissions by helping companies reduce unplanned downtime, which is costly and leads to more on-site visits from technicians”.<sup>14</sup> These combined benefits will drive a 2% to 5% product throughput increase, 2% to 3% asset utilization increase, 25% workforce productivity increase, 10% to 15% asset downtime reduction, and 10% to 15% maintenance, repair and operation (MRO) inventory reduction.<sup>15</sup>

More intensive use of digital services will increase the GHG emissions from the Information and Communication Technology (ICT) sector. However, 5G itself is expected to reduce energy use on a per bit of data consumed basis by 85 to 90% from what 4G required.<sup>16</sup> Building 5G with precision will facilitate the optimization of network performance on the new 5G frequencies while keeping capital and operating expenditures within certain limits and allowing a swift 5G rollout. This means service providers will be able to limit energy consumption growth when introducing 5G. By using artificial intelligence (AI), service providers will be able to operate site infrastructure

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<sup>11</sup> Link to source:

<https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/PublicTransportationsRoleInRespondingToClimateChange2010.pdf>.

<sup>12</sup> Link to source: [https://www.railjournal.com/in\\_depth/automatic-for-the-people-unlocking-the-benefits-of-automated-operation-on-the-main-line/](https://www.railjournal.com/in_depth/automatic-for-the-people-unlocking-the-benefits-of-automated-operation-on-the-main-line/).

<sup>13</sup> Link to source: <https://api.ctia.org/wp-content/uploads/2022/01/5G-Connectivity-A-Key-Enabling-Technology-to-meet-Americas-Climate-Change-Goals-2022-01-25.pdf>.

<sup>14</sup> Ibid.

<sup>15</sup> Link to source: <https://www.accenture.com/us-en/services/industry-x/intelligent-asset-management>.

<sup>16</sup> Link to source: [https://www.cwta.ca/wp-content/uploads/2020/10/5G\\_Role\\_In\\_Fight\\_Against\\_Climate\\_Change.pdf](https://www.cwta.ca/wp-content/uploads/2020/10/5G_Role_In_Fight_Against_Climate_Change.pdf).



more proactively through such things as predictive maintenance and no-touch problem-solving to reduce costs, site energy usage and site visits. Pilot studies of 5G deployment reveal that, when equipped with energy efficient tools (e.g., energy-saving software, machine learning (ML), smart sleep modes, etc.), 5G technology will be up to 90% more efficient than 4G in terms of energy consumption per unit of traffic (W/Mbps).<sup>17</sup>

### **5G-enabled technology will help feed a growing global population and advance sustainable agriculture and natural resources management practices.**

Today's global population of 7.7 billion people is expected to increase to 8.5 billion by 2030 and 9.7 billion by 2050.<sup>18</sup> By 2050, the world will need to produce 70% more food (based on the farming practices, techniques and technology of 2009), thereby further straining our natural resources.<sup>19</sup> Meanwhile, 33% of the land is currently degraded due to the erosion, salinization, compaction, acidification and chemical pollution of soils.<sup>20</sup> Water resources are also highly stressed; roughly 1.2 billion people are living in severely water-constrained agricultural areas.<sup>21</sup> In Canada, farmers are also under pressure to produce more food, enhance crop protection and soil conservation, manage labour shortages and skill mismatch, mitigate the effects of climate change and deal with new regulations and policies. 5G networks and complimentary technologies and applications will be able to help the farmers improve input costs of seeds, fuel, pesticides, herbicides and fertilizers; better weather forecasting; reduced water consumption and better soil conservation. Potential impacts of 5G solutions include:

1. **Controlled Traffic Farming** – This refers to guidance technologies (e.g., controlled traffic farming, driver assistance and machine guidance) that optimize machinery driving patterns and confine them to the least possible area of permanent traffic lanes. Trials of controlled traffic farming have shown a tractor fuel reduction of 40% and 70%; herbicide use reduction of 25%; increased nitrogen efficiency of 40% to 80% due to reduced soil compaction and improved soil biological activity; and a 15% increase in crop yield (compared to randomly trafficked soils) as a result of improved root growth that uses water and fertiliser more efficiently.<sup>22</sup>
2. **Variable rate applications** – Fertiliser production is responsible for approximately 1.2% of total global GHG emissions.<sup>23</sup> According to one study, only 45% to 50% of the applied nitrogen for crop growth is being incorporated into the agricultural products – the remainder leads to runoff and can cause damage to marine ecosystems.<sup>24</sup> Variable rate nutrient application (VRNA) technologies can reduce fertilizer use. VRNA prescription maps in two studies resulted in a 50% to 63% reduction of nitrogen fertilizer use (compared to uniform application). One study also reported that crop yield differed by

<sup>17</sup> Link to source: <https://www.ericsson.com/en/blog/3/2021/1/achieving-sustainability-with-energy-efficiency-in-5g-networks>.

<sup>18</sup> Link to source: <https://www.un.org/en/global-issues/population>.

<sup>19</sup> Link to source: [https://www.fao.org/fileadmin/templates/wsfs/docs/expert\\_paper/How\\_to\\_Feed\\_the\\_World\\_in\\_2050.pdf](https://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf).

<sup>20</sup> Link to source: <https://www.fao.org/3/i5199e/i5199E.pdf>.

<sup>21</sup> Link to source: <https://www.fao.org/3/cb1447en/cb1447en.pdf>.

<sup>22</sup> Link to source: <https://elk.adalidda.com/2017/08/sustainability-09-01339.pdf>.

<sup>23</sup> Ibid.

<sup>24</sup> Link to source: <https://www.mdpi.com/2071-1050/13/4/2400/htm>.



4% and costs fell up to 7%.<sup>25</sup> In addition, this technology can also be applied to reduce pesticide and water use. A study conducted by the European Parliamentary Research Service suggests that early, accurate detection and localized pest and disease treatment has the potential to reduce pesticide costs by up to 85%.<sup>26</sup> Agriculture currently accounts for 70% of all freshwater withdrawals,<sup>27</sup> and variable rate irrigation systems could reduce irrigation water use by 8% to 20%.<sup>28</sup>

3. **Health sensors** – In cattle, sensors such as smart ear tags are used to gauge the health of animals, and IoT feeders have been shown to increase milk yields in herds by 1% and improve milk quality by 20%. Moreover, this technology decreases the number of diseased cattle by 6% and the number of cows lost due to health problems by 24% (compared to a herd without sensor tags).<sup>29</sup>
4. **Smart water infrastructure** – Sensor-based leak detection technologies can allow utilities to monitor their networks in near real-time, thereby enabling proactive incident or maintenance responses. This technology has helped the Las Vegas Valley lower the average amount of water lost to leaks from roughly 30% to just 5%.<sup>30</sup> One report claims that “the expected deployment of smart water infrastructure could mitigate around 22% of the estimated increase in global municipal water withdrawals against a business-as-usual scenario.”<sup>31</sup>

### 5G presents opportunities to improvement waste management while introducing new challenges.

According to the World Bank, “the world generates approximately 2.01 billion tonnes of municipal solid waste annually, with at least 33% of that – extremely conservatively – not managed in an environmentally safe manner. Worldwide, waste generated per person per day averages 0.74 kilogram. ... Global waste is expected to grow to 3.40 billion tonnes by 2050.”<sup>32</sup> They estimate that solid waste management accounts for roughly 5% of global emissions, with food waste and improper management being major drivers of these emissions.<sup>33</sup> Potential impacts of 5G solutions include:

1. **Smart recycling technologies** – Currently, the global economy is only 8.6% circular.<sup>34</sup> In other words, less than 10% of the material used in a year is recycled or reused in some way. 5G enabled technologies such as radio-frequency identification (RFID), big data analytics (BDA), blockchain, AI and cyber-physical systems (CPS) should help

<sup>25</sup> Link to source: <https://www.mdpi.com/2071-1050/12/17/6893/htm>.

<sup>26</sup> Link to source: [http://www.europarl.europa.eu/RegData/etudes/STUD/2016/581892/EPRS\\_STU\(2016\)581892\\_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/STUD/2016/581892/EPRS_STU(2016)581892_EN.pdf).

<sup>27</sup> Link to source: <https://www.worldbank.org/en/topic/water-in-agriculture#1>.

<sup>28</sup> Link to source: <https://elk.adalidda.com/2017/08/sustainability-09-01339.pdf>.

<sup>29</sup> Link to source: <https://phys.org/news/2020-05-crop-animal-sensors-farming-smarter.html>.

<sup>30</sup> Link to source: <https://www.verizon.com/about/news/technology-water-how-5g-and-iot-can-update-our-water-infrastructure>

<sup>31</sup> Link to source: <https://gesi.org/research/download/36>.

<sup>32</sup> Link to source: <https://datatopics.worldbank.org/what-a-waste/>.

<sup>33</sup> Ibid.

<sup>34</sup> Link to source: <https://www.circularity-gap.world/2022#Download-the-report>.



increase the reuse and recycling of natural resources, thereby decreasing energy usage. According to one research study, “by knowing the waste levels and the locations of the corresponding bins, the routing and scheduling of the garbage picking procedures can be optimized, [allowing] service costs [to] be cut by 50%.”<sup>35</sup> Technologies such as Convolutional Neural Networks (CNN) can be leveraged to classify trash (glass, paper, metal, and plastic) with more than 90% accuracy.<sup>36</sup> This technology can be built into smart bins to accurately classify and segregate trash while requiring minimal effort to the users.

2. **Food waste-reduction technologies** – From 2010 to 2016, food production that ends up as food loss or waste generated 8% to 10% of total anthropogenic greenhouse gas emissions.<sup>37</sup> Moreover, one study finds that “an estimated 70% of biodiversity loss stems from agriculture and the cultivation of food, fuel and fibre, suggesting that food loss and waste contribute significantly to the decline in plant and animal species.”<sup>38</sup> Food waste-reduction technologies such as smart labelling, smart packaging, smart fridge, smart bin, applications for food planning, shopping, cooking, storage, sharing and redistribution, and recycling into animal feed and compost will drastically reduce food waste. The management of unavoidable food waste can be improved through recycling, energy recovery and engineered landfills.<sup>39</sup> Gartner predicts that by 2025, “20 percent of the top 10 global grocers by revenue will be using blockchain for food safety and traceability to create visibility to production, quality and freshness.”<sup>40</sup>

A challenge that is exacerbated by 5G adoption is the increase in electronic waste that will occur as devices and sensors become obsolete or non-functioning. Market Research Future estimates the global e-waste recycling market to grow at a compound annual rate of 16.2% by 2030.<sup>41</sup> It is reasonable that a similar growth rate in e-waste that does not get recycled is likely. Supporting the growth of e-waste recycling markets, finding other ways to divert e-waste from landfills, and reducing the toxicity of substances used in these devices are important steps for government, industry and stakeholders to undertake in partnership.

The U.N. Sustainability Development Goals (SDG) that are related to the use cases discussed under the Environmental pillar include:

- (1) No Poverty
- (2) Zero Hunger
- (7) Affordable and Clean Energy

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<sup>35</sup> Link to source: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8709486/>.

<sup>36</sup> Ibid.

<sup>37</sup> Link to source: <https://www.ipcc.ch/srccl/chapter/chapter-5/>.

<sup>38</sup> Link to source: <https://unepdtu.org/wp-content/uploads/2022/03/reducing-consumer-food-waste-using-green-and-digital-technologies.pdf>.

<sup>39</sup> Ibid.

<sup>40</sup> Link to source: <https://www.gartner.com/en/newsroom/press-releases/2019-04-30-gartner-predicts-20-percent-of-top-global-grocers-wil>.

<sup>41</sup> Link to source: <https://www.globenewswire.com/news-release/2022/04/21/2426699/0/en/E-Waste-Recycling-Market-will-Touch-USD-99-67-Billion-at-a-Whopping-16-2-CAGR-by-2030-Report-by-Market-Research-Future-MRFR.html>.



- (11) Sustainable Cities and Communities
- (12) Responsible Consumption and Production
- (13) Climate Action
- (14) Life Below Water
- (15) Life On Land

## 5.2 Social

**There are numerous 5G use cases in the healthcare arena that stand to improve the effectiveness and efficiency of healthcare delivery.**

As described in Section 3, healthcare systems face a range of pressures, such as adapting to an aging population, providing equitable access to services across population groups and regions, and responding to new public health challenges such as aggravations caused by climate change. Canada is also facing significant healthcare challenges: a culturally diverse population with unique healthcare needs; an aging baby boomer generation; escalating healthcare spending as a percent of GDP; extended waits in emergency departments for unavailable hospital beds; delays in various surgery procedures; unavailability of necessary home care services; and asymmetrical supply and distribution of nurses, doctors and other healthcare providers. In particular, rural Canadians have difficulty accessing primary healthcare, diagnostic services, and advanced treatments and struggle to keep healthcare providers in their communities.<sup>42</sup> 5G networks and complementary technologies and applications will be able to materially improve both the patient outcomes and healthcare service quality, while cutting the total healthcare system costs. Potential impacts of 5G solutions include:

1. **Improved connectivity** – Specifically in rural areas, technologies such as 5G FWA and 5G-enabled digital solutions such as remote patient monitoring, connected ambulance, HD virtual consultations, video-enabled prescription management and others, will allow governments, healthcare providers and healthcare recipients to experience a more efficient, effective and responsive health ecosystem. One report estimates that 5G-enabled access and digital solutions will reduce spending in the U.S. healthcare system by up to 30% through increased efficiencies.<sup>43</sup>
2. **Predictive analytics and AI** – The processing of comprehensive data generated by continuous patient monitoring will power predictive analytics and distributed AI-driven intelligent care and enable personalized medicine and treatment. Thus, patients can avoid potential stays in the hospital and hospital resources can be allocated more efficiently.<sup>44, 45</sup>

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<sup>42</sup> Link to source: <https://nursinganswers.net/essays/challenges-of-canadian-health-care-health-and-social-care-essay.php>.

<sup>43</sup> Link to source: <https://cip2.gmu.edu/2021/03/08/accnture-report-outlines-how-5g-technology-accelerates-economic-growth/>.

<sup>44</sup> Link to source: <https://haas.berkeley.edu/wp-content/uploads/5g-mobile-impact-on-the-health-care-sector.pdf>.

<sup>45</sup> Link to source: <https://5g-health.org/wp-content/uploads/2020/11/5G-Health-Whitepaper-V1.pdf>.

3. **Interactive smart pharmaceuticals** – “Smart inhalers or insulin pens, and similar devices equipped with embedded subscriber identity modules (eSIM) can record their application. Additionally, these devices might incorporate sensors and algorithmic functions to estimate the medication effect on the patient and consequently predict critical situations. These devices may also support personalized medication dose management and precision medication.”<sup>46</sup>
4. **Privacy-preserving contact tracing** – An example technology is PTBM: **P**rivacy-preserving contact **T**racing schemes in 5G-integrated and **B**lockchain-based **M**edical applications. According to one study about PTBM, “the 5G-integrated network is leveraged as the underlying infrastructure where everyone can perform location checking with mobile phones or even wearable devices connected to [the] 5G network to find whether they have been in possible contact with a diagnosed patient without violating their privacy. A trusted medical center can effectively trace the patients and their corresponding close contacts. Thorough security and performance analysis show that the proposed PTBM scheme achieves privacy protection, traceability, reliability and authentication, with high computation and communication efficiency and low latency.”<sup>47</sup>
5. **Smart disinfection** – Contact between patients and hospital staff, as well as exposure to infectious environments, can be further reduced by employing AI-driven robots and/or equipment. One pilot project has experimented with deploying a “disinfection robot” – equipped with ultraviolet disinfection, ultra-dry fog hydrogen peroxide sterilization, and air filtration – into high-risk areas, such as those containing patients infected with COVID-19. “Using the 5G network and laser navigation technology, the robot moves autonomously according to the set route, and automatically carries out regular disinfection in complex environments, ensuring all areas are appropriately disinfected.”<sup>48</sup>

### 5G technologies support sustainable urbanization.

According to the U.N., 68% of the world’s population will live in cities by 2050<sup>49</sup>, potentially leading to lower public safety, higher pollution, inadequate and overburdened services, inefficient public transport and traffic congestion. Potential impacts of 5G solutions include:

1. **Energy use optimization** – A study by McKinsey finds that “water-consumption tracking, which pairs advanced metering with digital feedback messages, can nudge people towards conservation and reduce consumption by 15% in cities where residential water usage is high.”<sup>50</sup> Technologies like smart street lighting and smart meter parking conserve energy and reduce traffic congestion. Experiments of smart street lighting demonstrate potential energy savings of up to 48% when compared to conventional

<sup>46</sup> Ibid.

<sup>47</sup> Link to source: <https://www.sciencedirect.com/science/article/pii/S0920548921000155>.

<sup>48</sup> Link to source: <https://www.nature.com/articles/s43856-022-00118-3>.

<sup>49</sup> Link to source: <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>.

<sup>50</sup> Link to source: <https://www.mckinsey.com/business-functions/operations/our-insights/smart-cities-digital-solutions-for-a-more-livable-future>.



street lighting.<sup>51</sup> Smart cities can also leverage 5G networks to enable building automation, which will reduce energy consumption and greenhouse gas emissions. Currently, buildings are responsible for over 30% of global energy consumption.<sup>52</sup> Smart buildings help reduce energy usage by utilizing reactive, automated system controls that ensure consistent optimization. Incorporating multiple smart building technologies results in compounded efficiencies: “whereas an upgrade to a single component or isolated system can result in energy savings of 5% to 15%, a smart building with integrated systems can realize 30% to 50% savings in existing buildings that are otherwise inefficient.”<sup>53</sup>

2. **Public safety and health** – A study by McKinsey finds that “deploying a range of [smart] applications to their maximum effect could potentially reduce fatalities from homicide, road traffic and fires by 8% to 10%. ... Incidents of assault, robbery, burglary, and auto theft could be lowered by 30% to 40%. ... Smart systems can optimize call centers and field operations, while traffic-signal pre-emption gives emergency vehicles a clear driving path. These types of applications could cut emergency response times by 20% to 35%.”<sup>54</sup>
3. **City operations** – A study by Deloitte includes a case study of a city that implemented a cloud-based command center to analyze data and insights on their operations pertaining to waste management, transportation, and others. In waste management, these efforts reduced energy costs by 20% and operational costs by 40%. Transportation costs fell by 10% to 27% across their electric vehicle charging network, bus lines, shared bicycle fleet, and parking infrastructure.<sup>55</sup>
4. **Environmental health** – Collaborative driving of connected and automated vehicles (CAVs) can lead to 3% to 20% in energy saving.<sup>56</sup> By implementing smart traffic signals, one U.S. city was able to reduce commuter travel time by 26% and reduce vehicle idle time by 40%.<sup>57</sup>
5. **Quality of life** – A study by McKinsey claims that if cities were to deploy all the smart applications in their analysis to their fullest extent, disability-adjusted life years (DALYs<sup>58</sup>) would fall by 8% to 15%.<sup>59</sup>

## 5G offers possibilities to improve accessibility for traditionally disadvantaged populations.

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<sup>51</sup> Link to source: [https://www.researchgate.net/publication/339309759\\_An\\_Energy-efficient\\_Smart\\_Street\\_Lighting\\_System\\_with\\_Adaptive\\_Control\\_based\\_on\\_Environment](https://www.researchgate.net/publication/339309759_An_Energy-efficient_Smart_Street_Lighting_System_with_Adaptive_Control_based_on_Environment).

<sup>52</sup> Link to source: [https://www.energyefficiencymovement.com/wp-content/uploads/2021/05/ABB\\_EE\\_WhitePaper\\_Smart-buildings\\_final-1.pdf](https://www.energyefficiencymovement.com/wp-content/uploads/2021/05/ABB_EE_WhitePaper_Smart-buildings_final-1.pdf).

<sup>53</sup> Link to source: <https://www.aceee.org/research-report/a1701>.

<sup>54</sup> Link to source: <https://www.mckinsey.com/business-functions/operations/our-insights/smart-cities-digital-solutions-for-a-more-livable-future>.

<sup>55</sup> Link to source: <https://www2.deloitte.com/us/en/pages/consulting/articles/smart-city-project-case-study.html>.

<sup>56</sup> Link to source: <https://www.sciencedirect.com/science/article/abs/pii/S0968090X18305199>.

<sup>57</sup> Link to source: <https://www.cmu.edu/homepage/computing/2012/fall/smart-traffic-signals.shtml>.

<sup>58</sup> Disability-adjusted life years, or DALYs, is a time-based metric that combines the years of life lost to premature death and the productive and healthy years of life lost to disability or incapacitation (<https://www.who.int/data/gho/indicator-metadata-registry/imr-details/158>).

<sup>59</sup> Link to source: <https://www.mckinsey.com/business-functions/operations/our-insights/smart-cities-digital-solutions-for-a-more-livable-future>.



5G-enabled digital technologies offer new capabilities that enhance the quality of life, economic opportunities and health outcomes of traditionally disadvantaged populations. While advancing equity through digital services is within reach, it will depend on establishing and supporting a common purpose between government, industry and other stakeholders to reduce rather than exacerbate so-called digital divides. The term “digital divide” refers to the gap between demographics and regions that have access to modern information and communications technology (ICT) and those that do not or have restricted access. The term can be extended to consider not only access, but also usability; that is to say digital services should be both broadly available to and usable by different demographic groups. In Canada, rural communities confront disproportionate connectivity challenges, and those with a connection frequently suffer from speeds below the CRTC’s minimum recommendation of 50/10 Mbps. This challenge of the digital divide in Canada in part causes complex socio-economic issues like opportunity, income and health education disparities, to name a few. Closing the digital divide with 5G technology like FWA will enhance the access of these disadvantaged communities into the digital economy and provide them the digital resources to actively participate in the new digital economy. Examples of how 5G-services can advance the needs of select demographic groups are provided below:


1. **Remote communities** – 5G connectivity brings new capabilities and benefits to rural communities such as high-performance telehealth services, improved remote/rural work opportunities and fully immersive workforce training using AR/VR technologies.
2. **Learners with diverse abilities** – 5G-enabled technologies and solutions will support easy access to online resources, be environmentally friendly, save time, increase productivity and make learning a collaborative and lifelong experience by, for example, allowing immersive learning environments that facilitate collaboration between dispersed learners. Teachers who provide physical, skills-based classes or want to provide a gamified learning experience could leverage VR and AR capabilities, which will be accessible with 5G. A study conducted by Nicklaus Children’s Hospital finds that medical personnel trained with VR retain as much as 80% of the course material after one year, while those trained with traditional methods retain only 20% of information after one week.<sup>60</sup>
3. **Seniors and persons with disabilities** – 5G FWA will increase accessibility for older adults and will provide technological solutions for age-related disabilities, such as reduced vision and hearing loss. Digital technologies are also being developed to help address loneliness and isolation among older people who are physically distanced from family and friends. Recent studies have shown that VR-based therapy can reduce chronic pain – a prevalent ailment in older adults – by 25%.<sup>61</sup> Other technologies such as voice-activated smart appliances, lighting, heating, emergency notification devices and home security can all enhance the comfort and quality of life for older adults.

A further consideration is the impact of digital services adoption on workforce dynamics. Reskilling the workforce to meet the demands of the digital economy will require a fundamental rethinking

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<sup>60</sup> Link to source: <https://learningsolutionsmag.com/articles/2427/healthcare-training-on-the-verge-of-vr-revolution>.

<sup>61</sup> Link to source: <https://www.frost.com/frost-perspectives/5g-set-to-disrupt-the-healthcare-industry-and-address-rising-aging-population-in-japan/>.



of current training and learning methodologies and support for impacted workers through this transition. Impacted workers include both those that are displaced by technology and those who need to use or understand these technologies to do their jobs. For example, a recent study by the Centre for Work highlights the need for greater investment in technology and innovation to increase output per worker, leading to better paying jobs that are also more safe.<sup>62</sup> As with reducing rather than exacerbating digital divides, collaborative models between government, industry and stakeholders are needed to ensure the labour market evolves in sync with digital services adoption – that workers have the skills they need to participate in an increasingly digitally oriented labour market.

The U.N. Sustainability Development Goals (SDG) that are related to the use cases discussed under the Social pillar include:

- (3) Good Health and Well-being
- (4) Quality Education
- (7) Affordable and Clean Energy
- (8) Decent Work and Economic Growth
- (10) Reduced Inequality
- (11) Sustainable Cities and Communities

### 5.3 Governance

#### **An increasingly connected fabric of technologies further complicates cyber security and privacy protection.**

Privacy, physical security and cybersecurity are at the forefront of both governments' and business organizations' agendas. These concerns transcend borders in the evolving digital age as organizations collect and process large amounts of sensitive personal data and have physical assets in numerous jurisdictions. With its ability to introduce a vast array of new connections, capabilities, and services, 5G also introduces potential new vulnerabilities for threat actors to exploit. A report commissioned by the U.S. National Security Agency and Cybersecurity and Infrastructure Security Agency outlines the "threat vectors" of 5G, which include undue influence from nation-states in defining 5G security standards; organizations and communications providers choosing not to implement optional security controls; use of counterfeit components in the ICT supply chain; and inherited vulnerabilities from 4G networks; among others.<sup>63</sup> In Canada, the Government is continuously enhancing its Security Review Program, led by the Communications Security Establishment in collaboration with Canadian telecommunications service providers. This program is expanding its scope to access risks from all key telecommunications equipment, software and application suppliers to support the MNOs further fortify their cyber security processes and network resiliency. To this effect, "the Canadian Government [has announced] its intention to implement the following actions:

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<sup>62</sup> Link to source: <https://centreforfuturework.ca/wp-content/uploads/2022/04/Where-Are-The-Robots.pdf>.

<sup>63</sup> Link to source: <https://media.defense.gov/2021/May/10/2002637751/-1/-1/1/POTENTIAL%20THREAT%20VECTORS%20TO%205G%20INFRASTRUCTURE.PDF>.

1. The use of new 5G equipment and managed services from Huawei and ZTE will be prohibited and existing 5G equipment and managed services must be removed or terminated by June 28, 2024.
2. Any use of new 4G equipment and managed services from Huawei and ZTE will be prohibited and any existing 4G equipment and managed services must be removed or terminated by December 31, 2027.
3. The Government expects that telecommunications service providers will cease procurement of new 4G or 5G equipment and associated services by September 1, 2022.
4. The Government further intends to impose restrictions on Gigabit Passive Optical Network (GPON) equipment used in fibre-optic networks.
5. During these transition periods, telecommunications service providers that use this equipment and managed services would be required to comply with any assurance requirements prescribed by the Government, building from the Communications Security Establishment's Security Review Program."<sup>64</sup>

5G networks will enable new capabilities that will help mitigate cybersecurity, privacy and resilience risks to a significant extent. These capabilities include stronger air interface security with user data integrity protection to prevent user data from being tampered with; transmission of users' permanent IDs in ciphertext to defend against privacy attacks; better roaming security through implementation of security protection for inter-operator signaling at the transport and application strata which prevents third-party operators' devices from tampering with sensitive data exchanged between core networks; and enhanced user privacy protection providing reliability and robustness against non-malicious unavailability situations (e.g., errors that appear due to unusual but expected bad radio conditions and broken links). Furthermore, 5G's compartmentalization functionality will aim to isolate potential security breaches from spreading to different parts of the network, and its increased bandwidth enables more frequent updates of temporary user identifiers.<sup>65</sup> "The use of technologies such as artificial intelligence (AI), cloud computing and the deployment of Internet of Things (IoT), all enabled by the strong backbone network provided by 5G, will help IT teams prevent new cybersecurity threats to operate entire business networks more securely."<sup>66</sup> Other security, privacy and resilience benefits of 5G networks are as follows:

1. **Network slicing** – "allows different networks and services to share the same infrastructure but are isolated and segregated from each other. Network slicing carves out (or slices, as it were) specific types of network traffic to match various use cases – be it enterprise, consumer, IoT or public safety."<sup>67</sup>
2. **New Radio Encryption Algorithm (NEA) and New Radio Integrity Algorithm (NIA)** – Both algorithms support the highly secure Advanced Encryption Standard (AES), which is the most robust security protocol. AES uses higher length key sizes such as 128, 192 and 256 bits for encryption, making it more robust against hacking. The robust encryption

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<sup>64</sup> Link to source: <https://www.canada.ca/en/innovation-science-economic-development/news/2022/05/policy-statement--securing-canadas-telecommunications-system.html>.

<sup>65</sup> Link to source: <https://www.ericsson.com/4a66f8/assets/local/news/2021/09172021-a-guide-to-5g-network-security-2.0.pdf>.

<sup>66</sup> Link to source: <https://www.infosecurity-magazine.com/opinions/5g-driving-cybersecurity-evolution/>.

<sup>67</sup> Link to source: <https://cybersecurity.att.com/blogs/security-essentials/what-is-5g-security>.



algorithm scrambles voice and data traffic between devices and cell towers, making it more difficult for hackers to decrypt information.

3. **Virtualization** – This implies the use of more intelligent software and “virtual” hardware solutions that can be deployed quickly to any network location to automatically respond to threats. “Instead of specialized hardware that could be compromised, ... data can be routed through virtual hubs and switches that can be moved or changed quickly if required.”<sup>68</sup>
4. **Edge computing** – With traditional or cloud computing, data usually travels to a server to be processed. With edge, data is processed closer to the source, improving threat detection.<sup>69</sup>

Common, robust standards are also important. Canadian stakeholders have a role to play in establishing security standards for 5G to safeguard sensitive and personal information. Collaboration between all participants of the 5G ecosystem, including governments and regulatory bodies who will establish and enforce the final security and privacy policies for 5G at the national level, is critical to ensure that the end-to-end 5G architecture encapsulates privacy-by-design approaches that are service-oriented and privacy-preserving. See Section 6 for further discussion about key actions to ensure the security of 5G and 5G-related technologies.

**Stakeholders should be mindful of the potential for negative consequences that could arise with the transition to an increasingly digitally oriented economy and society.**

Already discussed above are challenges with respect to: ensuring workers are not left behind and have the skills needed to participate meaningfully in the digital economy; ensuring 5G services reduce rather than exacerbate “digital divides”; and ensuring the responsible management of e-waste generated for reasons related to 5G. Additionally, there are some concerns about the public health risks posed by 5G, specifically with respect to radiofrequency (RF) energy transmitted by 5G base stations. The U.S.-based National Institute of Environmental Health Sciences has stated that “at this point, it is unclear exactly whether, or to what degree, human exposure to [RF energy] will change. What is known regarding 5G, however, is that while continuing to be exposed to the current frequencies, wireless consumers will be exposed to higher frequencies as well.”<sup>70</sup>

The U.N. Sustainability Development Goals (SDG) that are related to the use cases discussed under the Governance pillar include:

- (16) Peace, Justice, and Strong Institutions
- (17) Partnerships for the Goals

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<sup>68</sup> Ibid.

<sup>69</sup> Ibid.

<sup>70</sup> Link to source: <https://ntp.niehs.nih.gov/whatwestudy/topics/cellphones/index.html>.