accenture

Canadian Telecommunications Association

Canada's next sustainability frontier:

Powering digital transformation with connectivity

Commissioned by Canadian Telecommunications Association

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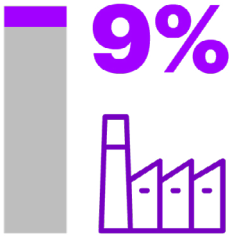
Executive summary

Accenture's 2020 publication, ***Accelerating 5G in Canada: The Role of 5G in the Fight Against Climate Change***[1], predicted how 5G would make wireless networks more efficient, and quantified the total carbon abatement potential. In this subsequent paper, we expand on the role that modern connectivity can play in achieving Canada's sustainability goals, focusing on the broader potential for industry reinvention, and illustrate with deep dives on specific sectors.

Severe weather events such as floods, wildfires, heat waves, droughts, and hurricanes have become more common in recent years. As a result, we are already experiencing the economic impacts and costs associated with climate change.

Canada signed the Paris Agreement in 2015, committing to achieving net-zero emissions by 2050, with an interim milestone to achieve 40% to 45% reductions by 2030.[2] While progress has been made towards achieving these goals to-date, **emissions have only reduced by 9%**.[3] At the same time, Canada is challenged with natural resource over-consumption,[4] and produces more industrial waste per capita than any other nation.



Emissions have only reduced by 9% towards Canada's net-zero target[5]

Businesses generate approximately 70% of Canada's greenhouse gas emissions today, and have an important role to play in building a more sustainable future for the environment and society.[6 a] While there has been no lack of attention on today's climate and environmental challenges, government programs and policies targeted at industry have often focused on renewable energy and clean tech which, while important, are only part of the solution.[7]

a. Excludes 30% of emissions from residential households and passenger transportation

How connectivity powers sustainability impact through digital transformation

Network & connectivity

Telcos provide the critical infrastructure and connectivity needed for businesses to conduct digital transformation by offering high-speed and high-capacity wireless and wireline technologies

Digital transformation

Using the infrastructure & connectivity offered by telcos, businesses can deploy and scale digital solutions to modernize their operations, processes & services

Operational efficiencies

This modernization improves operations, making them more productive and efficient by increasing productivity, improving utilization of assets, and enabling greater agility and innovation through more data

Sustainability impacts

As operations become more efficient and productive, they also become more sustainable, with businesses seeing decreased greenhouse gas emissions and energy consumption, increased workforce safety, and more

Digital transformation – the reinvention of Canada's industries powered by technology and a digital core – is an overlooked lever that can augment current strategies. Through digital transformation, business operations can become more productive, maintaining, or growing output with less inputs or waste, and shrinking energy and fuel consumption in the process. With access to better data on their operations, businesses can also further improve their processes over time, driving continuous improvement in both efficiency and sustainability.

Connectivity services, enabled by modern wireless and wireline networks, are an important foundation that make this transformation possible. Specifically, modern wireless and wireline networks provide the exponential growth in bandwidth and speed, simultaneous connections, and reliability needed to power IoT, data and AI, and cloud across industry sectors.

Connectivity-driven digital transformation sustainability impact

This intersection between connectivity, industry modernization, and sustainability takes two main forms: integrating new connected devices into business operations and facilitating broader enterprise transformation.

Connected devices – IoT, sensors, and robotics play an important role in making processes more efficient, whether incorporated directly into industrial processes to simplify operations, provided to workers to increase their productivity and safety, or deployed as standalone assets. Some examples include:

- **Connected assets:** Deploying massive amounts of network-enabled sensors on equipment and assets across large scale operations, powering digital twins with rich operational data and reducing downtime by optimizing production.[8]
- **Connected fleet:** Connecting existing fleet or deploying autonomous vehicles with rich telematics capabilities, improving the traceability of inputs and outputs in supply chains, and optimizing transport routes to reduce fuel consumption by 20%.[9]
- **Connected worker:** Equipping the workforce with wearables and other devices to provide contextual insights or XR overlays, and increasing collaboration and improving productivity, which can decrease waste by 10% while increasing workforce safety.[10]
- **Robotics & automation:** Deploying connected robots or autonomous drones that can replace manual processes and work reliably and efficiently, resulting in productivity gains in heavy industrial settings.

Enterprise enablement – In addition to transformation through specific use cases and deploying physical devices, connectivity also powers broader business reinvention, with benefits that are felt throughout the organization:

- **Shift to cloud:** Moving workloads to cloud is only possible with strong network infrastructure; in doing so, businesses can tailor their resource usage to exact demand, resulting in as much as 93% energy efficiency and 98% lower greenhouse gas emissions compared to traditional data centers.[11]
- **Data-driven decision making & AI:** With improved capacity to transfer large amounts of data over the network, organizations can make more informed, analytically powered decisions across the entire business, develop better visibility on their own emissions, as well as embed AI as a force multiplier, resulting in reduced wasted effort and energy.
- **Workforce transformation:** Re-imagining traditional ways of working with reliable network and infrastructure to enable remote working and flexible workforces, resulting in reduced emissions for commuting to work and energy consumption for powering working facilities.

Sustainability impact in industry

Digital transformation powered by connectivity can drive operational and sustainability benefits for every industry in Canada. For this paper, we further illustrate this impact potential through deep dives on the Oil and gas, Mining, and Agriculture industries.

Oil and gas

The oil and gas industry is critical to Canada's economy, and producers have been taking steps to become more sustainable in recent years, reducing emissions on their journey to net zero. Connectivity, and the digital transformation it enables, is an important part of achieving that goal, with opportunities across the value chain to use sensors and drones to monitor pipelines and equipment, make better real-time decisions with digital twins and AI, and unlock data-driven insights on operations and emissions. This in turn, allows producers to reduce their energy use and environmental footprint, as well as enhance worker safety. Specifically, predictive maintenance of oil rig equipment can significantly limit unnecessary downtime and energy consumption, while digital twins that leverage predictive maintenance can optimize drilling parameters and reduce wasted fuel use by 20%.[12] By embracing these and other opportunities for transformation, the oil and gas industry can drive more sustainable growth, while continuing to fuel Canada's energy needs.

of wasted fuel use reduced by predictive maintenance[13]

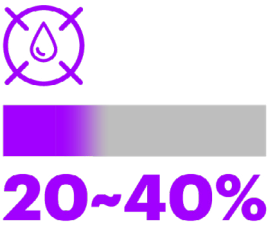
Mining

Canada's mining industry is facing surging demand for its critical minerals, and mining companies want to meet that demand with sustainability top of mind. Mining operations are often conducted in highly remote locations with challenging topography, and water- and energy-intensive processes during extraction, production, and refining. The mining sector is increasingly committed to meeting these environmental challenges, as well as building safer on-site work environments to protect and empower their workforce. Business modernization – enabled by high-speed wireless and wireline networks – is an important lever to do so and can take the form of connected workers and assets, autonomous haulage trucks, and broader enterprise transformation. Connectivity powers new solutions for some of the most critical mining-specific sustainability challenges, including mitigating fugitive emissions or managing tailings ponds with 90% decrease in incidents.[14] These, along with other transformation opportunities, can contribute to a bright future for both the mining industry and Canada.

decrease in incidents with network-enabled tailings pond management solutions[15]

Agriculture

To sustainably meet rising food demand, farms need to overcome challenges in crop and livestock management, labour shortages, and supply chain visibility. The future of farming is trending toward increased levels of automation and swarms of connected devices, which can help farmers manage their farm operations more efficiently, while also reducing their environmental impact. With high-speed wireline and wireless networks, farmers can tap into the power of cloud to contain their costs and energy consumption while unlocking the power of real-time insights and automation, including through precision agriculture, autonomous tractors, connected supply chains, and livestock management. For example, sensors and drones can be used to automatically monitor and manage crops, reducing water and fertilizer use by 20-40%.[16] Over time, farmers can make farms increasingly more autonomous, allowing them to focus on more value-add tasks and rapidly scale to support the increased demand in agricultural products. Doing so requires continued investments in networks and connectivity, as well as ongoing innovation to ensure use cases are accessible at a price point that farms can easily adopt, unlocking more sustainable farming practices.



20~40%

Reduced water and fertilizer use with precision agriculture[17]

Acceleration opportunities

While Canadian businesses have an immediate opportunity to tackle these types of transformation today, realizing the full potential and sustainability benefits requires key enablers. Maintained focus on building out and upgrading telecommunications network infrastructure is critical to support the demanding connectivity needs of advanced use cases, and to ensure businesses, no matter where they are, can become more sustainable. In addition, device manufacturers and the broader ecosystem of solution providers need to continue to innovate, and expand the availability of market-ready solutions that are cost effective and meet sector-specific needs.

Industry verticals, in turn, need to invest in those solutions, as well as build and retain the skillsets within their workforce that are needed to transform their operations and drive efficiencies. Incentives and public programs can also consider broadening their scope to encourage digital transformation and accelerate sustainability benefits further. Finally, a strong end-to-end impact measurement strategy can verify emissions and drive further innovation, accountability, and action. With these elements in place, Canada can capture the full economic and sustainability benefits offered by industry modernization and meet the challenges of tomorrow head-on.

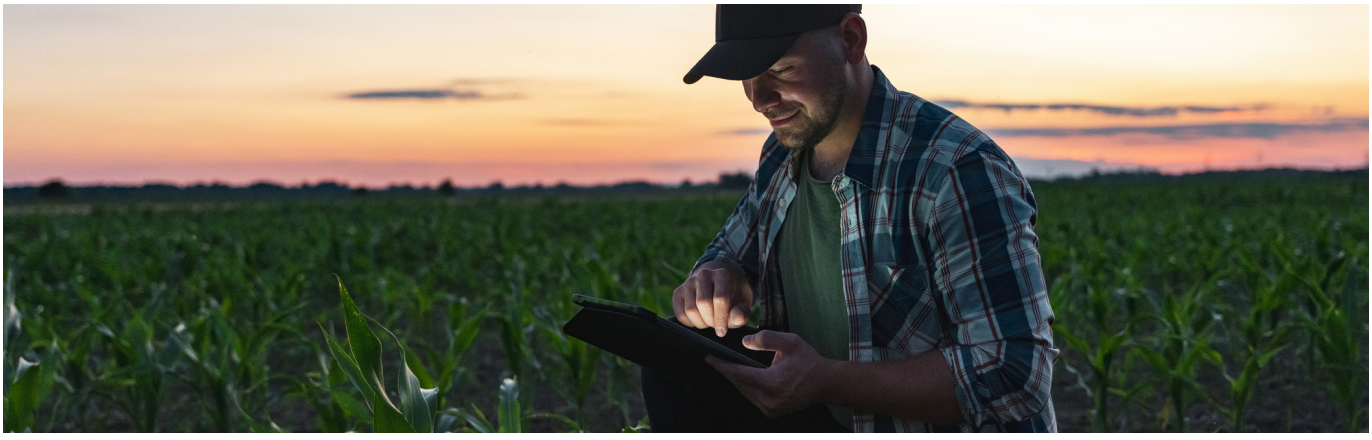
Introduction

Severe weather events such as floods, wildfires, heat waves, droughts, and high-impact storms have become more common in recent years, resulting in increased costs associated with climate change.

Although the climate crisis already receives significant attention, current government-led approaches often narrowly focus on renewables and clean tech solutions.[18] Digital transformation is an underutilized lever that can help Canadian businesses achieve greater sustainability.

Ultimately, businesses that modernize their operations with digital transformation can accelerate their sustainability goals by lowering greenhouse gas emissions, reducing waste and resource use, and increasing cyber-security and workforce safety. Telecommunications networks and connectivity play a pivotal role in enabling this shift, unlocking more efficient, effective, and sustainable ways of working in every sector in Canada.

Earlier analyses primarily focused on previous-generation technology like 4G LTE, the sustainability impacts of 5G specifically, or sustainability impacts outside of Canada. Accenture's 2020 publication, *Accelerating 5G in Canada: The Role of 5G in the Fight Against Climate Change*, predicted how 5G would make wireless networks more efficient, and quantified the total carbon abatement potential. In this subsequent paper, we investigate how digital transformation – powered by modern telecommunications networks – can modernize Canadian industry, how doing so can contribute to Canada's sustainability goals, and what levers exist to accelerate that benefit.



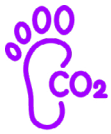
Understanding the sustainability landscape in Canada

Environment and Climate Change Canada defines climate change as "a long-term shift in weather conditions," measured by changes in major climate indicators (e.g., temperature, precipitation, wind).[19] Although industrial activity is fundamental to the Canadian economy, businesses play a vital role in mitigating environmental impact in Canada by managing greenhouse gas emissions, resource consumption, and waste.

Greenhouse gas emissions

Businesses directly or indirectly generate approximately 70% of Canada's annual greenhouse gas emissions, as a result of their economic activity. This occurs in several forms:

1. Direct emissions from the combustion of fossil fuels (Scope I) in business operations, such as burning coal to generate electricity.
2. Indirect emissions from energy consumption of purchased electricity, heat, or steam (Scope II) for business operations, as renewable sources (e.g., wind, solar) only account for 17.3% of Canada's energy production.[20]
3. Emissions produced up- and down-stream in the value chain as an indirect result of business activities (Scope III), such as those caused by employees commuting to work, production and transport of raw materials/inputs, or distribution of goods to end customers.

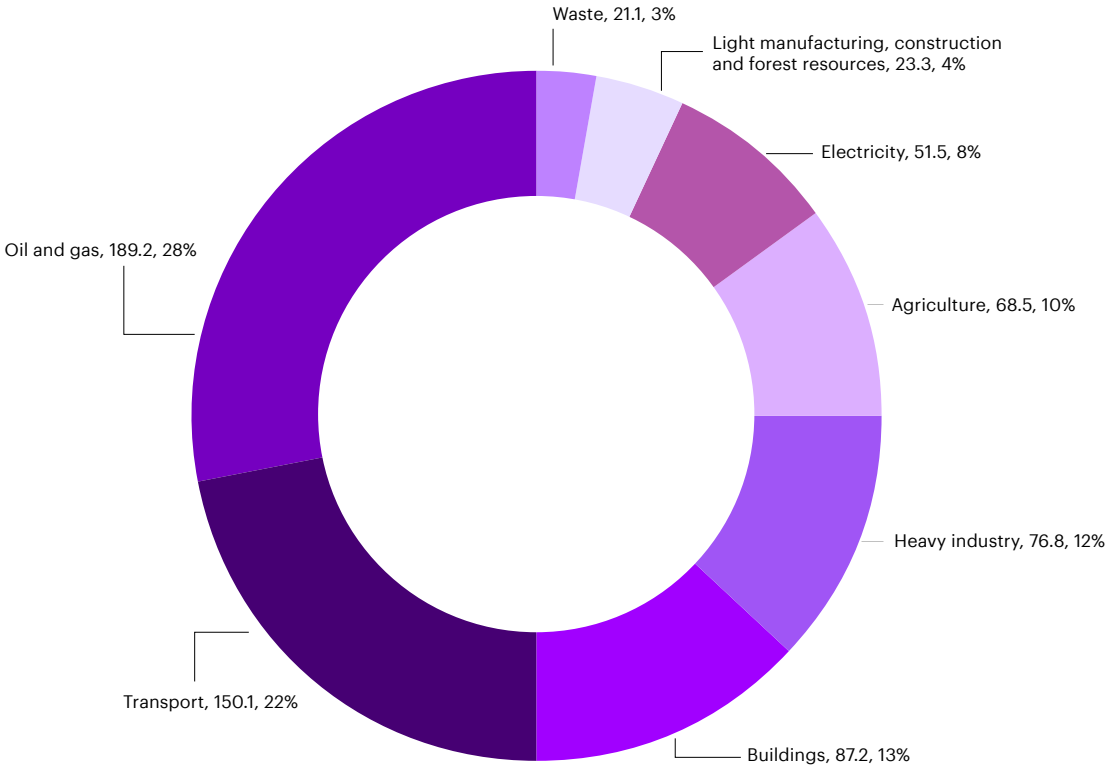


Businesses directly or indirectly generate approximately 70% of Canada's annual greenhouse

To reduce their overall environmental impact, businesses need to make their operations more sustainable across all three scopes, by reducing direct fuel consumption, limiting energy waste, or restructuring their value chains. Although emissions challenges are experienced across all economic sectors, the magnitude of these challenges varies. Oil and gas, transportation, buildings, and heavy industry are the largest contributors to Canada's overall greenhouse gas emissions, accounting for 75% of the total burden.[22] Historically, Scope III emissions have been difficult to quantify and address due to the interdependencies within value chains, but countries soon will be required to report against these as well.

Breakdown of emissions[23]

Breakdown of Canada's emissions (in Mt CO2 eq) by Economic Sectors in 2021



Canada made a commitment in Paris in 2015, along with other top global greenhouse gas emission contributors, to achieve net-zero emissions by 2050, with an interim goal to reduce emissions by 40% to 45% from 2005 levels by 2030.[24] To uphold this commitment, the government has provided incentives (funding programs, tax credits, and expertise) and penalties (taxes and fines) to encourage businesses to reduce their greenhouse gas emissions, though the focus of these programs has been centered on clean tech solutions, such as Carbon Capture Utilization Storage (CCUS) and renewables.[25]

Industry groups have also formed alliances and defined their own targets, in alignment with Canada's federal commitments. For instance, the Pathways Alliance,[26] consisting of oil sand producers responsible for over 95% of Canada's oil sand production, is working towards addressing greenhouse gas emissions and aims to achieve net-zero emissions by 2050.

By taking these steps, **Canada has already achieved a 9.3% reduction in greenhouse gas emissions from 2005 levels**.[27] However, this is just a start: current progress has encouraged businesses to be more mindful of their carbon emissions and invest in renewable technology but will not allow businesses to move at the pace required to achieve Canada's 2050 and interim targets. Since industry-generated emissions are for the production, distribution, and sale of more products, businesses need to consider the quantity of emissions released for every unit of economic output. Emissions reduction will need to outpace economic growth by five percentage points annually; in other words, if GDP averages growth of 1.5% between 2022 and 2030, then emissions will have to drop by nearly 6.3% each year to meet the 2030 target.[28]

Resource consumption & industrial waste

Beyond greenhouse gas emissions, Canada also faces environmental challenges in managing industrial waste and the consumption of resources.

Oil refining, chemical manufacturing, and metal processing makeup a portion of Canada's 1.12 billion metric tonnes of industrial waste.[30] A hefty amount of this waste contains toxic byproducts that can further impact the environment and health of Canadians. Global industrial waste levels are expected to increase by up to 70% by 2050 due to population and economic growth, factors that will also impact Canada.[31] Despite this, limited initiatives exist to encourage businesses to reduce toxic byproducts, resulting in siloed and less standardized approaches to tackling this challenge.

Canada has already achieved a

9.3%

reduction in greenhouse gas emissions from 2005 levels[29]

At the same time, Canada consumes natural materials, energy, and water at some of the highest rates in the world, with almost 75% of resources used being wasted.[33] For example, 83% of the total water withdrawn from water sources in Canada for agricultural activities does not return to its original source.[34] While awareness of this consumption is increasing, businesses need new ways to facilitate the effective reuse and preservation of these natural resources.

Canada produces

1.12 Billion Metric Tons

of industrial waste per year[32]

The federal government is responding to water consumption with policies and funding to promote reduced water use within sectors as well as encourage re-use to enable a circular economy. As a result, clean-tech startups are working to address the water consumption challenge through solutions like vertical farming, which consumes 95% less water than traditional farming processes, using reclaimed water.[35] While this has resulted in some progress, larger enterprises in water-intensive industries have more opportunities to reduce their net water consumption to make a larger magnitude of difference in solving the water consumption problem, requiring larger transformational changes that can help transition to more circular operations.[36]

Other important sustainability dimensions

In addition to the pressing environmental needs facing Canada, there are other dimensions that round out the sustainability picture. For example, **workforce safety** continues to be a challenge in industrial sectors specifically, where many jobs involve workplace hazards as part of day-to-day operations. Similarly, **cybersecurity and resilience** are important not only to protect Canadians' sensitive data, but also to ensure our daily lives and business operations can continue uninterrupted. Managing these elements is an important step in building a sustainable economy.

Despite the efforts made to address Canada's sustainability challenges and the successes achieved to-date, businesses still have an opportunity to drive sustainable impact on a larger scale by conducting transformational change. In the following section, we will examine how Digital Transformation and Connectivity can accelerate progress by providing operational efficiencies that lead to incremental sustainability benefits.

The case for digital transformation as part of the sustainability solution

What is digital transformation?

Digital transformation is the reinvention of Canada's industries powered by technology and a digital core, resulting in fundamental changes to how the business operates and delivers value.

Industrial Internet of Things (IoT), artificial intelligence (AI), cloud computing, and other digital technologies have the potential to significantly improve productivity by directly streamlining processes, automating operations, and making better use of data. By leveraging technology to produce the same or increased outputs with fewer inputs and waste, this improved productivity, in turn, reduces resource and energy consumption and greenhouse gas emissions. With access to better data on their operations, businesses can further improve their processes over time, driving continuous improvement in both efficiency and sustainability.

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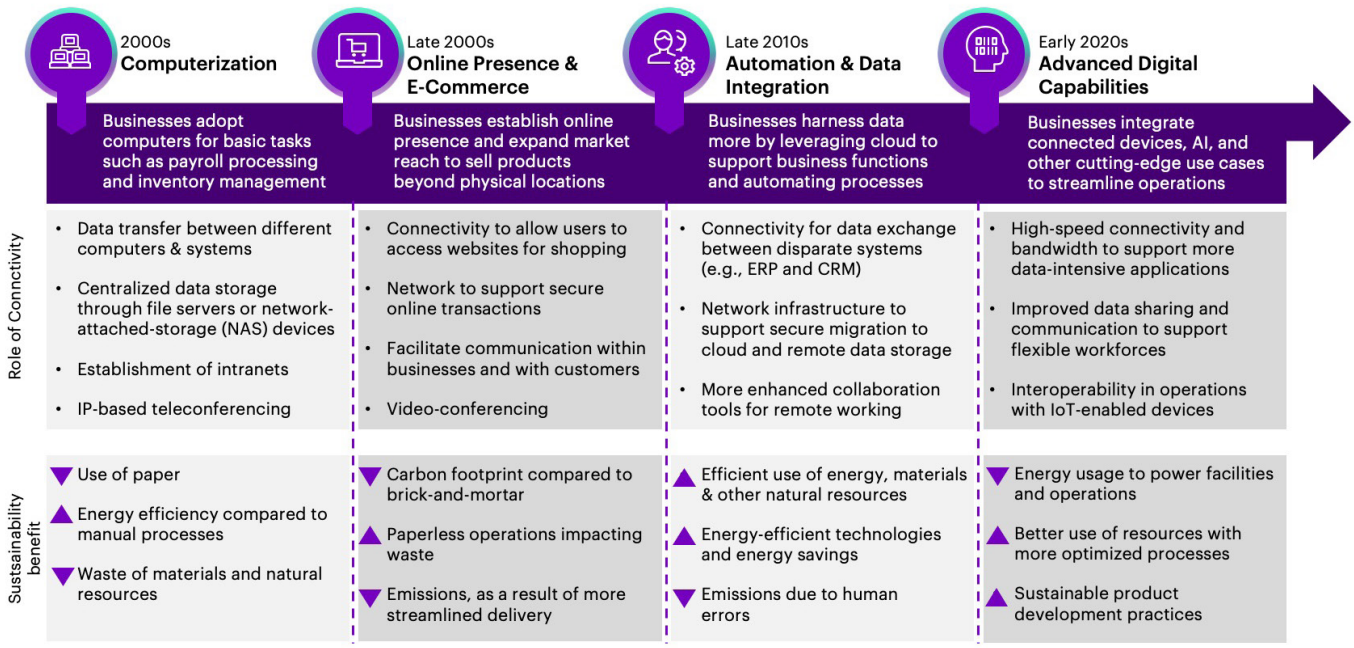
For example, an auto parts factory can use sensors and digital twins to monitor and optimize production processes in real-time. The sensors feed data from machines and equipment used for the creation of various parts, to digital twins, virtual replicas of the real-world factory operations, to identify bottlenecks and inefficiencies, making automatic adjustments that improve production efficiency and reduce downtime of operations.[37] By using sensors and digital twins to monitor and optimize production processes, the factory uses energy and various natural resource inputs more efficiently, reducing its greenhouse gas footprint and resource consumption.

What role does connectivity play?

Connectivity enables many types of digital transformation that require significant amounts of data and information transfer.

How the transition to digital has been enabled by connectivity



From satellite to fibre/coax and 5G wireless networks, the evolution and advancement of networks has enabled businesses to be more efficient. Connectivity and improved network performance have specifically empowered businesses to embrace new ways of operating, simplify processes, provide more work flexibility for employees, and stand-up new business models. At the same time, telecommunications networks have become more energy-efficient and sustainable to help businesses transition to a 'greener' economy.

Networks

In today's fast-paced business environment, demands on telecommunications networks are increasing rapidly. Businesses require faster data speeds, reduced latency, and more coverage to meet the demands of their day-to-day operations. As data becomes more critical for business operations, the need for reliable and efficient networks and connectivity has never been more significant.

Next generation networks enable digital transformation by providing businesses with higher bandwidth and speed, lower latency, massive number of devices, and increased mobility and coverage

Next generation networks enable digital transformation by providing businesses with **higher bandwidth and speed, lower latency, massive number of devices, and increased mobility and coverage**, compared with earlier forms of connectivity. Below, we examine the impact of these factors:

1. **Higher bandwidth and data speed**: Modern networks provide significantly higher speeds and bandwidth than ever before. According to the latest Ericsson Mobile Data Traffic Outlook study, data traffic in North America is projected to grow at a CAGR of 21% from 2022 to 2028.[38] To meet this demand, communications service providers (CSPs) have upgraded their wireline networks to provide faster speeds and have deployed 5G networks that contain enhanced mobile broadband (eMBB) capabilities. 5G can deliver connection speeds up to 100 times faster than current LTE networks at 10Gbps, enabling rapid streaming and the transfer of rich, high-quality video and dense industrial data.[39]

   These speeds are essential to unlocking the full potential of emerging technologies including computer vision, extended reality (XR), and digital twins, which all require high bi-directional data flow. For example, computer vision applications such as object detection, contextual image classification, optical character recognition, deep learning, and more can require processing high-definition video feeds, which can generate up to 1 terabyte of data per hour.[40] Similarly, digital twins require constant updates and synchronization between physical and virtual models, with many simultaneous devices providing large amounts of cumulative information. Modern networks have increased their capacity for higher throughput and speeds to support this demand and ensure data-intensive applications function correctly.

   Example: Aerospace manufacturing factories can use augmented reality (AR) to provide workers with real-time visual guidance and assistance during complex assembly processes, making the assembly process faster, more accurate, and less error-prone. Object detection and deep learning algorithms enabled by computer vision in cameras and AR devices can be used to track the position and orientation of assembly parts in real-time. AR can then overlay visual instructions and guidance onto the user's field of view, highlighting the correct tools, parts, and assembly steps as the user works. By using AR with computer vision, workers can be trained more quickly and easily, and the factory can reduce the likelihood of errors and speed up the assembly process, thereby reducing energy consumption to power production lines.

2. **Lower latency**: High speed wireline networks, with direct physical connections, have long had high reliability and low latency, allowing responsive real-time feedback. In recent years, modern wireless networks have developed ultra-reliable low latency (URLLC) capabilities, sending, and receiving data with delays comparable to wireline connections and as low as 10ms.[41] As a result, URLLC has become essential in supporting the most time-critical of wireless applications. More specifically, 5G networks are designed with Mobile Edge Computing (MEC) as part of the architecture, which allows for data to be processed closer to a business' operational site for quicker analysis, enabling lower latency. With data being processed at the edge, network traffic remains local which becomes more cost-effective for businesses that have high-processing data application use cases.[42] With URLLC, the time it takes to transmit and receive data enables near-immediate action at the edge, which helps improve the performance of robots, autonomous vehicles, quality inspection, and other time-critical applications.

   Example: Autonomous fleets rely on real-time data from sensors and other vehicles to make decisions about speed, lane changes, and other maneuvers to ensure safe and efficient operation. This necessitates a constant flow of data between 1ms and 10ms, allowing the centralized control system to make timely decisions and react quickly to potential accidents or delays, leading to increased productivity from real-time route planning and optimization.

3. **Support for massive numbers of devices**: The rise of the Internet of Things (IoT) and proliferation of smart devices is predicted to drive growth in IoT connections from 1 million to 5 billion by 2025.[43] To meet this demand, modern networks have been designed to support massive amounts of simultaneous connected devices. 5G enables massive machine-type communications (mMTC), connecting up to 1 million devices per square kilometre that have low data requirements and low energy consumption.[44] By enabling a massive number of connected sensors, mMTC can unlock use cases where sensors can help monitor and react to small changes in critical operations at locations over a wide area to enable targeted, near-real-time response to optimize processes.

   5G uses massive multiple-input multiple-output (MIMO), allowing it to efficiently allocate network resources to handle multiple tasks or requests from many users more effectively than previous generations of networks.[45] With this, businesses can connect many more devices at one time to each tower or node without overloading parts of the network, and take advantage of device interoperability. IoT-based digital use cases and applications are then possible, including advanced remote monitoring, smart cities, and connected assets, each of which can help businesses streamline operations, reduce downtime, and support new business models.

   Example: In smart manufacturing plants, thousands of individual sensors are utilized to monitor equipment performance and detect potential failures in advance. By collecting and analyzing vast amounts of data generated by these sensors, the plant can implement predictive maintenance programs, scheduling tasks at the most opportune time, ultimately reducing downtime by 35% to 45% and increasing productivity by 25%.[46] [47]

4. **Increased mobility and coverage**: Canadian networks have grown significantly in recent years to ensure seamless connectivity and high-speed internet access for businesses, enabling indoor and outdoor operations, at any time. CSPs have expanded fixed broadband, built new cell towers, installed satellite technology, and deployed small cells as well as distributed antenna systems to improve coverage and capacity. This expansion has enabled assets, devices, and people to operate in ways that were previously not possible, and ensures new devices remain connected to the network.

Example: Due to the expansion of enhanced networks, a delivery company that once relied on manual processes for tracking and dispatching orders can now utilize mobile devices and sensors to track delivery vehicles and drivers in real-time and efficiently monitor inventory levels. The combination of high-speed wireless and wireline networks allows the delivery company to optimize its inventory and delivery routes. For instance, the company can leverage cellular networks to provide mobile connectivity for its drivers, while using wired networks to support its inventory management and order tracking systems. As a result, the company allocates less time to manual processes and failed deliveries, reducing its carbon footprint.

In addition to these advancements, network design has evolved over time to become greener and more sustainable. Both wireless and wireline networks produce less emissions than past generations of networks, as CSPs continue to invest in energy efficiency to deliver more data and services with a lower footprint.[48] 5G networks, for example, require just 15% of the energy a 4G cell site would need to transmit the same amount of information.[49] Similarly, modern fixed broadband networks are substantially more energy efficient than previous forms, and becoming more efficient as CSPs decommission power-hungry legacy equipment and streamline their network operations.

Private networks

In some cases, businesses have highly specialized connectivity needs and the characteristics of those needs are more suitable for custom, private networks. This is especially relevant for cases where businesses face challenges in connecting many industrial sites due to physical scale and geographic location, such as highly remote and challenging terrains. Similarly, businesses with complex layouts of operations and specific throughput requirements may find Wi-Fi insufficient, resulting in blackspots that are impossible to avoid, and hindering the ability to harness the full power of cloud.

In both cases, private networks can help businesses meet these connectivity needs. Powered by the same cellular technology used by public carriers, these networks have evolved to become economical for individual enterprises seeking specialized requirements for security, control, and mission-critical use cases.

Private networks provide businesses with complete control over their network infrastructure, allowing for specialized control over security and reliability of data and communications. This level of control also allows businesses to customize their network to meet their specific needs and requirements, enhancing efficiency and productivity for mission-critical use cases and applications. Additionally, private networks offer an alternative option for coverage and increased signal quality due to increased bandwidth and throughput characteristics, for areas with limited or poor network availability.

Ultimately, public and private networks both have their own advantages for enterprises, and can both enable digital transformation; businesses must evaluate their specific needs for wireless complementing or enhancing their current infrastructure. By leveraging private networks, businesses can enable faster data-driven decisions that optimize critical business operations. According to an Ericsson case study, private 5G networks in manufacturing facilities allows the facility to have more control of its HVAC equipment and power consumption, resulting in a 25% decrease in energy consumption, and a 75% decrease in the use of wastewater. [50]

How does connectivity-driven digital transformation accelerate sustainability impacts?

This intersection between connectivity, industry modernization, and sustainability takes two main forms: integrating new connected devices into business operations and facilitating broader enterprise transformation.

Digital transformation through connected devices

Improved levels of connectivity allow for businesses to have full visibility and control throughout their operations. IoT, sensors, and robotics play an important role in streamlining inefficient processes and improving efficiency, whether incorporated directly into industrial processes to simplify operations, equipped by workers to empower them, or deployed as standalone assets.

Connected assets include deploying massive amounts of network-enabled sensors on equipment and assets across large scale operations, powering digital twins with rich operational data, and reducing downtime by optimizing production with computer vision. This allows businesses to easily capture and monitor rich information and telemetry, enhancing real-time monitoring and optimizing performance.[51] By feeding real-time data captured through computer vision to digital twins and having the twins leverage AI algorithms to instantaneously process the data, businesses can reduce downtime on mission-critical operations, and improve resource utilization and capacity, thereby reducing energy consumption and waste. Furthermore, specialized connected sensors can be placed on operating equipment to collect data on energy usage, waste management, water consumption, and other sustainability metrics, directly monitoring and measuring Scope I and II greenhouse gas emission levels, as well as waste or other impacts.

An example of connected assets is Sanofi's Framingham Lighthouse facility, which is a digitally enabled, continuous manufacturing facility. Digital twins are used by the company to conduct remote manufacturing, using real-time data capture that feed into scenario analysis to determine the optimal configuration of production. With optimized scenarios used in the real-world, the factory is 80 times more productive than a traditional factory. This higher productivity also has significant sustainability impacts, driving 80% less energy use and carbon emissions per year, 91% reduction in water footprint, 94% reduction in use of chemicals and 321 tons of waste reduction per year.[52]

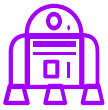
Connected fleet involves upgrading existing vehicles, or deploying new autonomous vehicles, with rich telematics data and sensing capabilities. With real-time information on driver behavior, vehicle position, and the environment, fleets can be managed more safely, by either human or machine operators, while improving performance and efficiency.[53] In turn, this optimizes transport routes and improves traceability of inputs and outputs in supply chains. Furthermore, network enhancements are driving fleet management platforms to transition from multiple independent data collection systems to robust single in-vehicle computers.

These computers can consolidate data from disparate systems, process the data in near-real time, and transmit the data to cloud for storage and trend analysis.[54] Businesses that use sensor-based fleet management solutions can expect to see 2x optimization of fleet and driver efficiency, and a 62% increase in overall fleet profitability from enhanced vehicle and driver insights,[55] which can reduce fuel consumption by up to 20%.[56]

Coopertrans Logistics used a fleet manager solution to monitor and analyze peaks in speed and driver braking and acceleration behaviours, as well as road conditions, to ensure safe transportation of chemical loads. The company very quickly saw an 80% reduction in accidents, and an 8% reduction in fuel consumption, leading to an overall improvement in their fleet's safety and efficiency.[57]

Connected worker equips workers with wearables and connected devices that provide contextual insights or XR overlays, to enable better visualization of operations, increase collaboration and productivity, and elevate workforce safety. XR technologies provide workers an immersive and interactive experience to enhance productivity and performance and enables workers to share information and data in real-time, regardless of their physical location. Workers can access and use real-time contextual insights, guidance, and support to handle equipment and assets in operations and collaborate with colleagues, while providing data on their surroundings back to the business. To enable the intersection of XR and IoT data, strong network infrastructure is needed that can support reliable, high-quality connections to many simultaneous devices.

To illustrate this, consider manufacturing facilities, where workers wearing smart safety glasses leverage AR to learn how to use equipment on production lines, as well as alerts and notifications when equipment presents a safety hazard. By keeping workers more informed, the plant can maintain output levels and avoid unnecessary downtime, resulting in lower net energy consumption and 10% reduced waste for a given amount of production, while increasing workforce safety.[58]



Robotics and automation are possible with the deployment of connected robotics systems, autonomous drones, and other machines to replace manual processes and work reliably. These systems are at their best when powered by reliable and high-speed data transfer, allowing them to respond to rich visual or other contextual information within the environment, as well as information on other steps in an industrial process. Many robotics systems can benefit from real-time, low latency data transfer to allow the robot to sense and react in a timely manner, performing tasks that require fast and precise movements. These systems work around the clock without breaks or fatigue, and can conduct tasks with higher accuracy and efficiency, resulting in increased productivity and faster turnaround times.

An example of how automation drives efficiencies can be seen in the manufacturing industry, where robots that conduct real-time data processing and analysis are used to perform repetitive tasks such as welding, painting, or drilling with high precision and efficiency, freeing up human workers to focus on more complex tasks that require critical thinking and decision-making skills, resulting in 30% increase in production efficiencies.[59] As a result, the production line not only substantially increases outputs, but it also requires less energy to power.

Digital transformation through enterprise enablement

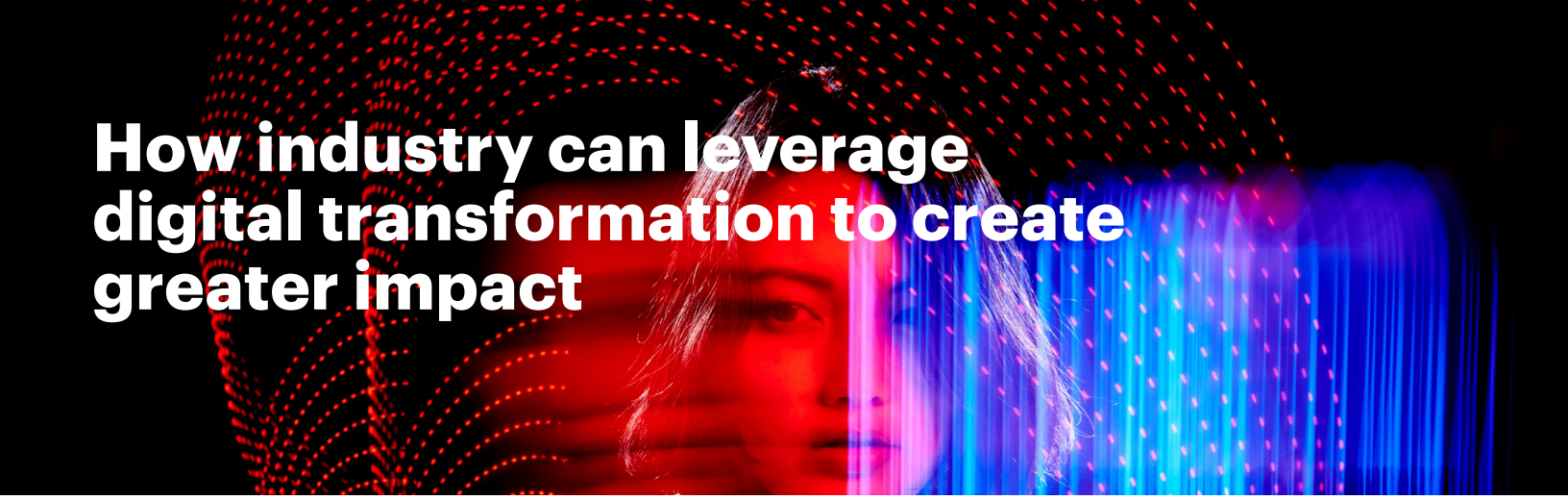
In addition to transformation through specific use cases and deploying physical devices, connectivity also powers broader business reinvention by establishing a digital core built on a modern cloud-based infrastructure, with benefits that are felt throughout the organization.

Shifting to cloud involves moving workloads from traditional data centres to scalable cloud services, which can fundamentally transform core end-to-end business operations. These cloud-based environments are only available with the support of network infrastructure to provide high bandwidth, reliability, and security. With cloud transformation, businesses can operate with more agility and flexibility to meet demand, reducing unnecessary costs as well as barriers to innovation. More importantly, cloud computing is 93% more energy-efficient and has 98% lower greenhouse gas emissions than on-premises data centres, making a significant difference in a business' sustainability impact.[60]

Data-driven decision making & AI can be used to greater effect as businesses are able to both capture and efficiently transfer large amounts of data over networks. This allows organizations to make more informed, analytical, and AI powered decisions across the entire business, on how to make operations more efficient, and to reduce carbon emissions, waste, and water usage. In addition to insights on core operations and productivity, businesses can also implement carbon intelligence specifically, bringing together disparate IT and OT data sources to develop deep end-to-end views of carbon production, and more readily identify opportunities to reduce Scope I emissions.

Workforce transformation is the evolution from traditional ways of working to increasingly flexible, agile, and adaptable models. Modern connectivity is central to this shift, providing the foundation for a wider range of professions to successfully perform their roles remotely and with more agility. Similarly, tools like generative AI, when wielded in the hands of workers, fundamentally change the nature of work. Together, these have the potential to improve workforce productivity, and require less on-site workers, reducing the energy consumption to power facilities, and greenhouse gas emissions from workers commuting, while empowering workers to be more effective.

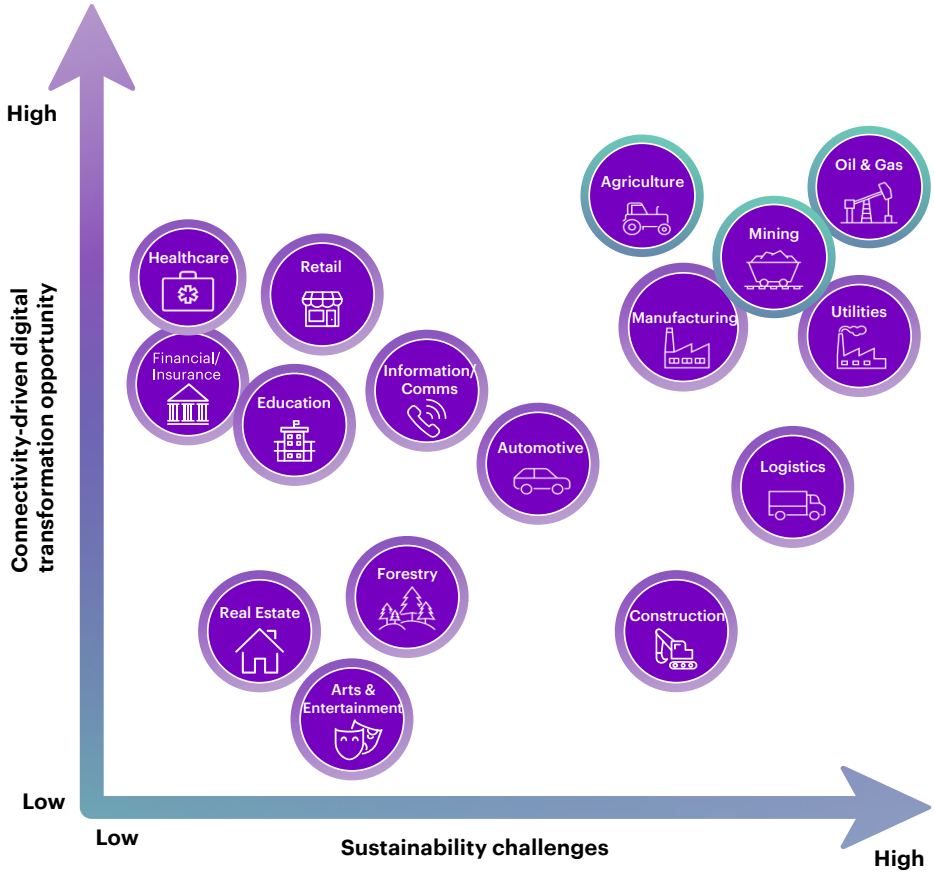
For example, the rise of telemedicine, by leveraging networks and connectivity, allows healthcare providers to connect with patients and other healthcare professionals in real-time, regardless of their location. This has been able to improve patient outcomes by enabling faster diagnoses, reducing hospital stays, and improving access to healthcare services, particularly in remote or rural areas, reducing the need for patient transportation and hospital infrastructure, driving-down greenhouse gas emissions and energy consumption.



How industry can leverage digital transformation to create greater impact

Connectivity-driven digital transformation can drive sustainability benefits across all Canadian industries. Still, the opportunity is larger and more immediate for certain sectors.

Industry plotting against sustainability & digital transformation



In the following section, we deep dive on three industry verticals – Oil and Gas, Mining, and Agriculture – in which connectivity-driven business modernization can drive significant sustainability benefits across greenhouse gas emissions, natural resource consumption, and waste. Within each, we highlight vertical-specific sustainability challenges, the role of digital transformation and connectivity to meet those challenges, and detail high-impact use cases. While sustainability impacts in this analysis are focused on Canada, we highlight global examples to demonstrate what can be adopted in Canada.

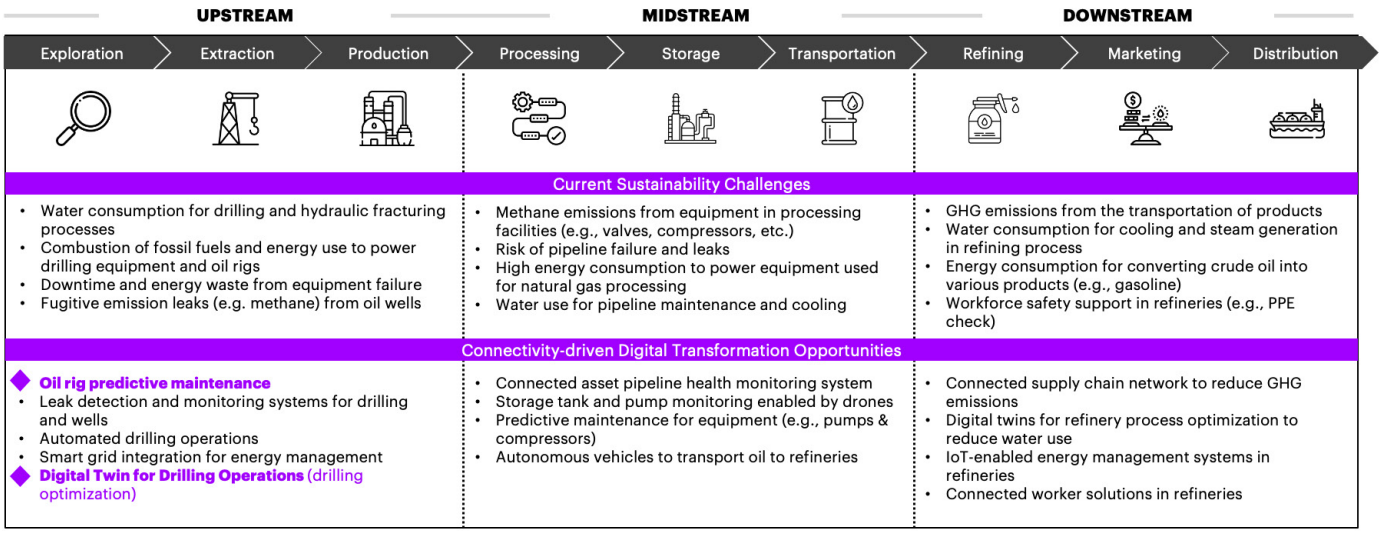
Oil and gas

The oil and gas industry in Canada is the fourth-largest producer of oil in the world and is a major driver of Canadian GDP ($105 billion in 2020) and jobs.[61] In addition to its economic importance, the industry has historically also had a sizeable environmental footprint, with 28% of Canada's greenhouse gas emissions (~189 Mt CO_2 eq).[62]

In recent years, Canada's energy trading partners have started to implement Carbon Border Adjustment Mechanisms (CBAMs) which impose carbon pricing on imported goods to prevent carbon leakage, and promote a level playing field for domestic industries.[63] Major Canadian export partners, including the European Union (EU) and the United States (US) have implemented these mechanisms, which could impact Canada's economy (including the 35% of GDP dependent on energy exports to the US) if greenhouse gas emissions do not decrease.[64] [65] Furthermore, under the Government's 2030 Emissions Reduction Plan, the federal carbon tax is set to rise from $65 per tonne CO_2 eq in 2023-24 to $170 per tonne in 2030-31.[66] As a result, the oil and gas industry needs to reduce its environmental footprint now more than ever before to avoid facing significant financial impacts.

Oil and gas producers understand the important role they play in reducing Canada's greenhouse gas footprint, with most companies already establishing Journey to Net Zero plans and ESG initiatives. These companies are making progress to reduce their Scope I and II emissions through investments in clean-tech research and development, integrating emissions reductions in project planning and operations, leading in carbon capture, utilization and storage, and other approaches.[67] Furthermore, industry consortiums such as the Oil Sands Pathways Alliance are orchestrating industry-wide efforts to reduce emissions.

Oil and gas sustainability challenges & digital transformation opportunities



Connectivity-driven digital transformation can help the oil and gas industry become more sustainable at each step of the value chain, whether that's through improved monitoring and visibility, streamlining operations with better data-driven decisions, or improving the ability to maintain and use assets efficiently. In the exploration and production phases, better sensors and mapping can reduce wasted drilling time to conserve energy and fuel. Similarly, at the transportation stage, drones and monitoring devices can detect and prevent hazardous spills before they cause harm to the environment. In refineries, digital twins of a refinery's operations can be powered by rich sensor data, allowing for simulation and optimization of processes, and reducing energy consumption.

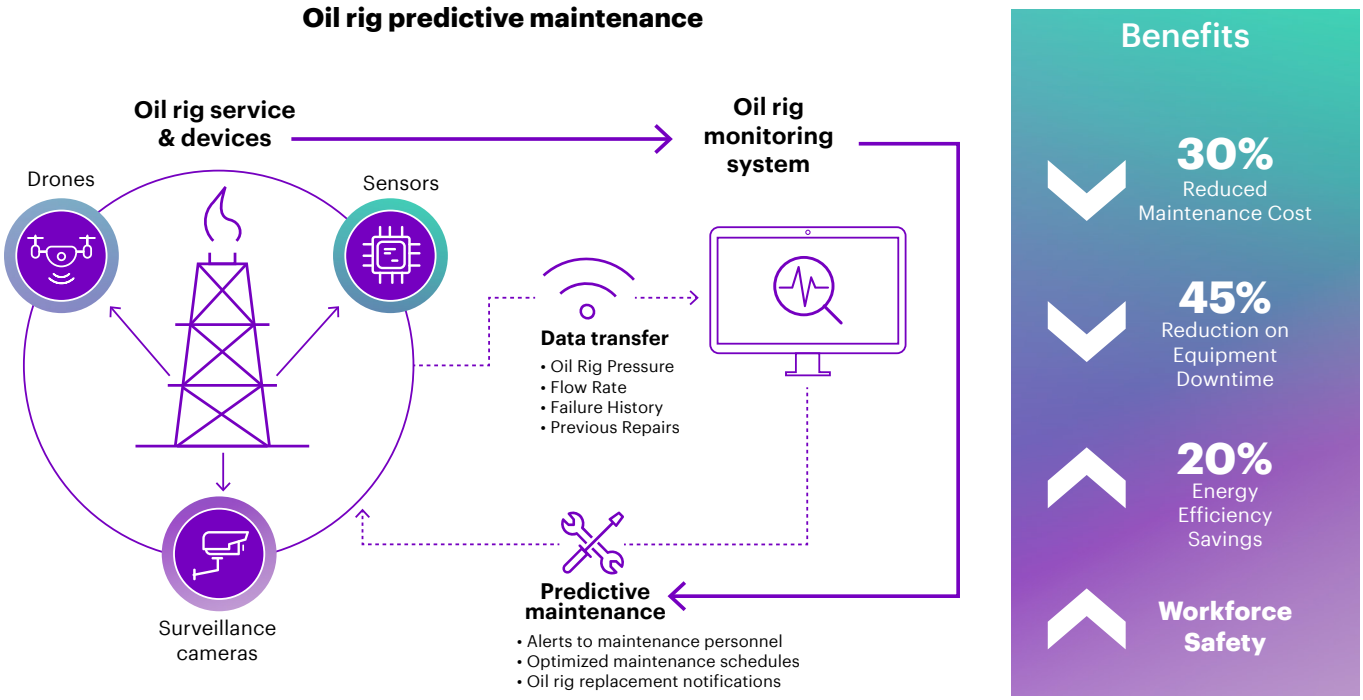
In addition to managing greenhouse gas emissions, digital transformation can drive additional sustainability impact through improving worker safety, such as through providing workers with connected devices that warn them of hazards in their environment.

Use case I
Predictive oil rig maintenance

Oil rig operations are powered by specialized, heavy equipment that, like any other assets, can degrade or break down over time. Today, maintenance on this equipment is performed on a fixed schedule or after machinery has already failed, resulting in significant downtime and waste, as well as creating workplace safety hazards. Unplanned downtime and shutdowns can, in turn, generate excess emissions from the use of backup power sources, flaring unused natural gas, or through the need to ramp up production elsewhere.

Today, routine, and planned maintenance causes energy consumption to increase by 30% to 60% depending on equipment type and level of maintenance required.[68] Equipment inefficiencies can lead to greater quantities of water use than necessary, as well as increased risk of water pollution and contamination. To reduce downtime, prevent total equipment failure, and minimize resource waste, it is critical to address equipment issues with 5G at an early stage, avoiding the need for premature replacement and additional resource consumption.

Oil and gas producers can meet these challenges by using surveillance cameras, sensors, and drones to remotely monitor equipment on drilling rigs and offshore platforms, predicting failure without manual inspection. As an example, drones, powered by computer vision, can fly over offshore platforms or other remote locations to conduct more frequent inspections of equipment and the environment that workers operate in.



As oil and gas companies start to leverage drones and surveillance cameras to conduct inspections, the need for personnel to enter hazardous areas reduces. This reduces the risks of injuries and accidents, enhancing workforce safety. Predictive maintenance powered by surveillance cameras, sensors, and drones can improve asset utilization, as recommendations enabled by 5G-powered devices reduce maintenance costs by 30% and equipment downtime by 45%.[69] By optimizing asset utilization, businesses can reduce their energy, water, and raw materials consumption, leading to lower environmental impact. A study conducted by the US Department of Energy found that **predictive maintenance techniques can result in 20% energy efficiency savings annually.**[70]

To conduct predictive maintenance in this way, businesses need access to high bandwidth networks to transfer large amounts of rich visual information and connect multiple simultaneous devices covering the vast geographic areas covered by oil and gas production plants. To analyze the data captured by surveillance cameras, sensors, and drones, businesses can use high-speed 5G-like networks to derive data insights in real-time. Businesses can stay ahead of the predictive maintenance curve by using wireline networks as a fail-over solution for mission-critical assets and operations, ensuring that operations run smoothly, regardless of any potential network disruption.

Case study
EcoPetrol 5G maintenance pilot test[71]

Oil producer, Ecopetrol, was experiencing operational delays and widespread inefficiencies caused by insufficient technology, outdated maintenance processes, and fragmented communication flows at its Barrancabermeja refinery. Historically, it would take between 3 to 8 days for EcoPetrol to conduct operational scheduled maintenance, resulting in significant downtime of assets and equipment. By leveraging 5G, IoT-enabled devices, and digital twins, EcoPetrol enabled remote assistance and maintenance of assets in real-time by providing access to information, images, and communication that plant personnel could leverage to identify solutions to problems, reducing technical response time to a matter of hours. With a high-speed wireless network EcoPetrol was able to establish real-time communication between assets and equipment, digital twins powered by cloud, and personnel to enable remote assistance and predictive maintenance. With lower downtime of equipment, EcoPetrol realized significant increases in productivity and maintenance processes, resulting in over $1 million in savings. By modernizing this part of their operations, EcoPetrol decarbonized its operations and enabled energy transition at the refinery.[72]

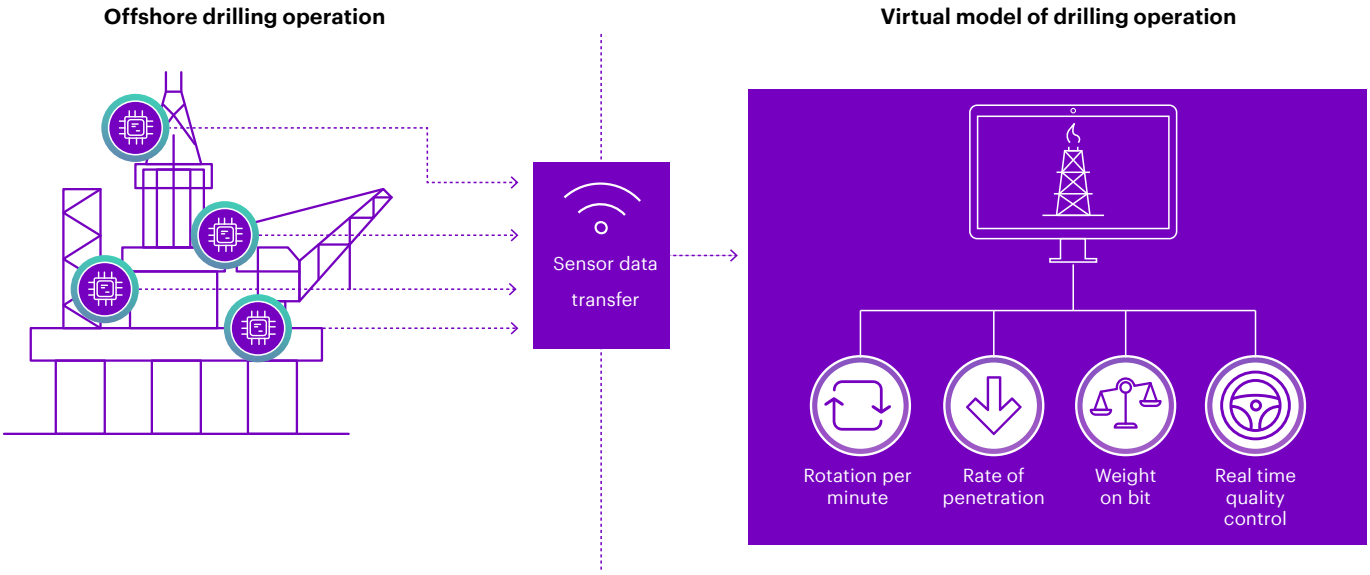
Use case II
Drilling operations digital twin

Drilling and extraction are responsible for at least 10% of upstream carbon emissions for some oil and gas companies.[73] Operating large generators and drilling equipment on oil rigs requires burning substantial amounts of fossil fuels, so any inefficient or wasted drilling directly generates unnecessary Scope I emissions.

Today, drilling operation control is highly manual and dependent on the expertise of the operator to adapt to change in conditions. Any misstep results in additional consumed fuel and increased emissions.

To combat this, digital twins can be used to create a virtual representation of the end-to-end drilling process, using connected sensors to survey the geology of the drilling site and the state of drilling equipment. This allows for rich simulations that empower operators to conduct scenario testing and optimize drilling parameters in a safe and controlled environment. This directly increases the precision and accuracy in drilling, reducing wasted fuel use and carbon emissions.

Drilling operations digital twin



After optimizing drilling operations using virtual models and simulations, digital twin technology can be used to remotely monitor the drilling process in real-time. Sensors in the physical environment and oil rig transmit real-time information to update the simulation, notifying operators of potential problems before they occur. This further reduces wasted drilling time and energy needed to power the drill, which can **allow producers to see reduced carbon emissions from energy consumption by up to 20%**.[74]

These detailed drilling simulations rely on advanced network capabilities. To ensure simultaneous connections to sensors in the oil rig, networks need to have the ability to transmit and receive data at high speeds. Low latency is also important when adjusting drilling parameters in real-time, where latency more than 5ms can cause missteps or errors. Given the remote nature of these rigs and the complex networking requirements involved, continued investment in specialized networks is critical to realize these environmental benefits.

Call to action

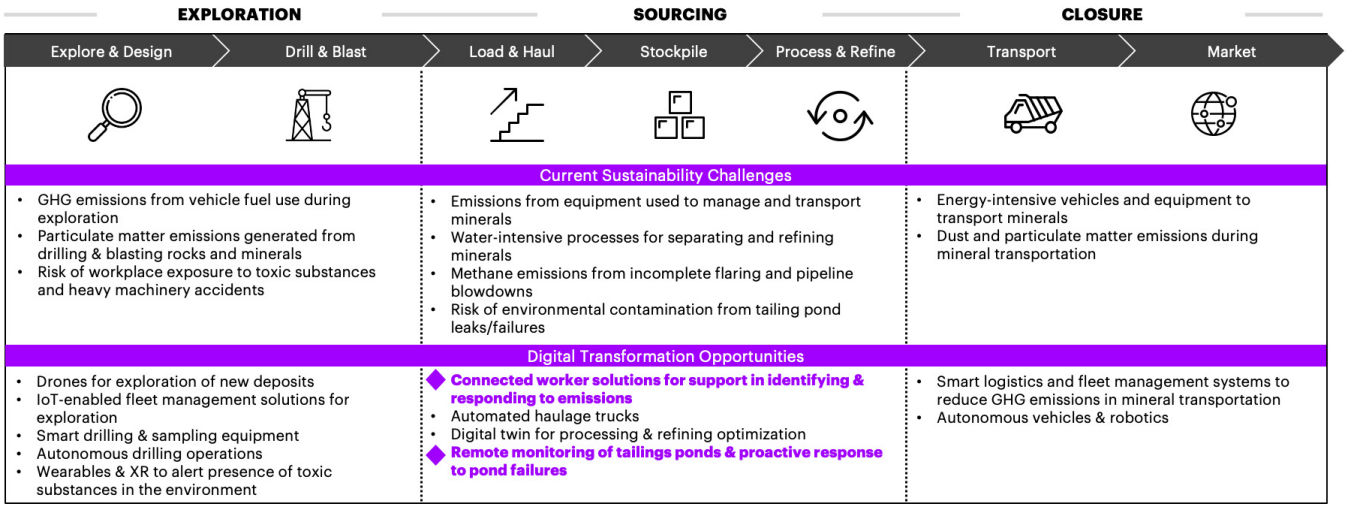
The oil and gas industry is critical to Canada's economy, and has an important role to play in realizing Canada's sustainability objectives. Producers are invested in moving towards net zero and are already making significant headway to reduce Scope I and II emissions. Connectivity, and the digital transformation it enables, is an important component of achieving that goal, with opportunities across the value chain to reduce downtime, improve asset utilization, and enable more efficient production. In turn, this drives sustainability impact, including further reduction of emissions. Predictive maintenance and digital twins for drilling optimization are two of many cutting-edge use cases that drive these immense benefits. By embracing this opportunity, the oil and gas industry can drive more sustainable growth, while fueling Canada and fulfilling its energy needs.

Mining

Canada is recognized as a leading mining nation, with large operations across coal mining, oil sands mining, and hard-rock mining. Canada produces 60 minerals and metals, which were valued at $55.5 billion in 2021, at almost 200 mines and 6,500 sand, gravel, and stone quarries across the country.[75] Mining operations in Canada are expected to significantly increase over the next decade with the rising global demand for Canada's critical minerals and materials to power the clean energy transition and advanced manufacturing.[76] While mining companies can drive economic benefits for Canada, they have an opportunity to do so with amplified sustainability.

In 2021, Mining emissions in Canada were reported at 30 Mt CO_2 eq (~5% of total emissions in Canada)[77] primarily from metals production and oil sands operations that result in fugitive emissions.[78] Furthermore, the industry consumed 240 million cubic meters of water in 2020[79] to support the use of chemicals and heavy machinery in processing and refining metals. Mining companies realize their environmental footprint and are attempting to address challenges regarding equipment reliability and maintenance, energy and water management, and workforce safety to reduce this footprint.

Mining sustainability challenges & digital transformation opportunities



Connectivity, and the digital transformation it makes possible, is an important lever for achieving this goal. Mining in remote locations and harsh conditions can present challenges to worker safety and productivity, but with **connected worker** solutions, wearables and devices can be used to access critical information and support. Mining companies can also benefit from **connected assets** that leverage data analytics and predictive maintenance to optimize equipment performance and reduce energy consumption. In parallel, autonomous haulage trucks can be used in large-scale operations where the transportation of materials is a significant part of the mining process to reduce emissions and waste.[80] By enabling more connected and automated operations, the role of the workforce in mining operations can shift to remote monitoring and work, increasing workforce safety.

Realizing these benefits necessitates having the right network in place, though individual mining sites can be situated in remote locations or have specialized network requirements due to their layout. Meeting these needs requires continued expansion of both public and private network infrastructure.

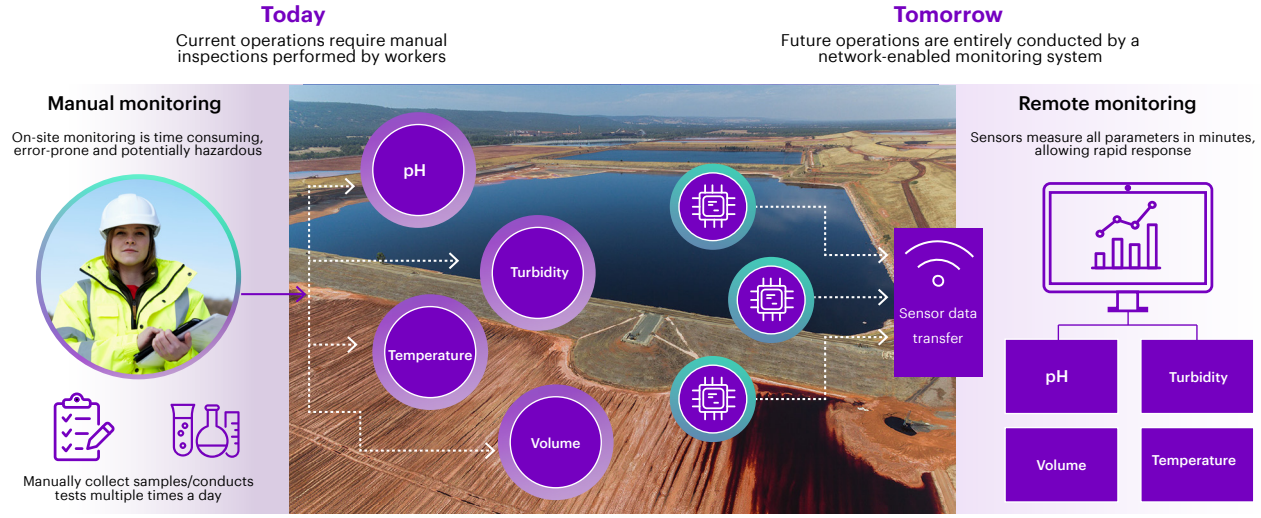
Use case I
Tailings pond sensors

In addition to valuable minerals, the mining extraction process also generates tailings containing heavy metals such as lead, mercury, arsenic, and cadmium, which pose environmental risks if not managed properly. To prevent this risk, mining companies store tailings in containment ponds, which have grown to cover an area of 300 square kilometers.[81] On average, there are 1-2 failures per year,[82] with each failure resulting in $350 million to $1 billion in repairs and fines incurred for non-compliance.

Given the environmental and financial importance of these ponds, businesses have tailings storage facilities to monitor and manage these ponds, with surveillance systems and on-site manual inspections conducted several times daily, along with more formal inspections every 15 days.[83] Most monitoring and management practices are conducted manually on-site today, introducing potential errors, as well as risking exposure to toxic chemicals and harmful gasses. Businesses need more technologies that can support these facilities to operate independently and more effectively.

Sensors installed in tailings ponds can be used to monitor pond conditions by measuring the pH, turbidity, volume, temperature, and other parameters of the water in the ponds in addition to the overall dam structure, specifically detecting any changes or anomalies that may indicate the presence of a leak, breach, or issue. These sensors are self-operated and can perform inspections in minutes, providing the business with rapid insights on pond conditions.[84] Once a business identifies a leak or dam failure, they can repair the dam and prevent a larger volume of the leak from occurring, which reduces the environmental harm of these incidents. By acting faster, businesses can realize 15% to 20%[85] in preventative maintenance savings. Connected sensors also improve reading accuracy, which can help Mining businesses determine when water can be recycled back into the environment and can **reduce environmental compliance safety incidents by up to 90%.**[86]

Tailings pond remote monitoring



Reliable networks and connectivity are crucial for the sensors to generate, transmit and analyze data near real-time and for the tailings pond monitoring systems to function effectively. These ponds are in highly remote areas, and with remote monitoring powered by networks, businesses can become more connected to a very critical part of their operations without needing to be on-site. On top of this, given the nature of the tailings ponds (the substances the ponds contain, and their impacts on the environment and society), data captured on ponds is sensitive and proprietary, which necessitates the use of highly secure networks to manage and access this information.

Use case II
Connected worker solutions for fugitive emissions

Fugitive emissions are the release of gasses into the environment that are produced as a byproduct of mining operations. Primarily, these take the form of methane gas, nitrous oxide, and hydrogen sulfide, and are released through venting and flaring, as well as from leaks, spills, and other releases during the handling and processing of minerals and ores. Flaring and venting require extensive manual effort, as workers must manually monitor airflow and ensure safety from potential leaks or hazards. While these methods are effective in controlling gas releases, any issues in these processes can expose workers to toxic gases, and delays in addressing the leaks due to the lack of field oversight and information.

Mining companies are currently implementing gas capture and utilization technologies that take unwanted emissions and use them as a fuel source for the mining operations themselves or for energy generation.[87] These companies are also investing in infrastructure, regular equipment maintenance, improved leak detection and repair programs, and using advanced monitoring technologies to identify and address leaks. However, this infrastructure and technology is expensive, and requires highly specialized equipment and expertise.

Wearables can be used to address sustainability challenges related to flaring, venting, and fugitive emissions by providing real-time monitoring on air quality, particulate matter (PM), and the concentration of gases in the environment. These devices warn workers of toxic gases in the environment and allow the mine to take corrective action quickly (e.g., repairing leaks), **delivering up to a 50% reduction in lost-time reportable incidents**.[88] In addition, wearables can help workers conduct real-time monitoring to measure the combustion efficiency of flaring systems and then adjust the flow rate of gas to optimize the combustion process and reduce emissions.

A combination of rapid data transmission and low latency is necessary in capturing real-time data on the field environment to ensure businesses can detect potential safety hazards quickly and take appropriate action. This helps businesses avoid greenhouse gas emissions from expanding into larger operational efficiency and safety problems.

A connected worker solution benefits from a reliable network however in Mining there is an opportunity for businesses to leverage private network as an alternative option. Today, many connected worker solutions use Wi-Fi or Bluetooth, which allows connectivity across shorter distances (10-20m), though large-scale mining operations are many kilometres wide, requiring more contiguous coverage. The need for connectivity, and the benefits of having connectivity in these remote areas of operations is a high-value opportunity for mining businesses, that these businesses can invest in independently to ensure there is adequate support for their business operations.

Case study
Suncor Safety & Productivity Solution[89]

Suncor developed a wireless mesh safety productivity solution in some of its mining facilities that enables workers to wear a device on their shoulder, within breathing radius, to help workers and the business monitor exposure to personal gases in their operating environment. Exposure tolerance was pre-programmed for H2S, SO2 and other hazardous gases in the wearables to comply with Occupational Health & Workforce Safety standards. When a worker enters an environment with levels of these gases higher than the thresholds identified as 'Safe', a panic button alarm goes off, informing local operations teams of exposure. The solution enabled workers to remain in-work zones 85% of the time, which drove increases in productivity, and enabled better control of workforce safety.

Call to action

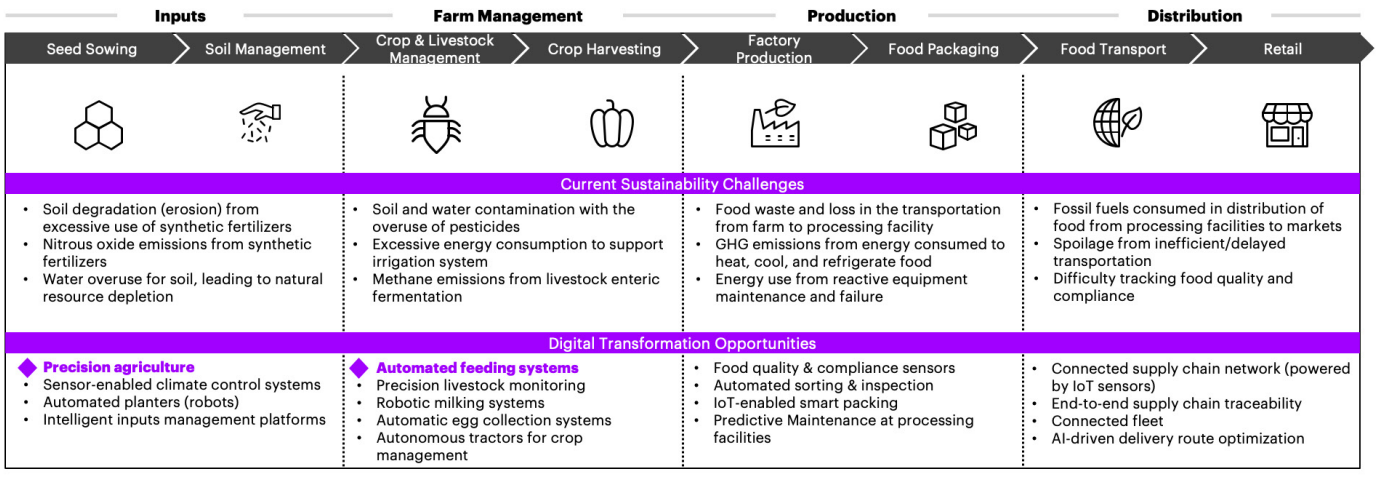
Canada's mining industry is expected to see a surge in global demand for its critical minerals, and mining companies want to meet that demand with sustainability top of mind. Mining operations are often conducted in highly remote locations with challenging topography, with water- and energy-intensive processes operations during extraction, production, and refining. The mining sector is increasingly committed to meeting these challenges, as well as building safer on-site work environments to protect and empower their workforce. Business modernization – enabled by high-speed wireless and wireline networks – is an important lever to do so and can take the form of connected workers and assets, autonomous haulage trucks, and broader enterprise transformation. Connectivity powers new solutions for some of the most critical mining-specific environmental challenges, including management of tailings ponds and fugitive emissions. These, along with the other cutting-edge opportunities, can contribute to a bright future for both the mining industry and Canada.

Agriculture

The global population is projected to increase from 7.6 billion to 9.8 billion by 2050,[90] and with this growth will come an increased demand for Canada's livestock, dairy products, and produce. This requires a rise in agricultural production, putting more pressure on our already fragile ecosystems. Canada's Agriculture sector produced 69 Mt CO_2 eq in 2021, representing approximately 8% of national greenhouse gas emissions. In addition to emissions,[91] chemical use, waste and spoilage are increasingly important for society and the agriculture industry, as 33% of food produced is lost before reaching consumers,[92] losing valuable resources including water and energy.[93] This is further underscored by the food security and affordability challenges Canadians have increasingly felt in recent years, and the importance of driving down the total cost of food production.

Farmers experience unique operational and sustainability challenges today, from the complexities of managing crops and livestock, supply chain visibility and optimization, and labour shortages. The average size of a farm in Canada is 809 acres, and livestock farms often contain large numbers of livestock (e.g., 100+ cows), making it difficult for farmers to manage operations efficiently across large geographies and herd sizes.[94] Farmers have limited visibility on crop and livestock conditions and health, resulting in one-size-fits-all care for crops and animals, reduced yield and increased emissions. Agriculture operations are also heavily reliant on manual labor, and labor shortages are becoming more common with rising demand: 74% of agri-business owners are working more hours to make up for the lack of staff, and 48% of agribusinesses have had to turn down sales or contracts due to labour shortages. In addition, farmers can benefit from increased visibility on product location, time to transport products, and other food distribution information that reduces the risks to food quality. Currently, a large part of this process continues to be manual and paper-based, which is time-consuming, error-prone, and results in higher food waste and greenhouse gas emissions, presenting opportunities to become more digital.[95]

Agriculture sustainability challenges & digital transformation opportunities

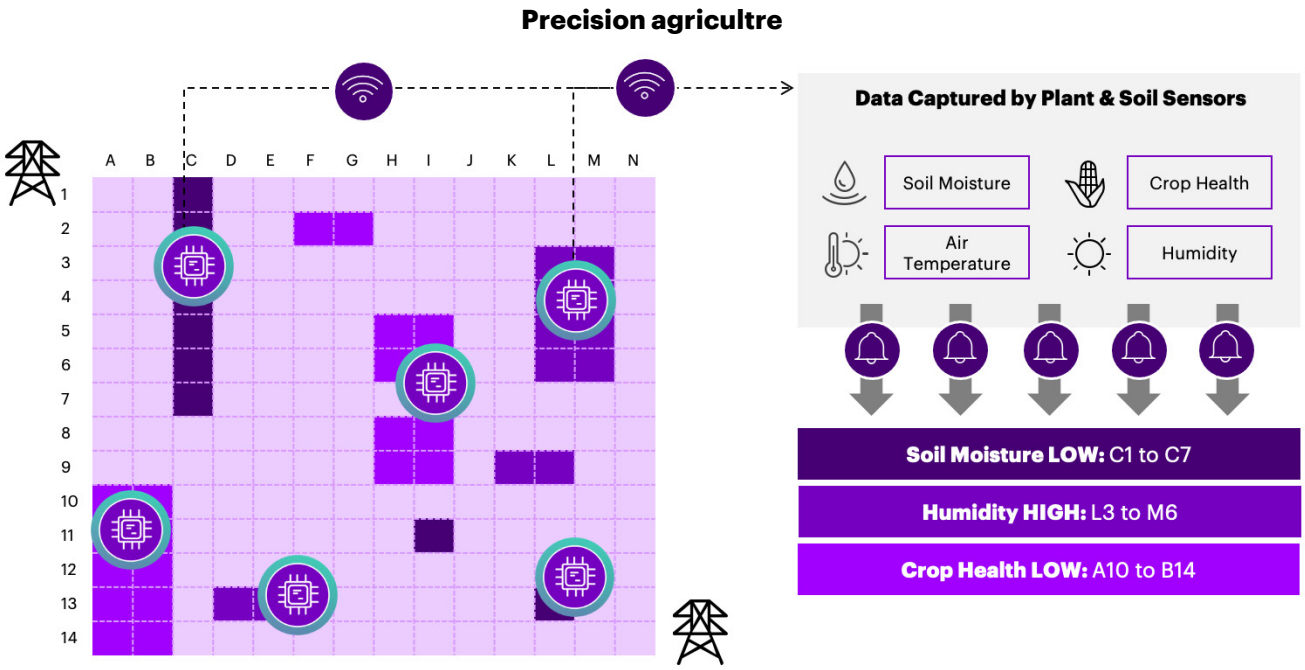


Connectivity-driven digital transformation can help farmers improve their business operations to address both sustainability and operational challenges**. Precision agriculture** through sensors and drones enables remote monitoring of crop health, providing nutrients to fields only when nutrients are needed to maximize yields. Similarly, autonomous planters, harvesters and tractors provide labour support to farmers for crop management with higher accuracy, limiting overuse of natural resources and nutrients. Additionally, developing a **connected supply chain network** through virtual models provides farmers with visibility and transparency on inventory levels and movements, thereby optimizing routes and decreasing food waste. **Automation and robotics systems** can perform many labor-intensive activities including feeding and daily care of livestock. In parallel, **livestock tracking** with the use of sensors and location-based technologies (such as a GPS) can allow farmers to better monitor and control the movements and location of animals. By embracing connectivity-driven digital transformation, farmers can ensure they are equipped to meet the challenges of their industry, while also reducing their environmental impact.

Use case I
Precision agriculture

Historically, farmers have relied on traditional methods for planting, fertilizing, and harvesting crops based on their experience and general knowledge of the land. These methods often result in uneven application of fertilizers, herbicides, and other inputs due to the variances in soil types within one field, which can lead to unnecessary waste, reduced yields, and higher methane emissions. Farmers may also not be aware of pests and diseases in their crops until it is too late to salvage them and require support in being able to monitor their fields to ensure pests do not directly injure plants or transmit bacterial, viral or fungal infections.[96]

Farmers can improve their crop management by placing sensors in the soil or on plants across the field to capture environmental data such as soil moisture, air temperature, and humidity. Every few seconds, the sensors transmit this data to a centralized system that determines which specific soil and crops require what specific quantity of fertilizer and nutrients. Equipped with this technology, farmers can maximize their yield and can spend less time manually monitoring their crops, applying fertilizers and treatments only when needed, reducing unnecessary methane emissions. In addition, these insights help farmers mitigate pest and disease risks, that can otherwise rapidly expand and lead to significant waste. As a result, precision agriculture **can reduce water and fertilizer use by 20% to 40% with no impact on yields**,[97] thus reducing greenhouse gas emissions and water waste.



Capable networks are important for precision agriculture systems to function. At connected farms, hundreds of sensors, spread out over a wide area, need to be able to reliably communicate at once to fine-tune irrigation and fertilization processes, as well as to respond to pests and diseases. Without reliable networks, farmers cannot respond quickly and accurately to the condition of their crops.

Case study

Niolabs powering an autonomous vineyard[98]

Niolabs provides a service that uses data from sensors in the soil in combination with the farmer's observations to autonomously control the vineyard pump and valves, delivering optimal water flow to each vine. The company allows the vineyard to use real-time data that turns a reactive, manual farming operation into a proactive, automated example of precision agriculture. This functionality is powered by connectivity, through a network that allows data to be transmitted between vineyard pumps and sensors in the soil, to ensure precise water flow to each vine. By enabling remote control of routine operations and predictive maintenance, vineyard farmers saw reductions in cost by up to 25%. Furthermore, with this method, nio enables farms to deploy less water, pesticides, and fertilizers, in the right place, and in the precise amount, reducing use by up to 40%.

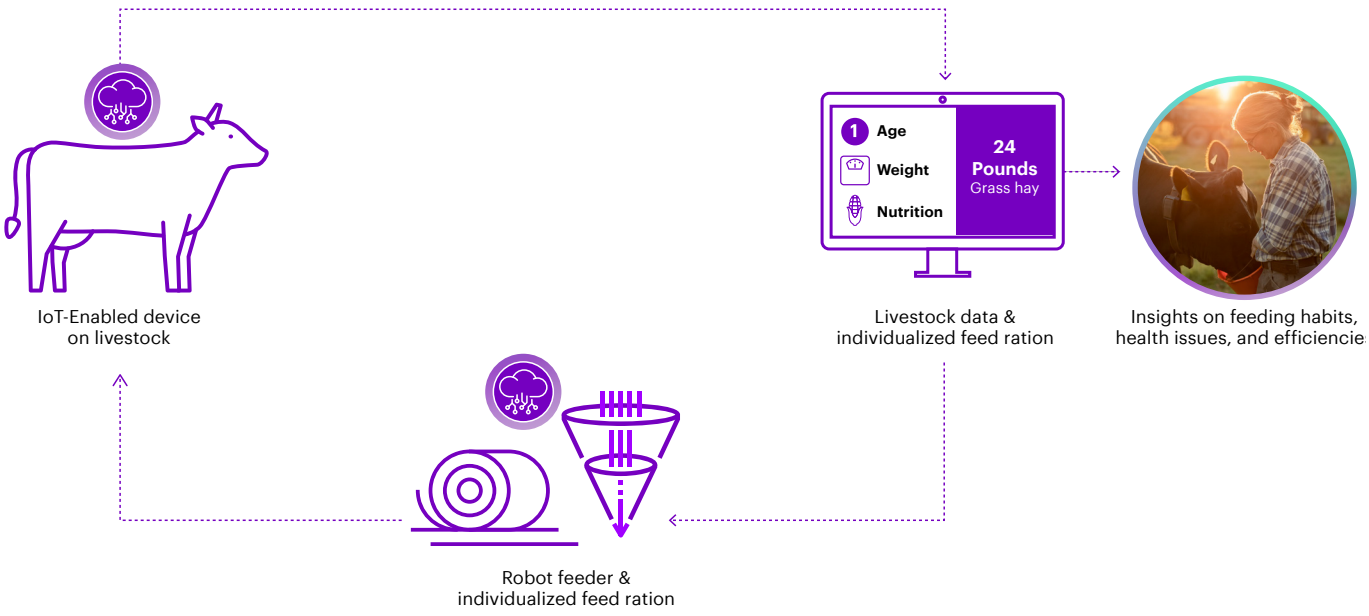
Use case II
Automated livestock feeding systems

Population growth, economic development and urban migration have stimulated unprecedented demand for animal protein, which is projected to increase by up to 70% by 2050.[99] In Canada specifically, animal production has significantly contributed to GDP, generating $5.7 billion in 2021 and exporting primarily to the US.[100] At the same time, livestock emissions – from manure and gastroenteric releases – account for 49% of methane emissions (39% enteric fermentation, 10% manure storage),[101] and these will continue to increase as well with increased demand for protein. Furthermore, an average farm in Canada has a herd size over 150 cattle and calves, and 40% of the total livestock inventory comes from Alberta.[102] This makes it incredibly difficult for a single farmer, or a small group of farmers to manage along with their other poultry and crop management needs effectively.

Traditionally, livestock farming involves raising animals such as cattle, pigs, sheep, and poultry for meat, milk, eggs, and other products. Farmers typically keep their animals in barns or outdoor pastures, where they are fed and cared for by hand. The animals are generally monitored by visual inspection, and their health is assessed by a veterinarian as needed. For example, a lactating dairy cow produces about 400 grams of methane each day.[103] A farmer typically spends at least 2 hours per day feeding, watering, and caring for its livestock, with digestive activities of cattle accounting for more than 3% of Canada's overall greenhouse gas emissions.[104] [105] Applying alternative feeding strategies and additives has helped farmers in reducing the environmental impact of their cattle however, these approaches are only expected to reduce methane emissions by 5% to 20% at most.[106] To generate further impact in reducing emissions, farmers should continue to shift to and apply alternative approaches for feeding and supporting their livestock.

Robots and computerized systems can receive inputs from IoT-enabled devices on livestock to monitor health and nutrition, and deliver feed to animals based on their needs, automatically. The system leverages sensors, wearables, and other connectivity-enabled devices placed on livestock to rapidly collect and process data on feeding routines and individualized feed rations for each animal, based on factors such as age, weight, and nutritional requirements. At the same time, a robot can use data received from the sensors, wearables and devices to move feed into the feeding stations, for the animals to consume it, controlling the amount dispensed at each feeding. With this fully automated system, farmers can obtain valuable insights on their herd's feeding habits and potential health issues, managing them more effectively and reducing dependencies on labour. An automated feeding system can reduce the time farmers spend feeding and monitoring their livestock by 80%.[107] Furthermore, dispensing feed in controlled, **automated amounts allows for 85% more energy efficiencies than traditional chain feeders.**[108]

Automated feeding system



Farms with limited cattle and calves can implement traditional feeding practices to sufficiently manage livestock; however, farms that contain 100+ livestock need an automated system to streamline these operations. Such a system needs to calculate ingredient ratios, track the amount of food being given to each herd, and provide farmers with data on livestock health and performance simultaneously.[109] This system functions effectively with high-speed wireless networks that can transmit data consistently between multiple sensors and the robot with low latency,[110] to assess the health needs of the livestock and provide controlled feeds based on those needs. Enhanced connectivity enables farmers and livestock managers to remotely monitor and control their herds, freeing up the manual efforts required in assessing and delivering feeds to livestock.

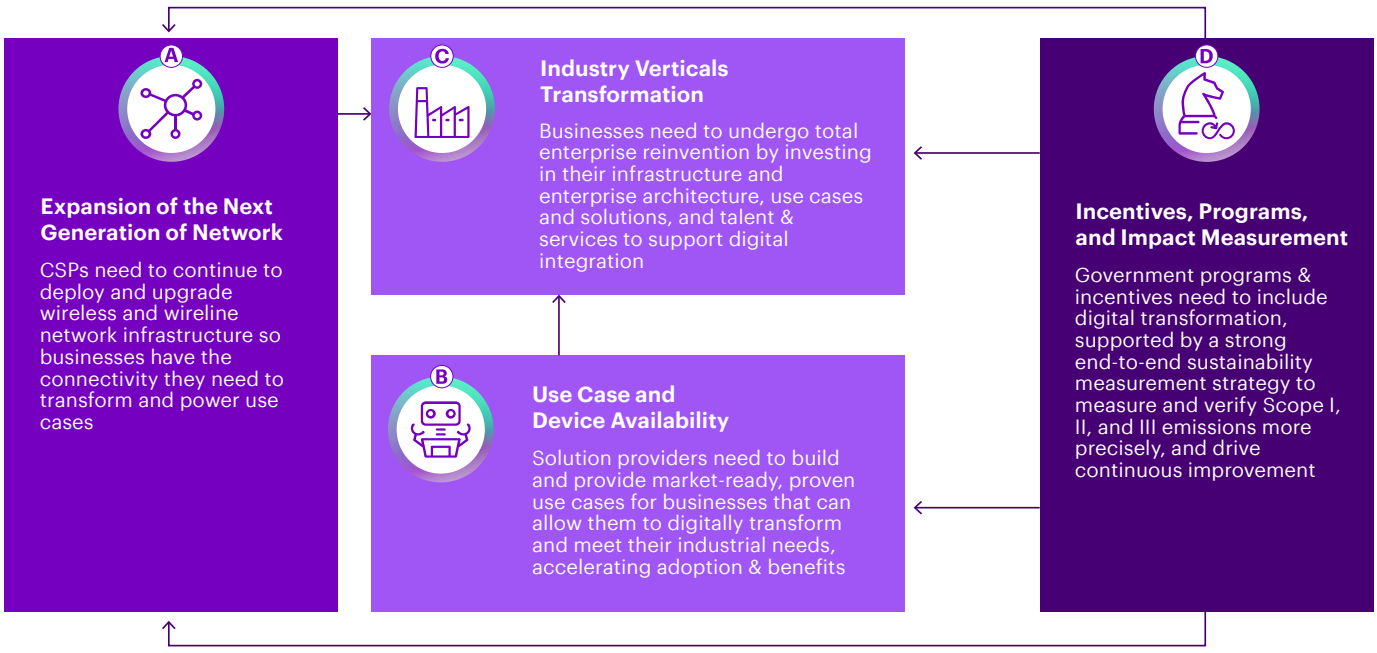
Call to action

To meet rising food demand sustainably, farms need to overcome challenges in crop and livestock management, labour shortages, and supply chain visibility. The future of farming is trending toward increased levels of automation and swarms of connected devices, which can help farmers manage their farm operations more efficiently, while also reducing their environmental impact. With high-speed wireline and wireless networks, farmers can tap into the power of the cloud and edge to contain their costs and energy consumption while unlocking the power of real-time insights and automation. Over time, farms can become increasingly more autonomous, allowing a shift in focus to value-add tasks and scale to support the increased demand in agricultural products. Doing so requires continued investments in networks and connectivity, as well as ongoing innovation to ensure use cases are accessible at a price point that farms can easily adopt.

Adoption challenges & opportunities

The examples we've shown so far illustrate how connectivity-driven digital transformation represents a significant lever in the fight against climate change, and to meet Canada's sustainability ambitions. To realize and accelerate these benefits, however, there are four critical enablers that can play important roles.

Canada's sustainability acceleration levers



Expansion of next generation networks

At its core, successful digital transformation relies on access to reliable wireline and wireless networks. As businesses look to develop new models, offerings, and ways of conducting operations, emerging technology will be at the core, along with advanced network and connectivity to support the transformation. CSPs realize this growing demand and are actively investing in expanding and enhancing networks – in 2021, CSP investments in wireless and wireline increased by 16% and 11% respectively, compared to 2020.[111]

However, realizing the benefits of digital transformation will require continuing investment in network expansion and enhancement. Many businesses in highly remote areas need access to network capabilities beyond what they have today. Even in communities with good connectivity, investment in improving and upgrading existing networks will be necessary to support more advanced data-intensive use cases and their associated sustainability benefits.

This is a weighty challenge: Canada has the second-largest land area of all nations, and much of that geography is sparsely populated.[112] This makes network infrastructure extremely difficult and expensive to deploy, and equally challenging to maintain.

Despite these challenges, CSPs, in large part due to a regulatory environment that recognizes that investors should be able to gain a reasonable rate of return on investment, have invested billions of dollars to build and operate world-class telecommunications networks. The need for CSPs to continue investing in the development and deployment of networks across the nation requires a similar regulatory approach. The payoff, in terms of benefit to Canada's economy (and allowing industry verticals to become more efficient and sustainable) is well worth it.

Use case & device availability

Even with the right networks in place, many of the benefits of digital transformation can't be fully captured without market-ready, proven use cases businesses can deploy.

While many of the devices that businesses need to digitally transform are available today, gaps still exist in the market to meet industrial needs. For example, in many settings, including oil and gas refining or chemical manufacturing, the threat of explosions limits the use of common everyday devices like cell phones or tablets that can produce sparks. To bring the benefits of connectivity to the core operations of these industry verticals while remaining compliant with Occupational Health and Safety Regulations standards, new intrinsically safe devices need to be developed and brought to market.[113]

In addition, many forms of digital transformation require deploying and integrating a complex mix of software and services on top of the devices themselves. For more businesses to be able to adopt these use cases and become more sustainable, ecosystem collaboration and innovation will be critical. Solution providers need to continue to bring together all elements of these solutions and innovate on price to accelerate their adoption and benefits.

Industry verticals transformation

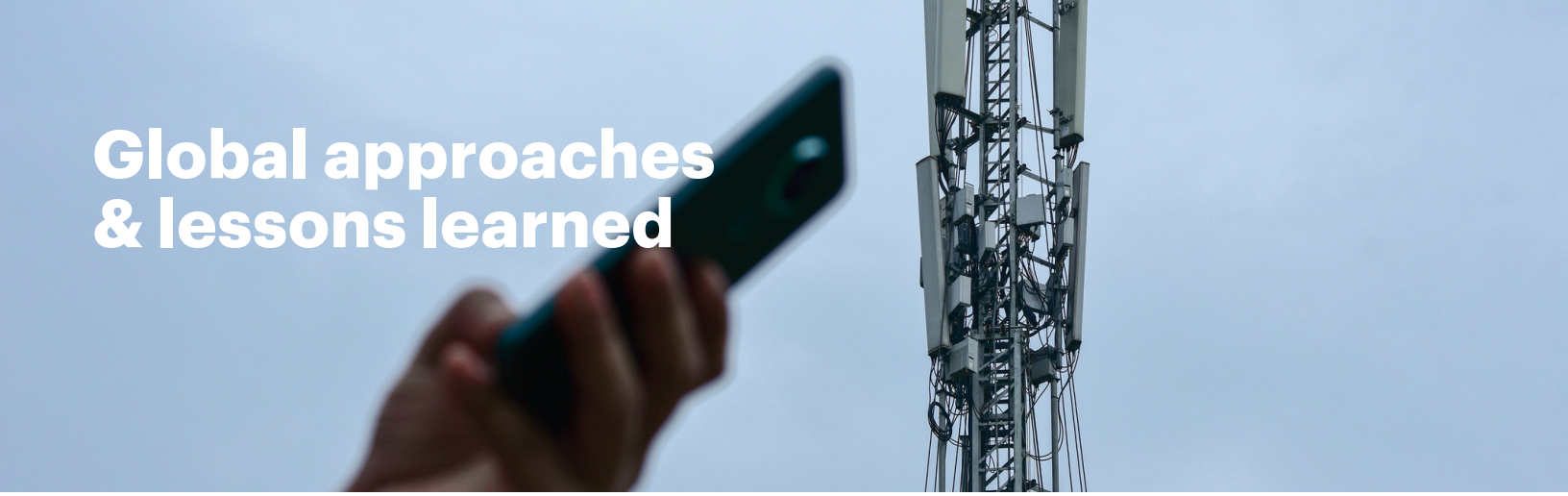
To modernize and become more sustainable, businesses need to embrace total enterprise reinvention, building a strong digital core as well as integrating the next generation of emerging solutions and use cases. This requires businesses to invest across several fronts – their own infrastructure and enterprise architecture as a critical foundation to diffuse data across the business, the use cases and solutions that directly enable the digital transformation, and the right talent and services to facilitate technology integration and digital transition. These investments require businesses and investors alike to be diligent and consider long-term value creation and ESG benefits when prioritizing the deployment of capital.

As industry verticals transform, the role of workers will further change, and organizations need to ensure they're hiring, developing, and retaining the specialized skillsets needed for tomorrow, such as the engineering skills required to maximize value from generative AI models.

Incentives, programs & impact measurement

Current government programs and incentives available to businesses have focused narrowly on clean technology investments and renewables. These funding sources often do not extend to the types of digital transformation discussed in this paper, despite the potential for substantial sustainability benefits. Canada must expand its approach to addressing environmental challenges, and in doing so make it easier for industry verticals to become more sustainable.

This has the potential to be even more effective with a strong end-to-end measurement strategy. Currently, many programs rely on businesses self-reporting, which is prone to variability and limits the ability to drive continuous improvement and informed investment decisions. In the future, being able to measure and verify Scope I, II, and III emissions more precisely, will allow both government and industry to focus on the specific types of digital transformation that have the largest impact, as well as drive further innovation, accountability, and action.



Global approaches & lessons learned

Several nations are crediting digital transformation as an accelerator of sustainability objectives and focusing investments on digital infrastructure and next-generation use cases to drive larger impact. Canada has an opportunity to learn from these governments, alliances, and companies and seek inspiration on how to encourage business modernization to drive sustainability outcomes.

Below we highlight global examples on the growth of investment in digital transformation for sustainability benefits:

EU - 5G Public Private Partnership (PPP)[114]

The 5G Public Private Partnership is a joint initiative between 5+ European governments and the telecommunications industry (including Nokia, Orange, Vodafone, Deutsche Telekom, and others). The European Union has committed to providing €700 million for this partnership, specifically for the development of network infrastructure, cloud computing, and the Internet of Things (IoT), as well as innovative applications and services that can leverage the capabilities of 5G networks. In parallel, the private sector has invested €3.5 billion in 5G research and innovation to support this. Some initiatives that have launched because of this partnership include:

- **Factories of the future:** This initiative aims to strengthen the competitiveness of the manufacturing industry by increasing the technological advancements of enterprises through the development and integration of innovative 5G technologies.
- **Energy-efficient buildings:** The initiative supports the construction sector by exploring innovative methods and technologies such as energy-efficient systems and materials for new buildings, to drastically reduce the energy consumption and carbon emissions of buildings.
- **Green vehicle:** The aim of the initiative is to promote research and development of key technologies that promote circularity and safety in transport planning.

The 5G PPP is playing a crucial role in Europe's journey towards a greener future by promoting digital transformation initiatives that rely heavily on the development and deployment of 5G networks. Rapid expansion of these networks has contributed to the formation of large-scale 5G ecosystems for the first time,[115] ultimately transforming businesses and society at large and creating a pathway to a digital and green economy for Europe. The success of this transition is attributed to the collaborative efforts of the participating nations' governments, telecommunications companies, and businesses across all spans of industry verticals, with a shared, common purpose and goal – to reduce the environmental impacts of climate change.

Canada has an opportunity to follow in Europe's footsteps and accelerate its own sustainability objectives by embracing a similar approach. By promoting investments in large-scale deployment of 5G networks and digital solutions, Canada can accelerate the path towards a more sustainable future. This will require collaboration between the federal and provincial governments, and the telecommunications industry to diffuse high-speed networks, and the use cases and digital solutions that these networks enable across the nation.

South Korea smart city ecosystem program[116]

The South Korean government is investing approximately $20 billion in its smart city ecosystem development. This investment has allowed federal and local governments to partner with ICT providers to establish smart city pilot projects in Seoul, Busan, Incheon, and Daejeon, focusing on transportation, energy management, public safety, and healthcare. The government has launched innovation incubators to have corporations develop and test new technologies and services, before scaling them for broader deployment across pilot cities. These incubators have resulted in the creation of smart electricity and water grids, smart waste management systems, and a smart city integrated platform – each driving unique sustainability benefits for urban centers.

For instance, Busan is using sensors and a smart water management system to conduct real-time monitoring of water pressure, temperature, quality, and consumption across the entire water management cycle (from rainfall capture to wastewater treatment and reuse). Busan is leveraging these insights to improve water quality and reusability, to become Korea's first water-specialized city with a goal of recycling 100% of the water used.[117]

South Korea's approach to the smart city ecosystem centres around 5G and the groundbreaking use cases it enables. More importantly, the South Korean government has developed a robust five-year roadmap, to unify and align the public and private sectors on their roles in achieving the vision of the program. Along each stage of the roadmap, the government plays a critical role in enabling smart city innovation, supporting technological and capacity development in relevant sectors, and nurturing the ecosystem through improved regulations, support for start-ups and cooperative governance. As a result, South Korea has succeeded in the rise of smart cities across the entire nation, accelerating its sustainability benefits.

South Korea's program is one of the most successful smart city programs in the world, providing inspiration and learnings for Canada. The success of this program is attributable to highly coordinated efforts and alignment amongst stakeholders across multiple industry verticals. Canada can learn from this example, even beyond smart cities efforts, as digital transformation of national scale will require extensive collaboration within and across verticals. Furthermore, the South Korean program has shown the importance of public and private sector alignment, and the value in working together on, and jointly investing in sustainability solutions.

Conclusion

To meet the challenges of our time, Canada needs to look beyond just renewables and alternative energy and embrace the role industrial transformation can play as part of a more sustainable future.

Canadian businesses, particularly in high-emitting sectors, have a significant opportunity to further modernize their current operations with the power of connectivity. Whether in the form of deploying connected devices in the field, or through enterprise-wide shifts like the move to cloud, these changes grow output, drive down wasted effort, and shrink fuel and energy consumption.

In doing so, we can move closer towards our environmental commitments, meaningfully decreasing greenhouse gas emissions as well as resource waste. At the same time, we become more competitive on a global stage, and create more sustainable, reliable workplaces for employees.

This transformation in how Canadian businesses operate is already underway, though meeting the full magnitude of our sustainability goals requires broader change. Doing so requires ensuring we continue to invest in the high-quality network infrastructure needed for the use cases of tomorrow, supporting a healthy device and use case ecosystem, developing the right talent and skills, considering the appropriate incentives and programs to spur investment in the private sector, as well as effective impact measurement.

Canada's future is bright and depends on modernization – governments, CSPs, and industry verticals can work together to use the power of connectivity in pivoting Canada to a more sustainable nation.

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