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MEMORANDUM TO THE DEPUTY MINISTER

FIFTH GENERATION (5G) WIRELESS TECHNOLOGY
OPPORTUNITIES, CHALLENGES AND RISKS FOR CANADA'S ELECTRICITY SECTOR

(For Information)

SUMMARY

- Fifth generation (5G) wireless technology will play an important role in transforming the electricity sector across the entire value chain—from generation and transmission to distribution and consumer use. 5G has the potential to make the electricity grid more intelligent and transform utilities into more safe, efficient and reliable operations.

- 5G technology may also play a significant role in decarbonizing energy. The speed, capacity and connectivity of 5G will provide many opportunities to protect and preserve the environment, including potentially increasing energy efficiency, reducing GHG emissions and enabling more use of renewable and distributed energy resources.

- Achieving the promise of 5G will not come without challenges. While 5G technology presents opportunities for the electricity sector and end users alike—electric utilities will face a number of risks and challenges such as cyber security and supply chain, financial, regulatory and technological—as they set out to adopt and deploy 5G across the electricity value chain.

- Attachment 1, a research paper *"5G Wireless Technology: Opportunities, Challenges and Risks for Canada's Electricity Sector"*, provides an overview of 5G wireless technology, including how it will transform the electricity sector.

- The paper presents NRCan's and the Canadian Electricity Association's (CEA) analysis and perspectives of the opportunities as well as the challenges utilities and manufacturers and suppliers of materials, technology, and services to the electricity sector will face when deploying 5G technologies. Potential actions the Government may consider exploring to help the electricity sector in overcoming security risks, and regulatory and technological barriers when deploying 5G technologies are also outlined.

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Assistant Deputy Minister, Low Carbon Energy Sector

Attachment: (1) - 5G Wireless Technology: Opportunities, Challenges and Risks for Canada's Electricity Sector

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FIFTH GENERATION (5G) WIRELESS TECHNOLOGY
OPPORTUNITIES, CHALLENGES AND RISKS FOR CANADA'S ELECTRICITY SECTOR

Abstract: This paper provides an overview of fifth generation (5G) wireless technology, including how it will transform the electricity sector across the entire value chain by exploring some of the potential use cases for 5G. This paper represents NRCan's and the Canadian Electricity Association's (CEA) analysis and perspectives of the opportunities and challenges utilities, manufacturers and suppliers of materials, technology, and services to the electricity sector will face when considering which 5G technologies to adopt and deploy. Potential actions the Government may consider exploring to help the sector in overcoming security risks, and regulatory and technological barriers when deploying 5G technologies are also outlined.

INTRODUCTION

- **Protecting the critical systems and infrastructure** Canadians rely on every day, including **Canada's telecommunications systems**, is a priority for the Government of Canada.

- Over the past decade, **cyber security has emerged as a crucial dimension of Canada's national security policy making**. Its importance will only increase in an evolving telecommunications environment as Canada continues the transition to **fifth generation (5G) infrastructure.**

- Wireless networks are the modern infrastructure on which the global data driven economy is built. The **global telecommunications sector is undergoing a transition** from 4G wireless technology to 5G.

    - In a globalized world, the deployment of **5G telecommunications** standards and technologies is essential to **Canada's economic competitiveness** and will help ensure Canadians continue to benefit from cutting-edge technology, enabled by world class wireless infrastructure.

    - 5G networks will operate at significantly **higher speeds** and will provide **greater versatility**, **capability** and **capacity** than previous generations. As a result, **5G networks will become a crucial component of Canada's critical infrastructure**.

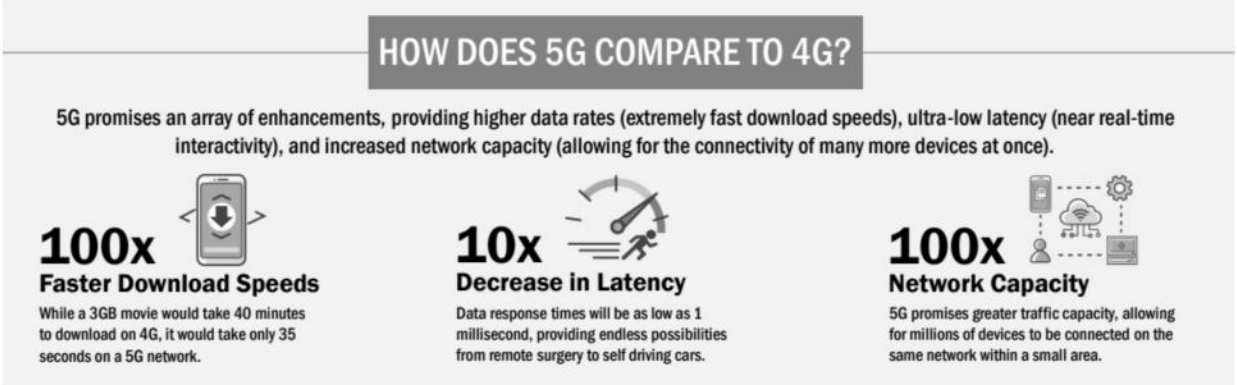

Figure 1.
Evolution of 5G

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- The **5G transition will take years**, but the goal is to **meet increasing data and communication requirements**, including capacity for **tens of billions of connected devices** that will make up the **Internet of Things** (IoT), ultra-low latency required for critical near-real time communications, and faster speeds to **support new and emerging technologies**. These connections will make the world of **"smart everything"** a reality and empower a vast array of new and enhanced critical services, from **autonomous vehicles** and **smart homes**, to **telemedicine** and **robotic surgery**, to **automated manufacturing** and **agricultural drones** to **smart grids**.

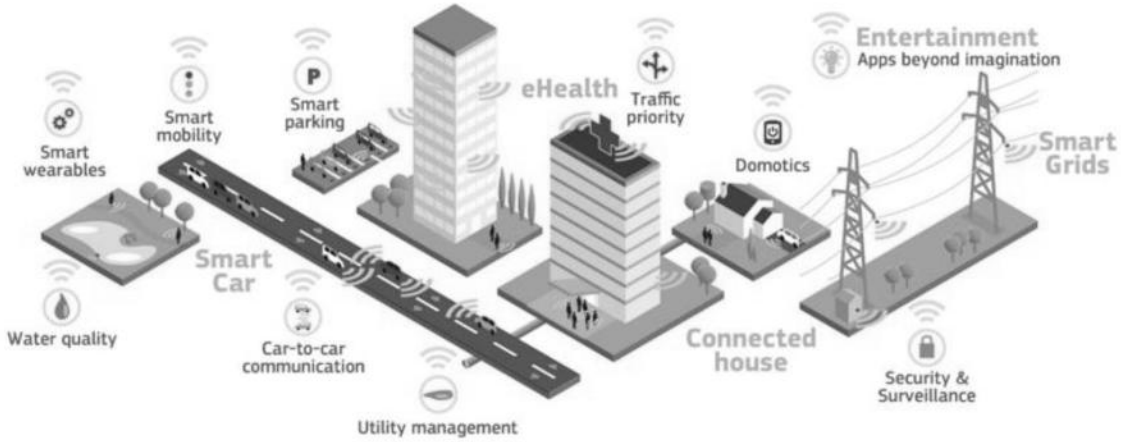

Figure 2.
5G Smart City

- Enhancing 5G connectivity could lead to substantial **economic**, **environmental** and **social benefits**.
  - A **2018 Accenture report** found that the adoption of 5G technology in Canada will spur innovation and investment across industries and significantly improve Canadians' quality of life and **increase Canada's GDP by nearly $40 billion by 2026**.
  - However, the Organisation for Economic Co-operation and Development notes, the extent of the benefits resulting from 5G technology will **depend on how quickly it is deployed and adopted**, as well as the **ability of the regulatory environment to adapt**.
  - 5G technology may also play a significant role in **decarbonizing energy**. The speed, capacity and connectivity of 5G will provide many opportunities to protect and preserve the environment, including potentially **increasing energy efficiency, reducing GHG emissions and enabling more use of renewable energy**.
- The **rollout of 5G in Canada gradually began in 2020**. There are currently three 5G service providers in Canada: **Rogers Wireless, Bell Mobility and Telus Mobility**. All three major telecommunications companies will use European suppliers—Ericsson and Nokia—for their 5G networks. The full implementation of 5G in Canada's federally-regulated wireless telecommunications sector will take several years beginning with the Government's 5G spectrum auction in 2021.

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GOVERNMENT OF CANADA 5G EXAMINATION AND HUAWEI IN 5G

- The **Government mitigates cyber security risks in telecommunications systems** in close collaboration with industry partners. Since 2013, the **Canadian Security Review Program** has worked to **mitigate the cyber security risks** stemming from designated equipment and services, including Huawei Technologies Co., Ltd (Huawei) in **3G/4G and LTE networks**.

- As the **telecommunications sector deploys 5G wireless technology**, these partnerships with industry will play an important role in **securing Canada's 5G systems**.

- A number of Canada's allies, including all its partners in the **Five Eyes** (FVEY) intelligence-sharing alliance, have **banned Huawei from supplying equipment to 5G networks** over fears it could use its access to spy for the Chinese government.

- The **Government is conducting an examination of emerging 5G technology** and the associated economic opportunities and security risks. Particular consideration is being afforded to the **foreign relations, economic, national security, and technical implications**.

- The **Government will continue to work with telecommunications service providers and vendors to mitigate security risks** in current and future networks as 5G technology is adopted by Canadians and businesses.

OPPORTUNITIES

- **5G technology** will play an important role in **transforming the electricity sector across the entire value chain**—from generation and transmission to distribution and consumer use. 5G has the potential to make the **electricity grid more intelligent and transform utilities into more safe, efficient and reliable operations**.

- The combination of 5G and digitalization through IoT devices will lead to **improved revenue models and customer satisfaction**. 5G will enable **utilities to allocate and distribute energy more efficiently** and help **customers monitor their own energy usage** and **conserve energy**.

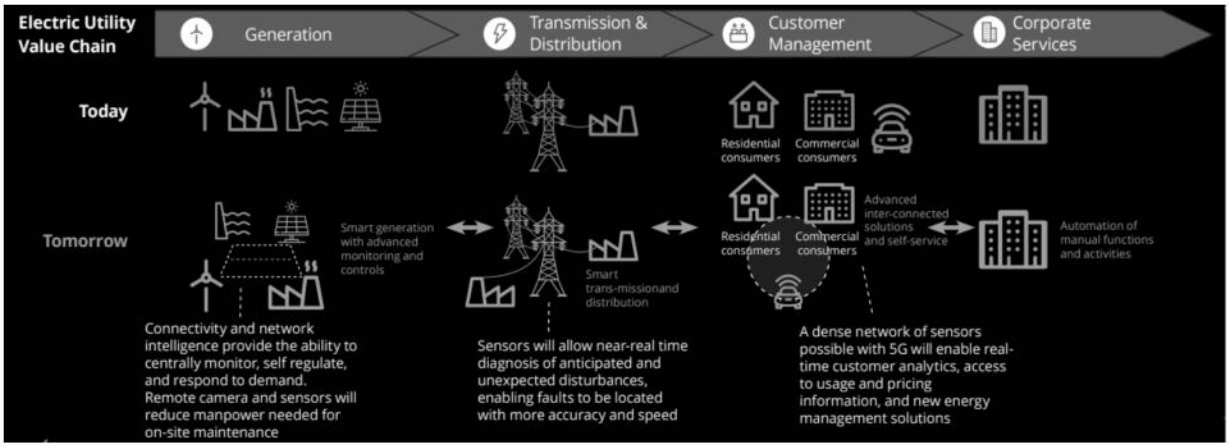

Figure 3.
5G Electricity Sector Use Cases

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- Predominantly, 5G and digitalization will generate new use cases within the electricity sector. Some key **5G use cases** include:

1. **Smart Everything: Smart grids, homes, cities and metering** – 5G can enable the next wave of smart grids and energy efficiency. The promise of smart grids, smarter homes and cities, and smart metering stands to deliver tremendous benefits to electricity producers, consumers and the environment. This can be achieved through the following applications:

   A. **Smart meters for monitoring energy assets and more efficient power generation** – Through smart meters and sensors, power generation can achieve more stability, allowing for more reliable electricity production. **Benefits of smart meters for the producer includes**:

      - **Assisting service suppliers** by remotely monitoring the health and readiness of equipment (e.g., on a wind farm they can monitor wind conditions, rotating speed, temperatures, power output etc.);

      - **Controlling and operating the equipment remotely** through sensors, actuators and IoT devices; and

      - Immediately detecting if something is wrong to **avoid unnecessary outages**, and manage large-scale fleets, comparing different power areas to analyse data and make adjustments accordingly.

   B. **Smart meters for monitoring energy consumption** – Just as 5G will enhance utilities' ability to monitor their assets, 5G will also help **customers monitor their energy usage and conserve energy**. Homeowners can access smart meters from their smartphones to monitor their daily energy usage. This helps make consumers more conscious of their energy consumption and more aware of how costs are broken down based on kilowatt hours.

   C. **Improved energy distribution within a smart grid** – Grid modernization coupled with 5G and self-correcting machine learning technology will give **utilities greater insights on predicting peak demand periods** so that they can make quick adjustments that yield more efficient power distribution.

   D. **Distributed energy resources –** As use of renewable resources continues to grow, consumers and enterprises are becoming small electricity producers who can share their excess energy with the grid. This is not a new concept, however **utilities can create a distributed energy grid**, capitalizing on smart grid capabilities that will make it easier to control bi-directional power flows, and monitor, control and support distributed energy resources such as solar and wind.

2. **Remote operations and real-time monitoring of assets and equipment** – 5G technology is expected to connect a massive number of embedded sensors, allowing users to control, support, and monitor equipment with a high density of units in urban areas and remote locations. Doing so will **provide utilities with continuous information on environmental parameters and allowing them to fine-tune the conditions to boost productivity**.

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A. For example, 5G coupled with artificial intelligence (AI) algorithms will enable utilities to **use drones that can transmit high-definition videos and images in real time to detect anomalies** along their remote production and transmission assets. It generally takes years for a utility company to survey its entire territory, however with improved drone technology, the drone can capture 360-degree images of the area for further assessment.

B. Similarly, as the majority of assets are maintained manually through thousands of trained technicians, 5G technology can digitally enabled technicians with augmented reality (AR) and virtual reality (VR) solutions. **AR/VR solutions will allow the technician to seek expert guidance remotely and remedy issues quickly** thereby reducing cost to train technicians and inspect sites.

   - A fully digitized field workforce environment, complete with connected sensors, AI and AR/VR solutions, can substantially **increase a utility's efficiency while lowering costs**.

   - **Remote operations will improve both grid uptime and worker health and safety**. It will also allow utilities to cut corrective maintenance costs substantially by using alarms that signal when parts of the system become overloaded. Such real-time data will enable utilities to **make better investment decisions** about **equipment maintenance** and **replacement**.

RISKS AND CHALLENGES

- While the deployment of 5G technology presents opportunities for the electricity sector and end users alike, there are **several risks governments and utilities must consider** stemming from **cyber security and supply chain** risks**, and financial, regulatory** and **technological** challenges.

<u>Cyber Security and Supply Chain Risks</u>

- **Cyber attacks have risen in frequency and magnitude**, increasing the vulnerability of the critical infrastructure that Canadians rely on every day. A successful attack can have devastating impacts and **significant consequences for the economy, national security and public safety**.

- **Energy systems** are more **connected** and **digitalized** than ever before and cyber criminals are taking advantage of security gaps to compromise these systems. In fact, a 2017 Statistics Canada *Cyber Security and Cybercrime in Canada* survey revealed that energy is among the highest targeted sectors.

- The **electricity sector is a target for adversaries** seeking to exploit **information technology** (IT), **operations technology** (OT), including **industrial control systems** (ICS), and **supply chains** (i.e., components, vendors, equipment and networks) for a variety of purposes.

  - The **electricity grid's reliability can be impaired** by cyber attacks on the **IT systems** that support its operations. **Cyber attacks on OT, including ICS** could also have **kinetic impacts** resulting in **widespread power outages** and **physical damage to electricity infrastructure**.

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- **OT and IT systems rely on hardware devices and software systems**, procured from a variety of manufacturers and vendors, often from international sources. Compromised components have the potential to affect the connectivity and security of transmitted data and information.

- Threat actors are becoming increasingly capable of carrying out attacks on the grid. At the same time, the **power grid is becoming more vulnerable to cyber attacks and supply chain compromises.** While the deployment of 5G presents opportunities for the electricity sector and end users alike, there are several security risks electricity utilities must consider, such as **increased attack surface**, **5G supply chain compromises,** and **network security** which malicious actors can exploit.

  1. **Larger attack surface:** 5G networks will enable the expansion for **billions of IoT devices**, supporting the advancement of smart grids and cities. While these innovations provide a wealth of new capabilities, they also **introduce the potential for increased attack vectors for malicious actors to exploit, as well as cascading consequences from successful cyber attacks**.

     - In 2018, **university researchers used large, real-world grid models to simulate** the feasibility and **impact on the grid of a coordinated cyber attack on smart home appliances**. The researchers found that malicious threat actors could compromise a large number of high-wattage IoT devices (e.g., air conditioners and heaters) and turn them into a botnet—a network of devices infected with malicious software and controlled as a group without the owners' knowledge. The malicious actors could then use the botnet to launch a coordinated attack aimed at **manipulating demand across distribution grids potentially disrupting the balance of power generation and consumption and ultimately causing a power outage**.

  2. **Supply chain:** The 5G supply chain is susceptible to the **malicious or unintentional introduction of risks such as malicious software and hardware, counterfeit components, and poor designs, manufacturing processes, and maintenance procedures**. This is because utilities rely on extensive networks of suppliers to support critical enterprise capabilities through the purchase of equipment, information, hardware, software, and services across the globe.

     - As supply chains are growing more complex, it is increasingly becoming more difficult to ensure the integrity, security, and resilience of the products and services deployed within energy systems. 5G technology is no exception to this trend.

  3. **Network security:** 5G will offer security improvements through new secure designs and features, however; it is likely that 5G equipment will also contain unidentified vulnerabilities, introducing weaknesses into energy systems. Additionally, while the design of 5G is more secure, 5G's specifications and protocols stem from previous networks that **contain legacy vulnerabilities**. Some of these legacy vulnerabilities, whether accidental or maliciously inserted by untrusted suppliers, **may affect 5G equipment and networks** despite the integration of additional security enhancements.

- The **Canadian Electricity Association** (CEA) noted that industry had echoed concerns related to the cyber security and supply chain risks noted above, particularly:

  - **Risk of foreign direct investment in 5G technology**, both internationally and domestically.

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- **Impacts of highly proprietary products on supply chains**, such as foreign technology embedded in technologies then branded by more reputable suppliers; being dependent on and unable to switch from a technology during times of economic or political instability; and risks not mitigated by data encryption.

- **Risks throughout the breadth of 5G infrastructure** (e.g., undersea cabling and landings).

Investments

- Another challenge utilities must consider is the investment required for establishing the infrastructure for the 5G use cases identified above. **Investment issues** are related to **reskilling or finding relevant workers** needed for adopting, deploying and securing 5G technology in the electricity sector.

    - Globally, there is a **cyber security workforce skills gap**. The shortage of skilled, qualified and trained cyber security professionals is estimated to reach upwards of 4 million unfilled positions globally by 2021. Additionally, as with any emerging technology, there is a **lack of workers with a clear understanding of 5G standards and knowledge of 5G related technologies** such as software defined networks and virtualization. This requires further investment in reskilling or hiring the relevant workers.

    - **Cost is a key criterion for use case selection in the electricity sector**. Utilities must consider the **significant investment required for establishing the infrastructure for their 5G use cases**. Selecting and prioritizing these use cases to deliver the desired Return on Investment will be a key factor in an organizations' decision regarding which use cases to invest in.

- The **CEA noted** that an area of concern for many providers will be **balancing existing and future Government guidance and direction around 5G risks** with the **need to make planning and investment decisions** years in advance.

CEA PERSPECTIVES – REGULATORY AND TECHNOLOGICAL CHALLENGES

- In addition to the multidimensional security threat landscape 5G networks will create, the **CEA noted** that both industry and the Government will need to **navigate new regulatory grounds**.

- As **industries across all sectors adopt and offer 5G-related technologies**, new strategies for new technologies will be required. **Regulatory changes will be necessary to adapt existing frameworks** for applications that were previously unanticipated. Additionally, **ensuring that jurisdictional authority is effectively defined and allocated within and across governments** will avoid redundancy and obscured lines of communication, and enable 5G technologies to reach their full potential.

- Specifically, the **CEA noted** the following **regulatory and technological challenges** the **electricity sector is encountering in the telecommunications space**[1]:

[1] It is important to note that the CEA's proposed actions around regulatory and policy reform in the telecommunications sector are directed at, and fall under the purview of Innovation, Science and Economic Development Canada (ISED) and the Canadian Radio-Television and Telecommunications Commission (CRTC).

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1. **Regulatory changes to allow utilities to operate a Private Virtual Network Operator (PVNO)[2]** – In Canada, the **regulatory licenses to route data wirelessly** (a Mobile Network Code or MNC) are only available to consumer wireless providers such as Rogers, Bell and Telus. If the electricity sector is to capture the full benefits of 5G, while minimizing cyber security risks, they will have to use their own data routing systems. The **Canadian Radio-Television and Telecommunications Commission** (CRTC) **is currently deliberating CEA's request for an expansion of eligibility for the data routing licenses to include the electricity sector**. PVNO would be operated over standard wireless networks by companies that work across a large geographic distribution, and enable significant cyber security standards while communicating critical information across that distributed area (i.e., the electricity and rail sectors).

2. **Closing the broadband technological gap –** CEA members are enthusiastic partners for closing the broadband gap and are active contributors to CRTC consultations on the matter. The CEA is concerned about recommendations that went to Government in January 2020 calling for the CRTC to assume regulatory control over electrical poles to accelerate deployment of 5G[3]. CEA views **the CRTC as an improper regulator for the electricity sector as their mandate does not include the safe, reliable, and affordable delivery of electricity.** The provincial regulators that already oversee this space ensure the best operation of Canada's existing grid and should not be disempowered.

3. **Economic regulation – The development and deployment of innovative technologies tend not to be incentivized, and can even be restricted, by provincial and territorial regulatory commissions.** This is a barrier to emerging technologies, including 5G-enabled smart grid applications. The Government should explore mechanisms to assist provinces and territories to incentivize and permit these investments by electric utilities, and this support should also be extended to grid modernization initiatives more generally.

4. **Spectrum licensing[4] –** Canadian industry, not just CEA members, needs an Industrial Internet of Things (IIoT) strategy. To date, federal spectrum allocations are focusing 5G spectrum on the consumer market. As such, **industry may be forced to use 5G networks owned by others**. Just

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[2] On October 30, 2018, the CEA, on behalf of its members requested the CRTC enact regulatory changes to allow Canadian electric utilities to operate a Private Virtual Network Operator (PVNO). A PVNO is an extension of Mobile Virtual Network Operator (MVNO) architecture. A PVNO therefore implements services for private enterprise use only and does not offer services to public users. In its request to the CRTC, the CEA noted that regulatory changes to permit a PVNO will allow utilities to provide better, more reliable and secure electricity services to Canadians by enabling significant innovation in the electricity market and electrification of the Canadian economy.

[3] In June 2018, the Broadcasting and Telecommunications Legislative Review Panel (Panel) was tasked by the Minister of Innovation, Science and Industry and the Minister of Canadian Heritage to review Canada's decades-old communications legislative framework, including the *Broadcasting Act*, the *Telecommunications Act* and the *Radiocommunication Act*. On January 29, 2020, the Panel submitted its final Report—*Canada's Communication Future: Time to Act*—with recommendations on modernizing the legislation governing Canada's communications sector. This is the first time that the three statutes were reviewed together in a comprehensive and integrated fashion.

[4] The term *radio spectrum* typically refers to the full frequency range from 3 kilohertz (kHz) to 300 gigahertz (GHz) that may be used for wireless communication. The Minister of Innovation, Science and Industry is responsible for spectrum management under the *Radiocommunication Act*. Spectrum management is the process of regulating the use of radio frequencies to promote efficient use and meet requirements for sovereignty, security and public safety. ISED has established rules and policies that wireless carriers must follow as conditions of licence for holding spectrum. As part of ISED's spectrum management responsibilities, it regularly holds public auctions for licences to operate in different bands of spectrum. An auction for the 3,500 megahertz (MHz) band that will be critical as 5G networks begin to roll out will begin on June 15, 2021.

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as a renter may not be able to modify their land to suit their needs, a network owned by another company may not be customizable to the degree industry needs. This challenge can be **overcome with local licensing for some pieces of 5G spectrum and other pro-industry considerations**. Localized spectrum is important for electrical utilities so that they can operate unique/customized wireless networks at their critical operations, such as hydro dams or nuclear facilities.

POTENTIAL ACTIONS

- The following are **potential actions the Government may consider examining**, which address both cyber security and supply chain risks and telecommunications policy and regulations, to **assist the electricity sector facilitate secure deployment and commercialization of 5G technologies**.

Cyber Security and Supply Chain Risks

- The **Government has already invested close to $1 billion to build Canada's cyber security defenses** and better protect Canadians from cybercrime, respond to evolving threats and help support critical infrastructure owners and operators defend their cyber systems.

- Cyber threats are large and growing – putting Canadians at risk. **5G networks will not be exempt from cyber threats and vulnerabilities,** and may even introduce more vulnerabilities than its predecessors. Mitigating these vulnerabilities will require governments and industry to work collaboratively.

- **NRCan is making cyber security a priority**, and in collaboration with domestic and international partners, is contributing to the whole-of-government efforts to **strengthen the cyber security and resilience** of the energy sector, including electricity.

- The **Government may consider** exploring the **following potential actions** to help ensure the **secure deployment and use of 5G wireless technology** in the electricity sector:

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Telecommunications Policy and Regulations

- The CEA noted the **electricity sector is encountering regulatory and technological challenges in the telecommunications space** and **proposes** that**:**

1. The **CRTC expand eligibility for the data routing licenses** to include the electricity sector.

2. **Provincial regulators**, and not the CRTC, **retain regulatory control over electrical poles** to ensure the best operation of Canada's electrical grid.

3. The **Government explore mechanisms to assist provinces and territories to incentivize the development and deployment of 5G technologies** and **permit investments** by electric utilities, and this support should also be **extended to grid modernization initiatives more generally**.

4. The **Government carefully examines and considers sharing spectrum allocations** with critical infrastructure entities including electric utilities, and **allow local licensing for some pieces of 5G spectrum** so that they can operate unique and customized wireless networks at their critical operations, such as hydro dams or nuclear facilities.

CONCLUSIONS

- The **global telecommunications sector** is undergoing a **transition from 4G wireless technology to 5G that will transform industries and societies**, and drive future economic growth. 5G will provide the speed, responsiveness and bandwidth to connect tens of billions of new devices to the Internet enabling innovation and new **markets, services and applications** such as **smart cities, autonomous vehicles, remote healthcare, factory automation** and much more.

- As 5G rolls out in Canada, industries such as transportation, energy, health and manufacturing are looking at what will be possible in the future. The **electricity sector represents one of the most significant test cases for 5G enabling technologies**. 5G is poised to **transform the electricity sector** helping to **drive improvements across the entire value chain**.

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- **5G wireless technology will help unleash the next wave of the "smart grid"**, modernizing it to make it **even smarter and more resilient**. 5G's enhanced capabilities make the technology particularly suited to the **real-time management and automation of the smart grid delivering electricity more reliably and efficiently**. **Consumers can also better manage their energy consumption and costs** because they will have easier access to their own data through the use of smart meters.

- **Security is fundamental to successfully deploying and utilizing 5G**. While 5G will offer security enhancements through new secure designs and features enabling utilities to deploy new applications and services, security risks will grow with the scale of connected devices enabled by 5G technology. An **increasingly connected world will make these networks and connected ecosystems more susceptible to cyber threats and supply chain vulnerabilities**.

- In addition to increased security risks, **5G presents regulatory and technological challenges for the electricity sector in the telecommunications space**. The CEA noted that both **government and industry will need to navigate new regulatory grounds to enable 5G technologies to reach their full potential**, including adopting new strategies for new technologies and making regulatory changes to adapt existing frameworks for new applications that were previously unanticipated.

- **Addressing these challenges and mitigating these risks will require the collaboration of government and industry** to ensure the security and integrity of 5G technology, including its secure deployment and use in the electricity sector. Governments and industry must work together to **advance the development and deployment of a secure and resilient 5G infrastructure**, one that enables enhanced **security, technological innovation, environmental benefits and economic opportunity** for Canadians and businesses alike.

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