SMART DEVELOPMENTS AT HOME AND ABROAD

Smart Cities Monitoring Report 2019–2020

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Preface:

ICTC is a not-for-profit, national centre of expertise for strengthening Canada's digital advantage in a global economy. Through trusted research, practical policy advice, and creative capacity-building programs, ICTC fosters globally competitive Canadian industries enabled by innovative and diverse digital talent. In partnership with a vast network of industry leaders, academic partners, and policymakers, ICTC has empowered a robust and inclusive digital economy for over 25 years.

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INTRODUCTION

Municipalities around the world are looking to emerging technologies as a method of "upgrading" or enhancing operations and services. They are beginning to augment design processes, seek ways to better serve their communities and, ultimately, prepare for a more connected and data-centric future. Many such initiatives at the city or community level fall under the umbrella concept of "smart cities."

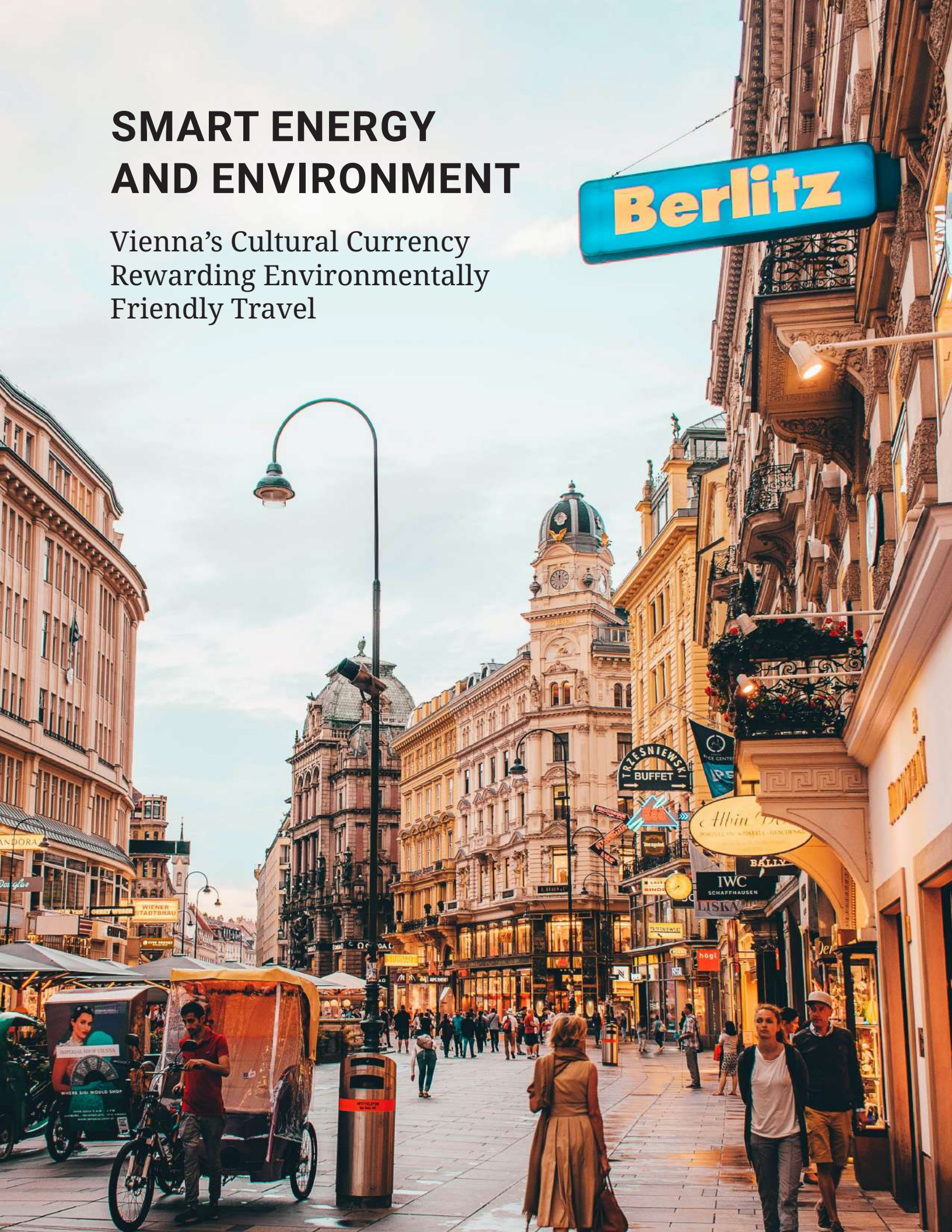
While Canadian municipalities come with unique needs and opportunities—considerations including population size, quality of infrastructure, energy needs, connectivity capabilities, labour market characteristics all play roles—many are undertaking a variety of projects in the hope of building a "smart" future.

This monitoring report examines national and international examples of smart city initiatives that took shape—either in concept or rollout—during the March 2019 to March 2020 period, and which also fall under ICTC's key smart city priority areas: smart energy and environment, smart infrastructure, smart mobility, smart government, smart health and wellbeing, and smart regulation.[1] Although this report does not investigate the early changes to urban centres as a result of COVID-19, it describes existing initiatives, highlights the technologies or concepts used, and addresses the potential labour market implications.

Although not intended to be an exhaustive comparison, these case studies point to the symbiosis between communities (encompassing urban/rural/cities/towns etc.) and human-centric design principles. ICTC will continue to monitor these developments over time, including the emerging impacts of COVID-19 on urban life.

SMART ENERGY AND ENVIRONMENT

Vienna's Cultural Currency Rewarding Environmentally Friendly Travel



BACKGROUND AND PROJECT IMPLEMENTATION

The city of Vienna is piloting an arts-and-culture-centric approach to encourage the use of alternative transportation methods and reduce congestion on its roads. The "Kultur – Token" pilot project uses blockchain technology to offer a digital reward in the form of "Culture Tokens"[2] (similar to a member points system) as a way to encourage non-car travel and help the city achieve its carbon-neutral goals.[3] City residents can earn credits (tokens) when they utilize methods of active transit like walking or cycling. These credits can then be exchanged for theatre and museum tickets.

This project relies on an app (commissioned by the city[4]) that utilizes a mixture of hardware (for motion tracking sensors) and smartphone software to quantify resident behaviour, assigning an associated environmental benefit according to avoided carbon emissions via each activity. Specifically, the app combines anonymized tracking data with other motion sensors, allowing it to identify if the user is travelling by car, bus, subway, walking, or cycling.[5] This data collected is then assigned a carbon-savings score and transmitted via a blockchain to generate a token for the app user. Once a participant has accumulated 20 kilograms of CO_2 savings (the equivalent of approximately two weeks of car-free commuting), they are provided with a token, exchangeable for a ticket to one of four cultural venues.[6] While there is no limit to the number of tokens that can be awarded to each user, once a participant has earned five tokens, new token generation is paused until one is used.

Transmitting this data via a blockchain helps simplify and automate the administrative process, while providing an extra layer of security and authenticity benefits.[7] Utilizing blockchain improves accuracy by removing the need for human involvement (without the need for a "middleman" to process transactions) in verifying or authenticating the generation and use of these credits, and the decentralized nature makes it more difficult for users to tamper with transactions.[8] This can prevent fraudulent generation of credits, for example (or more high-value fraud in other projects). While it is worth noting that the data will be anonymized, and the city has stated that privacy concerns are being taken very seriously, it has been proven that anonymized data can be used to re-identify people based on demographic attributes, with a high degree of probability. [9]

Benefits

This pilot project was met with a high level of interest from the city's residents—in fact, within two days of the launch of registration, the city received 3,000 applications. Of these, 1,000 users were chosen to test the app. If fully adopted, this project could be effective in further encouraging alternative forms of transportation. Alternative forms of transportation (instead of personal car use) can lead to better health through walking and biking as well as decreased air pollution. Encouraging environmentally friendly travel also reduces congestion in the city. Congestion leads to increased carbon emissions, outdoor air pollution, and traffic risks[10] while also negatively impacting quality of life for citizens.[11]

In addition to the direct environmental and health objectives, additional community-based benefits also exist. The ability to earn credits that can be exchanged for admission to costly arts and culture activities potentially allows low-income residents to attend. Increasing participation in cultural activities may also lead to a greater sense of civic pride and civic engagement (with an increased sense of inclusion).[12]

The city also hopes to leverage the pilot to bolster continued adoption of blockchain. While this project does not use highly sensitive data, Vienna is expanding its use of blockchain in city projects to provide greater openness, transparency, and authenticity of city data (citizens would be able to check the history of this data).[13] The city is increasing its use of blockchain technology to also provide transparency for supply chains and give users full control of their own data (related to the idea of "self-sovereign identity").[14]

Labour Market Implications

If this project is successful and the city continues to develop additional similar projects (with a broader Vienna Token system[15] that can nudge citizens toward positive behaviour in the future, such as submitting tax returns in a timely manner[16] or allowing users to pay for parking[17]), these could have numerous impacts on the city's labour market. As the city expands its partnerships[18] to incorporate blockchain technology, it will likely have increased needs for privacy and security staff, such as data protection officers, data analysts, privacy officers, and IT technicians. In turn, this approach (with larger amounts of data gathered) may necessitate growth in urban planning roles, industrial engineers, and behavioural economics policymakers to further incentivize positive citizen behaviour.

SMART INFRASTRUCTURE

Smart Concrete Strength Monitoring at the London City Airport Expansion

Background and Project Implementation

The growing traffic at London City Airport has resulted in the need for significant amounts of new construction. The addition of a new taxiway, terminal buildings, and aircraft hangar space required large volumes of concrete in the construction. Given the critical nature of this infrastructure, it is important to ensure that the concrete has set properly. The concrete must pass strength tests before further construction can commence.

Typically, traditional concrete testing introduces delays in the construction pipeline, as samples are relayed to labs for rigorous analysis. This process is often slow, adding significant costs and time to a project. During the expansion of London City Airport, a new technique was developed: the project team integrated sensors into the physical infrastructure (as the concrete was poured) and developed the world's first Artificial Intelligence (AI)-based concrete strength prediction engine. This project was a collaboration by BAM Nuttall, a UK civil engineering firm, and the sensor firm Converge (partially funded by an Innovate UK government grant in 2018).[19]

This project and its predictive engine for concrete strength were made possible through the unique access to Converge's existing concrete performance dataset, gathered from approximately 200 previous projects.[20] The predictive model combines weather data, historic concrete-pouring data, and real-time measurements from hundreds of wireless sensors embedded in the London City Airport infrastructure to help determine the concrete's strength, without having to stop the project to measure it.[21] Each sensor carries a unique QR code, scanned during placement of reinforcing rebar to record its location prior to the concrete pour. Then, a thermometer takes readings from the concrete, and a cable from the sensor extends out of the concrete to transmit readings to the Cloud for processing. When a section is determined to have reached targeted strength, the system alerts engineers on the ground, letting them know which location is ready for further work.[22] AI technology is used to predict the strength of the concrete days in advance, but the model is adaptive and can continuously update its predictions given other data and changing environmental readings.

Benefits

As a result of this project, construction contractors can anticipate challenges and issues related to concrete strength performance, instead of having to react to it when it occurs. This improves project management efficiency, as subsequent work can be planned for when the concrete's critical strength is expected to set. Traditionally, additional construction scheduling could only commence once the concrete was confirmed as ready, meaning that construction crews were often engaged elsewhere in the meantime, potentially contributing to significant delays.[23]

As one of the project's contracting engineers noted, "The [model's] predictive nature is particularly useful , as it is a very restricted site. If we can predict when we're going to move cranes, we can gear suppliers up so we can have just-in-time deliveries."[24] The

project team found that the strength results from the model are highly accurate, often able to predict when concrete will cure down to a 10-minute window. [25]

In the future, embedding sensors directly into infrastructure may be adopted by other projects to confer similar benefits. For the London City Airport project, benefits largely pertained to savings in construction time; however, better knowledge of critical infrastructure overall is likely to result in further benefits such as optimizing equipment utilization, environmental efficiencies (reduced concrete wastage, for example), and better predictive ability for infrastructure maintenance or repairs.

Ultimately this leads to quicker, more efficient, more predictable infrastructure construction, and helps address complex logistics related to the movement of construction materials and machinery onsite. Since the software tools become more accurate as they gather more data, it is likely to have even better performance and cost efficiency benefits in the future.[26]

Labour Market Implications

This project is an excellent demonstration of the increasing integration of digital technologies and their associated skills within the physical industries. In the future, infrastructure projects and construction will likely require additional AI-related roles such as software developers and data analysts. While some of these future needs may be met by new graduates in these fields, it is also highly likely that existing professionals in construction and utilities may need to upskill or retrain to adapt to the introduction of new technologies.

While it is unclear if this technology and its related efficiencies will positively or negatively impact labour needs, greater efficiencies and reduced costs of construction should make a higher volume of projects financially feasible. Given the significant infrastructure needs across most cities, new technology could allow more projects to be implemented, which would create new construction labour demand. This may also have direct impacts in the manufacturing industry, as trends toward smart sensors can lead to increased production needs.

SMART MOBILITY

Calgary Transit MyFare Smartphone App

Background and Project Implementation

To increase the convenience and efficiency of the public transit system, Calgary Transit is upgrading their fare system with MyFare, a ticketing smartphone app that allows commuters to buy, display, and validate transit passes entirely on their phones.[27] This addresses the city's need for a more modern fare system that can take advantage of digital technologies that many other jurisdictions around the world are using.

This project, which cost approximately $5 million,[28] has been part of a longer modernization process. The new smartphone app allows for the purchase of adult or youth monthly passes as well as single-trip tickets. This is the first step of the project, and Calgary Transit plans to add more sophisticated options, including partially subsidized passes for low-income Calgarians, senior citizens, and university students. In addition to the software development component, this project also requires hardware: the installation of 1050 validators on buses) and additional mobile validating equipment for proof of fare purchase. The project was initially trialled with 250 customers on four bus routes between July and September 2019.[29]

It is worth noting that this new system does not replace the previous system (currently, for example, riders must purchase monthly passes at the beginning of each month at local retailers). Instead, it exists alongside the current system to offer more choice and convenience for commuters. The MyFare app and support system is expected to be fully operational in mid 2020.[30]

Benefits

This project was designed to benefit transit users by providing a convenient solution for purchasing fares and allowing digital proof of payment. Increasingly, it is expected that most transit systems will embrace digital payments and data collection. In addition to having advantages for ensuring payment compliance and avoiding fraud, digital systems can scale better, and offer most robust data analytics to enable an overview of mobility patterns throughout a region, which can then be harnessed for urban planning and transportation investments in the future. While Calgary is not unique in its transition to a digital payment system for public transit, it is a notable smart city development that demonstrates how technology adoption occasionally skips steps (a process known as leapfrogging[31]--for example, the adoption of smartphones in developing countries instead of landlines). Calgary had previously experimented with a "smart card" called the "Connect" system, which included a reloadable card-and-tap functionality, but the initiative was abandoned in 2015 due to software issues (issues of user experience and reliability).[32] Calgary's public transit system is also benefiting the lessons learned and best-practices in digital-fare adoption in other cities.[33]

Labour Market Implications

The upgrading of Calgary's public transit system will require increased labour needs, including technicians to install sensors and fare-validating hardware on transit vehicles and

throughout the city. Furthermore, transit staff will require additional training in the use of the smartphone app and mobile validating equipment (to check for proof of payment).

The in-house development of the app by the City of Calgary will require software developers to expand and test further planned functionality and maintenance of the app. The data gathered through usage patterns will also require the involvement of roles such as data analysts and software engineers. Furthermore, building these digital sensor systems and making use of this additional data collection to improve decision-making will call upon additional infrastructure support (IT technicians, installers, and network administrators).

SMART GOVERNMENT

Seoul’s Blockchain Adoption for Referendums and Government Services

Background and Project Implementation

Seoul, the capital city of South Korea, is aiming to become a pioneer in the use of blockchain for city services. The adoption of blockchain systems and a transition to digital government has been part of the city's strategy over the last several years. Many of these initiatives are tied to a municipal "S-coin" token that integrates transportation services, municipal services, taxes, and public opinion polls. The token also ties into document filing and an identity system for citizens.[34] As a form of "digital currency," its aim is to reward residents of Seoul for participating in social activities, charity work, and for health-oriented physical activity.[35] Other examples of incentives for positive behaviour include completing surveys or providing feedback on municipal proposals. S-Coin blockchain also integrates into "ZeroPay," a citywide QR code network that allows citizens to pay for services and merchandise using their smart phones, with no charge to merchants. In practice, this has been largely limited to blockchain-based basic administrative services, whereas the more ambitious $105M (USD) plan to address social insurance and employment administration has faced challenges. [36]

Another specific use case for blockchain is improving the local referendum system to avoid fraud through double voting in elections and plebiscites. This is the continuation of an earlier online voting system that began in 2013 and was used by 5.64 million people; however, this previous system faced substantial challenges, largely due to hacking and fraud concerns.[37] The newer system that utilizes blockchain authentication bolsters transparency and security, addressing issues related to voter authentication and the recording of results so as to prevent alteration. These citizen-engagement efforts are part of the *Democracy Seoul*[38] program, a digital democracy platform that enables citizens to propose and debate topics they would like the city government to tackle. After voting on these issues, those that meet a certain level of support become part of the local government's agenda and require its formal response.

Previously, a nationwide petition system required a response from the Korean government when petitions reached 200,000 signatures. This process has now been introduced at a municipal level, exclusive to residents and involving a lower threshold of 1,000 votes, which then requires a mayoral response. Using local referendums is seen as a method of testing the system before using it for higher stakes voting, such as a national election.[39]

Seoul's former mayor, Park Won-soon, noted that there is a regulatory component to the ongoing success of the project (related to ICTC's *Smart Regulations* priority area), as laws governing cryptocurrencies would need to be reviewed: "In order to make an S-Coin, we need to prepare institutional and legal support, such as bylaws."[40]

Benefits

There are a wide range of anticipated benefits for these initiatives. A digital identity and transition to digital administration of municipal services is expected to increase efficiency and reduce friction of citizen interactions with public administration. Advancing blockchain-enabled services and identification can reduce the risk of fraud and abuse, given the technology's increased transparency (as all transactions are recorded and viewable) and

authentication abilities (the identity of users is stored and verified on the blockchain). The immutable nature of blockchain technology will also be useful for ensuring that the data collected is securely recorded and cannot be lost or altered. Furthermore, the use of tokens and a digital municipal currency is also expected to help promote civic engagement and incentivize the positive behaviour of city residents.

The specific use of blockchain technology for referendum voting can help improve civic engagement and democratic initiatives. By improving security and transparency (as blockchain can avoid issues around lack of trust, voter authentication, and double voting), this is likely to improve trust in e-voting systems, therefore benefiting participatory democracy at a municipal level.

Labour Market Implications

The most direct labour market impact of these initiatives is a growing need for blockchain-related roles, including blockchain developers, as well as cybersecurity support roles. In addition, the increased use of these digital systems will likely necessitate increased hiring for the management and analysis of the collected data. Further digital skills training and blockchain fundamentals will also be necessary to allow local government staff to fully realize the benefits that are possible through largescale blockchain adoption.

Ultimately, this should also have spillover benefits for wider blockchain adoption and strengthen employment in related software development and hardware roles (for example, sensors or network installation). These technology initiatives involve significant public and private sector involvement and cooperation. The city of Seoul will provide its administrative services as testbeds and run a Blockchain Policy Advisory Panel made of up experts to assist the execution of these projects.[41]

SMART REGULATION

Toronto CCTV and Emerging Facial Recognition Technologies

Background and Development

One of the most significant areas of concern for smart cities development is privacy and data collection. While issues of privacy legislation are addressed at the provincial and federal levels,[42] citizens are increasingly concerned about how this is applied in practice within municipalities. Often, issues of privacy intersect with advances in AI, data collection, and facial recognition software. Several Asian countries, such as China, Singapore, and Malaysia, are leading the development of facial recognition software for the purposes of law enforcement and security monitoring.[43] Other jurisdictions in the UK and the US are increasingly interested in utilizing facial recognition software and other surveillance tools such as closed-circuit television (CCTV). This has led to pushback on the ethics and legality of these technologies, with cities like San Francisco (CA), Oakland (CA), Somerville (MA), and Cambridge (MA) banning facial recognition technology.[44] Numerous other cities are looking to set regulations around the use of these technologies, citing the risk of inaccuracy and bias, especially given the proven inability of facial recognition to accurately recognize women and people of colour.[45]

While the City of Toronto is not currently actively developing a smart city initiative to address these issues, global developments in facial recognition technology have led to higher levels of scrutiny for the use of surveillance tools. Technology researchers have identified Toronto as Canada's "most surveilled" city due to the high number of CCTVs in use (including public and private settings).[46] The now-cancelled Sidewalk Labs initiative had already raised questions around privacy and data collection in Toronto but concerns were also raised over the use of the controversial facial recognition software Clearview AI. Clearview has faced significant criticism over the breadth of its scraping of web images and its use by authoritarian governments such as Saudi Arabia.[47] After initial denials, Toronto's police later admitted that some members of the police force had used the technology in 2019; however, the police chief ordered his officers to stop using this specific software after learning of its use.[48] The use of this software technology triggered investigations by the Office of the Privacy Commissioner of Canada, with the purpose of developing guidance for the use of emerging biometric technologies, including facial recognition across various jurisdictions, including Alberta, British Columbia, and Quebec. In response to the Canadian Privacy Commissioner's investigation, Clearview AI announced in July 2020 it would cease offering its facial recognition software in Canada. [49] However, the use and regulation of facial recognition technologies remains highly contentious.[50]

Toronto's use of technology to address issues of crime and public safety have also been brought to the forefront by other projects such as the proliferation of CCTV cameras in the city (in response to gun violence)[51] and concerns over CCTV usage and the possibility of facial recognition in Chinatown.[52] Some critics have highlighted issues of public oversight and questioned whether Ontario's Freedom of Information and Privacy Commissioner has been sufficiently involved in these developments.[53] While the expansion of CCTV usage has been funded as part of an anti-gun violence strategy, residents are concerned about the lack of public consultation, including questions of how collected data will be handled and what protocols are in place to protect privacy. These issues demonstrate the need for clear and responsible policies and regulations.

Benefits and Concerns

Facial recognition software and CCTV surveillance has been adopted by many jurisdictions globally with the goals of improving public safety in response to crime or terrorism. The justification is that these tools permit more rapid responses, provide evidence for prosecution, and help track suspects. [54] Facial recognition is sometimes used in conjunction with other tools to match identifying documents in issues of fraud.[55] Other possible uses include helping locate missing children or disoriented adults.[56] The need to address public safety concerns and violent crime has led to a significant increase in the installation of CCTV (and other surveillance) tools around the world. However, this has been met with pushback, particularly as public awareness grows around the power and reach of this surveillance.

Detractors of facial recognition software contend that any benefits should be weighed against concerns, and that there is little correlation between CCTVs (and related technologies) and crime or public safety.[57] Beyond concerns about privacy and violations of civil liberties, several commentators have criticized the minimal contribution of these technologies in the context of the total number of crimes committed.[58] Furthermore, it has been suggested that cameras in one neighbourhood may simply displace crime to other neighbourhoods; that citizens might take fewer precautions, believing they are protected; or that the recording and increased reporting of crimes could create the perception that crime is increasing. [59] The Office of the Privacy Commissioner of Canada has noted that the growing perception of the ability of video surveillance to increase security combined with the proliferation of surveillance (due to decreasing size and costs of CCTV devices) points to a strong need for regulatory guidelines in the use of this technology.[60]

Labour Market Implications

The increased use of surveillance equipment and software is likely to have various labour market impacts, both for technicians working with the equipment, and for regulators and planners working to ensure safe applications for the technology. These projects are likely to result in increased demand for installation technicians, who will increasingly require a higher level of digital skills training, given the networked nature of Internet of Things (IoT) devices. For example, the Toronto CCTV camera initiative involves $3M to cover equipment and infrastructure spending as well as ongoing operational costs (for maintenance and monitoring roles). [61]

In addition, it is likely that a regulatory framework for the use of surveillance and facial recognition technologies will also create greater need for cybersecurity professionals and IT network technicians to manage the infrastructure behind these networked systems. Furthermore, as this field develops, there will likely be a growing need for senior leadership roles such as for chief privacy officers at the municipal level and support roles such as freedom of information and privacy analysts, information security officers, and data privacy officers.[62]

SMART HEALTH AND WELLBEING

Moose Cree First Nation Drone Delivery for Medical Supplies

Background and Project Implementation

Rural and remote areas in Canada can often face challenges due to their distance from large city centres. Small populations, insufficient infrastructure, and challenging environments can make issues of supplying these regions with necessities very difficult. Inequalities and health challenges are reflected in the statistic that shows Canadians living in remote areas have a shorter life expectancy by 3.7 years than Canadians living in large cities other than Toronto, Montréal, or Vancouver.[63] [64] Previous research has identified high transportation costs coupled with the need for reliable access to sufficient medical supplies and equipment as significant challenges for remote communities.[65]

Building road and bridge infrastructure is expensive (and in some places, impossible due to terrain), however, the use of rapidly maturing drone technology may provide a viable option. In Ontario, cargo drone delivery operator Drone Delivery Canada (DDC) received conditional approval for a Moose Cree First Nation project in 2019.[66] This project is a $2.5M partnership with the Moose Cree First Nation to deliver supplies.[67] The arrangement involves DDC's "Sparrow" drones, machines that can carry 5KG of goods, such as medical supplies and other items.

DDC has estimated that there are 1,000 remote communities facing infrastructure and logistics challenges across Canada. Recent research in Ontario suggested that remotely controlled drones may be faster to arrive and deliver life-saving medical supplies like defibrillators to the scenes of rural emergencies than ambulances, which must navigate traffic. This has significant implications given the low survival rates for cardiac arrest in rural Canadian communities.[68]

This project makes sense because Moose Cree First Nation is on an island situated on the Moose River. The river can be crossed by boat in summer and ice road in winter from nearby Moosonee, but travel becomes much more hazardous in the spring and fall. Helicopter transportation can be difficult and expensive. Drone delivery, on the other hand, uses GPS coordination to guide a drone to a depot on the island, where there is a technician stationed to receive the parcel. After two years of planning and testing, the project has now been approved for commercial service. [69] The project will build permanent drone depots and implement its commercial business model.

While this is one of the most advanced projects of its kind, it is one of several other Canadian efforts. Others include DDC's regional warehouses in Milton, ON, a pilot project to deliver prescription drugs in BC, and the establishment of a drone delivery hub at Edmonton International Airport (YEG) – the first such hub at a major Canadian airport.[70]

Benefits

The Moose Cree drone delivery project is a valuable trial of drone delivery technologies for rural and remote communities. The Moose Cree First Nation is likely to benefit from better transportation links more populated areas resulting in more reliable and cheaper access to supplies. Increased reliability and delivery speeds are of great importance for transporting medical supplies to the isolated community. DDC is first to focus on remote communities

because drones offer a solution to the high costs of delivering critical products such as medicine to remote locations.[71] The ability to deliver groceries also helps address issues of food insecurity, providing health and wellness benefits (whether through better nutrition or reduced anxiety over food availability and finances).

Moose Cree First Nation's Director of Economic Development also hopes that "the project will provide a positive impact to the cost of living as well as bring an economic boost to the Nation by creating jobs and training opportunities." Lastly, this project can help build connections for the region and demonstrate that remote Indigenous communities can be early adopters of innovative technology.[72]

Labour Market Implications

The development of the drone delivery market is likely to increase the demand for jobs in the drone industry—drone operators, logistics roles, maintenance and repair, etc. Furthermore, while drones may be most useful for delivering large packages to remote communities, they can produce additional benefits through reduced costs of transportation (and increased supply delivery). This will likely lead to more jobs in last-mile delivery services. As delivery volume increases, there will also likely be more delivery occupations needed to move goods from drone delivery depots to the final destination (as well as the work in developing this transportation infrastructure).

CONCLUSION

Communities around the world have responded to growing social, economic, and environmental challenges using a variety of methods. Digital technologies provide opportunities to consider and address these issues in ways that reflect the local needs and expectations of residents. Typically, these developments can be categorized under one or more priority areas: Smart Energy and Environment, Smart Mobility, Smart Health and Wellbeing, Smart Government, Smart Infrastructure, and Smart Regulation.

Some projects or developments may be largely software based, such as those utilizing blockchain to ensure voting integrity and support municipal administrations. Other projects rely largely on hardware, such as those using drones to delivery critical supplies to remote communities. Smart city developments, however, benefit from the integration of hardware and software technologies as the physical world becomes increasingly digitized. As noted in the case of Toronto's CCTV applications, sometimes the introduction of new technologies open challenging discussions about the need for regulation to ensure that these innovations are deployed responsibly.

When considering future cities, the solutions provided by the continuing trend toward predictive data analytics, increased efficiency, and improvements in the delivery of government services create opportunities to greatly improve the wellbeing of citizens across Canada in communities of all sizes.

Although COVID-19 has created implications related to urban living and the very notion of smart cities, it is too soon to tell which initial behavioural changes will materialize into actual trends over time. ICTC will continue to monitor these developments both within Canada and internationally to better understand the changing nature of our cities and their resulting technological and labour market needs.

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