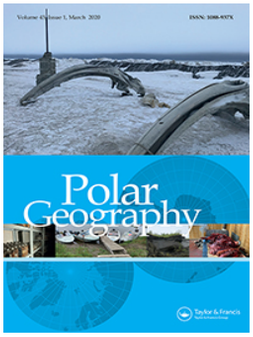

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A tale of three cities: the concept of smart sustainable cities for the Arctic

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ABSTRACT

This article considers established metrics for smart city development and evaluates their suitability for implementation in Arctic urban settlements. To do this, the article first surveys smart city literature and the standardization of 'smartness' metrics, with particular interest in the International Standards Organization's (ISO) categorization efforts. It then proposes a northern framework of measurement to evaluate smart cities that adjusts smart metrics from current non-Arctic scholarship to the relatively low populations, peripheral development, remote locations, and harsh climate conditions of the circumpolar north. To test this argument of a new smart framework, the article moves to examine the strategies of three circumpolar cities at different points of smart development: Anchorage (United States), Bodø (Norway) and Oulu (Finland). The article concludes by identifying areas of success and shortcomings for each city analyzed. Smart cities can be a crucial step towards a sustainable future in the circumpolar north, contributing to a 'smarter' approach to economic, social, and environmental development. Exploring this is important because these frameworks have implications for how policymakers in northern regions choose to plan and implement their city strategies.

KEYWORDS

Smart city; Arctic; urban planning; sustainable development

Introduction

Since the Age of Exploration, when Eurasian men sojourned north to the furthermost stretches of their known maps, many different stories have been constructed about the future of the Arctic region in relation to southern (non-Arctic) cities and societies. During the seventeenth and eighteenth centuries, the Arctic economy was conceived as a natural sanctuary, flush with circumpolar fauna to be extracted for southern needs. Eventually, the fur trade and whaling activities that dominated the region's economic development gave way to subterranean extractions of minerals, materials, and ultimately fossil fuel in all its forms. Historically, and with few exceptions, the Arctic has been developed as provinces for extraction and shipment of raw materials rather than a region wherein local resources contribute to regional growth based on localized innovation.

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Climactic, geographic, and demographic factors have both discursively and tangibly constrained a shift from extractive to innovative growth. These limitations include, but are not limited to, the North's harsh climate; a low density and uneven distribution of population; long distances to global markets; the difficult access to Arctic-based professional skills training and education; depopulation processes, particularly among youth; and a large share of professionals working in the public sector. These problems are similar for many sub-regions within the Arctic, and are exacerbated by the movement of populations away from rural areas and into the cities of resource-rich regions (Suter, Schaffner, Giddings, Orttung, & Streletskiy, 2017, p. 112). Although unique in many ways, the Arctic takes part in the global trend of urbanization and depopulation of rural landscapes (Ramboll, 2013; Stephen, 2018, p. 226). The Arctic 'is intensely urbanizing' as 'towns grow at a rapid pace and people settle in urban centers, often far away from their home settlements' (Dybbroe, Dahl, & Müller-Wille, 2010, p. 120).

Today, roughly three-quarters of the Arctic's population live in urban areas (Heleniak & Bogoyavlenskiy, 2015, pp. 93–94). And though much of the regional economy is still reliant on industrial development, bulk trade from primary industry, and public administration, urban Arctic economies are diversifying to create a distinct knowledge economy based on increasing primary, secondary, and higher education opportunities (Rasmussen, Hovelsrud, & Gearheard, 2015, p. 438). These shifts in populations, economies, and ultimately cultures that accompany the circumpolar north's urbanization come with novel opportunities and challenges, making it a critical field for future research. This turns our attention to an emerging, but underexplored topic in Arctic research: Arctic *smart cities*.

The smart city concept has been developed as a method to portray cities as attractive places for working and living, promising better life quality through the smart management of city assets and the use of modern technology. To varying degrees, several cities across the Arctic have embraced the smart city concept. This article considers the 'smart' strategies of three cities in the North American and European circumpolar north: Anchorage (United States), Bodø (Norway), and Oulu (Finland). The three cities were selected because there share a set of similarities, but are also situated at different points of the smart development spectrum. Generally, Arctic and sub-Arctic regions on both continents are characterized by a sparser distribution of cities over a greater area. Despite being of different size, all three cities are demographically dense and geographically large with regard to their local setting. Each is of immense importance to regional economic development and political administration in their broader regions, are cities with large universities, and are in turn connected globally. By using a comparative case study method, we aim to identify similarities and differences across the cities' smart initiatives (Goodrick, 2014, p. 1). Thus, we aim to produce more generalizable knowledge about the implementation of smart city concepts in a northern setting.

A considerable amount of research already exists on what the dimensions of a smart city ought to be, and how their performance can be quantitatively measured (Anthopoulos, 2017; Brorström, Argento, Grossi, Thomasson, & Almqvist, 2018; Fernandez-Anez, Fernández-Güell, & Giffinger, 2018; Garau & Pavan, 2018; Grossi & Pianezzi, 2017; Huovila, Bosch, & Airaksinen, 2019; Lazaroiu & Roscia, 2012; Lombardi, Giordano, Farouh, & Yousef, 2012; Mora, Bolici, & Deakin, 2017). There is reason to believe that due to factors such as relatively low populations, peripheral development, remote locations, and harsh climate conditions, these existing frameworks may not be entirely suitable to evaluate the performance or statues of smart cities in the Arctic. Exploring this is important because these frameworks have implications for how policymakers in northern regions choose to plan and implement their city strategies. The cataloguing of smart measurements for Arctic cities and subsequent

analysis is meant to provide a foundation upon which further research will build. Our goal is not to quantitively measure the performance of the chosen cities, but rather to discuss their different strategies in relation to current smart city standards to highlight if non-Arctic frameworks are suitable for circumpolar urban areas.

Definition and dimensions of an Arctic smart sustainable city

More than half the world's population lives in urban areas, a number that will only increase in the decades to come (Eurostat, 2016; United Nations (Department of Economic and Social Affairs Population Division), 2014). Cities fuel economic development as centers of capital, workforce, knowledge, information, and technology. However, global cities are also confronted with a multitude of key challenges, including traffic congestion, unplanned development, poor land use regulation, and a lack of basic services (Bansal, Shrivastava, & Singh, 2015, p. 551). Additionally, cities significantly contribute to climate change, as they are directly or indirectly responsible for approximately three quarters of all energy consumption and greenhouse gas emissions (Garrido-Marijuan, Pargova, & Wilson, 2017, p. 3). To meet these challenges, urban planners have pioneered solutions that are environmentally sustainable and link all areas of a city's economy together in a more efficient way. This often involves more efficient public transportation, energy efficient buildings, and a stronger focus on research, innovation, and knowledge.

Chief among the frameworks to mitigate these challenges are strategies to develop 'sustainable', 'smart', 'resilient', and 'green' cities, all of which are interconnected in their indicators and goals. While there exists a plethora of development frames within which cities can measure their progress, this article will focus specifically on smart sustainable cities – the intersection of the two interrelated concepts of sustainable cities and smart cities. Sustainable cities achieve 'a balance between the development of the urban areas and protection of the environment with an eye to equity in income, employment, shelter, basic services, social infrastructure and transportation in the urban areas' (Hiremath, Balachandra, Kumar, Bansode, & Murali, 2013, p. 556). Within this frame, cities must achieve sustainability in the environmental, social, and economic pillars of the concept; however, there has been criticism that sustainable cities elevate environmental indicators at the expense of social and economic performance metrics (Berardi, 2013; Robinson & Cole, 2015; Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010). During the past decade, sustainability has been superseded in popularity by the concept of 'smart cities', as a means to achieve urban sustainability (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017, pp. 235–236; Huovila et al., 2019, p. 142). Smart cities build off the previous work of sustainable cities but instead focus development on the implementation of technology, especially information and communication technologies (ICTs). A smart city exists 'when investments in human and social capital and traditional (transport) and modern (ICT) communications infrastructure fuel sustainable economic growth and high quality of life, with a wise management of natural resources, through participatory governance' (Caragliu, del Bo, & Nijkamp, 2011, p. 70). Building on a public-private-people-partnership approach, which is the cooperation between the public sector, companies and individuals, this definition synthesizes the important aspects of ICTs, sustainable growth, and the human component, both in terms of participation and life quality. For the purposes of this article, the definition and indicators as laid out by the International Standards Organization (ISO) definition of smart cities will be applied. Set forth in document ISO 37122, a smart city is one that:

> increases the pace at which it provides social, economic and environmental sustainability outcomes and responds to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how it engages society, applies collaborative leadership methods, works across disciplines and city systems, and uses data information and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment. (ISO (International Standardization Organization), 2019)

Nonetheless, similar to the critique of sustainable cities' environmental focus, the concept of 'smart cities' has been widely criticized for its techno-centricity, lacking proper attention to cities' needs and environmental sustainability (Grossi & Pianezzi, 2017; Huovila et al., 2019, p. 142; Rosati & Conti, 2016). Due to the deficiencies within both sustainable city and smart city frameworks – the former being biased towards environmental components and the latter towards technological ones – there has been a contemporary push towards their integration, founded on the notion that sustainable and technological goals must coexist. In 2015, the United Nations specialized agency for information and communication technologies (ITU) developed a definition combining the two concepts. A 'smart sustainable city' is one which

> is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects. (International Telecommunication Union (ITU), 2015)

Although the use of modern technology has been recognized as key aspect of a smart city, both academia and policymakers have developed a great number of different definitions with slightly different angles of what smart means in a city (planning) context (Ahvenniemi et al., 2017; Anthopoulos, 2017; Meijer & Bolívar, 2016; Mora et al., 2017).

To adapt this concept to the Arctic region requires reviewing established, standardized metrics for evaluating both the smartness and sustainability of a city; surveying current and anticipated initiatives, polices, and projects in Arctic cities identified as smart through three cases; identifying which smart city metrics are more prominently pursued in Arctic urban development; and considering the challenges that hinder and catalysts such smart pursuits.

Measuring a smart city: metrics and standardization

In order to clarify what an Arctic smart city is and how it can be evaluated, a closer examination of the different aspects that make a city *smart* is required. ISO catalogues a set of 22 distinct smart dimensions, each with a set of specific measurements of a smart city that can be quantitatively measured and steer the performance of city services and quality of life. These indicators and their measurements are categorized below into six smart city components, *see* Table 1: Smart energy, smart people, smart governance, smart mobility, smart environment, and smart living (Lombardi et al., 2012).

Thus, a smart and sustainable Arctic city is one that can score highly in each of these measurement through mobilizing and using 'available resources to improve its inhabitants' quality of life, significantly improves its resource-use efficiency, reduces its demands on the environment, builds an innovation-driven and green economy, and fosters a well-developed local democracy' (Garau & Pavan, 2018, p. 4).

Table 1. International standards organization smart city metrics.

People	Governance	Mobility	Environment	Living	Energy
Education	Governance	Transportation	Urban/local agriculture and food security	Housing	Energy
Health	Telecommunications	Finance	Environment and Climate Change	Population and social conditions	Finance
Economy	Finance	Environment and climate change	Solid Waste	Recreation	Telecommunications
Telecommunications		Energy	Wastewater	Safety	Urban/local agriculture and food security
Housing			Water	Sports & Culture	
				Urban Planning	

Source: Own compilation.

Though wide-ranging in the measured sectors, scholars note that smart city frameworks, such as the ISO one, lack robust climate change specific indicators (Ahvenniemi et al., 2017). As climate change is warming the circumpolar north at more than twice the rate of the global average, climate mitigation and adaptation are foundational measures for ensuring that Arctic cities meet present needs without compromising future ones. The proposed framework for Arctic urban analysis must integrate metrics of sustainability, and in particular those related to climate change, into the smart city standardization set forth by ISO (Höjer & Wangel, 2015). The Arctic smart city survey to follow also considers quantitative indicators for performance measurement of smart cities to meet the need of climate mitigation and adaption by including particular consideration for greenhouse gas emission targets in smart environment and resilience building in smart environment and smart living.

A comparative evaluation of smart city approaches

The concept of smart cities is a relatively new approach for urban development in the circumpolar north. Bodø, for example, is just developing related strategies, while Anchorage (and North American Arctic cities more generally) more often use the term 'smart' to solely refer to telecommunication connections. While the novelty of Arctic smart cities underscores the need for more analyses like the examination herein, its early stage implementation proves a hinderance for an in-depth quantitative measurement of related performance. Data, ranging from the survival rate of new businesses to greenhouse gas emissions, is often compiled on a larger scale than Arctic urban areas given its historically low population density and economic concentration on extractive industries in more remote geographies. At present, a lack of localized reporting across economic, social, environmental, and technological indicators in Arctic cities inhibits comprehensive measurement and evaluation of circumpolar urban settlements smartness and sustainability.

To perform a quantitative measurement of all standardized metrics on Arctic cities would be unavoidably incomplete in both breadth and depth due to this lack of localized data. Therefore, the analysis to follow takes a foundational step in first surveying current and intended city policies, initiatives, projects, and strategies designated as 'smart'. This permits for an analysis on which metrics are being pursued more thoroughly, and allows

future researchers to monitor and compare the implementation of smart Arctic city solutions. Using the six set dimensions within which indicators were categorized, the case studies below use publicly available municipal data to survey the smart city government endeavors of Anchorage, Bodø, and Oulu. Where datasets are not available, written policies, official speeches, as well as secondary literature both from scholarship on urban development, city planning and Arctic studies are used to fill data gaps.

Our choice of indicators broadly follows the framework as developed by (Huovila et al., 2019) and is organized through six key components: Smart living, smart economy, smart environment, smart mobility, smart governance and smart people (Lombardi et al., 2012). Within each component, ISO standardized indicators are used when possible to survey the progress within the above categorization that illustrate (1) smart city dimensions, (2) related initiatives, (3) year of implementation, and (4) performance, see Table 2. Finally, we draw conclusions on the catalysts and barriers to high indicator measurements for operating as a smart city in the circumpolar north.

Anchorage, United States: on the smart city path?

The Municipality of Anchorage is the largest city in the State of Alaska; as such, it is home to an estimated 297,483 inhabitants, with an additional 104,166 inhabitants residing in the wider economic region of the Matanuska-Susitna Borough (State of Alaska, 2017). With just over half of Alaska's population living within the metropolitan area of Anchorage, the city is an economic, social, and political driver of the state's development. Despite the significant geographic distance from financial and industrial production centers, the GDP per capita for Anchorage metro area is among the highest in the United States.

In 2001, the city government of Anchorage released the *Anchorage 2020 – Anchorage Bowl Comprehensive Plan* (Municipality of Anchorage, 2001). In brief, the strategy seeks to guide the city government's ability to accommodate the population and economic growth of Anchorage while simultaneously providing efficient services to advance quality of life. To do this, the plan sets forth guidelines for determining the type and location of industrial, commercial, recreational and residential development. The plan itself does not include the terms smart city, smart growth, or ICTs to describe infrastructure, services, and community development; however, the civic initiatives implemented over the past two decades to achieve the strategy's aims have utilized smart approaches.

Smart governance

To implement the 2020 comprehensive plan to the contemporary edge of innovation, Anchorage has invested in building out a smart governance infrastructure. In May 2016, the Mayor of Anchorage established a Chief Innovation Officer (CIO) position to examine the city's business practices and the ways Anchorage government uses data and technology to deliver services (Winkle, 2016). The CIO, and two additional city employees, make up the i-team, an internal consultancy that has a physical space in city hall and time to discuss on city solutions for an extended period of time before implementation (Kelly, 2017a). In addition to providing the staff and physical space for innovation, Anchorage has created a transparent online Open Data Portal;[1] integrated city bus routes onto Google Maps; created a text-message system to check food stamp eligibility, and a separate automated text-based alert system to plug in car engines when temperatures drop below 20 degrees Fahrenheit in many different languages, including Yupik. More recently, in May 2018 the City of

Table 2. Measures of smartness in Arctic cities.

	Measures		
Category	Anchorage, Alaska	Bodø, Nordland	Oulu, Northern Ostrobothnia
Smart people	• 33.2% of borough residents aged 25 years and older had attained a bachelor's degree • Anchorage residents earned on average $62,521 (about €54,373), more than $5000 (about €4348) above the national average	• 35.9% with university degree • 0.93 patent applications per 10,000 capita (annual average 2016–2018) • 2.7% of staff in business sector per 1000 people employed, works in the R&D sector (annual average 2016–2018)	• 33% with university degree • 2 patent applications per 10,000 capita (annual average 2016–2018) • 23.8% of staff in business sector per 1000 people employed, works in the R&D sector (annual average 2016–2018)
Smart energy	• Energy Smart Lighting Initiative is retrofitting Anchorage streetlights with LED fixtures • Municipal Maintenance and Operations converted 12,000 lights with annual cost savings of $780,000 • 1.3% wind power, 10.9% hydro, 1.4% landfill gas, and 86.3% natural gas • Energy and Sustainability Coordinator	• Zero emissions neighborhood in the new city district • Goal of making all 50% of all building mass energy effective • 99.6% of energy costs in Bodø municipality used on renewable energy (2018) • 99% of the total use of energy in the county's own buildings from renewable energy sources (2018)	• *E-lighthouse* project, focusing specifically on Energy efficiency advice and energy saving for domestic retrofit and new buildings
Smart environment	• City climate strategy (cutting CO2 by 80% by 2050 and reducing solid waste and capturing methane emissions, building resilience for climate-related emergencies, and improving forest management and wildfire prevention)	• Environment one of three key focus areas in city community plan • 87.1% of total household waste recycled (2018) • Climate risk assessments in all new building and housing projects	• City climate strategy (cutting CO2 by 20% by 2020) • 7.8 tonnes CO2 emissions (below national average of 13–14.3 tonnes)
Smart mobility	• Rider participation in Anchorage's annual Bike to Work Day has increased by 260% since 2007 • Over 500 Anchorage residents drive partial or fully electric vehicles • 'Complete Streets' approach to planning and engineering stand for road that considers all road users • Intelligent Transportation System (ITS) Architecture adopted	• € 300 million to improving bike- and walk paths, public transport and roads • € 5 million for reducing carbon emissions • 75% of households have access to broadband of 100 mps or higher	• 600 km bike paths • HTML5 site showing live locations of buses • Traffic light priority solution for buses to stay on schedule
Smart governance	• i-team, an internal consultancy for smart solutions • Government Open Data Portal • Code for America partnership to reduce barriers and connect job seekers	• Citizen participation key in city plans and strategies	• Citizen participation (PATIO, free public data sets)

		• Public requests and sources easily available online • Bodø Bylab • MoBo app for accessing all information about transportation options and carbon footprint	• Increase R&D expenditures to €1.2 billion by 2020
Smart living	• The Welcoming Anchorage Roadmap and the revitalization of the Design District in downtown Anchorage to enhance civic engagement; connected, safe, and healthy communities; education; economic development and entrepreneurship; and equitable access	• New culture house and culture quarter ready in 2014 • Public safety, personal growth and diversity is underlined as a key goal in the city plan strategy (2014–2026)	• 30% of public services and communication available as e-service by 2018

Source: Own compilation.

Anchorage hired its first Energy and Sustainability Coordinator to manage energy efforts across all sectors of public service, including waste management, transportation, and building efficiency (Rydell, 2018).

Smart people

With just over one third of residents aged twenty-five or over holding a university degree, the Anchorage economy constitutes a diverse employment ecosystem, dominated by oil and gas; the military; transportation; and the convention and tourism industry. Indeed, the Ted Stevens Anchorage International Airport is the world's fifth busiest airport for cargo traffic, and the Port of Anchorage services 74% of all the waterborne freight and 95% of the refined petroleum products entering the state through Southcentral Alaska ports (Anchorage Economic Development Corporation, 2018; Port of Alaska, 2018). Government employment, including military employment, education, and health services constitute the other sectors of the economy of Anchorage.

In creating a smart economy and living through economic diversification, the residents of Anchorage are mobilizing to create needed plans, structures, and spaces. Launch Alaska, a business accelerator that invests in scalable start-ups in food, water, transportation, and energy; The Boardroom, Anchorage's first co-working space; and 1 Million Cups, a program to engage and educate entrepreneurs, all contribute to the necessary foundation upon which a new smart economy is being built.

The University of Alaska Anchorage, with just under 18,000 students, holds the promise of advancing Anchorage's success in smart people measurements. With over $40 million (about €35 million) in research grant funding and ten centers for research on economic development, technology, health, and education, among others, the University is a major force for developing the population of the city (University of Alaska, 2018). However, in July 2019, the Governor of Alaska Mike Dunleavy has proposed a $135 million budget cut for the University of Alaska system. This sum was reduced in August 2019 to $25 million state funding cut this year and another $45 million cut over the following two years (Hanlon, 2019). While the result of this proposal remains to be seen at the time of this article submission, such a budget cut would significantly reduce all smart city measurements under the smart people category.

Smart mobility

While Anchorage has excelled in advancing smart governance and civic services, it is seemingly difficult to ignite change and invest environmentally in large-scale solutions, which can be seen when we evaluate its smart mobility and smart environment dimensions. In 2018, Anchorage began a four-month trial of replacing one diesel bus with a Proterra Catalyst E2 electric bus to test how the vehicle and its batteries operate in cold weather. If the trial is successful, up to 10 diesel busses may be replaced, with a yearly reduction of 250,000 pounds of greenhouse gas emissions per bus (Grove, 2018).

In 2015, Anchorage adopted an Intelligent Transportation System (ITS) Architecture, a framework that supports sharing of information and data flows between computerized systems to improve transportation efficiency. ITS includes computerized traffic signal control, real-time People Mover bus arrival times, people Mover 'Smart' Fare Boxes, easy Park 'Smart' Pay by Phone, provision of real-time traffic condition information to travelers, enhanced operational efficiency, and road weather information systems. Importantly, the architecture adopted is a planning tool and not an already operational system that will

help to ensure that needed data can be extracted from future systems as they are implemented.

Smart environment

On 21 May 2019, the Anchorage Assembly adopted the Anchorage Climate Action Plan, providing the city with its first strategic framework for reducing greenhouse gas emissions and adapting to the impacts of climate change. Considering community-wide greenhouse gas emissions, projected climate impacts, and the priorities and concerns of Anchorage residents, the plant prioritizes actions that result in economic, environmental, and community benefits while cutting carbon emissions by 80%. The plan rests on seven sectors, each with a 2050 vision, objectives for 2030, and the action steps to achieve these objectives. These sectors include: (1) buildings and energy; (3) land use and transportation; (3) consumption and solid waste; (4) health and emergency preparedness; (5) food systems; (6) urban forest and watersheds; and (7) outreach and education. The plan focuses on both mitigation and adaptation with a focus on climate equity to ensure that the effects of climate change are addressed through policies and projects that directly address inequality and equally disperse the benefits to all residents.

Smart energy

The City of Anchorage committed to replacing 4000 sodium-vapor streetlights with energy-saving LED lights. The instillation of these new smart lights, controlled wirelessly to be brightened, dimmed, or monitored, will lead to a 50% reduction in energy consumption at a savings of $400,000 (about €347,871) (Kelly, 2017b). The city government has also announced that an Anchorage Greenhouse Gas Emissions Inventory will be released in the future (Kimmel et al., 2009; Municipality of Anchorage, 2018). Currently, wind power accounts for 1.3% of electricity, hydro for 10.9%, landfill gas 1.4%, and 86.3% natural gas. With a stated objective to increase renewable energy resources and decrease Anchorage's reliance on natural gas, the city aims to both increase resilience and decrease localized air pollution.

Smart economy

In 2016, Anchorage residents earned on average $62,521 (about €54,373), more than $5000 (about €4348) above the national average (Open Data Network, 2016). Despite Anchorage's robust status as the largest Arctic city in the United States and a higher-than-average GDP per capita, it does not escape from the boom and bust cycle of Alaska as an oil state. Much like other peripheral settlements in the north that rely on natural resource extraction for economic growth, the city budget, employment rate, and private sector civic support in Anchorage is dependent on the global petroleum market. In August 2014, petroleum prices began to plummet from overproduction, sending the State of Alaska into an economic contraction and subsequent recession (Erickson & Barker, 2015, p. 3). Anchorage employment peaked in 2015; thereafter the state-side recession has negatively impacted the city's budget, business, and commerce, with particularly acute job losses in professional and business services; oil and gas; construction; and state government sectors (Anchorage Economic Development Corporation, 2017, p. 5).

Smart living

The commitment to building a tech-based business sector for a smart Anchorage is also mirrored by a commitment to build a livable city for a twenty-first century society – one that is

equitable, inclusive, and culturally rich. Two initiatives of many embody the scope of these efforts: The Welcoming Anchorage Roadmap and the revitalization of the Design District in downtown Anchorage. The Roadmap, adopted in 2014, aims to create a city that 'is a globally competitive, culturally vibrant community where every resident feels a sense of belonging and has equal opportunity to access all the community offers' (Municipality of Anchorage, 2017, p. 3). The vision focuses on driving change through improving five 'vehicles': Civic engagement; connected, safe, and healthy communities; education; economic development and entrepreneurship; and equitable access.

Nonetheless, like many American cities, Anchorage faces three structural social challenges that limit its scoring on smart people; poor performing public schooling; homelessness; and the opioid crisis, connected to wider public health challenges – all of which are exacerbated by the recession. In a 2018 study published by the National Assessment of Educational Progress, Alaska students scored collectively at or near the bottom in the United States for math and reading competency (Hanlon, 2018). An average of eight in ten Anchorage high school students in the Class of 2017 graduated in four years (Hanlon, 2017). The homeless population of Anchorage in 2017–2018 fluctuated between 800 and just over 1000 individuals, many of whom are vulnerable residents, including mentally ill, physically disabled, and drug addicts (Armstrong & Chamard, 2014).

Bodø, Norway: the world's smartest city?

In 2017, the Norwegian government granted NOK 2.4 billion (about €250 million) to move the airport in Bodø, allowing the city to start its ambitious journey towards becoming the 'smartest city in the world' (Bodø Kommune, 2017). The needed update of the airport was used as a window of opportunity to renew and update the entire city. Located just above the Arctic Circle, Bodø is the second largest city in Northern Norway, with about 52,000 inhabitants. Bodø is one of the fastest growing cities in Northern Norway and the population is expected to increase by 40,000 people in the next 50 years (Asplan Viak, 2015). This creates a great need for new housing, work, schools and other basic functions of a city. The local government also has population growth as a stated goal in their city plan strategy, with a goal of 70,000 inhabitants by 2030 (Bodø Kommune, 2014b, p. 8). Thus, the 'rebranding' of the city as 'smart' serves an important role of increasing regional attractiveness.

The term 'smart city' has been prominently used in Norway for the past decade. Cities like Oslo, Stavanger and Trondheim are already considered to be 'smart'. It is therefore no surprise that the smart city concept has reached Bodø. The local authorities worked towards becoming a more sustainable and smarter city well before the decision to move and update the airport was made in 2017, through planning a more compact city and developing the city center (Breivik, 2017, p. 9). However, when the Norwegian government decided that the air force base was going to be moved away from Bodø, 'Smart Bodø' really gained attention, with the decision being made to build a smaller civilian airport 900 meters southwest of the current airport.[2]

The move and the shutdown of the military airport will open up large areas of the city center that can be developed. An additional area of 3.4 km^2 will be released, which constitutes the entire size of the current city center (ZEN Research Centre, n.d.). The plan is to create a completely new city district, based on a smart city concept. The Smart Bodø[3] project is a broader vision for the future development of the city (ZEN Research Centre, n.d.). Although

the new airport will not be done until 2024–2026, the planning and implementation of Smart Bodø has already begun.

Smart people

Bodø is an important trade-, service-, administration-, educational and communication center in Northern Norway. About 86% of the jobs in Bodø are within the service industry, and 13% in the industry sector (Dalfest & Thorsnæs, 2017). Further, Nord University and the Police Academy are also important employers. In Nordland county, 2.7% of the staff in the business sector per 1000 people employed, works in the R&D sector (Middleton et al., 2019, p. 40). This is significantly lower than the national average. Similarly, the number of patent applications in Nordland county is relatively low (0.93 patent applications per 10,000 capita), compared both to the national level but also the level of Northern Ostrobothnia (= Oulu) with 2 patent applications (Middleton et al., 2019, p. 41).

Meanwhile Bodø scores relatively high on the Talent Index, which is based on the number of population with a University degree. 35.9 percent of the population (over 16 years) in Bodø Municipality has a university or university college degree, while the national average is 33.4% (Petrov, 2017, p. 74; Statistics Norway (SSB), 2018). In 2015, the GDP per capita in Nordland County was approximately €40,000, while the average in Norway is about €60,000 (Kommuneprofilen, 2015).[4] Technology and innovation are key parts of the Smart Bodø project. The project has established a City Lab (ByLab), which will both be a work space and a meeting place for the municipality, students, researchers and businesses in the region. This is a part of the city's focus on research and development. The City of Bodø has also created a 'Innovation committee' with the goal of increasing both the number of jobs and economic development in the region. Their aim is to create 10,000 more jobs in the municipality by 2050 (Furulund, 2017).

Smart energy

Bodø is a part of the international project *E-lighthouse*, funded by the European Union's Regional Development Programme. The goal of the project is to build energy efficient communities and it consists of cities, municipalities and research institutions in Norway, Finland, Sweden, Greenland, Ireland and Scotland (Elighthouse.eu, n.d.-b). Several of the measures lay within the smart energy dimension. For example, Bodø will focus on building green buildings (energy efficient buildings) and use green energy (bio-energy plants). The energy saving in municipal buildings and lighting activities will involve 40 municipal buildings, and the goal is to reduce energy use with 5%, and increase input from renewable energy sources by 3%. The goal is to update 50% of the city's buildings to become energy effective, including both public and privately-owned buildings. The city has already developed and implemented a district heating system, which uses biofuel based on recycled materials.

Bodø Kommune is also a part of the national research project on Zero Emission Neighborhood (ZEN). A zero-emission neighborhood aims to reduce its direct and indirect greenhouse gas emissions towards zero over a period of time. The aim is that the ZEN goals will be implemented in the new city district developed in Bodø. More specifically, Bodø will develop and design a planning toolbox to integrate energy and emission aspects into the planning process of the new city district, evaluating different options based on scenarios (ZEN Research Centre, n.d.). The project includes building environmentally friendly housing,

with 2800 new housing units, kindergartens, schools and business in the new airport area (Bodø Kommune, 2016, p. 2).

Northern Norway is one of the largest producers of hydro power in Norway, and in 2011, 14.9% of the total electric power production came from Northern Norway (Kunnskapsparken Bodø, 2014, p. 6). The goal of building an energy efficient community has become particularly visibly in the county's own buildings and energy use: In 2018, 99% of the energy use in city and county owned buildings came from renewable sources (Statistics Norway (SSB), 2019b).

Smart environment

It is a stated goal both of the Nordland county and Bodø Municipality to create more compact, sustainable and innovative cities (Bodø Kommune, 2017, 2018a, p. 19; Nordland Fylkeskommune, 2016, p. 15). Reducing emissions is also a key part of the Smart Bodø plan (Bodø i Vinden, 2018). This will be done, among other things, through smarter transportation and building more energy efficient buildings (Bodø Kommune, 2018a, p. 6).

Additionally, the city plan of Bodø (2014–2016) states that Bodø is a future oriented low emissions city, where all future city planning should be environmentally friendly and seek to enhance the safety of its citizens (Bodø Kommune, 2014b). The city has also introduced strict requirements for climate risk assessments, handling of sea level rise and central heating in all new housing and building projects. Nordland County has the goal of reducing the total CO2 emissions of 20% compared to 1991 (Bodø Kommune, 2014a, p. 10). The CO2 emissions in 2016 were measured at approximately 206,000 tons (CO2 equivalents), which amounts to 4 tons per capita (Miljødirektoratet, 2018). This is well under the national average of 8.6 tons per capita. The E-lighthouse project also encompasses waste management. There is a plan to reduce the CO2 emissions through waste, to recycle more and to recycle the waste into energy (Elighthouse.eu, n.d.-b). In 2018, over 80% of the waste from households in Bodø was recycled (Statistics Norway (SSB), 2019a).

Smart mobility

The transport and logistics sectors are a key focus in making Bodø a smarter city. Bodø Municipality, Nordland County, Avinor (the Norwegian airports' network), the Norwegian Railway Directorate, the Norwegian Coastal Administration and the Norwegian Public Roads Administration are cooperating to create a joint progress plan for Bodø, with the goal of reducing the growth in traffic to zero. Bodø has already devoted NOK 2.9 billion (about € 300 million) to improving bike- and walk paths, public transport and roads through Bypakke Bodø (City Package Bodø), which started in 2015. The public transport system in Bodø was reorganized in 2012, and led to an increase in the number of bus travelers by 18% from 2012 to 2013 (Bodø Kommune, 2014b). According to Avinor, also the airport will use new technology and innovative solutions to ensure efficient operations, reduced investments and improved passenger experience (Avinor, 2017).

Through the E-lighthouse project, Bodø has an ambition to replace fossil energy with hydrogen or biogas. Further, in 2018, Nordland county secured 50 million NOK in a national competition for smarter transportation, which has turned into the project Smarter Transportation Bodø. Through this project, Bodø will create a joint platform for all transportation service providers, improve the level of information on flow of people in, in to and out of the city through collecting more data and making it available to those interested, and to create mobile infrastructure with high coverage (Smartere Transport Bodø, n.d.). Currently,

75% of households have access to broadband of 100 mps or higher, which is close to the coverage nationally (Middleton et al., 2019, p. 32).

Smart governance

Citizen participation is underlined as a key component of Smart Bodø. The Bodø municipality community plan for 2018–2030 states that their 'smart city thinking is about putting people in the centre' (Bodø Kommune, 2018a, p. 4). Further, the strategy indicates that improving people's lives should be done through technology, but also involvement. Most public services can be requested online, and larger projects, such as the moving of the airport are out for public hearing.

Several public events have been organized where citizens can express their opinions about the new airport and the smart city concept in general. The Bodø City Lab is an important measure in that regard. It aims at being a platform for citizen participation, and is both a place where decision makers can meet stakeholders and where citizens can express suggestions, concerns and ideas about city planning (Bodø Kommune, 2018b). A part of the Project Smarter Transportation Bodø is to make citizens more aware of their carbon footprint, and how the daily decisions they make affect the amount of emissions. This will be done through technological solutions, such as individual climate dashboards and gathering all information about transportation options in an app (Smartere Transport Bodø, n.d.).

Smart living

Building a local community that ensures public safety, personal growth and diversity is underlined as a key goal in the city plan strategy (2014–2026) (Bodø Kommune, 2014b, p. 8). A city that actively promotes the well-being of its citizens is also a part of Bodø's overall goal of increasing regional attractiveness and reaching the goal of a population of 70,000 by 2030 (Bodø Kommune, 2014b, p. 8). According to the action plan for public health, the five key goals for Bodø Municipality are to increase city led activities in local communities; enable participation and inclusion; support and cooperate with the volunteer sector; create health focused and health promoting kindergartens; and create health focused and health promoting schools (Bodø Kommune, 2018c, pp. 11–13). Culture is a focus area for Bodø, also highlighted in the City Plan (Bodø Kommune, 2018c, p. 13) (Authors translation). The culture house Stormen was opened in 2014 and consists of a concert house, a public library and an outside area. The Bodø Municipality spent approximately NOK 1.2 billion (about €127 million) on the building of the so-called 'culture quarter'.

For decades, the 'district policy' of Norway has been focused on increasing regional attractiveness of all areas of the country (Norwegian Ministry of Local Government and Modernisation, 2017). Branding a city in Northern Norway as 'smart' and creating more jobs in the region could thus help to increase the city's attractiveness and make more people interested in living and working there.

Oulu, Finland: the hub of Arctic Europe?

For decades, the Finnish city of Oulu has been characterized as an ideal 'smart city', based on the large presence of electronic industries and other high-tech activities (Glomsrød et al., 2017, p. 51; Rantakokko, 2012). Today, it serves as a prime example of urban-oriented Arctic innovation that holds important lessons for cities across the North.

Located just 170 km south of the Arctic Circle, Oulu was ranked as the third 'Silicon Valley' due to its ICT competences and related R&D expenditure as early as in the 1990s (Ojala, Hakanen, Salmi, Kenttälä, & Tiensyrjä, 2009). The city's digital economy started in the 1980s with Nokia's Research Center and the Oulu Technology Park, which housed small-to-midsize ICT enterprises (Rantakokko, 2012). It did not take long for local authorities to proclaim the city to be a technology city (Jauhiainen & Inkinen, 2009, p. 506). Largely due to the global success of Nokia, Oulu's ICT cluster experienced extraordinary growth in the 1990s and the number of related jobs rose to more than 15,000 in 2000. These numbers started to stagnate in the early 2000s due to Nokia's continuous reduction in local labor force and the company's eventual downfall (Vincze & Teräs, 2016, p. 95). However, despite Nokia's demise, Oulu is still ranked as one of the best global cities for start-ups and is currently home to two bigger science parks: Technopolis Plc and Medipolis Ltd (Akhtar, 2012). The city has about 650 ICT companies, some of which utilize open platforms, including a 5G test network,[5] OuluHealth (a health sector innovation cluster),[6] OULLabs (Oulu Urban Living Labs) and its key user community and user involvement tool PATIO, and a city-wide open and free wireless network (panOULU). PanOULU's cooperation agreement was signed in 2003, making it one of the oldest outdoor wireless networks in Finland (Anttiroiko, 2016; Jauhiainen & Inkinen, 2009, p. 506; Laakso, 2017). Moreover, the City of Oulu also provides broad open public data sets for public use free of charge (Oulu City Data Portal).[7] The city's most recent success is often explained by its 'public-private-people-partnership approach', and the long tradition of co-operation between the public sector, companies, education and research institutes, and individuals (Finne, 2018; Rantakokko, 2012). Such new public-private partnerships have particularly been catalyzed by BusinessOulu, the business division of the City of Oulu, that holds the responsibility for the municipality's business politics and development, promoting Oulu as high-technology city (Finne, 2018; Vincze & Teräs, 2016, p. 99). Accordingly, the Oulu Innovation Alliance (OIA), which was created in 2009, aims to carry on the city's long tradition of cooperation (Hintsala, Niemelä, & Tervonen, 2017, p. 83; Rantakokko, 2012, p. 249). This cooperation agreement between various stakeholders from the public sector, research institutions and businesses is a symbol of the city's cooperation success (Finne, 2018). As self-proclaimed network of networks, the purpose of the alliance is to focus on jointly agreed innovation areas, invest in the development of agreed infrastructures, and create and develop innovative tools and methods for mutual use (Hintsala et al., 2017, p. 83). For the period 2016–2020, OIA's five key ecosystems are Agile Commercialization, OuluHealth, ICT & Digitalization, Industry 2026, and Northern City with Attractive Opportunities (Business Oulu, n.d.).

Smart people

A city of roughly 200,000 inhabitants, 3.5% of the entire country, Oulu's population is one of the youngest in Europe, with an average age of about 36 years. In 2016, 67,000 of its inhabitants above age 15 (162,000), had upper secondary education (Official Statistics of Finland, 2017a, 2018a), with the University of Oulu and the Oulu University of Applied Science having a combined number of around 25,000 students (Finne, 2018). About 8,000 people work in the education sector and 5500 in professional, scientific and technical activities (Official Statistics of Finland, 2018a). Thus, Oulu (and Northern Ostrobothnia, respectively) has nearly a twice higher level of R&D human resources than Finland on average (Middleton et al., 2019, p. 40). This is further highlighted by a fairly high level of patenting activity in

Northern Ostrobothnia with 2 patent applications per 10,000 capita and 23.8% of the staff in the business sector per 1000 people employed working in the R&D sector (Middleton et al., 2019, p. 41). In 2015, Oulu's GDP amounted to €33,339 per capita, which was slightly lower than the national GDP per capita (€38,245) of Finland in the same year (Official Statistics of Finland, 2018a, 2018c). Yet, estate is considerably lower, with the city consciously aiming to follow a low housing price policy (Finne, 2018). In 2017, for instance, the rent per square meter was €11 in Oulu, €12.5 in Turku or €16 in Helsinki (Official Statistics of Finland, 2018a). According to BusinessOulu, 18,500 people are currently employed in high-tech jobs in about 650 ICT companies (Rantakokko, 2018). Since 2014, over 500 start-ups have started to operate, making Oulu the fastest growing city of the broader European Arctic, with an expected population growth of 20% over the next 20 years (Official Statistics of Finland, 2016; Rantakokko, 2018). In 2016, €663 million were spend on R&D, allocated between the higher education, public and business enterprise sector, with the latter receiving €488 million. Overall, R&D expenditure amounted to €5.9 billion in Finland in 2016, with €3.9 billion being spent on business enterprises (Official Statistics of Finland, 2017b, 2018a).

However, Oulu experiences specific employment problems by either lacking highly qualified expertise in specific sectors in key tech industries or facing unemployment among young people without or a lower degree of education. This amounts to currently about 4700 unemployed jobseekers aged under 25 in the region of Northern Ostrobothnia every month (European Commission, 2017; Finne, 2018).

Smart environment & energy

The City of Oulu has actively carried out climate policy since the 1990s. Its current greenhouse gas emissions made up a total of about 1,530,000 tonnes (CO2 equivalents), which amounts to 7.8 tonnes per capita in 2014, which is below Finland's emissions per capita of between 13 and 14.3 tonnes (City of Oulu, 2018a; Ivanova et al., 2017, p. 5). A climate strategy for the Oulu region was adopted in 2009 and pledged to cut CO2 emissions by 20% by 2020. Accordingly, Oulu was also one of the first signatories of the EU's Covenant of Mayors for Climate & Energy, an initiative that brings together thousands of local governments voluntarily committed to implementing EU climate and energy objectives. Together with Bodø, the City of Oulu also takes part in the *E-lighthouse* project, focusing specifically on Energy efficiency advice and energy saving for domestic retrofit and new buildings (Elighthouse.eu, n.d.-a).

Smart mobility

With about 1 million passengers in 2016, Oulu Airport is currently the second busiest in Finland after Helsinki-Vantaa Airport (Official Statistics of Finland, 2018b). In order to enhance the reliability of public transportation, the City of Oulu provides real-time information through an HTML5 site showing live locations of buses on a map. Moreover, a traffic light priority solution helps buses to stay on schedule. Both initiatives helped to increase the number of public transportation passengers after a declining trend between 2002 and 2014 (Salpeter, 2018).

Smart governance

In the 1980s, the City of Oulu, in cooperation with the local industry and research institutions, established a first regional business development strategy, focusing extensively on ICT and electronics (Rantakokko, 2012, p. 252). In 2013, the city strategy for 2020

(*Kaupunkistrategia Oulu 2020*) was adopted, a goal-oriented description of how Oulu should look like in 2020. As such, the strategy outlined strategic priorities, success indicators, as well as the present economic state and the-to-be-targeted results for both 2016 and 2020 (City of Oulu, 2013). The highlighted priorities focused on the multidimensional promotion of businesses, a sustainable lifestyle, a balanced economy and a diverse urban culture with an increased in migration of young, educated people. Accordingly, the city aimed to create 20,000 more jobs by 2020 (compared to 2010), reduce the unemployment rate from 13% in 2012 to 9% in 2020, increase total exports of the Oulu region from €3.1 billion in 2012 to €4.1 billion in 2020 and increase R&D expenses from €976 million in 2011 in the entire Oulu region to €1.2 billion in 2020 (City of Oulu, 2013, pp. 8–9).[8] From a user's community point of view, the strategy also highlighted essential topics such as data openness and citizen governance participation. This includes, the above-mentioned PATIO program, as well as providing public data sets for public use free of charge.[9] Generally, the strategic objective is to become the most robust city community of Northern Scandinavia, carrying responsibility for northern global urbanization and competence-based development of the European Arctic. This vision was further updated in 2018 by Oulu's city strategy 2026 (*Valovoimainen Oulu: Kaupunkistrategia 2026*), aimed to make the city a sustainable growth center in the North by 2026 (City of Oulu, 2018b). Moreover, Oulu is also part of Finland's six city strategy (*6Aika*), a program for sustainable urban development carried out by Finland's six largest cities: Espoo, Helsinki, Oulu, Tampere, Turku and Vantaa.

Smart living

The city also actively promotes the well-being of its citizens, which among others ranges from being a *Child-friendly-City* and a related service platform[10], to an extensive cycling route network of about 600 km (900 km in the Oulu region) and to the investment in R&D of wellness technology applications that should support the abilities of the elderly. Thus, digital service solutions are thought to be a key enabler. Oulu has set a goal that 30% of public services and communication to be available as an e-service by 2018, with 80% capacity utilization rate by 2020 and an envisaged high customer satisfaction (European Commission, 2016).

These activities reflect Oulu's evolution from 'innovation hub' to 'innovation node' in a regional network extending both inside and beyond Finland's borders (Anttiroiko, 2016). As an Arctic gateway city, Oulu cooperates with other European Arctic and sub-Arctic cities such as Luleå (Sweden) and Tromsø (Norway) in projects like the Barents-ICT-cooperation, a joint research agenda between the cities' universities. In this Nordic-based model, 'smart' does not only mean the creation of jobs and businesses, but also enhanced involvement of citizens in planning and administration. For instance, Oulu coordinates the European Union's Urban Agenda *Partnership on Digital Transition* to provide better public services to citizens around Europe.

Comparison

In conducting a survey of smart strategies enacted in or planned for Anchorage, Bodø, and Oulu, summarized below in *Table 2: Measures of Smartness in Arctic Cities*, a number of trends begin to emerge in which smart city metrics are more prominently pursued in Arctic urban development. First, Anchorage, Bodø, and Oulu are similar to non-Arctic cities in their prioritization of developing a comprehensive plan and vision to define goals

for smart development. Within these plans, a reliance on ICTs and top-down government action often connect intentions across smart energy, environment, and mobility, leaving metrics in smart governance, people, and living as secondary considerations. In particular, creating a technology-driven economy takes precedent before any other sector. Arctic cities exist – and thrive – on the slopes of boom and bust cycles of fossil fuel development (Anchorage), military investment (Bodø), and national economic strategies (Oulu). Aspiring to be a smart city in the face of a historic reliance on a single industry that often bleeds into the present necessitates Arctic cities to be resilient, innovative, and creative.

Strategies in Anchorage, Bodø, and Oulu also heavily rely on, and often equate smartness to efficiency. Energy efficiency, efficiency in transportation, and government service efficiency and self-sufficiency act as guiding for smart government action. To achieve smart energy, environment, government, and mobility systems in Anchorage, Bodø, and Oulu, strategies focus on changes in infrastructure that often require a large-scale investment. In these strategies, urban residents are described as end-users rather than active participants in fostering a smart city. Equity issues, including indicators such as income inequality, youth unemployment, and social conditions, among others, were not prioritized in smart development in any city. Cultural and social livability objectives often relied on outside financial and technical assistance. Without the funding and expertise from large national organizations, such as Bloomberg Philanthropies in the case of Anchorage, smart living would be left unsupported. In varying degrees, initiatives listed in Table 2 in smart living are supported by foundations, non-profits, and social enterprises outside the circumpolar north.

While it falls without the purview of this article to quantitatively measure each ISO metric with relation to Arctic city development, this survey can form the foundation upon which future researchers can build such an analysis. For those engaged in Arctic smart city analysis, the methodological frameworks of (Garau & Pavan, 2018) and (Huovila et al., 2019) offer a comprehensive approach for further evaluations.

Conclusion: what is Arctic smartness?

This paper aimed to investigate the application – successful and unsuccessful – of southern smart city concepts in an Arctic setting (Goodrick, 2014, p. 1). Anchorage, Bodø, and Oulu all have divergent strengths and weaknesses, and thus all require different support mechanisms with locally-distinct emphases to achieve 'smartness'. These differences derive from their individual histories, geographies, and home nation states. Bodø and Oulu have benefited from the relatively shorter distance from the southern political and economic centers in Norway and Finland when compared with Anchorage and its long geographic distance to the contiguous United States and major North American cities. The Nordic case studies also profited from long-standing national commitments to sustainable development and a healthy environment, and a strong national economy and local investments in their respective northern regions. This has resulted in national public and private sector decisions, such as the decision to move the airport in Bodø and the decision to locate Nokia headquarters in Oulu. Conversely, Anchorage has only embraced smart strategies in the last five years due to the election of a local champion of innovation and smart urban strategies in its current Mayor, Mayor Berkowitz. Having a local champion of smart city concepts resulted in increased investments in high-level government coordinators and increased attraction of outside expertise

and funding sources, such as Anchorage's partnership with Code for America and funding from Bloomberg philanthropies.

Despite these local contexts and distinct challenges, our analysis has identified important catalysts and obstacles for Arctic cities to achieve smartness. First, in order to achieve 'smartness' in the six categories measured, each city required a clear, comprehensive strategy. A detailed roadmap and vision based on local contexts and urban characteristics is requisite to enacting sound policy. Second, external investment by businesses and foundations is essential to augmenting local capacity. In Oulu, such external investment was found in Nokia and successive tech-sector businesses. In Bodø, the Norwegian government and transport sector are providing the necessary financial and logistical support to propel the city onto a smarter path. In Anchorage, critical support has been given by national foundations to augment smart governance, living, and people. Third, economic diversification and implementing a smart economy is acutely important for Arctic cities due to the resource dominance of the regional circumpolar economy. In Oulu, investment in developing a tech sector allowed for a transition beyond manufacturing and forestry; in Bodø, the closure of the airport forces the city to expand employment beyond the military sector to a multifaceted local economy; and in Anchorage, the 2014 fall in global oil prices and recession allowed social, tech, and energy entrepreneurship to grow.

In all, a universal fixed system for smart cities may be difficult to define with the variety of characteristics of cities worldwide. However, it has been made clear that the definitions posed by particular cities calling themselves 'smart cities' lack universality. A smart city assessment must take into account that cities have different visions and priorities for achieving their objectives, and that each urban center must promote an integrated development of different aspects of smart infrastructure (Albino, Berardi, & Dangelico, 2015). Urbanization is taking different courses in different regions, and the Arctic is no different (Dybbroe et al., 2010, p. 122).

Notes

1. https://data.muni.org.
2. Bodø Airport is located south of the city center, on the tip of the Bodø peninsula, only a 15-minute walk away from the city center. The airport has been a combined military and civilian airport since 1952 and the main airbase of the Royal Norwegian Air Force in Northern Norway.
3. Official documents refer to the project with different names, including NyBy, Smart Bodø and Smart City Bodø.
4. GDP per capita per municipality is not available for Norway.
5. With a 6G Flagship Ecosystem already been formed under the lead of the University of Oslo.
6. https://www.oulu.fi/cht/ouluhealth_rdi.
7. https://data.ouka.fi/fi.
8. R&D expenditures dropped both in Oulu and in Finland between 2011 and 2016 from the indicated €976 million (Oulu) and €7.2 billion (Finland) to the above-mentioned €663 million (Oulu) and €5.9 billion (Finland), which mostly relates to years of economic stagnation in Finland, especially between 2008 and 2015.
9. https://www.oulunjoukkoliikenne.fi/oulu/english/open-data.
10. https://lapsuus.ouka.fi/en/.

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