

GROWING SMART CITIES IN DENMARK

DIGITAL TECHNOLOGY FOR
URBAN IMPROVEMENT AND
NATIONAL PROSPERITY

ARUP

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ABOUT

About Invest in Denmark

As part of the Ministry of Foreign Affairs of Denmark, Invest in Denmark is a customized one-stop service for foreign companies looking to set up a business in Denmark.

www.investindk.com

About Arup

Arup is an independent consultancy providing professional services in management, planning, design and engineering. As a global firm Arup draws on the skills and expertise of nearly 11,000 consultants. Arup's dedication to exploring innovative strategies and looking beyond the constraints of individual specialisms allows the firm to deliver holistic, multi-disciplinary solutions for clients.

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About CEDI

CEDI is a consulting company with expertise in public sector digitization in Denmark. CEDI provides strategic consulting to the government and the IT industry based on solid insight into the subjects of digitization and technology, extensive knowledge on the administrative and decision-making processes of government agencies, and a deep understanding of the political agenda.

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EXECUTIVE SUMMARY



**DENMARK HAS AN
OPPORTUNITY TO BECOME
A WORLD LEADER IN
SMART CITIES**



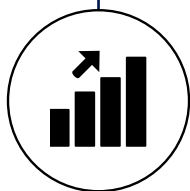
EXECUTIVE SUMMARY

Over the last decade the 'smart city' concept has emerged to represent technology-driven urban benefits and the products and services that deliver them. For national governments, the smart city is attractive because it represents an opportunity to improve its towns and cities and to access a large global market, estimated to be in the order of \$1.3 trillion and growing by 17% each year. National governments are ramping up their efforts to remove barriers that are preventing regional and municipal governments from applying smart city solutions and local businesses from developing and exporting related products and services. There is a recognition that government action is required to give the country a head-start in the race to attract international companies, talent and investment.

In Denmark, smart city projects have been carried out in many towns and cities, usually by the municipal government in collaboration with business and academia. Looking at four very different Danish cities (Copenhagen, Aarhus, Vejle, Albertslund) shows the widespread pursuit of smart city benefits by all of these players. For example, in the Capital Region of Denmark, employment in companies that operate in the smart cities market has risen by 60% between 2003 and 2013, which amounts to 19,500 jobs. Smart city activities in Denmark are, however, mainly small in scale and solutions are not applied widely. Businesses are frustrated by “pilot sickness” where projects are carried out without any subsequent investment or scaling up. This is not unique to Denmark. The failure to scale up smart cities pilots in Denmark reflects the wider situation in many countries around the world. Our global research indicates that five main requirements are needed to enable widespread smart city activity in a country. Reviewing these five requirements in Denmark provides insights into why smart city projects are not scaling:



Municipal capability. Denmark municipalities have powers and funding to commission smart city projects, receiving 50% of the national public budget. Over half of the municipalities in Denmark have carried out smart city projects, some of which have gained global recognition. Yet many lack skills, knowledge, and a cross-departmental organisation to grow these projects. Municipalities are unclear about which smart city solutions to buy, which vendors to buy them from, how to buy them in a way that avoids risks like technology redundancy.



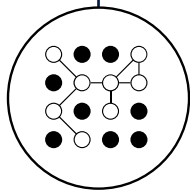
Investment certainty. The challenges that Danish municipalities face, including a lack of scaling beyond the pilot phase, sends a message of risk and uncertainty to the private sector. Businesses in Denmark have developed innovative smart city products and services, often in collaboration with each other and with universities, municipalities, and citizens. Yet the demand for these solutions is limited by the indecision of municipalities and their limited cooperation. Without clear and combined municipal interests, solutions are restricted to one-off implementations in individual towns and cities in Denmark, which detracts on-going private investment.



Skills and research. Denmark has people with advanced digital skills in many industries, such as renewable energy, healthcare, and lighting. Universities have invested in smart cities research to support the development of solutions and knowledge in the field. Yet many businesses cannot access the digital skills they need (this is estimated at 25% of the Danish companies in the digital industry) and do not have a clear view of the relevant industry solutions and components that are available within Denmark.



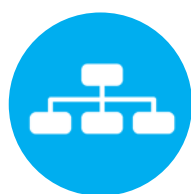
Public acceptance and digital literacy. There is widespread access to digital infrastructure and education in Denmark, demonstrated by the country's top ranking in the EU Digital Scoreboard. Yet there are concerns among the general public about data privacy and cyber security related to smart city solutions, which has the potential to stall uptake. For example, one-third of the population feels unsafe when using the public sector's digital services.



Sharing of data. The publishing of data for public consumption is common among all levels of the public sector in Denmark to provide political transparency and stimulate business activity. Most municipalities have open data portals and Copenhagen is developing a platform for businesses to share their data with the municipality. Yet valuable city data is locked up

within private and public organisations where the case for its release has not been made or heard. Organisations are developing smart city systems that cannot be integrated with those of other organisations, limiting innovation between organisations.

Denmark has a strong base in these five requirements, which has placed the country in a good position to realise the benefits of smart cities relative to other countries. But Denmark is coming up against the limits of what it can achieve opportunistically. All of the requirements need to be fully met for the country to progress. Lessons can be learnt from the actions of other governments to grow smart cities in their countries as an industry and tool for urban improvements. Drawing on these lessons and Denmark's attributes, five actions are proposed for the Danish public authorities to grow smart cities for Denmark:



Develop municipal digital governance. Help municipalities to create their own vision and strategy to guide their use of digital technology to improve the city. Support the creation of a capability within municipalities to manage smart city projects to address issues or opportunities across municipal services, and provide a single point of entry to the municipality for solution providers.



Strengthen city collaboration. Build on current networks between municipalities to support the sharing of knowledge to improve digital governance and the pooling of interests to attract private investment. Use these networks and the regional governments to identify and highlight areas of expertise within Denmark and attract global recognition.



Clarify standards and regulation. Monitor and provide guidance on the numerous existing policy and standards to address the needs of municipalities on legal and technical issues relating to smart cities. Work with world leading organisations on remaining issues on standards for data sharing.



Address public concerns. Ensure municipal governments listen to the concerns and needs of their citizens related to smart city projects, adapting their digital education programmes or feeding back needs to national government. Apply the Danish user-centred design approach to smart city projects so human concerns are addressed through the design of the project or product.



Communicate the opportunity. Publish a national smart cities vision to generate a better understanding of the value of smart cities to Denmark and to convey commitment to its growth, including clear outcomes and targets to be achieved. Analyse the domestic and global market for smart cities to identify priority sectors and geographies, aligning domestic competencies with global opportunities. Set national research challenges to spur the development of products and services, and to grow digital skills and literacy domestically.

Denmark is at an inflection point: the public authorities could continue in an opportunistic fashion to meet the requirements for smart cities when actions coincide with other agendas, such as the digitisation of public services. Or the public authorities could take systematic action to fully address all of the requirements. No country has comprehensively achieved this yet although there is an emerging set of front runners. Acting now could enable Denmark to take a lead in the market and avoid costs related to inaction, similar to the country's response to climate change. Being a market leader would involve new flows of funding and employment opportunities. Systematically and holistically pursuing smart cities would also improve Danish towns and cities, making them more efficient, environmentally friendly, and liveable.

INTRODUCTION



**SMART CITIES ARE A TOOL FOR
COUNTRIES TO IMPROVE THEIR
URBAN AREAS AND GROW THE
NATIONAL ECONOMY**



REPORT BACKGROUND AND METHODOLOGY

This report sprang from a common recognition among the Danish public authorities that smart cities represent a tremendous opportunity to Denmark. Together the Ministry of Foreign Affairs and members of the steering committee commissioned this research to examine the current and future role of the Danish public sector in developing smart cities to support Denmark's economy.

The report consists of three chapters and each chapter addresses a different research question:

1. Smart city activity in Denmark. This chapter addresses: what smart city activity has taken place in Denmark and could more be done? Smart city activities in Denmark are presented through the progress made by four cities: Copenhagen, Aarhus, Vejle and Albertslund. The cities were selected to represent a range of urban types in Denmark. Denmark's strengths and weaknesses in the five requirements are then reviewed to understand how well the country is realising the opportunity from smart cities. Input for this review included existing research on smart cities in Denmark and workshops with the steering committee.

2. Lessons from other countries. The second chapter looks at what Denmark can learn from government actions in other countries to address the weaknesses identified in Chapter 1. Governments around the world are reacting in different ways to harness the opportunity from smart cities. Specific lessons are drawn for Denmark based on our research and experience of public sector activities in other countries. The impact of their activities is highlighted where possible.

3. Recommendations for Danish Public Authorities. The third and final chapter outlines recommendations for how the Danish public authorities can grow Denmark's economy and improve its urban areas through smart cities. The recommendations are drawn from the findings of Chapters 1 and 2.

This research was carried out by a joint Arup and CEDI team, with input from the steering committee, which included Danish public authorities and specialists in academia and other public organisations (the members are listed on page 2).



PHOTO: TY STANGE, COPENHAGEN MEDIA CENTER

THE OPPORTUNITY FROM SMART CITIES

Over the last decade, the smart cities concept has emerged to represent the opportunities and challenges enabled by digital technology in an urban context. Technologies such as sensors, smartphones, robots, augmented reality, cloud computing and data analytics, are being used to make cities more smooth running, more productive, and more democratic. These benefits are growing in importance as more people move into cities globally and as urban lifestyle expectations rise. At the same time, this wave of technological innovation has brought challenges. Digital technology can isolate and exclude sectors of society. It can threaten individual privacy and national security, displace labour, and become obsolete and expensive.

From an economic perspective, the smart cities concept provides an enticing opportunity to national governments. The global market for smart cities solutions is large and growing, estimated to be in the order of \$1.3 trillion and growing 17% each year¹. The market consists of a range of products and services, including consultancy services,

THE CONCEPT OF SMART CITIES REPRESENTS TWO INTERTWINED OPPORTUNITIES FOR COUNTRIES: THE OPPORTUNITY TO IMPROVE URBAN AREAS AND TO GROW THE NATIONAL ECONOMY



PHOTO: CLAUDS RANDRUP, COPENHAGEN MEDIA CENTER

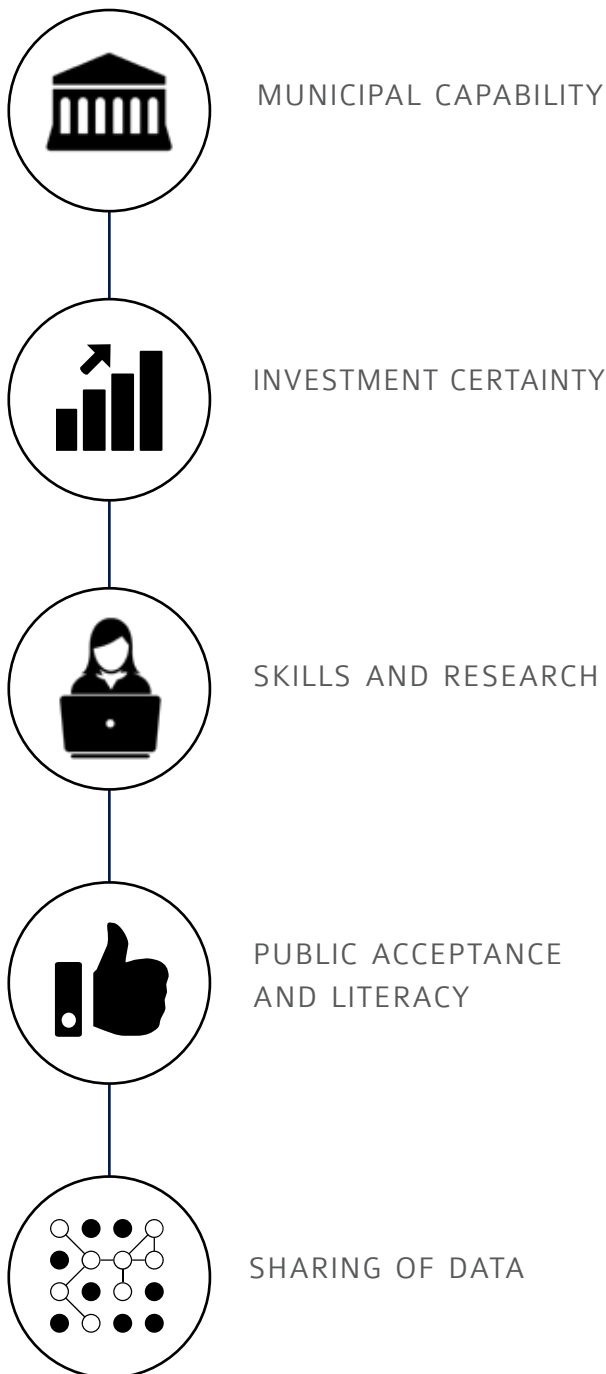


PHOTO: THE MUNICIPALITY OF AARHUS

software and hardware products, and associated physical infrastructure. To roll out a smart lighting initiative in your city could involve, for example, purchasing software for data sharing and storage, hardware such as sensors and a faster Wi-Fi network, infrastructure such as LED light bulbs and new lamp posts, and consultancy to help develop the business case and procurement contracts. Developing and implementing smart city products and services domestically can create economic benefits through export but also by making nicer cities that are more attractive to talent and investment. The concept of smart cities, therefore, represents two intertwined opportunities for countries: the opportunity to improve urban areas and the opportunity to grow the national economy.

THE GLOBAL MARKET FOR SMART CITIES SOLUTIONS IS LARGE AND GROWING, ESTIMATED TO BE IN THE ORDER OF \$1.3 TRILLION AND GROWING 17% EACH YEAR

NATIONAL REQUIREMENTS FOR SMART CITIES



How can countries realise the opportunity from smart cities? Our global research indicates that five requirements are needed:

1. MUNICIPAL CAPABILITY

Arup's report "Delivering the Smart City" found that municipal governments can no longer operate by traditional modes of governance if they want to use digital technology to improve their cities. Technology applications will be restricted to existing processes and delivery models without addressing issues and opportunities that span municipal departments. Municipalities need a capability to coordinate the use of digital technology across departments and convene actors in different sectors and industries². This digital governance can involve new skills, leadership, and an organisational culture, to develop a vision and strategy and to implement smart city projects. With this new capability, municipalities can attract investment and partners for smart city projects and provide a single point of entry to the municipality for solution providers. This could allow them to transform the operations of a municipality using technology and reinvest the savings into new services and initiatives.

2. INVESTMENT CERTAINTY

The return on investment of smart city projects and their associated products and services is, in general, not clear to the private sector. There is a perception of high risk related to innovative solutions, large volumes of investment required, long delays in realising profitability, and limited capacity for municipal public funding³. This uncertainty is related to municipal digital governance, without which there is no clear buyer for smart city solutions. As a result smart city projects are mainly being financed through research and innovation funds, which prevents them from being scaled to support every city. Business models are needed for smart city projects that define a robust, attractive offer to the private sector and to the other actors involved – public and non-profit sectors and citizens. Long-term government commitment is also needed to grow confidence among investors to unlock funding, such as a dedicated industrial policy and research on the smart cities market opportunity⁴.

3. SKILLS AND RESEARCH

Researchers and professionals are needed to invent and deliver smart city solutions. Their research and skills must cover different disciplines and areas of expertise in relation to digital technology and urbanism. There is a shortage of digitally skilled professionals in many countries⁵. Governments are investing in education and vocational training programmes to improve digital skills but the pace of technological change means that education is not always tied to business needs. More research is needed on topics such as smart city business models, governance structures, and data privacy to support the scaling of initiatives. This is being enabled to an extent by the emergence of industrial policies dedicated to digital or information economy in many countries to support research activities, new businesses, and the development of digital skills.

4. PUBLIC ACCEPTANCE AND LITERACY

Smart city solutions depend on the general population being able to use the technology involved and to feel comfortable with how their data is being used. Governments globally have been investing in their country's information and telecommunication networks, computers, and educational programmes to ensure their populations can access and participate in the online world. These efforts are driven by the recognition that digital literacy is key to grow the economy and provide public services. Governments have done less to make their citizens and businesses aware of how to protect their privacy and security in the digital age. Public concerns are increasingly coming to light over data privacy, including how our 'digital traces' are being used, such as the signals emitted from mobile phones or search histories on the internet⁶. The public needs to be able to use and trust digital technology in their lives for the development of smart cities.

5. SHARING OF DATA

Smart city solutions are based on combing data on different aspects of a city, from live transportation and energy data to support the electrification of transport, to social media and planning data to involve citizens in the design of new city developments. Governments at all scales, national to local, are providing some of this city data through "open data"

initiatives, where data sets owned by the government are made freely available to the public online, often with the aim of increasing transparency, stimulating economic activity, and improving public services. There is, however, a lot of valuable city data that is not being shared and there are machines that cannot communicate with other machines being implemented to operate parts of the city. This restricts the ability of a city to function as a system, where the energy system knows what the transport system is doing, for example⁷. Standards and protocols can enable data sharing and interoperability but the landscape of smart city standards and guidance is complex and in great motion. Many different organisations have developed standards and guidance, including traditional standards bodies, private companies, international organisations, making it difficult for cities to navigate and influence⁸.

THE PUBLIC NEEDS TO TRUST
THE DIGITAL TECHNOLOGY
IN THEIR LIVES FOR THE
DEVELOPMENT OF SMART CITIES



PHOTO: THOMAS HØYRUP CHRISTENSEN, COPENHAGEN MEDIA CENTER

INTRODUCTION TO THE DANISH GOVERNMENT

In Denmark, government is structured on three levels: the national government, the regions, and the municipalities. The country is divided into five regions, which are popularly elected administrative units. The regional governments are responsible for the running the hospitals and some social institutions. They are also responsible for regional development, which includes supporting business and urban development in their regions⁹. As part of this role, the regions play an important role in creating partnerships between municipalities to support smart cities and in building partnerships between the private, public and academic sectors. For example, the Central Denmark Region has initiated and supported many of Denmark's smart city projects. The regions are funded through block grants from the national government, which are designated to be spent on certain areas¹⁰.

There are 98 municipalities in Denmark, which are also popularly elected administrative units. The municipalities are responsible for a wide array of tasks, including primary schools, child care, elderly care, as well as libraries, museums, parks and recreation. The municipalities are funded partly through block grants from the national government, and partly through separate municipal income and property tax, the size of which may vary between municipalities. The municipalities have been the primary agents for implementing and operating smart city projects in Denmark.

The map below shows all five regions of Denmark, with the Central Denmark Region further broken down to municipalities, to illustrate the three tiers of governance.



FIGURE 1: MAP OF THE DENMARK'S FIVE REGIONS AND THE MUNICIPALITIES THAT MAKE UP THE CENTRAL DENMARK REGION. SOURCE: CEDI.



PICTURE OF CHRISTIANSBORG, THE DANISH GOVERNMENT BUILDING
PHOTO: CEES VAN ROEDEN, COPENHAGEN MEDIA CENTER

SMART CITY ACTIVITY IN DENMARK



DENMARK IS ADVANCED IN ITS USE OF SMART CITIES BUT THE COUNTRY COULD GO FURTHER





GLOBAL CITY: COPENHAGEN

Copenhagen is the largest city in Denmark with about 600,000 inhabitants in its city area and almost 2 million in its greater metropolitan area. The capital is generally considered to be highly advanced in regard to technology as well as quality of life and in 2014 Copenhagen won the prestigious World Smart Cities Award in Barcelona for the concept, "Copenhagen Connecting".

Copenhagen Connecting

Copenhagen Connecting is a concept for a digital infrastructure across the entire city. The assumption behind the concept is that digital infrastructure will be the future platform for smart city innovation and will cover the city in a similar way to physical infrastructure today. A business case states a socio-economic potential in the order of 4.4 billion DKK, if the concept is implemented¹¹.

Copenhagen Solutions Lab

The Copenhagen Solutions Lab was initiated in late 2014 and spawned the Smart City Street Lab as a tool for citizen involvement and development of business, by testing smart city solutions in the area around City Hall¹². The Street Lab is a test bed for smart city solutions in Copenhagen to showcase the newest technologies and catalyse partnerships with the private sector and academia.

Urban planning and carbon neutrality

The municipality has focused its smart city initiatives on environmental issues related to its commitment for Copenhagen to be an entirely carbon neutral city by 2025¹³. The socio-economic gain of the carbon neutral city will be at least 1 billion DKK yearly from savings in the use of heating and electricity¹⁴. The adherence to the goal of carbon neutrality is evident in the urban development currently taking place in Copenhagen. For instance, the design of the new Nordhavn district of Copenhagen, which is currently being built, took into account renewable energy supply forms and green means of transportation. In a helix partnership¹⁵, the City of Copenhagen has established a Smart City Energy Lab in Nordhavn. Over the next four years (2015-2019), the Lab will develop and demonstrate future urban energy solutions. The project utilizes Copenhagen's Nordhavn as a full-scale smart city energy lab and demonstrates how

electricity, heating, energy-efficient buildings, and electric transport can be integrated into an intelligent, flexible, and optimized energy system¹⁶.

Open data

Another priority for Copenhagen with regard to their smart city strategy is the publishing of accessible and open data. Through its open data portal, www.data.kk.dk, the municipality has published more than a hundred data sets, including maps of parking spots, public toilets, and simulations of traffic flow, for example. A vast amount of future publications of data are planned, such as energy statistics for the city's buildings and demographic data. In addition the potential of 'big data' is being explored as the Japanese technology company Hitachi is establishing a big data platform (City Data Exchange) in the spring of 2015 in cooperation with the City of Copenhagen, the Capital Region of Denmark and CLEAN. The platform aims to bring together private data and open public sector data to create better public solutions and new business opportunities for companies¹⁷.

THE SOCIO-ECONOMIC GAIN OF
THE CARBON NEUTRAL CITY WILL
BE A LEAST 1 BILLION DKK YEARLY



FAST GROWING MID-SIZED CITY: AARHUS

With around 260,000 inhabitants in the inner urban area and almost 850,000 in its greater urban zone, Aarhus is the second largest city in Denmark and the largest on the peninsula of Jutland. Acting as a regional centre for research and education, as well as home to Scandinavia's largest university, Aarhus is a fast-growing and evolving city in terms of its population and economy.

Dokk1

Aarhus opened a new innovation centre at Dokk1 in 2015. The centre for innovation supports and strengthens innovative projects that will create specific everyday improvements for citizens in Aarhus. The work of the centre relies on combining strong partnerships with innovative ideas. The centre is also a physical space – a neutral zone for inspiring creativity, innovation and collaboration. The City of Aarhus runs the centre with the purpose of facilitating innovation processes that bring together different public institutions, citizens, and other private actors. Employees at the centre will take on the role as partners and facilitators in the different projects bringing in their practical experience to assist at any point in the innovation process

Smart Aarhus

The smart city efforts in Aarhus, Smart Aarhus, are organized around the principles of citizen involvement and co-production, where cross-sector collaboration between public, private, and academic entities is the norm and an important part of Aarhus strategy to promote business and growth potentials. In short, anyone who is interested can join in the so-called four-strand helix of smart city innovation in Aarhus – public sector, industry, research and education, and civil society¹⁸. Due to this, the Aarhus University has been capable of establishing a viable smart city research centre, which is not only an influential local player, but also has clout on a national and international level. Smart Aarhus represents a new way of raising political awareness and organization with the aim of finding effective and sustainable solutions to the challenges faced by many cities today. An ongoing example is the Centre for Telemedicine in Aarhus that focuses on developing smart solutions for the health care sector. The Centre is driven by the Central Denmark

Region, a key player in and co-founder of Smart Aarhus and since its inception in 2012, has connected the foremost experts in the field of telemedicine from hospitals, municipalities, and private clinics. The goal is to further the use of telemedicine to the benefit of ordinary citizens¹⁹.

Internet week Denmark

Internet Week Denmark is a festival taking place in and around Aarhus. The festival celebrates the success and the impact of the internet on innovation, business, and our everyday lives. The backbone of Internet Week Denmark is a week-long festival based on crowd-sourced events which promote citizen involvement and co-production. This means that companies, educational institutions, networks, and individuals contribute by hosting events during the festival. The festival brings attention to the impact of the internet economy on business and growth potentials as well as to the attraction and retention of talent and entrepreneurship. Internet Week Denmark is a public festival, open to all, just like the internet is an open platform for all. The festival was originally initiated by Smart Aarhus and was part of the Smart Aarhus development process in 2012. In 2015, more than 4,500 guests attended more than 100 different events at the festival. Internet Week Denmark is an annual event, the next one taking place on May 9th-13th in 2016.

Open Data Aarhus

In accordance with good smart city practice, the Municipality of Aarhus is also continuously sharing a wide variety of accessible and open data via its data portal, www.odaa.dk. Two examples of such published data are real-time traffic information, and a map of running routes. The BlipTrack sensors collecting real-time traffic data, for instance, are an open invitation for smart city innovation within traffic and mobility. Based on readily accessible and open garbage data, Aarhus itself has already made a visual map of the available space at its recycling stations, which can be accessed through the Internet²⁰.

TOP: DOKK1. PHOTO: AARHUS PUBLIC LIBRARIES

LEFT: INTERNET WEEK DENMARK, AARHUS. PHOTO: MUNICIPALITY OF AARHUS

RIGHT: DOKK1, AARHUS. PHOTO: AARHUS PUBLIC LIBRARIES



THE SMART CITY EFFORTS IN AARHUS, SMART AARHUS, ARE ORGANIZED AROUND THE PRINCIPLES OF CITIZEN INVOLVEMENT AND CO-PRODUCTION



SMALLER CITY: VEJLE

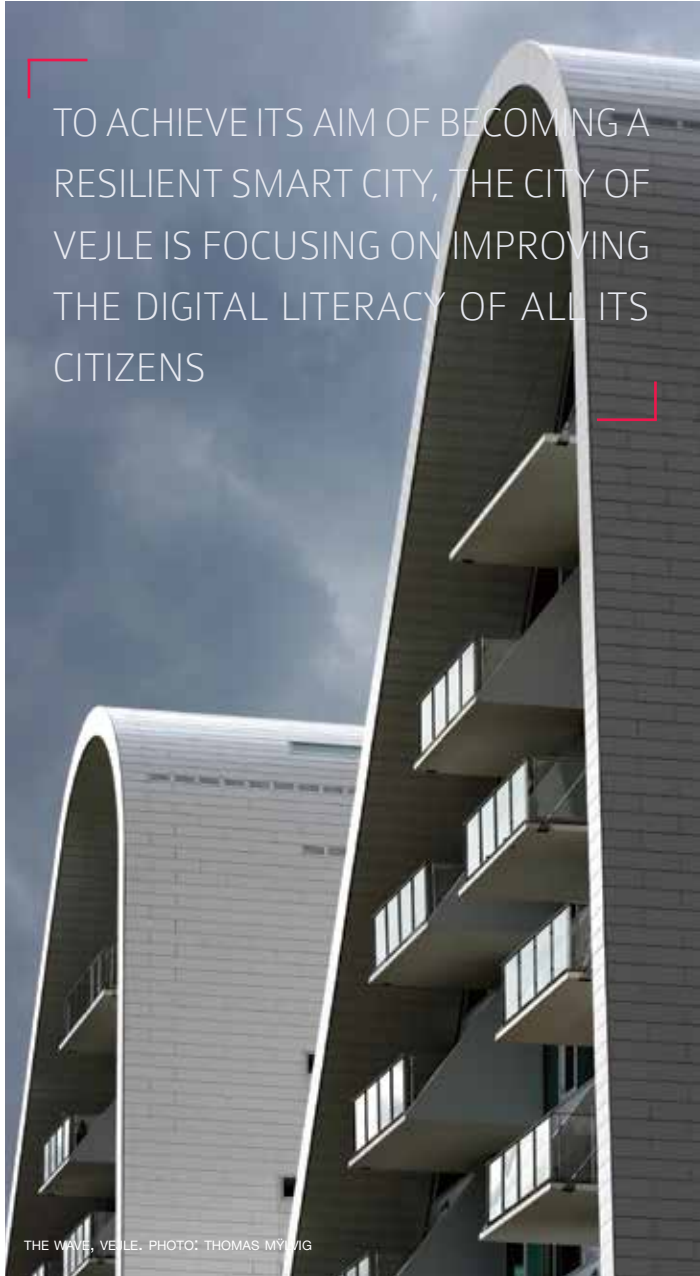
The old city of Vejle is located inside a beautiful fjord in southern Jutland. Due to its dominance in the textile industry decades ago, Vejle was once nicknamed “the Manchester of Denmark”, and to this day the city has retained its cultural and economic dominance in the region. That being said, Vejle is not a very large city in terms of population – just about 55.000 people inhabit its urban area. When it comes to digital innovation and smart city initiatives, however, Vejle is very much a first mover.

Resilient Vejle

Due to its geographical position, Vejle is particularly vulnerable to environmental hazards like climate change – slight rises in sea levels could cause half of the city to be flooded²¹. In 2013 the city became a member of the worldwide network “100 Resilient Cities” funded by the Rockefeller Foundation. The city is using the momentum from the membership of the network to become an innovation lab for resilience, building the robustness of Vejle to both sudden and long-term threats, and inspiring others as they go along²². Vejle is one of the smallest cities in the partnership – far from the size of Rio de Janeiro or Los Angeles – but aspires to show that smaller provincial cities can be agile frontrunners of innovation and development. The City of Vejle works with resilience in four focus areas – climate & flooding, social resilience, resilient smart city and co-creation.

Smart Citizens

To achieve its aim of becoming a Resilient Smart City, the City of Vejle is focusing on improving the digital literacy of all its citizens, and has launched a Digital Inclusion programme. Vejle aims to develop efforts beyond the usual groups of elderly, immigrants and socially excluded groups. For instance, young people may be digital natives, but some still have a hard time reporting their income on the taxing agency’s online self-service platform. Likewise, businesses are expected to have high levels of digital competencies, but that is not necessarily the case for a farmer, a hair dresser, or a kebab shop owner. In all of those cases, Vejle engages in dialogue to develop better and more easily understood digital solutions, co-creating solutions with civil society on how to empower all societal groups in the digital society.



TO ACHIEVE ITS AIM OF BECOMING A
RESILIENT SMART CITY, THE CITY OF
VEJLE IS FOCUSING ON IMPROVING
THE DIGITAL LITERACY OF ALL ITS
CITIZENS

THE WAVE, VEJLE. PHOTO: THOMAS MYRVIIG

PIONEERING CITY: ALBERTSLUND

The City of Albertslund is an ex-industrial suburb situated west of Copenhagen. The city has 28,000 inhabitants from 106 nationalities, an active local community, and a tradition for cross-cutting dialogue between authorities, citizens and businesses.

Innovative city renewal

Faced with a large renewal plan, including the renovation of 6,000 social housing units, renewal of technical facilities, including outdoor lighting, and the renovation of public buildings, the Albertslund Municipality established two new innovation committees in 2014. One committee is focused on “Urban Innovation” and the other on “Innovation & Welfare”. Each include members from businesses, local organizations, and five elected council members. For both committees, smart cities is high on the agenda and is being approached from different angles.

The Urban Innovation Committee carries out activities to promote and identify opportunities for business and economic growth. This includes initiatives to help communities to modernize and adapt to the use of digital technology and green resources. During the first years, the work included the projects “indoor and outdoor lighting solutions”, “Wi-Fi in the town centre” and “smart grid”. As part of the move towards a smarter city, Albertslund is in the process of replacing its entire street light system, creating a digital infrastructure backbone with integrated fibre communication and sensor capabilities that will cover the entire city.

The Innovation & Welfare Committee handles the identification and development of healthcare solutions. Here, as well, the aim is to focus on smart city solutions, for example health-promoting intelligent lighting for the elderly and smart solutions to support the municipality’s new care and health centres. In 2016 a new health and rehabilitation centre in Albertslund will open as a living and learning lab for innovative healthcare solutions. Planned focus areas include remote health monitoring and simulation training environments for healthcare workers and students.



CONTROL ROOM BUILDING IN PLAYFUL LIGHTING. PHOTO: DAVID ZINCK

DOLL – Danish Outdoor Lighting Lab

The Danish Outdoor Lighting Lab (DOLL) is a European platform for developing future LED-lighting solutions. DOLL is a consortium consisting of The Technical University of Denmark (DTU), the municipality of Albertslund and Gate 21. DOLL consists of three laboratories: 1) Quality Lab located at DTU’s Photonics department in Roskilde, which offers manufacturers and buyers tests and documentation of all aspects of artificial lighting, 2) Virtual Lab located at DTU Photonics which can test, develop, and validate light solutions virtually generated in 3D, and 3) Living Lab located in Hersted Industrial Park, Albertslund that offers a 1:1 experience of the outdoor lighting. DOLL has created a large ecosystem of lighting and smart city vendors to pilot new solutions in the city. This has made Albertslund the largest European showroom for the future of lighting technology, receiving regular international delegations who visit the city to experience the technology first hand. DOLL is expanding their platform to test, demonstrate and develop smart city solutions in Albertslund, through its Smart Urban Services project. Beyond the city, the partners behind DOLL are working to make Greater Copenhagen a ‘Lighting Metropolis’. This is a new large-scale initiative that brings together the nine major municipalities in the region to develop smart lighting solutions with universities and companies. DOLL has allocated 54 million DKK of funding to the initiative and 20 pilot projects are planned so far.

REVIEW OF DENMARK'S ACTIVITIES

We now take a wider look at smart city activities in Denmark by looking at the country's strengths and weaknesses in the five areas required for smart cities.

MUNICIPAL CAPABILITY

Decentralized governance and a collaborative approach towards problem-solving provide conditions for the effective management of smart city projects in Denmark. Compared to other countries, municipal governments in Denmark are well funded, receiving 50% of the national public budget, which itself accounts for 57% of gross domestic product (GDP)²³. Municipalities in Denmark also have greater powers compared to cities elsewhere, including dimensions like being able to set policy and vision, own and operate assets, and control budget. Copenhagen, for example, owns and operates the city-wide district heating network and was able to set a policy mandating households to connect to it²⁴. The opportunity from smart cities has been pursued widely by municipalities in Denmark, irrespective of their size. A survey carried out in 2014 with 53 of the 98 Danish municipalities showed that just more than half (28 municipalities) had launched activities that they classify as related to smart cities (Box 1). This level of adoption is high considering that there is no related national government funding or mandate.

MUNICIPAL GOVERNMENTS IN DENMARK ARE WELL FUNDED, RECEIVING 50% OF THE NATIONAL PUBLIC BUDGET, WHICH ITSELF ACCOUNTS FOR 57% OF GROSS DOMESTIC PRODUCT

The smart city activities carried out by Danish municipalities cover a wide range of areas, such as environment, safety and health care, mobility, political awareness, citizen involvement, and business and growth. In particular a large proportion of the initiatives in the survey were related to the sustainable

use of natural resources, such as apps for helping citizens to share bulky refuse with each other instead of discarding it. Many initiatives were also related to citizen participation, such as apps that allow citizens to inform the municipal authorities of broken street lights. This reflects the country's expertise in green living, renewable energy, and inclusive policy making.

The majority of smart city initiatives were carried out by municipalities without any supporting governance; only 17% of the municipalities had a smart city vision, strategy, plan, administrative focus area, or taskforce. Comparing the municipalities with and without smart city governance shows that those with governance in place had implemented a greater number and a wider range of initiatives.

Municipalities in Denmark often collaborate with other sectors to deliver smart city initiatives, including the private sector, academia, and civil society. This "four strand helix" is well established in Denmark and is crucial for smart city projects²⁵. There are many consortia involving municipalities, regions, universities and private business in the field of smart cities, such as the Gate 21 partnership, which is focused in the greater Copenhagen region, and the EnergyLab Nordhavn, which is focused on smart energy solutions for cities. The Copenhagen Solutions Lab is a cross-departmental incubator for smart city initiatives for the municipality of Copenhagen. The Lab collaborates with citizens, companies and knowledge institutions to tackle urban challenges such as traffic, air quality, water and waste management²⁶.

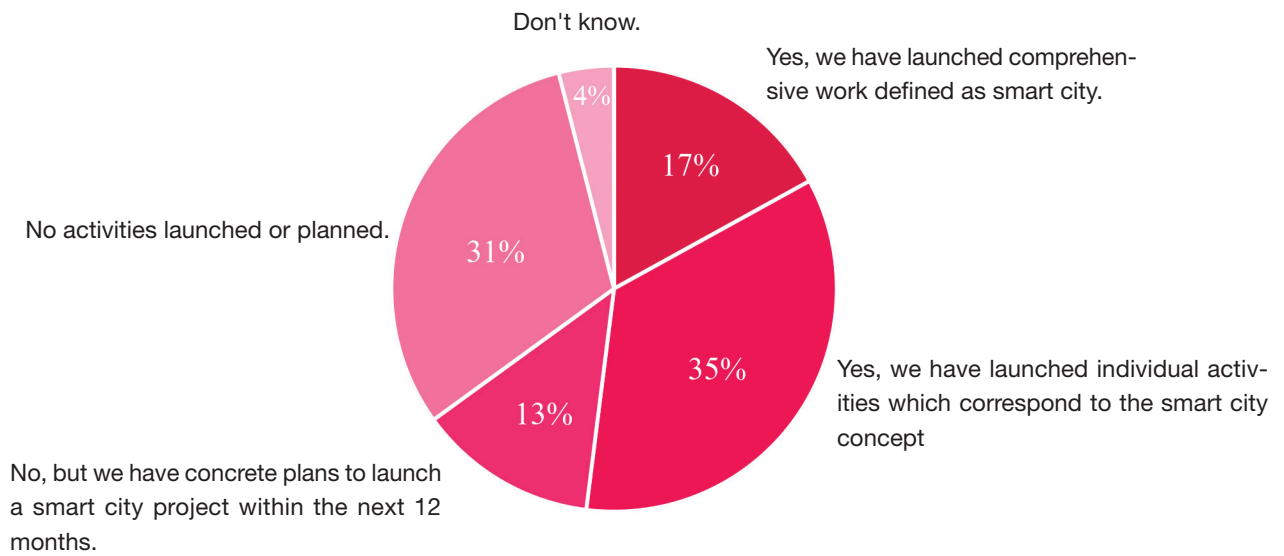
Municipalities in Denmark are sharing knowledge with each other on smart cities through national and regional networks. The Danish Business Authority and the University of Aarhus coordinates a national smart city network that brings together national policy makers, municipalities, organizations and researchers to exchange knowledge, experience and ideas on smart cities²⁷. The regional governments in Denmark also work together on smart city initiatives and many have integrated smart city thinking into their regional business and growth plans. The Central Denmark Region, for example, has created a policy framework 'Smart Cities in Smart Regions' to support collaboration between the municipalities, companies,

BOX 1: SURVEY OF SMART CITY ACTIVITY BY DANISH MUNICIPALITIES

The survey was answered by 53 municipalities out of a total of 98 municipalities in Denmark.
 Source: CEDI (2014) "Smart city i de danske kommuner – status og initiative".

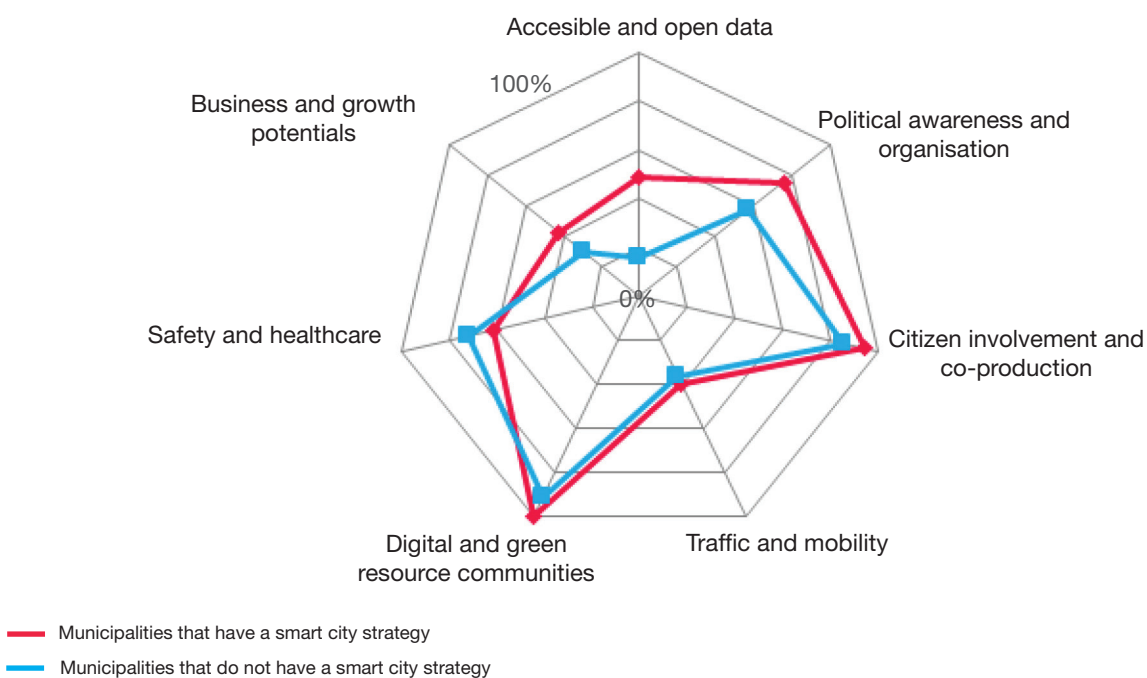
HAS YOUR MUNICIPALITY LAUNCHED SMART CITY ACTIVITIES?

[Percentage of municipalities that have launched activities related to smart cities]



COMPARISON OF THE QUANTITY AND TYPES OF INITIATIVES CARRIED OUT BY MUNICIPALITIES WITH A SMART CITY STRATEGY VERSUS THOSE WITHOUT A SMART CITY STRATEGY

[Percentage of municipalities with at least one initiative in each surveyed category]



SMALL BUSINESSES PERCEIVE THE DANISH GOVERNMENT AS AN OPPORTUNITY TO PROVE THE SUCCESS OF THEIR PRODUCTS AND GAIN A REPUTABLE STAMP FOR EXPORT

knowledge institutions, and citizens in the region²⁸. In the wider Copenhagen area, the Capital Region of Denmark is setting up a data hub and competency centre to support businesses and municipalities in the region to use data and digital technology. In the so-called “triangle area” of Denmark in the southern region, six municipalities have been collaborating since the 1960’s on city operation, business development, and specialized education²⁹.

Despite the uptake of smart city initiatives and collaboration among municipalities in Denmark, many feel uncertain over their approach to implementation. A recent workshop involving 16 members from universities, municipalities, organisations and the private sector, indicated that some municipalities feel isolated and call for closer cooperation with other municipalities. They are uncertain about which smart city solution to buy, which vendors to buy from, and how to procure solutions in a way that avoids risks like vendor lock-in or technology redundancy. Municipalities are concerned by whether they are generally moving in the right direction. For example, how can they create long-term eco-

nomic value from their open data initiatives, moving beyond the “hackathon”, and how can they draw on new technologies and trends and like the sharing economy³⁰. These questions indicate a demand among Danish municipalities for more capabilities to implement smart cities.

INVESTMENT CERTAINTY

Innovative smart city products and services are being created in Denmark thanks to organisations that help to de-risk the development of smart city solutions and demonstrate their benefits. One such organisation is the Danish Outdoor Lighting Lab (DOLL), which invites an array of lighting vendors to test and demonstrate their smart lighting solutions within the city of Albertslund. Copenhagen Solutions Lab is another example with its Smart City Street Lab, a test area outside the City Hall which showcases new smart city and Internet of Things technologies³¹. Others, such as Gate 21 and CLEAN, are bringing together large and small businesses, government and institutions in Denmark to invest in smart cities solutions. The approach of the Danish government towards working with small and medium enterprises (SME) also drives the development of innovative smart city solutions. In other countries, SME often perceive municipalities as an unattractive market due to their cumbersome procurement process. In Denmark SMEs perceive the Danish government as an

LEFT: THE LOOP, PHOTO: BIG GROUP

RIGHT: STREET LAB IS COPENHAGEN’S TEST AREA FOR SMART CITY SOLUTIONS IN REAL URBAN SPACE, PHOTO: TY STRANGE, COPENHAGEN MEDIA CENTER



opportunity to prove the success of their products and services and gain a reputable stamp for export³².

The national government has developed economic plans and convened cross-sector teams to stimulate business growth in technologies related to smart cities. The “ICT and digitization growth plan” allocated DKK 1 million of investment in 2015 to promote Denmark internationally as a place for developing and testing smart city solutions³³. This included a collaboration between the Ministry of Foreign Affairs and the Singaporean government to improve each other’s understanding and implementation of smart city initiatives, combining the strengths of both countries, such as Singapore’s advanced technology solutions with Denmark’s expertise in citizen participation³⁴. Alongside the growth plans, growth teams consisting of CEOs from successful businesses and other high ranking leaders from public and private organizations aim to provide the Government with policy recommendations in their fields of expertise. Three of the teams have emphasised smart cities: the ICT and Digitization team, Energy and Climate team, and Health and Wellbeing team^{35 36 37}.

WHILE INVESTMENT IS FLOWING TO DEVELOP NEW SMART CITY SOLUTIONS IN DENMARK, IT IS LESS AVAILABLE TO DEVELOP EXISTING SOLUTIONS AT SCALE IN MANY CITIES

At the municipal level, cities are combining their interests to attract the private sector to invest in smart city solutions. One striking example is Loop City. In 2014 the Ministry of Transport and Building, the Capital Region of Denmark and 10 municipalities formed a coalition to enable the construction of a new light rail transit around Copenhagen. The costs for the light rail (estimated to be DKK 4.4 billion) are being

shared between the stakeholders. When open in 2020/21, the light rail will consist of 28 stations and transport over 1 million passengers each month, providing a catalyst for new housing and business in the suburban municipalities. A strategic organisation, Loop City, is responsible for driving a wider urban development strategy in parallel with the light rail construction, which includes the development of smart city initiatives. With plans to provide Wi-Fi and install sensors along the light rail, Loop City plans to use big data and smart services to attract residents, business and investment to the area around the new light rail. A common infrastructure need has brought municipalities together to develop smart city opportunities³⁸.

While investment is flowing to develop new smart city solutions in Denmark, it is less available to develop existing solutions at scale in many cities. The uncertainty of Danish municipalities in procuring and delivering smart city solutions spills over to the private sector, which already differs from the municipalities in terms of their financial time horizon and commitments, such as salaries, growth goals, and competition³⁹. Companies are suffering from “pilot sickness” where smart city development activities are carried out “on a project basis”, without taking into account subsequent activities, for example ongoing investment, thereby missing a link between development and subsequent operation. As a result “few smart city projects are converted to full scale operating investments”⁴⁰. For Denmark, where smart city innovation and cross-sector collaboration are already in place, this investment uncertainty is a key barrier.

SKILLS AND RESEARCH

Leading research has been carried out in Denmark on topics relevant to smart cities and the four strand helix approach ensures that research is related to business and societal needs⁴¹. For example, the national public-private Smart Energy Denmark Partnership Network acts as a catalyst for research, development and demonstration of energy solutions that will meet the country’s energy policy goals. Tied to this work, Denmark now hosts a third of smart grid projects and demonstrations in Europe, such as PowerLabDK on the ‘green island’ of Bornholm, where smart grid technologies are tested and demonstrated under realistic conditions.



Bornholm's vision is to become a "100% sustainable and carbon-free community by 2025"⁴².

Denmark has a base of skilled professionals relevant to smart cities based on its advanced application of digital technology in industries such as renewable energy, healthcare, agriculture, design and architecture. The advancement of these industries was facilitated by the national government's cluster policy, which has been adopted for many years to stimulate economic growth for specific sectors. According to EU rankings, Danish clusters are some of the strongest in Europe, especially in the fields of environmental and digital industries⁴³. The strength of the green technology sector can be traced back to the 1980s roadmap, which set the country on course to achieving a fossil fuel free future by 2050. Today new companies in the field of clean energy and sustainable construction account for 8.5% of employment in Danish enterprises, compared to 1.5% of jobs in the UK^{44 45}.

Architecture and urban design represent another strong cluster of economic activity in Denmark with relevance for smart cities. Denmark's architecture has become synonymous with sustainability and quality, with its low-energy buildings and innovative designs. Meanwhile Danish urban design is associated with liveability and a people-centred approach, through the work of Gehl Architects in particular. Digital healthcare is an emerging cluster, driven by the national digitisation agenda, and a number of telemedicine initiatives are being launched, such as patient-reported outcome measures, which take the form of digital surveys that help assess the treatment needs of chronic patients⁴⁶.

25% OF THE DANISH COMPANIES WORKING IN DIGITAL INDUSTRIES HAVE POSITIONS THAT CANNOT BE STAFFED DUE TO A LACK OF PEOPLE WITH THE RIGHT SKILLS

However, in Denmark, like in many other countries, there is a shortage of the "digital skills" needed for digital industries, including smart cities. According to research by the Danish Business Authority in 2014 an estimated 25% of the Danish companies working in digital industries have positions that cannot be staffed due to a lack of people with the right skills⁴⁷. The national government set out a plan to promote digital skills and education in its "ICT and digitization growth plan" (2011-2014) and in other growth plans, such as energy and climate which supported skills related to smart grids⁴⁸. Such government plans are needed to plug the gap in skills for the delivery of smart cities.

ONE-THIRD OF THE POPULATION FEELS UNSAFE WHEN USING THE PUBLIC SECTOR'S DIGITAL SERVICES

PUBLIC ACCEPTANCE AND LITERACY

In general the Danish population has access to good digital infrastructure and education. A high percentage of the Danish population access the internet daily (85%), compared to the EU average of 65%⁴⁹. Denmark has been ranked as number one in the EU Digital Scoreboard, which measures the progress of European countries' according to five key indicators: Connectivity, Human Capital, Use of Internet, Integration of Digital Technology, and Digital Public Services⁵⁰. In addition to digital infrastructure, Denmark also has an advanced educational programme for the general population on digital technology, which is driven by the municipalities and the National Agency for Digitization.

Municipal governments are responsible for funding and managing initiatives to ensure that their citizens can access the benefits of digital technology. The Danish government has an established programme for educating adults in adapting to the world of public services that digitization has brought about – both publicly and through civil society. For example, the association of Danish municipalities, Local Government Denmark (LGDK), offers an in-service training program for municipal employees, which helps them become “digital ambassadors” for digital solutions⁵¹. In addition to this, organizations from civil society engage in digital education. An example is the cooperation between Ældresagen, an association that works to improve conditions for the elderly in Denmark, and the Municipality of Aalborg⁵². The national government awards a prize for “digital initiative of the year” to an organization in civil society to support digital education and literacy⁵³.

Despite these government efforts, there are public concerns regarding data privacy and security. A survey by Dansk IT and Rambøll indicates that one-third of the population feels unsafe when using the public sector's digital services⁵⁴. While Denmark has advanced digital public services compared to other countries driven by the eGovernment Strategy, there is an opportunity for a more systematic use of digital technology to support an interactive dialogue with citizens on the design of public services at a municipal level⁵⁵. The cross-ministerial innovation unit, MindLab, provides a prece-

dent for involving citizens in the design of public services at a national level. Such platforms at a local level would allow citizens to directly express their needs and desires, share concerns and challenges, and fund solutions collectively⁵⁶.

SHARING OF DATA

A national strategy is in place to ensure municipalities in Denmark share their data, and indeed most municipalities have open data portals. The eGovernment Strategy establishes making public data available for business innovation as a priority⁵⁷. One initiative within the strategy is the National Basic Data project, which aims to make data from public records more readily accessible, such as data on properties, companies, water quality and geographic maps. The project is estimated to secure socio-economic gains of at least 800 million DKK yearly by 2020⁵⁸. In addition, the Danish Business Authority is developing standards around data sharing for cities and Denmark's national standards organisation, Danish Standards, monitors and participates in the development of international smart city standards. For example, Danish Standards is working with the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) on mapping needs and preparing standards for smart cities⁵⁹. Danish Standards also collaborates at the European level through the EU “Smart and Sustainable Cities and Communities Coordination Group (SSCC-CG)⁶⁰.

Like in other countries, Denmark's municipalities have been driving the open data movement alongside, and sometimes ahead of, national government, and in collaboration with the regions. Copenhagen is leading globally in terms of its use of open data and is currently driving an innovative initiative, City Data Exchange, to facilitate the sharing of data across the public and private sector. To develop the business case and technical specification for the platform, the City of Copenhagen engaged with the private sector and universities during a three-year tender process, which involved a pre-procurement stage. Danish cities are collaborating with each other to share best practice and guidance on smart city solutions and to coordinate on policy issues. For example, Copenhagen, Aarhus, Odense, Aalborg and

Vejle have come together in “a network of five cities” with the Central Denmark Region to run an initiative, Open Data DK, which aims to put open data on the national agenda and to create a national portal, where data from public institutions and private companies can be found. Another city collaboration, “OS2 – Open digitization Community”, involves over 50 Danish municipalities to create and share digital solutions.

Many Danish municipalities participate in international networks engaged in developing smart cities standards, such as the Open & Agile Smart Cities (OASC) initiative and the EU Smart Cities and Communities (SCC). Currently seven cities are members of either or both of these networks: Copenhagen, Aarhus, Aalborg, Vejle, Kalundborg, Sorø, and Hillerød. Launched in January 2015, the OASC network has grown quickly and now includes 61 cities from 12 countries. The aim is to “kick-start the use of a shared set of wide-spread, open standards and principles, enabling the development of smart city applications and solutions to reach many cities at once, by making systems interoperable between cities, and within a city.”⁶¹ Municipalities are also working individually with cities in other countries. Aarhus is working with the cities of Santander and London in the EU project OrganiCity, the goal of which is to scale smart city solutions⁶². Copenhagen is working with Helsinki and Antwerp to develop guidance on the pre-procurement process for smart city initiatives⁶³.

Municipalities’ active engagement in national and international collaborative networks signify the need of Danish cities to tackle issues that are not currently addressed at a national government level. There is a proliferation of standards and protocol around smart cities, which is confusing for municipalities and businesses. Solutions are being developed that are proprietary to specific vendors, blocking the free flow of data across city systems to support service delivery. This is hindering the smart cities market; McKinsey estimates that interoperability between systems is required to realise 40% of the total economic value enabled by the Internet of Things, which they estimate as \$4-11 trillion a year by 2025. The confusion over standards could explain why only a proportion of municipalities in the survey (32%) had implemented solutions in the theme of ‘accessible and open data’, despite the national government open data programme.

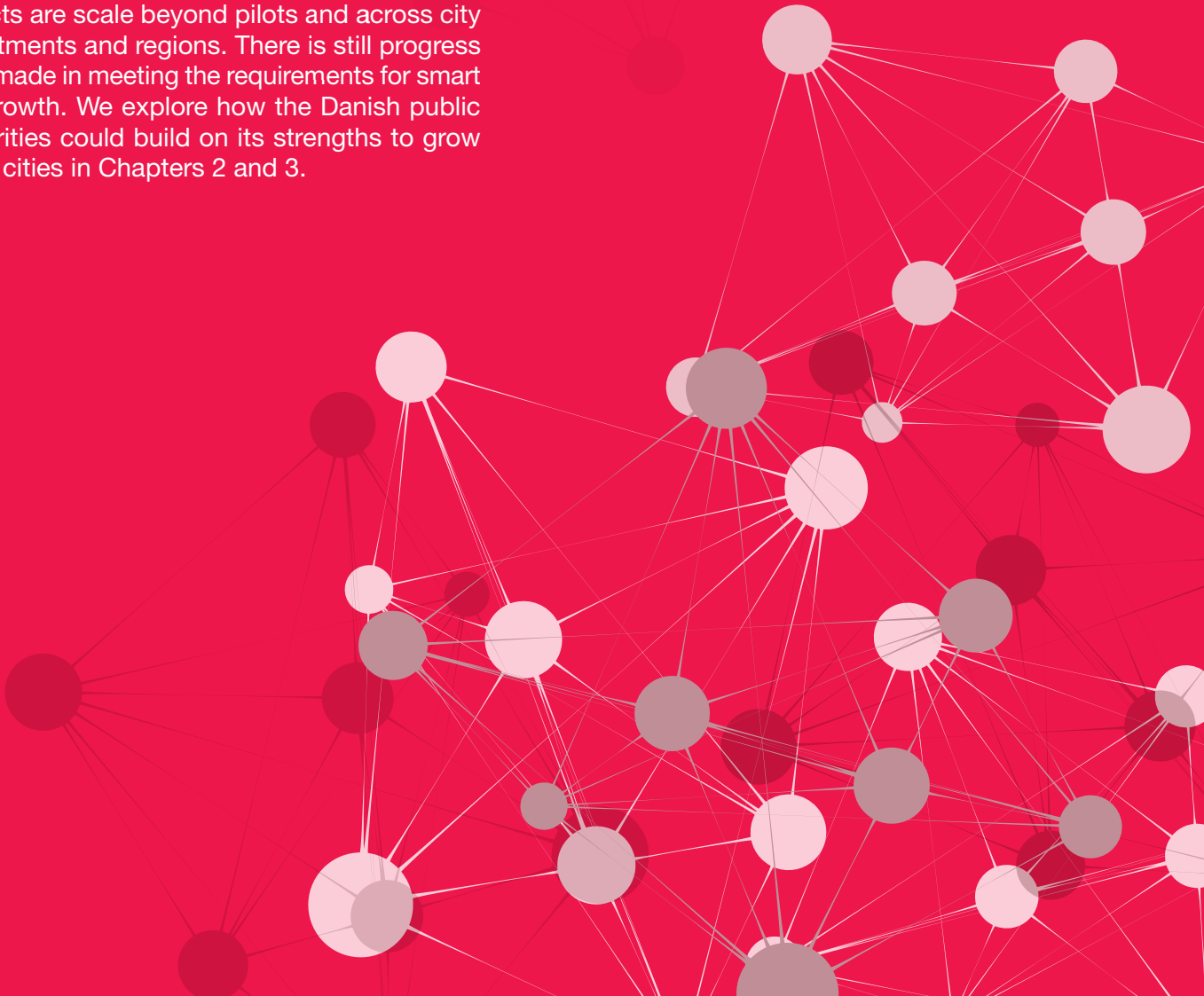
DENMARK’S MUNICIPALITIES HAVE BEEN DRIVING THE OPEN DATA MOVEMENT ALONGSIDE, AND SOMETIMES AHEAD OF, NATIONAL GOVERNMENT



GREEN FIELD CITY OF VINGE
PHOTO: HENNING LARSEN ARCHITECTS

CONCLUSION

Smart city activity is taking place across Denmark in small, medium and large cities; from small towns like Vejle to mid-sized cities like Aarhus, larger cities like Copenhagen, and innovative new greenfield sites like Vinge; from projects utilizing cutting-edge technology in Copenhagen and Aarhus, cities which enjoy a strong position in the global smart city community, to projects in the more rural areas of Denmark that use technology in innovative ways to improve public service delivery and business growth. This activity is having an economic impact: it is estimated that employment in smart city companies in Denmark has risen by 60% from 2003 to 2013. In the capital region of Denmark this amounts to 19,500 jobs⁶⁴. Yet Denmark could realise greater benefits as projects are scale beyond pilots and across city departments and regions. There is still progress to be made in meeting the requirements for smart city growth. We explore how the Danish public authorities could build on its strengths to grow smart cities in Chapters 2 and 3.



LESSONS FROM OTHER COUNTRIES



GOVERNMENT ACTIONS TO GROW SMART CITIES IN OTHER COUNTRIES PROVIDE INSIGHTS FOR DENMARK



MUNICIPAL CAPABILITY

Denmark's challenges in growing smart cities are not unique. National, regional and municipal governments around the world are reacting in different ways to harness the opportunity from smart cities. Here we look at how governments in other countries have removed barriers to smart city growth. Their actions provide lessons for Denmark and their inaction highlights opportunity.

LESSON: CHANGE THE MUNICIPAL WAY OF WORKING FOR DIGITAL INNOVATION

Many city governments around the world are using digital technology in a limited fashion: applying it to improve existing processes without considering how it can transform a service to better meet the needs of users. As a result, there are many examples of digital public services that are difficult to use and do not meet the needs of citizens. Examples show that broad organisational and cultural change is usually required to use technology to make public services more easy to use and effective. The work done by the UK Government Digital Service (GDS) team provides a valuable lesson in how to carry out this change within government. The UK government established GDS in 2011 to oversee the digitisation of public services at a national level. The original mandate of the team was to build a digital layer for government that could “empower and make life simpler for citizens and, at the same time allow government to turn other things off” saving money in the process⁶⁵. The GDS team has since become both the architect and the engine room of government digital service provision. They developed a set of simple design principles to guide the creation of digital public services and instil a user-centred design approach to technology across government⁶⁶. They also launched a new single website for the UK government⁶⁷. The work of GDS has helped the UK government to save an estimated £1.7 billion in 2014-2015⁶⁸. Furthermore the UK government recently pledged to invest a further £450m in GDS⁶⁹.



ABOVE PHOTOS: GDS.BLOG.GOV.UK

LESSON: ESTABLISH DIGITAL LEADERSHIP WITHIN MUNICIPALITIES

It is the responsibility of city governments to create a clear vision and strategy to manage smart city projects and improve digital technology to improve the city. Some cities such as New York City have created the post of a Chief Digital Officer (CDO) to advance the city's digital strategy. Similarly, in Chicago, Mayor Emanuel created two new positions of Chief Technology Officer and Chief Data Officer to advise the Mayor on strategic technology and data matters. Situating these positions in the Mayor's Office has facilitated the process of working with different city departments, rather than within one⁷⁰. Pursuing this organisational change to become an early mover in municipal digital governance can bring commercial benefits as well as providing better services to citizens. As one of the first countries to digitise its public services, Estonia has exported its e-solutions, such as i-Voting, e-Cabinet, and e-Health systems, to over 40 countries. National government can play a role in stimulating this change among municipalities. The UK Government incentivised 30 municipalities to develop smart city strategies through the Future Cities Demonstrator competition, awarded each city with £50,000 to devise a strategic application for a further pot of £24 million in smart cities spending.

PURSUING THIS ORGANISATIONAL CHANGE TO BECOME AN EARLY MOVER IN MUNICIPAL DIGITAL GOVERNANCE CAN BRING COMMERCIAL BENEFITS AS WELL AS PROVIDING BETTER SERVICES TO CITIZENS



INVESTMENT CERTAINTY

LESSON: DEVELOP A STRATEGY TO CREATE DEMAND FOR DIGITAL SOLUTIONS

Through its Smart Nation strategy, the Singapore Government has managed to cultivate a local economy for smart city products and services and signal investment certainty in Singapore. Launched in 2014, the strategy involved putting in place a vision (Smart Nation Vision), policies, partnerships and significant investment in ICT (US\$1.44 billion in 2014 and US\$1.63 billion in 2015)⁷¹. It is coordinated via a national-level agency, the Smart Nation Programme Office (SNPO). A key part of the strategy is the Smart Nation Platform developed by the Government which has involved installing over 1,000 sensors throughout the city to enable smart city applications. The platform ensures connectivity and interoperability between all of the sensors to enable effective data sharing.

THROUGH ITS SMART NATION STRATEGY, THE SINGAPORE GOVERNMENT HAS MANAGED TO CULTIVATE A LOCAL ECONOMY FOR SMART CITY PRODUCTS AND SERVICES AND SIGNAL INVESTMENT CERTAINTY IN SINGAPORE

In addition to the Platform, the Government has created demand in Singapore for the development and export of new digital solutions. One example is the work done by Housing Development Board (HDB), the organisation within the Singapore Government which is accountable for over 80% of Singaporeans' homes. HDB created a framework for its implementation of digital technology that focuses on four key areas: Smart Planning, Smart Environment, Smart Estate, and Smart Living. Alongside this framework, HDB provides

a platform for testing smart housing solutions in energy and waste management, assisted living and others. The take-up of these technologies is encouraged through government incentive schemes. The Singapore Government's commitment to invest in smart solutions and in enabling infrastructure has provided relative certainty for private companies, amongst other positive outcomes for Singapore.



LESSON: ASSIGN NATIONAL LEADERSHIP FOR SMART CITIES

An OECD report from 2009 has shed light on the importance of national government in coordinating smart city activities⁷². Many national governments have created portfolios and leadership roles for 'digital' and 'cities' within government to drive these agendas forward and to manage new regulatory demands, such as industry disruptions caused by new digital companies. Drawing up his government in 2015, Prime Minister Malcolm Turnbull of Australia appointed the country's first Minister for Cities to ensure that all levels of government work together to help cities progress⁷³. The Prime Minister's Cabinet has also taken over the Digital Transformation Office of the country to drive the Open Government agenda from the top⁷⁴. Since 2011, the UK has also appointed a Minister for Cities and created the UK All-Party Parliamentary Group (APPG) on Smart Cities to bring together political parties, academics, businesses and local governments to discuss pressing challenges related to smart cities and share expertise to find solutions.

SKILLS AND RESEARCH

LESSON: ENSURE DIGITAL EDUCATION IS RELATED TO BUSINESS NEEDS

Matching digital education with business needs is crucial in a world of fast technological developments. Businesses in many industries are experiencing difficulties in recruiting people with the right digital skills⁷⁵. It is the role of both government and industry to address this skills shortage. An initiative which exemplifies this process is the New York Mayor's Tech Talent Pipeline industry partnership⁷⁶. Organisations from the public and private sector came together to define employer needs, develop and test training and education solutions to meet these needs, and scale solutions that work throughout the city.

“WE NEED TALENT, WE NEED IT NOW, AND WE SIMPLY CANNOT FIND ENOUGH”

The ultimate goal of the industry partnership is to grow a talented workforce that can help local businesses to grow. Large technology companies such as Google, Microsoft and Facebook have joined the initiative and expressed their support through an open letter to Mayor de Blasio: “We need talent, we need it now, and we simply cannot find enough. One in five New York City businesses employs tech talent, fuelling the growth of a tech sector that today represents nearly 300,000 jobs and \$30 billion in annual wages”⁷⁷. The active engagement of the private sector in such initiatives and their outright support shows how businesses can help to grow and diversify their tech workforce, which New York has seen to grow by 57% between 2007 and 2014, nearly six times faster than overall citywide employment⁷⁸.

LESSON: CREATE A NATIONAL RESEARCH FRAMEWORK

In addition to skills development, research is needed to drive innovation in smart cities. Given the breadth of the smart cities concept, research in this area involves many disciplines and fields of study, which often lie outside traditional research programmes. A coherent approach towards research on smart cities is needed that brings together sectors including city governments, businesses and universities. The United States provides an example of how the government can enable this collaboration and champion this new field of study. In September 2015 President Obama's Administration announced a new “Smart Cities Initiative” which aims “to build a research infrastructure for Smart Cities”. The initiative is part of the White House's overall commitment to use federal resources to meet local needs and support community-led solutions. It will involve investing \$160 million in federal research and leveraging the resources of more than 25 new technology collaborations. A key part of the initiative is the participation of more than 20 cities and universities, which have come together in the MetroLab Network, a platform to support emerging city-university relationships through the sharing of successful projects and coordinating multi-city, multi-university research efforts. The founding members of the new Network have collectively committed to undertaking more than 60 smart city projects in 2016⁷⁹.



PHOTO: DANIEL BORMAN

PUBLIC ACCEPTANCE AND LITERACY

LESSON: ADDRESS CITIZEN CONCERNS OVER DATA PRIVACY AND SECURITY

Citizens are just starting to realise the dangers related to their personal data created through their use of certain sites and digital services. The furore over the hacking of many high profile websites in 2015, including Experian, one of the largest data brokers and credit agencies in the world, and AshleyMadsen, the extramarital dating site, has raised the profile of data breaches and the financial and social damage that can be caused. For the public sector this translates into citizen uncertainty about how their data is being used and shared, and creates public fears over data privacy and security. For example, smart metering roll-outs are under particular scrutiny from potential users because of the implications for people's privacy and security.

With the 'Internet of Things' and smart city solutions being implemented more widely, data will be generated from everyday objects as well as traditional sources and the linking of this data will be more common place. By connecting more data, from more sources, with increasingly sophisticated analysis, it is possible to identify individuals more readily. Therefore the concept of anonymous data is being challenged. Already telecommunications companies are sharing anonymous data from their users' smartphones on location and journey patterns with third parties. The public needs to be able to trust that anonymous data is what it purports to be. The risk is that further data breaches and their consequences create a backlash against the use of anonymous citizen data, impacting on the roll-out of more socially benign applications such as smart metering.

Governments at all levels have created legislation to address concerns around privacy; however, such approaches have been piecemeal. For example, the EU legislation on the 'right to be forgotten' allows for people to remove online information about themselves⁸⁰. Legislation needs to catch up with the speed of technological developments and the new services enabled through these technologies. Governments need to understand how data is being collected, used and shared through new technologies and decide on

appropriate legislation to regulate the use of data in the interests of citizens.

As a starting point, city governments should be clear to citizens on how data it collects through smart city services is used and shared. A good example is the privacy policy created by the New York City government LinkNYC programme. The LinkNYC programme is a huge communications programme that will deliver bring up to 10,000 public information terminals to NYC streets, offering free Wi-Fi at gigabit speeds to the public. The programme will be funded through advertising. Early privacy concerns prompted the development of a robust privacy policy which details how users' information is used and promises that it will never be sold⁸¹.



SHARING OF DATA

LESSON: RELEASE MEANINGFUL DATA QUICKLY AND DEMONSTRATE ITS VALUE

Generating open data is only the first step in attaining value from it. The remaining challenge is to get citizens and businesses to use it. The London Datastore was one of the first online platforms to make public data available to all and to help the city function better. The objective of the Datastore is to make data accessible and meaningful to citizens, not just the developer community, and give entrepreneurs the opportunity to use the data to create new businesses and solve city problems. This has contributed to creating an open data marketplace in London.

The successful establishment of the London Datastore can be attributed to several factors. First, the focus was on opening existing public data sets without worrying too much about the data quality, which can be improved by intermediary companies along the value chain. Second, it was critical to ensure that the released data was meaningful both to citizens and the developer community. Finally, being able to identify and showcase the value generated from using this data was the cornerstone in convincing local authorities and

other public bodies that freeing up data can add value to their work and the services they provided. To facilitate the release of open data from local authorities within London, the Borough Data Partnership has been founded. This is enabling London's boroughs to share, organise and structure data better, and to look at data across borough boundaries. This gives boroughs an overview of the bigger picture, and an opportunity to collaborate on the use of analytical tools that can make decision-making more accurate and efficient.

The impact of releasing London's data is already evident. The digital economy is one of the fastest growing sectors in the UK, with businesses emerging at each stage of the information value chain. Evidence for this is the vibrant "information marketplace"⁸² in transport, with over 460 transport apps having been created using data from the London Datastore. In order for Denmark to be able to spread the culture of open data amongst local authorities and create an open data marketplace, it is crucial to systematically engage with a broad range of stakeholders – "from data experts, to urban designers, behavioural scientists and city planners" – and find out what they can do with city data.





THROUGH THE ODI, THE UK GOVERNMENT CAN ALSO CONNECT WITH OPEN DATA BUSINESSES, ENTREPRENEURS AND INNOVATORS, THUS ENABLING THE PRIVATE SECTOR TO INFLUENCE PUBLIC POLICY

LESSON: COLLABORATE ON STANDARDS

The UK Government provided £10 million of funding over five years (2010-2015) to establish the Open Data Institute (ODI), an organisation that has been instrumental in enabling businesses to use public sector data. The ODI is an independent organisation co-founded by Sir Tim Berners-Lee, inventor of the world wide web, and Professor Nigel Shadbolt. It helps businesses to use the growing amount of public sector data published to create new products and services. Through its research, educational, business incubation and support activities, the ODI has become the hub of open data knowledge and expertise in the country. To date the ODI has “unlocked over £40m in investments, contracts, sales and efficiencies globally, [and] trained 2.8k people in open data”⁸³. It has also become the primary partner for the UK Government in shaping the future of data infrastructure in the UK, connecting the government with open data businesses, entrepreneurs and innovators.

It is crucial for national governments to collaborate with the private sector to develop technical standards for smart cities. A consortium of 40 technology companies in the UK has developed a specification called HyperCat to ease the communication between machines and applications without human intervention. The specification, which has received £6.4m of government funding, aims to ensure a secure and interoperable Internet of Things^{84 85}. Given the important role ICT plays in smart cities, the UN’s telecommunications standardization body (ITU-T) has also set up the Focus Group on Smart Sustainable Cities, which published a set of 21 technical specifications and reports guiding the integration of smart technology in cities⁸⁶.

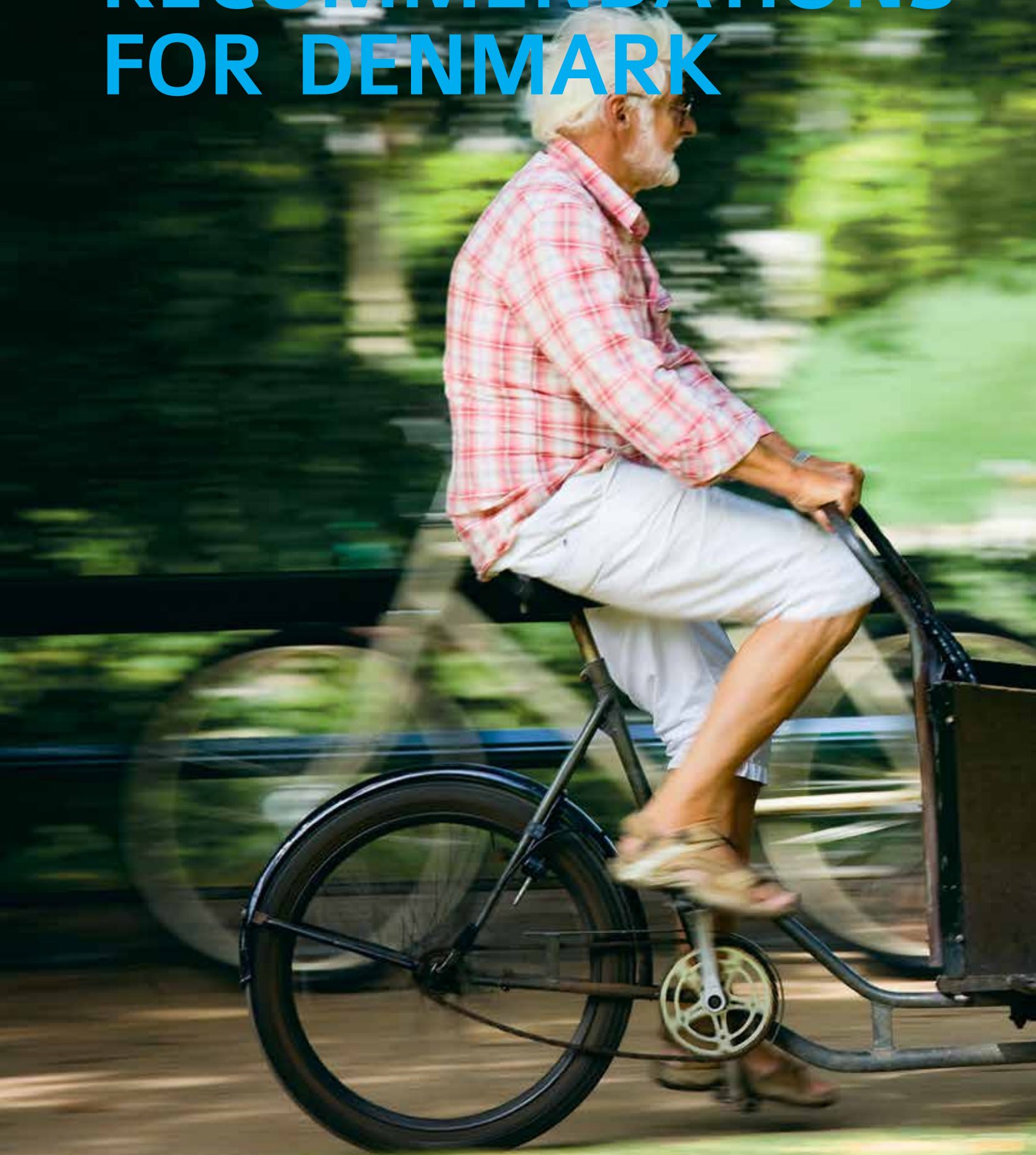
The Dubai Data Law was launched in October 2015 to allow the sharing of government data with the private sector. The aim is to spur innovation and entrepreneurship by creating opportunities for public and private sector to collaborate. The process will be governed by the newly established ‘Dubai Open Data Committee’, which will be responsible for drafting the law, framework, classification and roadmap for the law’s implementation⁸⁷. The Dubai Smart Government has also published guidelines for new developments in the city to facilitate the sharing of data and interoperability of systems between private developers and the government. These Dubai District Guidelines are important given the level of construction and development in the city.

CONCLUSION

Countries all over the world are working on smart city topics, at various different levels. At a city level, many city governments are creating leadership and capacity to implement and manage smart city projects and programmes—like advanced city datastores. However many of the barriers to smart city growth need to be tackled at a national level. National governments are increasingly becoming involved to coordinate and strengthen smart city activities across their countries. Singapore is the most high profile example of this coordination, but many other governments are addressing individual barriers. For example, standards and legislation around privacy need to be established at a national and international level. The UK government established the Open Data Institute to collaborate around open data standards. Denmark is in a good position to learn from what has and has not worked and piggyback on their efforts to establish a leadership position in smart cities. Chapter 3 outlines what Danish Public Authorities can do to grow smart cities as an industry and as a tool for urban development.



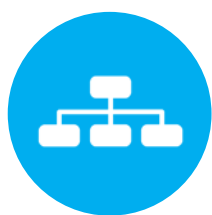
RECOMMENDATIONS FOR DENMARK



**THE DANISH PUBLIC AUTHORITIES
COULD ENABLE DENMARK TO
BENEFIT GREATLY FROM SMART
CITIES, IF THEY ACT NOW**



RECOMMENDATIONS



DEVELOP MUNICIPAL
DIGITAL GOVERNANCE



STRENGTHEN CITY
COLLABORATION



CLARIFY STANDARDS
AND REGULATION



ADDRESS PUBLIC
CONCERNS



COMMUNICATE THE
OPPORTUNITY

Denmark has many of the conditions required to grow smart cities as an industry and as a tool for urban development, including the advanced agendas of its municipalities, innovative business solutions and a collaborative “four strand helix” approach to problem solving. Yet investment uncertainty, a lack of digitally skilled professionals, and public data privacy concerns are holding back the country’s progress (Chapter 1). Government actions in other countries highlight ways in which the Danish public authorities could address some of these barriers (Chapter 2). This final chapter provides recommendations for the Danish public authorities based on Denmark’s strengths and lessons from other countries.

DEVELOP MUNICIPAL DIGITAL GOVERNANCE

We recommend that the Danish public authorities support the municipalities in Denmark to develop their smart city capabilities in order to scale projects and unlock investment. The results from the survey with 53 Danish municipalities show that the municipalities with a dedicated smart city strategy (around 17%) had implemented a greater number and wider variety of initiatives, particularly in the categories of “accessible and open data” and “political awareness and organization”⁸⁸. This follows our research of cities around the world, which shows that city governments need new capabilities to deliver smart cities⁸⁹. The first step could be to provide support, in the form of funding and guidance, to help municipalities develop a vision and strategy to guide their use of digital technology to improve their cities. Further guidance could then help the municipalities create an appropriate governance structure to identify and manage smart city projects, which will probably involve new skills and processes. A central, connected approach to developing municipal digital capabilities should assist rather than prescribe, so that municipalities retain their heterogeneity.

STRENGTHEN CITY COLLABORATION

We recommend that the Danish public authorities expand and strengthen networks between the Danish municipalities on smart cities to support knowledge sharing and the pooling of interests. The public authorities could facilitate and incentivise collaboration between municipalities, by gathering and promoting the issues and opportunities that municipalities are trying to address, such as the procurement of data platforms or smart lighting, for example. This activity could draw on the Denmark's existing smart city networks, such as the national network, regional networks, and international city networks. New networks could be supported between the larger cities in Denmark to gain global recognition, like Finland's Six City Strategy (6Aika), and among the towns and smaller cities to enable them to gain the same level of international recognition as the larger cities and create a critical mass to engage the private sector and funding bodies.

These collaborations could be instigated by identifying a common, much needed service or piece of infrastructure, following the Loop City model, described in Chapter 1. To support the sharing of knowledge on procurement, a 'smart cities' category could be included in the national tender platform to enable municipalities to identify tenders relating to smart city solutions and find joint opportunities⁹⁰. The public authorities could use the strengthened city networks to gain a view of Denmark's areas of expertise in the market to guide national economic strategy.

CLARIFY STANDARDS AND REGULATION

We recommend that the Danish public authorities monitor and provide guidance on the numerous policies and standards to address the needs of municipalities on legal and technical issues relating to smart cities. Standards and guidance are a crucial part of the implementation, functioning and scaling of smart city solutions. Municipalities in Denmark show the need to collaborate on creating common standards

and shareable solutions by having formed and joined national and international networks. The national government is in a unique position to be able to listen to what municipalities need and to guide them towards existing standards, guidance and networks. It could gather and represent the needs of municipalities on legal and technical issues relating to smart cities, such as data privacy, displacement of labour, procurement, interoperability, and performance measurement. This could involve working with other governments and world leading organisations on issues that are not met by existing standards, such as working with the Open Data Institute on standards for data sharing and to provide tools to help municipalities monitor the socio-economic value of their open data. A more coordinated approach from central government could be pursued to promote the use of open and free data among municipalities. Building on the national core data programme, the government or its nominated agency could develop guidance on open data for municipalities, including how to create a data infrastructure that is adaptable and can interconnect with other city systems and the national platform. By enabling open data and system interoperability at a city level, the public authorities will create competition and a more innovative, diverse economy, with more technology providers and lower costs⁹¹.

ADDRESS PUBLIC CONCERNS

We recommend that the Danish public authorities respond to the concerns and needs of their citizens in relation to smart city projects. With the support of national government, municipal governments could advance their digital education and training programmes. This would involve listening closely to the technology related needs and concerns of their city's citizens and businesses to ensure they are equipped with appropriate knowledge and tools. The municipalities could draw on their city networks and refer to leading third party organisations for ideas and support. Outstanding citizen and business needs could be fed back to national government by the municipalities so that national strategy remains relevant. The authorities could encourage businesses to apply Denmark's expertise in design to cre-

ate technology in cities that puts people first – so human concerns are addressed through the design of the project or product. This user-centred approach, inherent in Danish design thinking, would help to ensure that smart cities are liveable cities.

COMMUNICATE THE OPPORTUNITY

We recommend that the Danish public authorities develop a national smart cities vision and strategy encompassing the challenges of cities to generate a better understanding of the value of smart cities and convey commitment to its growth in Denmark. A national smart cities vision could generate a better understanding of the value of smart cities among government, businesses and citizens in Denmark, and convey commitment if clear outcomes and targets are included. A strategy could then set out how the vision would be achieved. Developing the vision and strategy could involve economic analysis to identify priority areas for Denmark in the smart cities market, including target sectors and geographies, based on Denmark's domestic competencies and global market opportunities. Our research for this report indicates that the following areas could be opportunities for Denmark in the smart cities market:

Data privacy and liveable smart cities. As public concerns about smart cities and data privacy remain unaddressed by many governments, Denmark could become a leader in providing solutions that protect data privacy and civil liberties, and that focus on people's needs and experience. This would build on Denmark's reputation as a centre for design excellence and liveable cities. The Government could develop 'smart city design principles' to develop a Danish approach. For example a principle could be: digital technology should be simple, easy to use, and unobtrusive, and only do the things that only it can do well, leaving people in control to do the things they enjoy doing.

Waste and the circular economy. Analysis of the global smart cities market indicates that waste is an undeveloped

sector⁹². Denmark is a world leader in waste-to-energy technology and, related to this, generates a high amount of waste per capita. Smart city solutions could build on Denmark's expertise in the sector and help to shift the country away from incineration to reduce the amount of waste generated and increase recycling. The Central Denmark Region has made progress in this direction, putting the circular economy on the national and regional agenda.

Urban mobility. The Danish municipal survey data shows that mobility solutions are one of the less common types of smart city initiatives. Denmark is a leader in green mobility infrastructure indicating that there could be an opportunity for municipalities to develop specialisms in areas like smart-enabled bicycle freight, flexible parking structures, and green journey planning.

Smart towns and villages. Denmark is ahead of other countries with its implementation of smart cities projects at the scale of smaller cities, towns and villages, including greenfield town developments like Vinge. This represents an opportunity in the global market that has been primarily driven by large, global cities. Denmark could set a precedent in demonstrating how smart city solutions can create value at a smaller scale, while addressing particular issues in Denmark's towns, such as access for the elderly to healthcare and a community.

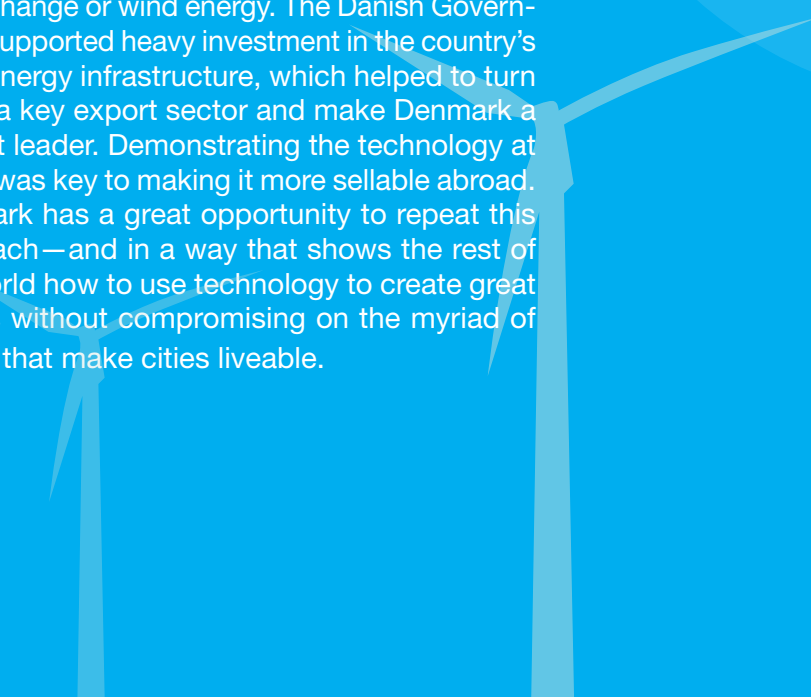
As part of its smart cities strategy, the government could deliver initiatives to pursue these market opportunities. National research challenges could be set to spur the development of specific products and services. A digital skills programme could develop stronger links between school curricula and the business needs to meet demand for skilled professionals in digital industries. A smart cities trade initiative could help Danish businesses to sell their solutions abroad and help overseas buyers to navigate the smart cities market in Denmark. For example, a smart city tour of Denmark could be coordinated for overseas buyers and new partnerships formed with countries, regions and cities, to promote Denmark's solutions and expertise.

CONCLUSION

In 2016 there will be an ever greater number of government leaders becoming aware of and adopting the smart city concept, according to the US analyst firm, IDC. Strategy and implementation road maps will be developed by cities, counties, states and central/federal government agencies, and by 2017, at least 20 of the world's largest countries will have created national smart city policies to prioritize funding and document technical and business guidelines⁹³.

Denmark is at an inflection point. The public authorities could continue in an opportunistic fashion to meet the requirements for smart cities when actions coincide with other agendas, such as the digitisation of public services. Or they could take coordinated action to fully address all of the requirements, which no country has yet achieved. Systematically pursuing smart cities at a national level would enable Denmark to take a lead in the market, bringing new flows of funding and employment opportunities, and to avoid costs related to inaction. It would also improve Danish towns, cities, and regions, making them more efficient, environmentally friendly, and liveable.

The impact of coordinated action on smart cities would be similar to the country's response on climate change or wind energy. The Danish Government supported heavy investment in the country's wind energy infrastructure, which helped to turn it into a key export sector and make Denmark a market leader. Demonstrating the technology at home was key to making it more sellable abroad. Denmark has a great opportunity to repeat this approach—and in a way that shows the rest of the world how to use technology to create great places without compromising on the myriad of things that make cities liveable.



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