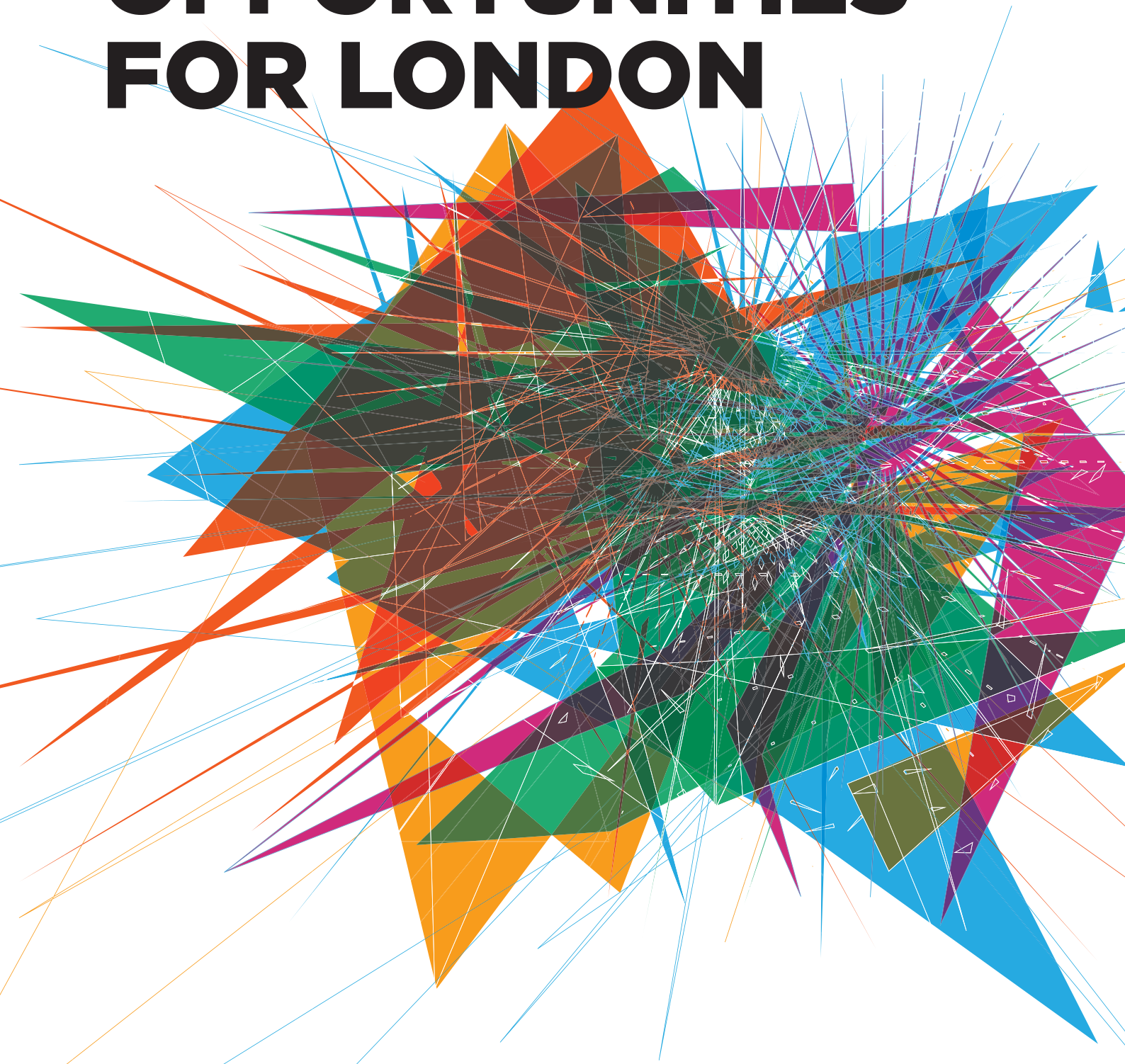
SMART CITY OPPORTUNITIES FOR LONDON



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1 Executive Summary

The 21st century is increasingly referred to as the "century of cities". According to Michael Bloomberg, C40 Board President and UN Special Envoy for Cities & Climate Change Cities, "[cities] are poised to play a leading role in addressing the challenges of the twenty-first century" [1]. The global challenges of rapid urban population growth, climate change, and pressure on resources, infrastructure and the provision of services can all start to be addressed at the city scale.

The many challenges that cities face worldwide present big opportunities for digital businesses. London-based companies and public service providers are increasingly using data, digital technology to deliver services and respond to Londoners' needs. London offers a fertile environment for businesses with smart city products and services to establish and grow, and offers a sizeable market to tap into. Our estimations show that the potential of London's smart city market could reach approximately $13.4 billion by 2020 across the following sectors: smart energy, smart transport, smart healthcare (including assisted living), smart infrastructure (combining waste and water sectors), smart governance, smart security, and smart buildings.

London has underlying conditions to enable it to become a world-leading smart city. The Greater London Authority (GLA) has already embarked on a path to become a leader in smart cities by setting up the Smart London Board and laying down its priorities in the Smart London Plan. Digital solutions can support many of the priorities of the GLA and other key city stakeholders, including the following:

- Reduce congestion and disruption of London's transport system
- Improve urban air quality
- Increase Londoners' wellbeing
- Enable greater public participation in policy processes
- Deliver economic benefits
- Optimise public service delivery

Businesses and entrepreneurs in the smart city sector can play an important role in helping to achieve these priorities. They benefit from London's innovation ecosystem, which includes:

- Top digital practitioners
- Business support and investor networks
- World-class research and leaders in education
- Infrastructure megaprojects
- Open data
- City-as-a-system initiatives that cut across silos

Sector opportunities

We estimate that the London smart city market could reach $13.4 billion (approximately £8.8bn) by 2020. Almost half of this market, approximately $7 billion (or £4.6bn), will be from the following five sectors: energy, water, waste, transport and health. Each sector is at a different stage of development with regards to deploying technology and data-driven solutions. However, they all present interesting opportunities that businesses can take advantage of.

Smart energy: London faces energy challenges, including security of supply, ageing infrastructure, fuel poverty, and failure to align retail energy prices with wholesale costs.

International and national policies prescribe switching to renewable sources of energy as a way to reduce the use of fossil fuels as well as address climate change and the depletion of resources. The deployment of smart solutions has started to address energy challenges in London, such as trialling smart grid solutions (UK Power Networks) and installing smart meters in homes. There are plenty of opportunities for companies to develop and implement more solutions in renewable energy, smart grid and electric transport. We estimate that the market for smart energy solutions in London could grow to $2.1bn by 2020.

Smart water management: As a result of London's growing population, it is estimated that the demand for water will exceed supply by 10% by 2025 [2]. In addition, climate change poses a threat to London's flood-prone areas. Smart technology has not been used to its full potential to address these challenges and therefore presents opportunities for business, for example to provide water utility companies with solutions in the areas of smart leakage detection, smart metering, data analytics and smart flood risk management. We estimate that the market for smart water and waste management solutions in London could reach a combined size of $1.8bn by 2020.

Smart waste management: Solutions within the waste sector need to address London's growing population and scarce resources. Digital technology can facilitate the transition from the linear model of making, using, and disposing of items to a circular model of reusing and remanufacturing. Opportunities for smart technologies exist in the areas of data analytics, resource management, online sharing platforms, smart bins, and optimised refuse collection. These solutions can help waste companies optimise collection vehicle travel routes, improve recycling rates, material recovery and encourage behavioural change. We estimate the market for smart waste and water management solutions in London to reach a combined size of $1.8bn by 2020.

Smart transport: Transport is one of London's most advanced sectors with regards to using data and technology to improve decision-making and service delivery. The city's growing population creates challenges for the transport network, which is already congested and contributes significantly to air pollution. Transport for London (TfL), responsible for the city's public transport and road network, is heavily reliant on data and smart technologies to optimise traffic flows and improve customer experience. Solutions which help TfL perform these tasks better present market opportunities for new and existing businesses. We expect that the market size for smart transport solutions might reach $1.2bn by 2020.

Health and assisted living: Longer life expectancy, mental health and obesity are some of London's major challenges in health. The need to provide adequate health and social care solutions is becoming more pressing than ever. Opportunities exist in telecare solutions, accessibility applications, and fitness and health monitoring devices. However, in order to unleash a market that could reach $2bn by 2020 and attract investment, a clear route to market and a simpler way to contract with the National Health Service (NHS) needs to be ensured. In addition, an evidence base of the effectiveness of digital solutions needs to be developed.

Recommendations

Key stakeholders in London's smart city market include the GLA, borough authorities, utility providers, waste contractors, TfL as well as national players such as the NHS and the UK government. London's regulated sectors (energy, water and waste) face specific challenges, for example, there is little incentive for waste contractors to operate more efficiently, and fixed water charges deter reducing water consumption. In addition, the pathway to market in most industries is unclear and technologies do not attract the investment needed to scale. To overcome these barriers and allow businesses to implement their smart, innovative solutions in London, several measures need to be taken.

The GLA could help to enable greater coordination across the ecosystem to allow all stakeholders to overcome challenges and take advantage of opportunities. Such an integrated smart city approach would require the GLA to, for example, convene the boroughs, understand what they need and raise their awareness of smart technologies and how they can be beneficial to them. It could also involve setting standards on the role of digital technology in new developments to help local authorities and private developers embrace the opportunities that technological improvements can bring. Such actions need a coherent strategy to drive London's digital agenda forward and include other stakeholders. We recommend the following actions:

- Utility providers, waste contractors, and the NHS need to ensure that small and medium-sized businesses can access their supply chains in order to have the opportunity to scale up their innovative solutions. This would include shortening the procurement cycles, which tend to be too long or inflexible for the fast paced technology market.
- Water companies and waste contractors, supported by boroughs, need to find ways to release non-sensitive open data in order to stimulate new solutions to aid transparency and improve performance in the sectors, as well as to enable the development of more customer friendly interfaces.
- Boroughs could engage with citizens to help build trust and confidence in using smart technologies, such as smart meters and smart bins, to help increase their uptake.
- Boroughs using and trialling new smart solutions need to ensure that best practice is shared and they cooperate to deploy cross-borough solutions.
- Boroughs could help drive innovation in the regulated industries by incentivising contractors to operate more efficiently through renewed contracts.
- TfL should ensure that data produced by other service providers and from applications created on the basis of transport open data is collected and used to improve decision making.
- Private sector actors need to be open to sharing data with the public sector when such data can help the more efficient delivery of public services.

London provides a fertile environment for smart city businesses to set up, grow and flourish. There are barriers that need to be overcome to unlock the smart city market, estimated at over $13bn by 2020, and its associated social, environmental and economic benefits. Our view is that a combination of dedicated political and civil leadership at the GLA, working with the boroughs and stakeholders from the public and private sectors can make a real difference. London is the home of great talent and resources, which makes it such an exciting place to live and do business, now and in the future.

2 Introduction

Cities across the world recognise that the benefits of digital technology are multi-fold, including helping cities to solve their challenges and contribute to the growth of their economies. This report was commissioned by the Greater London Authority (GLA) to investigate how London can make the most of the benefits of digital technology by assessing London's strengths as a smart city and identifying the opportunities for stakeholders in the smart city market. These stakeholders include the GLA, London's boroughs, utility companies, public contractors, businesses, entrepreneurs, and citizens.

The findings of this report will support the update of the Smart London Plan, the capital's smart city strategy. It looks at five key industries in detail – energy, water, waste, transport and health – setting out the barriers to be considered now and in the future, and making recommendations as to how to maximise the opportunities that these sectors present. These sectors have been chosen because of their significance to the London economy and the opportunities they present. The research will show the size of the smart city market within each of these sectors and potential gaps for innovative products and services.

The report structure below outlines the key themes explored in each chapter. Even though the report can be read as a coherent and complete report, each chapter has been designed to stand alone so the reader can read specific chapters that are of interest to them.

Report structure

London faces the same challenges as any other growing, global city, including rapid population growth, climate change and increasing pressure on finite resources like water and energy. These challenges present opportunities for digital businesses. Our estimations of the size of the smart city market in London will be shown in the next chapter, **Chapter 3**. The challenges specific to London as a whole will be explored in **Chapter 4**, with some discussion about the opportunities to address them with smart digital solutions. The report then focuses on each of the five sectors that are critical to London and there is a chapter dedicated to each:

- Smart Energy (**Chapter 5**)
- Smart Water Management (**Chapter 6**)
- Smart Waste Management (**Chapter 7**)
- Smart Transport (**Chapter 8**)
- Health and Assisted Living (**Chapter 9**)

London already has an ecosystem that helps businesses thrive and makes the city a great place for smart city businesses. The strengths of this ecosystem will be explored in **Chapter 10**. However, to take advantage of the opportunities in London's smart city market, both public and private sector stakeholders need to break down existing barriers and anticipate future barriers to making London the 'smartest' city in the world.

Methodology

This report has been produced by conducting primary and secondary research including interviews with experts from across industry, academia and non-governmental public bodies. A list of all interviewees is provided in Appendix 1.

The report includes an estimated size of the smart city market for London, which is based on analysis of existing global smart city market estimates (more detail on how the estimate was calculated is given in the next Chapter 3). Results are estimated for 2020 based on forecasts contained within the following seven reports published since mid-2013:

Table 1 List of Global Smart Markets Size reports (accessed via the British Library)

Publisher	Study	Publication Date
Frost & Sullivan	Strategic Opportunity analysis of the global smart city market	Aug-13
TechNavio	Global Smart Cities Market 2015-2019	Feb-15
Marketsandmarkets	Smart Cities Market – Worldwide Market Forecasts and Analysis (2014 – 2019)	May-12
Marketsandmarkets	Update: Smart Cities Market – Worldwide Market Forecasts and Analysis (2014 – 2019)	Jan-15
Transparency market research	Global Smart Cities Market - Industry Analysis, Size, Share, Growth, Trends and Forecast (2013-2019)	May-14
Mordor Intelligence LLP	Global Smart Cities Market - Growth, Trends and Forecasts (2014-2020)	Sep-15
BIS & Arup	The Smart Cities Market: Opportunities for the UK	Oct-13

3 Estimating London's Smart City Market Size

London's growth creates opportunities for businesses in the smart city market. To highlight the opportunity for smart solutions in London, we have estimated the size of the smart city market in London in 2020. The market consists of a range of products and services, including consultancy services, software and hardware products, and associated physical infrastructure.

Top-down analysis was undertaken to break down global estimates of the smart market size to a more manageable city level estimate. This involved a review of existing industry information and reports on the global market size for smart cities, and triangulation of that information in consideration of the contrast in scope of the different studies.

Economic ratios (GDP1 and GVA2) were then used to apportion the contribution of the global market to the UK and then London for the energy, water, waste, transport and health sectors. Seven different reports published since mid-2012 were used to inform the research, which found that London's contribution to the global smart cities market in 2020 could reach approximately $13.4 billion USD (or roughly 1% of the estimated global market potential).

We have based the analysis on the following seven sectors that were considered most relevant to London:

- Smart energy
- Smart transport / mobility
- Smart healthcare (including assisted living)
- Smart infrastructure (combining waste and water sectors)
- Smart governance
- Smart security
- Smart buildings

In this report, we will look at the following sectors in detail: smart energy, smart water and waste management, smart transport, and health and assisted living. In our estimations, almost half of London's contribution, or roughly $7bn USD (approximately £4.6bn), could be attributed to these sectors in 2020 combined (see Figures 1 and 2).

It is important to note that the results presented above are based on desktop, top-down research and have not been developed through bottom up analysis of Standard Industrial Classification (SIC) codes or company data. Results are estimated for 2020 based on forecasts contained within the listed reports (see Table 1 above).

[1] Gross Domestic Product (GDP) measures national income and output for a given country's economy. GDP is equal to the total expenditures for all final goods and services produced within the country in a stipulated period of time. GDP in the United Kingdom was worth $2,941.89 billion US dollars in 2014. The GDP value of the United Kingdom represents 4.74% of the world economy. [164]

[2] Gross Value Added (GVA) is a measure of the increase in the value of the economy due to the production of goods and services. GVA is a recognised way of measuring how much each city contributes to the UK economy. ONS Regional GVA from Dec 2014 suggests London represents 22.2% of the UK's total GVA. [165]

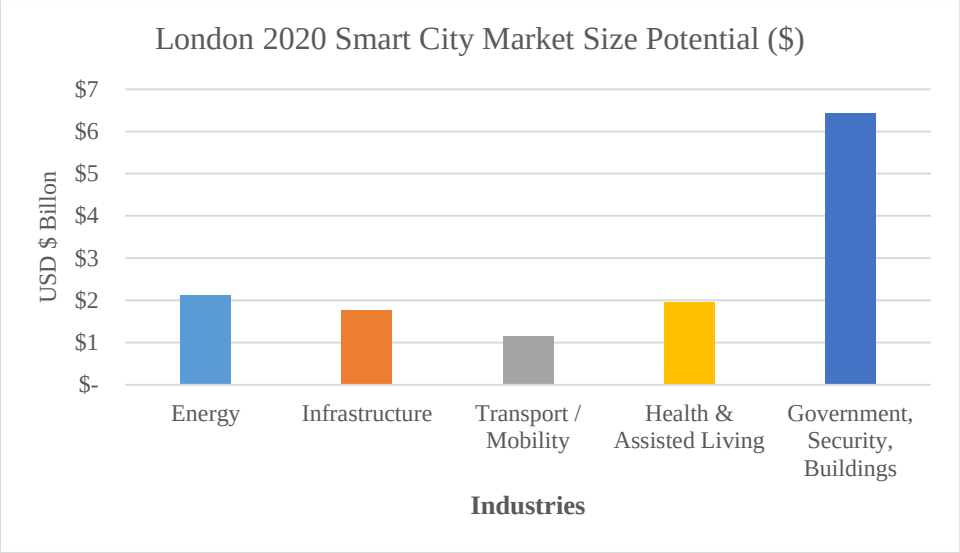

Figure 1 London 2020 Smart City Market Size Potential (in $)

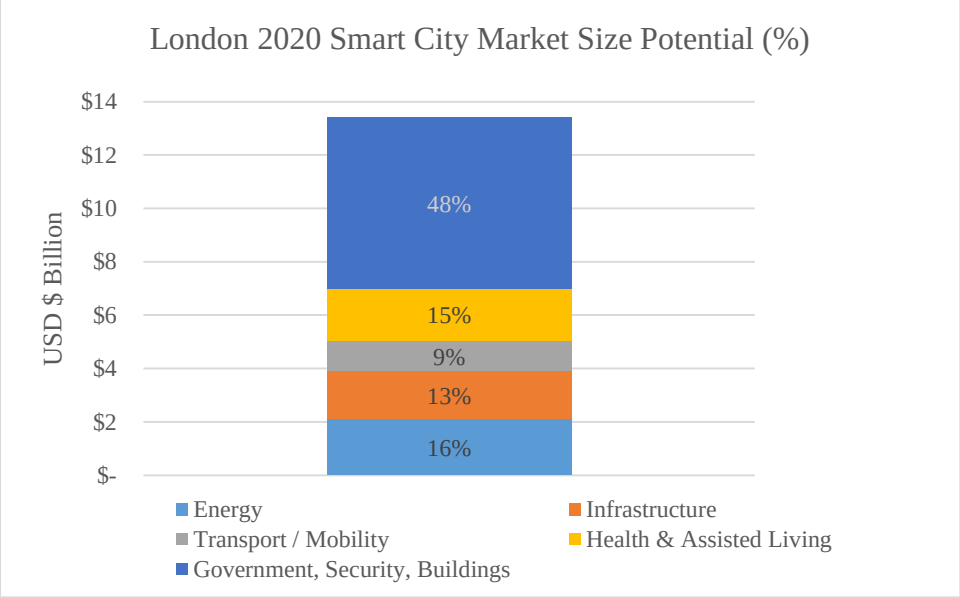

Figure 2 London 2020 Smart City Market Size Potential (%)

4 Addressing London's Challenges with Digital Solutions

London is a global city, growing quickly both in population size and economic activity. The challenges that stem from this growth are not unique to London. They are faced by cities across the world such as New York, Singapore, and Sydney. The GLA responds to these challenges by facilitating innovative activities which aim to make London a better place to live and do business. This chapter will focus on the digital technology-enabled solutions that can help to tackle London's challenges.

The Mayor of London established the Smart London Board in 2013 to devise a strategy on how digital technology can improve the lives of Londoners. This resulted in the Smart London Plan being published later in 2013, and further updated in March 2016 with the support of this study's findings.

The aspirations of the plan are expressed in the following way:

> "Londoners at the core, with open access to data, leveraging London's research, technology & creative talent, brought together through networks, to enable London to adapt and grow, and City Hall to better serve Londoners' needs, offering a 'smarter' London experience for all." [3]

London's growing population (estimated to grow from 8.5 million in 2015 to 9 million by 2020 [2]) makes achieving the ambitions set out in the Smart London Plan more challenging but it also creates opportunities for digital and social entrepreneurs to offer their solutions and help solve the city's challenges. London's growth and the commitments outlined below therefore drive demand for digital solutions. Some of the emerging opportunities are outlined below, each illustrated by a case study of a company already delivering a solution.

- Reduce congestion and disruption of London's transport system
- Improve urban air quality
- Increase Londoners' wellbeing
- Enable greater public participation in policy processes
- Deliver economic benefits
- Alleviate pressure on infrastructure

Reduce congestion and disruption of London's transport system

The Centre for Economic and Business Research has estimated that the annual gridlock cost in London will reach $14.5 billion by 2030 [4]. TfL and other transport providers need to therefore find solutions to improve the efficiency, quality and cost of their services, in the context of a growing population. The financial year 2014/15 saw a record number of public transport journeys – 1.3bn journeys on London Underground and 2.4bn on buses. This is half a billion more journeys in total than the amount in 2009/10. [5]

With open access to data provided by the London Datastore, companies such as CityMapper offer solutions that improve personalised travel information. Others, like Moovit, use crowdsourced data from users, coupled with transport open data, to provide real-time data on the location, arrival and departure times of public modes of transport. This aims to reduce both time spent commuting and to improve the customer experience on public transport. In addition to such application providers, a new type of company has emerged. TransportAPI was one of the first to provide "data broker" services for app developers by providing an open platform and consulting services for developing transport solutions. [6]

Improve urban air quality

Nearly 9,500 people die early each year in London due to long-term exposure to air pollution. [7] Public Health England has also reported that "approximately 29,000 deaths per year in the UK could be attributable to man-made particulate matter pollution" [8]. According to the Department for Environment, Food & Rural Affairs (Defra), the cost to the UK economy is estimated at about £16 billion per year [8]. Reducing particulates is therefore essential to improving air quality in London and the living standards of Londoners.

The Future Cities Catapult's "Sensing London" project has set up five "living laboratories" across London to monitor air quality and provide vital insights into its impacts. The data will also inform the provision of solutions such as smartphone applications informing asthmatics about areas with minimum exposure to air pollution as well as supporting business cases for new technologies that improve human health in the long-term [8].

Increase Londoners' wellbeing

The "Well-being in London" report from 2014 shows that "[r]esidents of London had higher anxiety and lower life satisfaction, happiness, and less of a sense that the things that they have done in their life are worthwhile, than those living in the rest of the UK" [9]. In order to address this issue, the report states that solutions are needed to encourage Londoners to interact with the city, improve community building and social cohesion and increase access to healthcare and education.

Digital technology can play a role in providing such solutions. SpeakSet, for example, is a remote care service set up by East London entrepreneurs. The aim is to connect elderly people with a health professional via the patient's television [10]. London is also the home of the very successful online learning platform FutureLearn – a MOOC (Massive Open Learning Courses) platform developed by the Open University. Since its inception in September 2013, it has made education accessible to 2.7 million people globally [11].

Enable greater public participation in policy processes

Supporting citizen-led, bottom-up initiatives, and engaging a broad spectrum of people is at the heart of the Smart London Plan [3]. The advance of digital solutions increases the possibility to engage citizens in the political process, e.g. in public debate or policy development, and shape the design and function of the city from the bottom-up. Offering digital solutions that support this vision presents opportunities for entrepreneurs to help achieve this ambition. Talk London, for example, was created by the GLA to enable Londoners to participate in policy making by joining online discussion, polls and surveys. The initiative has so far involved approximately 15,000 members [12].

SpaceHive, the London-based platform for crowd-funding civic projects, has so far raised £1.6 million for projects across 68 cities, towns and villages since its inception in 2012 [13]. The platform allows citizens to propose ideas for projects they'd like to develop in London and invite others to support the idea by funding it. In addition, the Mayor's High Street Fund can pledge up to £20,000 to crowdfunding projects on SpaceHive aimed at reviving London's high streets [14]. In 2015, the Mayor pledged £600,000 in total that helped 37 projects [15].

Deliver economic benefits

London has many ingredients that have attracted and supported the growth of digital technology businesses[3], including a strong research base and creative talent. The latest estimates from the newly launched Tech Map London shows that London has nearly 45,000 digital companies producing a turnover of £30.5bn (6% growth year on year) and employs 173,418 people (7% growth year on year) [16]. According to Irene Graham, CEO of the Scale Up Institute, start-ups created more jobs than FTSE100 companies in 2015 [17]. In addition, the digital and technological transformation of the UK government is estimated to have saved £1.7bn in 2014/2015 [18].

The wider benefits delivered by these digital technology businesses have been recognised by both the public and private sector. Because of this recognition, a variety of accelerator and incubator programmes are available in London to support entrepreneurs to set up and grow their digital businesses. This has created an ecosystem for digital businesses that will be discussed in further detail in Chapter 10.

Alleviate pressure on infrastructure

London's growing population will have an immense impact on the infrastructure of the city and on the way services are delivered. In 2014, the Mayor of London launched a consultation for the London Infrastructure Plan 2050 to address particularly these problems, recognising that "London's infrastructure is already under pressure, and its population continues to grow - current projections suggest it will hit 10 million by the early 2030s." [19]

The next five chapters of the report (Ch. 5-9) will analyse the market opportunities in specific sectors in London. The analysis will also offer insights into where the barriers lie and what actions need to be taken in order to ensure that the full market potential in each sector is reached.

The five sectors that will be explored are:

- Smart Energy (Chapter 5)
- Smart Water Management(Chapter 6)
- Smart Waste Management (Chapter 7)
- Smart Transport (Chapter 8)
- Health and Assisted Living (Chapter 9)

[3] Digital technology business is defined as a "business that provides a digital technical service/product/platform/hardware, or heavily relies on it, as its primary revenue source." [172]

5 Smart Energy

London accounts for nearly 10% of the electricity consumption in the UK [20], hence improvements to efficiency of the power network and reduction of fossil fuel dependency is at the forefront of London's energy policy. Initiatives are attempting to improve demand side management through smart metering and energy storage, while encouraging renewable energy production.

This chapter explores the following questions specifically in regards to London:

- What are 'smart' solutions in the Energy sector?
- How large is the market for smart energy solutions?
- Who are the key stakeholders in the sector?
- What are some global and London-specific challenges related to energy supply and consumption?
- What drives innovation and deployment of smart energy solutions?
- What are London's strengths in this sector?
- What are the market opportunities for smart solutions?
- What barriers need to be overcome in order for businesses to access the opportunities in the market?
- What do the key stakeholders need to do in order to overcome these barriers?

5.1 Smart energy market size

Our estimations show that by 2020 the Energy sector could have a 16% share of London's total smart city market opportunities, reaching up to **$2.1bn**.

Arup's report for BIS defines **smart energy management technologies** as:

> "technologies [that] can help utilities and distributors to forecast and manage loads better, reduce the need for costly infrastructure expansion, and improve service quality and customer satisfaction. Meanwhile consumers benefit from service quality reliability improvements, new tariff options, the ability to reduce their energy bills." (BIS report)

5.2 Key stakeholders

The Department for Energy and Climate Change (DECC) is the UK government body responsible for securing clean and affordable energy supplies. DECC has nine supporting agencies and public bodies that oversee energy production and supply [21]. The Office for Gas and Electric Markets (Ofgem) regulates the energy markets to protect the customer and the environment. Ofgem regulate the energy suppliers, including the 'big six': British Gas, EDF Energy, npower, E.ON UK, Scottish Power, and SSE. These energy suppliers use the National Grid's asset network to deliver the gas and electricity to the customer's home. The asset network is managed by National Grid, but Ofgem have regulatory power over upgrades and cost of delivery.

The GLA has limited power over energy; however, it maintains control over energy policy. The London Plan for example guides how new developments need to consider energy. In addition, the GLA can encourage low-carbon energy through various schemes and initiatives, and provides guidance and planning policy on how to put these in place.

5.3 Sector challenges

London's major challenge in the energy sector is to reduce its dependency on fossil fuels to tackle the global issue of climate change. To do this London must switch to cleaner sources of energy without hitting the consumer with higher fuel prices. It is a complex challenge that requires multi-faceted, cross-stakeholder solutions, many of which are enabled by digital technology.

Climate change

The 2008 Climate Change Act committed the UK government to reduce greenhouse gas emissions by at least 80% (from 1990 baseline) by 2050 [22]. In London, the Mayor has set a target to reduce London's carbon dioxide emissions by 60% of their 1990 level by 2025. The majority of emissions have been identified to be a result of heating and powering buildings and the remaining 20% from transport. In addition the climate is changing in the capital with predictions of hotter and drier summer seasons and warmer and wetter winter seasons. [23] Digital technology can help measure, monitor and model these effects as well as help deliver low carbon power to the city.

Fuel poverty

In London, 10% of all households live in fuel poverty, compared to 10.4% of all homes in England [24]. In his climate change mitigation and energy strategy, the Mayor has set out measures that will help tackle this issue. This includes the RE:NEW programme that aims to retrofit London's homes with energy efficiency measures to help save money off energy bills.

Whilst this is a good start, there are many other digital interventions that could help tackle this challenge including a more detailed and comprehensive measurement of consumption data; benchmarking and comparison to find outliers to focus interventions; more sophisticated digital information sources about cheaper energy sources; and digital technology to enable decentralised energy systems or to manage peaks in energy demand.

Old housing stock

One of London's challenges is the low energy efficiency of the city's old buildings. Currently London's homes contribute to 36% of the capital's total carbon footprint [25]. Similar to the challenge above, the GLA's RE:NEW and RE:FIT programmes are tackling this issue by providing support for retrofitting old buildings and reducing carbon emissions in London's homes. Digital technology can tackle this challenge in identifying who is in most need of intervention, performance of intervention, modelling and information sharing, to name but a few.

5.4 Drivers for digital innovation

This section outlines some of the key drivers for developing innovative solutions in the energy sector.

Ageing infrastructure: The UK, amongst other high-income countries, is faced with an ageing energy infrastructure. According to Ofgem estimates, up to £200 million will be spent in the next ten years to replace the energy infrastructure in the UK to respond to growing energy needs. In London specifically, the electricity infrastructure system is reaching full capacity and investment is required to ensure that development of new housing stock is not hindered as a result [2].

Energy efficiency targets: The Mayor of London and the UK's national government have committed to reducing carbon dioxide emissions by 80% (from the 1990 baseline) by 2050. In order to achieve this, several measures need to be taken, including improving energy performance of new and old buildings, producing energy from renewable sources, and shifting to smart energy demand and storage [26].

Need to ensure local energy supply: The Mayor has set the targets to supply 25% of London's energy from local sources by 2025. London's electricity is currently supplied from power stations outside of London. Programmes which are aimed at reaching this goal include Decentralised Energy Project Delivery Unit, Celsius and Licence Lite [27]. These will be described in more detail in the next section.

5.5 London's strengths

London has already developed programmes and initiatives which support the deployment of smart solutions in energy. Some of these strengths are illustrated with examples below.

Local energy generation

Localised energy generation has been encouraged by a national £10 million fund administered by the Urban Community Energy Fund [28]. One of the awarded projects in London is the South East London Community Energy (SELCE). It was formed by a not-for-profit social enterprise comprising of residents of Greenwich and Lewisham, and has raised £250,000 from the community to install solar panels in schools and help eliminate fuel poverty [29]. Local initiatives such as the Decentralised Energy Project Delivery Unit (DEPDU) is helping London boroughs and other partners get decentralised energy projects off the ground. DEPDU is already helping 19 projects, worth a total investment of £210m, to be brought to market [27].

Smart metering

The UK government's commitment to reduce greenhouse gas emissions and combat fuel poverty have contributed to increased funding and interest in smart solutions to energy challenges. The Data Communication Company is the UK body delivering and managing the platform for shared communication on smart meters. This allows a universal communication network for smart meters, empowering customers with the freedom to switch suppliers [30]. Much of the UK's smart grid capability is being trialled in London, with benefits already reaching customers. For instance, Camden-based Tempus Energy were established to provide the cheapest energy to customers through dynamic sourcing and employing smart meters in customers' homes [31]. The GLA have contributed with a £250,000 investment in Tempus in November 2015 [32].

Energy efficiency in transport

As well as smart metering schemes, TfL have been aiming to improve energy efficiency in the transport sector throughout the capital. Light-emitting diode (LED) street lighting has been introduced to reduce energy consumption and improve visibility on the A4 road with the view of expansion across London [33]. London's bus network now features 80 hydrogen fuel buses and 17 electric buses [34], and is an indication of the commitment from TfL to reduce energy consumption.

Demand management

The UK is also changing domestic energy consumption habits with apps such as the Hive. Introduced by British Gas, this application allows customers to regulate their heating and hot water remotely and thus reduce wasted heating. User side innovations in the energy market are therefore driving change by giving more control to energy consumers.

Local initiatives

The GLA has also launched programmes such as Decentralised Energy for London, providing free advice to local authorities, as well as energy efficiency programmes RE:FIT and the London Energy Efficiency Fund, helping reduce energy consumption in buildings. In addition, the London Energy Plan allows the modelling of London's energy demand, supply and infrastructure to 2050. This can help identify the impact of the city's growth on its energy infrastructure and suggest options for reducing and meeting existing energy demand and minimise and meet new demand whilst keeping costs down and hitting the climate change targets. [35]

Research strengths

Leading institutions in London are carrying out breakthrough research into the future of energy in light of the energy challenges the world faces. The Energy Futures Lab at Imperial College London is a cross-discipline institute carrying out research on five key themes: Clean Fossil Fuels, Energy Infrastructure, Low Carbon Transport, Policy and Innovation and Sustainable Power. [36] The UCL Energy Institute, in addition, delivers world-leading research and provides policy support on the challenges of climate change and energy security. The Institute is part of The Bartlett: UCL's global faculty of the built environment, and collaborates with industry, government and other academic bodies, to apply its research and deliver a real-world impact. [37]

The London-based UK Energy Research Centre (UKERC) carries out world-class research into sustainable future energy systems. UKERC carries out world-class research into sustainable future energy systems, focusing on six core themes: future energy system pathways, resources & vectors, energy systems at multiple scales, energy, economy & societal preferences, decision-making, and technology & policy assessment. UKERC also acts as a bridge between the UK energy research community and the wider world. [38]

In addition to the academic body of work, the Energy Institute (EI) provides a wealth of knowledge on the energy sector through its EI Knowledge Service, which undertakes project based research, overseen by the EI's Energy Advisory Panel. [39] UK Green Building Council, on the other hand, offers a range of learning and development activities to inspire best practice and leadership in green building policies, including zero carbon new build, retrofit of existing homes, and operational energy measurement and reporting. [40]

5.6 Market opportunities

The challenges which London faces in the energy sector, accompanied by the drivers for innovation and solutions development, provide plenty of opportunities for businesses. A selection of these opportunities, which have emerged from our desk research and interviews with experts, are outlined below:

- Local energy production
- Smart grid
- Reducing end energy consumption
- Electric vehicles infrastructure

Local energy production

Since London's energy supply is reliant upon international markets, local sources can ensure London's resilient energy supplies and minimise the cost of the city's energy infrastructure. The GLA's Enabling Infrastructure report stresses the importance of local energy projects: "from smaller scale to large scale projects capable of providing significant amounts of energy to London" [2]. Local renewable energy generation is also being encouraged through the London Energy Efficiency Fund (LEEF). This £100m loan fund is available for individuals, communities and companies to provide energy solutions that reduce carbon dependent consumption [41]. This is aimed at renewable energy projects and district heating, and provides a low interest loan to attract new technologies and companies to trial sustainable solutions in London. Currently only 2% of London's energy consumption is fulfilled from sources other than gas, petrol, and diesel [2].

Smart grid

London is establishing itself as a hub of smart grid innovation. The Low Voltage Flexible Urban Networks being trialled in London are an example of how Power Electronic Devices (PEDs) can be utilised in low voltage grids to release and employ spare network capacity [42]. This is one of four Smart Grid/Metering projects currently being trialled by UK Power Networks, aiming to improve management, storage and use of energy, improving efficiency and reducing cost. Of these four projects, three are being trialled exclusively in London. These innovative projects signify UK Power Network's progressive approach to trialling new smart grid solutions and the opportunities this opens up for businesses developing solutions in this area.

Reducing end energy consumption

The GLA's "Enabling Infrastructure" report recognises the need for "reduced energy use from buildings, more efficient use of primary energy input, [and] the high utilisation of infrastructure capacity through the application of smart systems and energy storage." [2] The GLA aims to restrict growth in peak electricity demand by 2020, with 10,000MWh/annum of contracted supply and demand response [3]. This will be enabled through partnerships with energy providers such as Kiwi Power and Tempus Energy.

Electric vehicles infrastructure

The density of London provides opportunities for electric transport solutions, and the infrastructure to support this is well established in London. Source London manages over 1,300 charging points across London [43], providing the crucial infrastructure to encourage the adoption of electric cars.

5.7 Barriers to adopting digital solutions

Lack of smart grid standards

Both the European Commission, specifically the Smart Grids Task Force [44], and the UK government have laid out plans to establish standards and operation framework for smart grids. However, before these standards and regulations are put in place, the deployment of smart grid solutions would remain ad-hoc in London, like in the rest of Europe.

Privacy concerns

The roll-out of smart meters has raised concerns about the way energy data will be stored and used. Data privacy and security is one of the most important considerations that need to be taken into account for the whole smart city agenda. The public needs to be able to use and

trust digital technology in their lives for the development of smart cities. [45] Unless addressed at the early stages of technology roll-out, privacy issues could hinder the take-up of smart technologies.

Electricity capacity

Electricity currently fulfils only less than a third of energy consumption in the capital (in comparison to 45% by gas). [2] Charging electric vehicles (EVs) requires access to electricity and therefore the electrification of vehicles in London puts additional pressure on the system. The successful deployment of EVs would be dependent on the increased capacity of London's electricity system.

Complexity of energy supply systems

The transition from fossil-fuel reliant sources to low carbon, renewable energy sources is happening gradually. The complexity of such a distributed energy system makes it difficult to plan even basic energy services, including heating and transport. Decision-making on planning such services is made even more challenging by the need to take several priorities into account, such as pollution, convenience for energy users, carbon commitments and price models.

5.8 Recommendations

Such a complex area requires intervention from all stakeholders at a national and local level. Many of these barriers need to be addressed by national government, for example by setting standards and regulations for smart grids deployment, or guiding the use of smart meter data. Local government, through the GLA, is playing its part with programmes like RE;NEW and RE:FIT but there is room for more innovation from across the spectrum. We set out our priority recommendations to be considered by all here.

Ease regulatory barriers

Being based in the capital, London's stakeholders have the opportunity to access Government officials and lobby for changes to regulations. By voicing the need for new business models and standards to guide smart energy services, local actors can work more closely with national government to encourage development of standardisation of approaches through regulations nationally or contracts locally.

Publish live data that can be used and shared

The London Energy Plan is a positive step towards modelling London's energy demand, supply and infrastructure to 2050, under several scenarios. Access to dynamic, real-time information could make energy modelling easier and help London's stakeholders create realistic plans to transition to a low carbon future. Knowledge about gas and electricity usage in a specific place at a given time can help tackle peak demand for energy. Such data can also help address behavioural change and demand management within housing. Data on how much people consume and clear information on different tariff bands can help consumers develop consumption habits that reduce peak demand. Energy modelling can also support the priority of the Mayor of London to focus on energy efficient infrastructure:

> "This will require reduced energy use from buildings, more efficient use of primary energy input, the high utilisation of infrastructure capacity through the application of smart systems and energy storage, and the use of local-to-London energy resource where economically viable to eliminate the dependency on imported energy from the world market." [2]

An important consideration should be how citizens' data privacy will be protected in order to enable the safe publishing and sharing of data.

Develop a clear Internet of Things policy

The Internet of Things (IoT) has the potential to have a transformational effect on cities. By allowing objects to interact, e.g. electric cars communicating both with people and the grid, IoT helps break down the silos within the city and allows them to start interacting with each other. Therefore, in order to reap the full benefits of IoT, a comprehensive policy, considering both privacy and security issues, needs to be put in place. Following the recommendation in the Government Office for Science report "The Internet of Things: making the most of the Second Digital Revolution", public bodies need to consider how to best enable the use of data to support IoT applications:

> "Open application programming interfaces should be created for all public bodies and regulated industries to enable innovative use of real-time public data, prioritising efforts in the energy and transport sectors." [46]

6 Smart Water Management

Water is one of London's regulated industries, which ensures that prices are maintained at an affordable level. On the flipside, however, low prices result in high consumption, which puts pressure on the water networks. High demand requires smarter management of the water networks. This chapter explores the following questions specifically in regards to London:

- What are 'smart' solutions in the Water sector?
- How large is the market for smart water management solutions?
- Who are the key stakeholders in the sector?
- What are some global and London-specific challenges related to water supply and demand?
- What drives innovation and deployment of smart water management solutions?
- What are London's strengths in this sector?
- What are the market opportunities for smart solutions?
- What barriers need to be overcome in order for businesses to access the opportunities on the market?
- What do the key stakeholders need to do in order to overcome these barriers?

6.1 Smart water management market size

In our analysis we estimate that the market for smart water and waste solutions and services in London could reach **$1.8bn** by 2020, which is a 13% share of London's total smart city market. The estimate for these two sectors is a combined figure since the reports analysed for these markets provide a joint estimate for them under the heading 'smart infrastructure'.

The market opportunity in the water sector will also be influenced by the decision of the UK Government to create a competitive water market. From April 2017, 1.2 million non-household customers will be able to choose their supplier of water and waste water services, making it the largest retail water market in the world. The Open Water programme, governing the delivery of the new competitive market, has estimated that this will lead to around £200 million of overall benefit to customers and the UK economy [47].

Arup's report for BIS defines a **smart water system** as one in which

> "technology manages the distribution and management of water resources, where advanced water treatment is present. […] A smart water network [also] offers utilities an opportunity to improve both efficiency and customer service whilst reducing water scarcity." (BIS report)

Smart Water Management also includes flood risk management, wastewater management and the provision of water services to other sectors.

6.2 Key stakeholders

Water services in the Greater London area are provided by four privatised companies: Thames Water, Affinity Water, Essex & Suffolk Water and Sutton & East Surrey Water. Of these four, Thames Water services almost 80% of the market. The Office of Water Services,

Ofwat, is the economic regulator which fixes the revenues of the water industry at five-year intervals.

The role of the GLA is to bring stakeholders together, for example in complex developments, where property developers, end users and water companies need to work together to provide services effectively.

6.3 Sector challenges

The water industry is faced by two pressing challenges, namely scarce supply and the effects of extreme weather conditions, such as heavy rainfall and flooding, as a result of climate change.

Demand exceeding supply

Thames Water's projections show that by 2025 demand for water will exceed supply by 10%, rising to 26% by 2050 mostly due to the increase in population [2]. This raises questions about how to provide water services efficiently, including managing potable and non-potable water in order to make use of the full water cycle. The Smart London Plan stresses the importance of 'smart' approaches through London's planning system, e.g. using data to guide planning and design, including the deployment of digital infrastructure to future proof new developments.

Climate change

A recent climate change study by Nature sets out the case for the increase in extreme weather events as a result of climate change and this impacts our city and water systems in several ways [48]. Approximately 15% of London is in flood plain, protected by flood defences. This area includes both homes and vital infrastructure, including 49 railway stations, 75 underground stations and 10 hospitals [49]. The weather events of winter 2013/14 showed us that these parts of London are at great risk when there are high levels of rainfall.

Not only will this result in more flooding events but it will increase the imbalance between supply and demand of water, most likely increasing the pressure on water sources and the network [50]. This is further exacerbated by London's ageing infrastructure which requires on-going maintenance[4]. Integrated water management that brings together blue, green and grey infrastructure can create reliable, resilient and sustainable water services. Ways to make use of green infrastructure, such as green roofs and rain gardens, need to be considered in order to decrease reliance on traditional so-called grey infrastructure, such as piped drainage and water treatment systems.

Smart solutions can help address both of these complex challenges by offering innovative approaches to analysing data, engaging customers and managing water supply. Opportunities to offer such solutions are set out in Section 6.6.

[4] Over the period from 2020 to 2050, it is projected that water infrastructure operational expenditure will total some £34 billion in the period in real terms, increasing 1% per annum, on average, in that period [50].

6.4 Drivers for digital innovation

Solving the challenges outlined above is motivated by the following key drivers.

Political will: As set out in the "Enabling Infrastructure: Green, Energy, Water & Waste Infrastructure to 2050" paper [2], the Mayor of London expects water companies to invest in new technologies that would lead to leakage reduction and wiser use of water, e.g. through metering and consumer awareness. The Smart London Plan also promotes the use of smart grid technologies to better manage demand and supply of energy and water.

Population growth: Similarly to the other sectors discussed in this report, the water sector will also be impacted by London's growing population. This will require better management of water supply in order to meet higher demand and tackle water scarcity. The availability of lower-cost sensors and opportunities to engage with customers in real-time could drive lower consumption and help influence customer behaviour.

Climate change: Adopting climate change adaptation measures is essential to alleviating the stress created on the water systems as a result of the increased impacts of flooding. This requires better flood risk management solutions. Improving asset management and increasing resilience measures are vital in the response to both population growth and climate change.

Retail market opening: The opening of the retail water market in 2017 will increase competition between water providers. It will therefore become even more vital to manage the water cycle and provide sustainable water solutions in order to operate cost effectively in the future.

6.5 London's strengths

Professional expertise

Besides the drivers which motivate authorities to address its water challenges, London also has the professional and entrepreneurial expertise to provide solutions. The city is a hotspot for experts in numerous areas, ranging from technology providers through to consulting and engineering services such as Arup and Mott MacDonald. These companies have a global reputation and bring best practice from all over the world. London also offers essential support services for legal and financial aspects.

World-class research

The academic sector contributes to this ecosystem of experts by providing world-class research. The Climate and Water Research Unit (CWRU) at UCL and the Environmental and Water Resources Engineering Section at Imperial College London address some fundamental research topics that have an immense impact on society, such as flood protection, sustainable water resource development, the provision of safe water supplies and sanitation, and the management of wastes and their environmental impact. This section at Imperial College has also received the highest achievable 6-star Assessment Exercise (RAE) rating for its research. [51]

In addition to this ecosystem of experts, there are emerging programmes and policies that focus specifically on the promotion of smart solutions. The GLA is currently working on three key initiatives, amongst others: Smart Flood Risk Management, Smart Pressure Management, and Smart Leakage Detection. More details of these programmes are set out in Section 6.6.

6.6 Market opportunities

There are many complex factors that contribute to the sector however, through our research, we have identified three areas with immediate substantial opportunities for smart technology:

- Smarter supply and demand management
- Data analytics
- Smart flood risk management

Smarter supply and demand management

The challenge of increasing demand for water calls for solutions both on the supply and demand side of water management. London's largest water supplier Thames Water has identified in its strategy "three pillars of demand management": **leakage**, **metering** and **demand management** [52]. There are opportunities to provide solutions within each of these three areas. Taking each one in turn:

Smart leakage detection and management/reduction: Thames Water have reported losses of 665Ml/day during 2014/2015, aiming to reduce this by 59Ml/day by 2020 [53]. Reducing leakages is therefore key to managing the water supply/demand balance. The GLA have launched several programmes that address this issue but require more solutions from industry to help deliver these programmes. The Smart Pressure Management and Smart Leakage Detection programmes, for example, aim to predict which pipes are vulnerable. Smart solutions providing a more targeted approach and smarter pressure management will help take pressure off pipes. Through the dynamic control of pumping pressure, water can be pumped only at the required levels depending on demand.

Smart metering: In order to address the challenge of scarce supply, demand management and encouragement of lower consumption levels are essential. Smart metering can be an enabler for this. Currently only about 40% of customers in England and Wales have a water meter. [54] Reports show that the UK is one of the European countries experiencing fastest transition to adopting two-way smart water meters. [55] Smart metering investment is one of Thames Water's key planned enhancement expenditures, amounting to a total of £1.3 billion before 2050 [50]. Thames Water plans to fit 900,000 meters by 2020. In addition, every home will be offered a Smarter Home Visit to install free water saving devices and provide tailored advice as the progressive metering programme is rolled out [52].

Smart meters collect usage data and allow residents to monitor their consumption online. This data could allow applications, like the Hive[5] thermostat and heating control app, to move into the sector and increase engagement with users, encouraging better water management and lower consumption.

Demand management: In order to manage growing demand, water companies require solutions to help them lower consumption. Smart solutions that engage with consumers through digital apps and platforms can help communicate consumption information to users and advise them on reducing water usage. Thames Water have launched several demand management programmes. For example, the water efficiency software for homes TAP (Talk and Products) produces a water saving report for consumers. A further initiative is Smarter

[5] Hive Active Heating was launched by British Gas in September 2013 allowing customers to control their heating and hot water remotely – from mobile, tablet or laptop.

Home which includes visits in several London boroughs during which homes are fitted with dual flush.

Data analytics

The water industry is one of the sectors that have not utilised the power of digital technology as much as similar sectors such as the energy sector. Data analytics is still centred on predictions and forecasts rather than focusing on real-time analytics and 'nowcasts'. Obtaining and analysing data is crucial in monitoring water quality, mapping assets, as well as detecting leakages, bursts and flooding. Data can provide even wider benefits to the water sector, which is where businesses can help with providing solutions. Alex Nickson, Policy and Programme Manager at GLA, summarises the need for solutions:

> "[Data collection and analysis requires] a coherent approach. Lots of different pieces of the jigsaw all need to fit together – you need interconnectivity, telemetry, data management, a sophisticated control centre; you need someone to work through the decision processes and how all the information can be combined and crunched; we need an evolution from forecasts to 'nowcasts' – and all these things are required [as open-source, non-proprietary solutions]."

Smart flood risk management

Flood defence is another key expenditure for Thames Water, comprising measures to increase flood resilience. Expected flood defence-related expenditure reaches an estimation of nearly £1 billion before 2050 [50]. GLA's Smart Flood Risk Management programme is also looking at smarter solutions to facilitate the move towards a more proactive combined blue, green and grey infrastructure. Real-time data across the system can help monitor the heights of rivers and flows and depending on the capacity of the system make smarter decisions on whether to retain or discharge water into the Thames. A smart telemetry system with smart control measures can be used to manage flood risk according to the most sustainable option.

6.7 Barriers to adopting digital solutions

When considering the opportunities in the smart water market, businesses need to also keep in mind the barriers that are present in the industry. A few are outlined below.

Fixed water charges

Since Ofwat is pressured to keep household bills low, there is very little incentive for occupants to reduce consumption. The fixed charges also deter water companies from investing money in research and development, or deploying innovative solutions as they cannot charge a premium for it.

Lack of openly shared data

Water usage data held by the water companies is currently not shared openly, which makes it more difficult to track the performance of assets. Lack of data means there is no real insight into the blue, green and grey infrastructure assets in London and does not allow for wastewater treatment to be priced accurately. Applying the lessons from other sectors, if data is shared more openly by the water companies, there will be more scope for tracking the performance of assets and developing innovative solutions to tackle London's challenges.

Route to market

The BIS report found that small and medium-sized enterprises (SMEs) in the UK find it difficult to sell to water utility companies as they are more "conservative" and "risk-averse" [56]. However, there have recently been increasing attempts for innovation by the sector. For example, Anglian Water's Innovation Network provides a marketplace for innovative companies to enter their supply chain. However, the impact of the solutions provided through this platform is still not available. The relatively low investment levels in digital water technologies has also been recognised as a barrier, with innovation spend sometimes being described as "minimal" [57]. For example, Thames Water has reported a £20m spend on R&D in the 5-year asset management period (AMP5) in 2010-2015 [58].

6.8 Recommendations

In order to drive adoption of smart technologies in the water sector, actions need to be taken both at a national and local level.

Share water data

The transport sector has been successful in releasing data which is beneficial for businesses to use as raw material for new products and services. Therefore, it would be beneficial for Thames Water to collaborate with institutions such as the Open Data Institute to explore what non-sensitive data it would be beneficial to release in order to create an open data marketplace in the water sector. With the rolling out of smart meters, there could be more opportunities for real-time data collection. By sharing data, water companies can also improve tracking the performance of assets and help improve decision making across London.

Dynamic water pricing

As a result of London's growing population, more pressure is put on water supplies. It has emerged from our interviews that a pricing mechanism could be designed to manage water scarcity better. Smart metering could allow new capabilities for collecting data and informing such dynamic pricing. However, such policy needs to be discussed and implemented at a national level, in collaboration with Ofwat. Dynamic water pricing could be considered in the future when the retail market opens in 2017 and tariffs will need to ensure that "each class of business customers can be served profitably at both the wholesale and the retail levels" [59].

Encourage innovation

Despite innovation programmes run by water companies such as Thames Water and Anglian Water, it has been recognised that innovation in the sector needs to develop further [60]. Collaboration between Thames Water and London's technology sector would be beneficial for driving forward the development of solutions that address London's challenges. Arup, for example, has recently launched the Venturi innovation portal for the water industry [61], which is designed to offer the market a new vehicle to speed up innovation adoption in the UK water sector. Endorsing certain manufacturers which produce water-efficient products, water companies can also help drive innovation within their supply chain.

7 Smart Waste Management

Smart technology in the waste sector is primarily focused on increasing the efficiency of collection and separation. Our research re-affirms the findings of Arup's report for the Department for Business, Innovation and Skills (BIS) "The Smart City Market: Opportunities for the UK", namely that the smart waste management market is still "nascent" [56]. However, there is great potential for smart technology to enter the waste market and facilitate the transition to a circular economy, whereby valuable and increasingly scarce resources are not wasted; instead they are reused to maximise their value:

> "A circular economy is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life." [62]

This chapter explores the following questions specifically in regards to London:

- What are 'smart' solutions in the Waste sector?
- How large is the market for smart waste management solutions?
- Who are the key stakeholders in the sector?
- What are some global and London-specific challenges related to waste management?
- What drives innovation and deployment of smart waste management solutions?
- What are London's strengths in this sector?
- What are the market opportunities for smart solutions?
- What barriers need to be overcome in order for businesses to access the opportunities on the market?
- What do the key stakeholders need to do in order to overcome these barriers?

7.1 Smart waste management market size

The estimations shown in Chapter 3 reveal that the combined size of the waste and water markets for smart products and services in London would be **$1.8bn** by 2020. This represents a 13% share of London's total smart city market opportunities. We are providing a combined estimate for the size of the waste and water markets based on the data available in the global reports we have analysed.

7.2 Key stakeholders

There are three major waste types generated in London including household waste, commercial and industrial waste (C&I waste), and construction, demolition and excavation (CD&E) waste.

It is the responsibility of waste collection authorities (WCA) in London to collect municipal solid waste[6]. The waste disposal authorities (WDA) are responsible for the treatment and disposal of the waste provided to them by the WCA. There are four statutory joint WDAs in London and 12 in dependent WDAs. The waste collection, treatment and disposal is

[6] A new waste definition was introduced in 2011 of 'Local Authority Collected Waste' (LACW), which includes household waste and any other waste collected by the local authority.

undertaken either in-house by local authorities (e.g. London Borough of Hackney, London Borough of Sutton, London Waste), or by private waste contractors (e.g. Biffa, Bywaters, Cory, Grundon, SUEZ and Veolia).

Even though the GLA does not regulate waste, it steers the sector and sets objectives and policies for municipal waste and business waste. In addition to the GLA, the London Waste and Recycling Board (LWARB) was set up to provide a strategic approach to waste management in London. LWARB manages a £20 million investment fund to provide tailored financial support to businesses interested in developing waste infrastructure projects in and around London.

There are other stakeholders such as the Waste & Resources Action Programme (WRAP) promoting sustainable resource and waste management at national level. The regulator for waste management is the Environment Agency and as such they can play an important role in implementing digital solutions in the waste sector in areas like licensing and duty of care.

7.3 Sector challenges

Growing population

As London's population is rising, the amounts of waste produced will also increase unless measures are taken to reduce waste and increase the reuse and recovery of materials. In the short-term, councils will need to manage the increasing amounts of waste more efficiently and sustainably. Waste will need to be managed at a lower cost, using less space and resources [56].

Scarce resources

Valuable materials are wasted by being disposed of instead of being reused and recycled. Today's linear 'take, make, use, dispose' economic model contributes to a depletion of the world's resources [63]. This model is also not sustainable anymore due to resource scarcity and price volatility of commodities, which have been sharply increasing in price since 2000. According to calculations made by Defra, UK businesses could benefit by up to £23 billion per year through more efficient use of resources, whilst McKinsey estimates that the global value of resource efficiency could eventually reach $3.7 trillion per year [62].

7.4 Drivers for digital innovation

Both national goals and local targets drive innovation in Smart Waste Management.

Move to a circular economy: The Mayor of London has requested that LWARB develops a Route Map to the Circular Economy for London by early 2016, working with the private sector and the London Infrastructure Delivery Board. This will involve putting incentives in place that promote and encourage the adoption of circular economy systems by FTSE 100 companies and SMEs alike [64].

50% recycling target: The Mayor has set a 50% recycling target by 2020 as well as to recover high quality recyclate and maximise the income generated from that material [65]. One of LWARB's business plan objectives is to help local authorities generate more value from their waste management services and help them encourage waste prevention and re-use [64].

National strategic goals: The UK Government's Waste Strategy for England 2007 has set out that waste should be managed as close as possible to the point of production. This has led to London setting a target to manage 100% of London's waste within London by 2026 [65].

7.5 London's strengths

Several initiatives in London are providing advantages to local authorities and businesses in Smart Waste Management.

Support for local authorities

The LWARB was established under the Greater London Authority Act 2007 to "promote and encourage the production of less waste; an increase in the proportion that is reused or recycled; and the use of methods of collection, treatment and disposal of waste that are more beneficial to the environment." [64] In addition, programmes such as Resource London have been set up by LWARB and WRAP to support waste authorities to manage their services efficiently whilst maximising recycling performance [66].

Funding

LWARB's 2015-2020 Business Plan has announced a £20 million fund to help businesses in the waste sector expand. Since its inception in late 2008, "LWARB has supported around 50 businesses in the reuse and recycling sectors and has provided funds to develop four new [waste management] facilities - three of which are now operating, whilst the other is in construction" [64].

Research expertise

Research into the waste sector is undergoing a major shift, with a focus on how waste can be avoided in the first place or used as a raw material. Leading research is taking place at a range of universities and institutes across London. The Resource Efficiency Research Centre works in collaboration with the Institute for Sustainability at the University of East London on research and development of a demonstrator facility, which enables large-scale feasibility testing on aggregates designed and manufactured using a wide variety of waste materials arising from industry partners based at the London Sustainable Industry Park (LSIP) and surrounding area. [67] Research into waste management and the sustainable use of materials, bioconversion of biodegradable wastes, and the application of sewage sludge to agricultural soils also takes place at the Imperial College London Environmental and Water Resource Engineering section. [68] In addition, UCL CircEL, the Circular Economy Lab, is a cross-faculty, cross-discipline initiative, exploring solutions for improved design of buildings and products, their re-use and recycling, and the return of their constituent materials back to the economy. [69]

7.6 Market opportunities

Wider trends within the waste sector have seen the development of solar-powered bins for recyclable materials, smarter ways to collect waste, and smart logistics for the collection and movement of waste. However, such developments have had little impact on how waste is managed in London to-date. In addition, digital is considered as one of the main enablers in the transition to circular economy throughout all stages of circulating materials, components and products: sharing, maintaining, reusing, refurbishing, and recycling (see Figure 3). This

presents a great opportunity for companies to deliver smart technology and digital solutions in the following areas:

- Circular Economy
- Data Analytics
- Smart Public Realm Bins
- Refuse Collection Vehicle GPS Tracking
- Automated Waste Collection Systems

Circular Economy

Resource management and material recovery are becoming ever more important in a time where resources are scarce and the technology is there to optimise resource use. With the Mayor's request to draw a Route Map to Circular Economy by 2036, there are opportunities for businesses to provide solutions that enable more efficient management of resources and recovering of valuable materials [70].

LWARB's report "Towards a Circular Economy" stresses the importance of smart technology in the circular economy:

> "The link between SMART technologies and the acceleration of a more circular economy is clear, offering the opportunity to track and trace products, facilitate reverse logistics capabilities and offer online platforms for collaboration and the sharing economy." [71]

According to Andrew Richmond, Policy and Strategy Manager for Energy and Waste at the GLA, the transition to circular economy presents the biggest market opportunity. The reason for being such a great opportunity is that it encompasses innovative design for remanufacturing and innovative ownership models across industries. A new economic model, called collaborative consumption, has emerged: "Systems that reinvent traditional market behaviors – renting, lending, swapping, sharing, bartering, gifting – in ways and on a scale not possible before the internet." [72] New business models include servitisation of products, leasing, and sharing.

Some of the opportunities for digital solutions are outlined below:

Sharing platforms: Avoiding waste is the first step in the transition to circular economy. This can be enabled through peer-to-peer online exchange of assets. Digital platforms such as AirBnB allow this to happen. AirBnB help people to share underutilised spaces and therefore the need for building new hotel accommodation is reduced. Other examples include sharing surplus food from supermarkets and restaurants with people who need it through schemes such as FareShare thus reducing food waste.

Maintaining assets: A recent report published by the Ellen MacArthur Foundation, a charity established in 2010 with the aim of accelerating the transition to the circular economy, is stating the importance of the Internet of Things in enabling a less resource-dependent circular

economy. Intelligent assets[7] can signal their need for maintenance before they break down and are sent to landfill, thus reducing the amount of waste and increasing their life cycle:

> "The circular economy helps decouple economic value creation from resource consumption. Its four value drivers – extending the use cycle length of an asset, increasing utilisation of an asset or resource, looping or cascading an asset through additional use cycles, and regeneration of natural capital – can be combined with one (or several) of the three main intelligent asset value drivers – knowledge of the location, condition, and availability of an asset." [73]

The connection between intelligent assets and the circular economy already offers opportunities for businesses in multiple sectors, including optimising materials flows and waste management.

Reuse and redistribution: Keeping materials, products and components at the highest use and value at all times is helping to reduce waste. Online applications such as the London-based Globechain allows for businesses, charities and people to reuse unused materials and products. Similarly, another London-based company Fonebank specialises in the reuse of mobile phones, collecting and re-distributing old devices to customers in Africa and Asia. Such an innovative ownership model ensures that existing assets are being optimised.

Product as a Service: Digital can also support innovative business models such as servitisation, or offering 'product as a service', whereby the company offers access to a product but retains ownership of it. This incentivises companies to prolong the life of a product by maintaining it better. An example of such a service is the Philips 'pay-per-lux' model, which offers lighting as a service instead of selling lighting infrastructure [74]. Data is key for monitoring the performance of such a system in order to track energy consumption and the state of the lighting system.

'Designing out waste' in construction: Optimising the use of materials is key to reducing waste from construction activities. The New House for London project, a collaboration between Arup, Carl Turner Architects and The Building Centre, demonstrated flexible construction solutions and modular systems [75]. It illustrated how under-utilised brownfield land could be used to locate prefabricated, adaptable spaces, suitable for modern urban living. The need to reduce waste in construction creates opportunities for new solutions which use materials effectively, reuse and repurpose built environment components, and monitor the performance of assets in order to prolong their life cycle.

Design for remanufacturing: To support the transition to circular economy, solutions for innovative remanufacturing are needed. This includes finding new ways to reduce, reuse, recycle, and reclaim materials so that they are not sent to landfill. Remanufacturing solutions include "technologies which restore worn and damaged components to the same functional performance of new products," as described by experts at Caterpillar. [76]

[7] "Physical objects that are able to sense, record and communicate information about themselves and/or their surroundings. This definition incorporates IoT objects but also includes assets that are not continuously transmitting information, and things that do not feature wireless communication." [73]

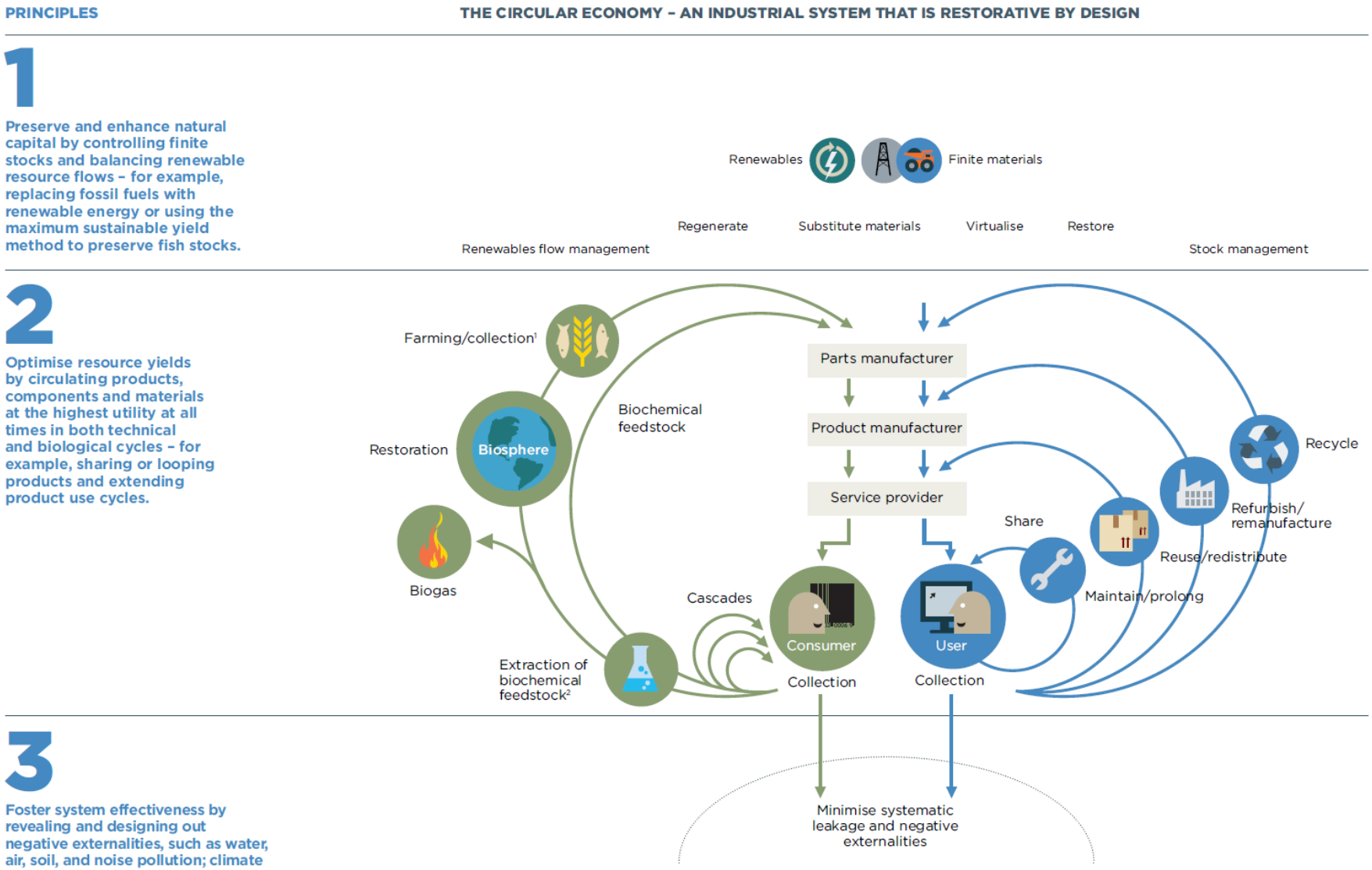

Figure 3 - Circular Economy [73]

Recycling: Some of London's waste contractors Bywaters [77], Veolia [78] and London Waste [79] have already established materials recovery facilities (MRFs) and organic waste treatment facilities to optimise recycling and material recovery. Veolia's MRF in Greenwich, for instance, handles up to 75,000 tonnes of mixed dry recyclables per annum, which are separated, bailed and sent on for reprocessing into new items [78]. East London Biogas Ltd is operating an organic waste treatment facility at the London Sustainable Industries Park in the London Borough of Barking and Dagenham. The facility has the capacity to process 49,000 tonnes per annum of food and green waste via a 30,000 tonnes per year anaerobic digestion plant, and a 19,000 tonnes per year in-vessel composting plant [80]. The facility produces approximately 1.4MW of renewable electricity and an organic fertiliser for agricultural use.

Data Analytics

Visual display of how much waste is generated through an interactive online tool, for example, could generate comparisons between recycling rates, food waste, etc. amongst boroughs. This could encourage behavioural change and allow boroughs to target specific areas that have low recycling rates or generate more food waste to launch educational and awareness campaigns. In addition, analysing waste-related datasets can help London boroughs improve the efficiency of services. The London Datastore shares insights on how waste data can be used by drawing a comparison with New York: data on waste generation throughout the year produced a model which can predict future service demand and thus help plan more efficient collection routes and times [81].

Data on future developments will also be added to London's Infrastructure Mapping Application, which will help identify where strategic waste sites are located, helping to inform waste infrastructure investment opportunities [82].

Smart Bins

Technologies that can monitor the fill levels of bins can facilitate more efficient waste collection. Sensor fill alarms monitor how full each bin is, allowing authorities to decide when to collect the bins. Big Belly Solar UK, for example, produces a street waste collection bin powered by the sun, which alerts collection contractors when the bin is 85% full. A study undertaken by Big Belly Solar over six years with 162 UK Councils shows that on average the frequency of bin collection dropped by 86% after the Big Belly Solar bins were installed [56]. In London, the number of boroughs trialling the bins is growing: from Westminster in 2013 to Islington (since March 2015 [83]) and Ealing (since April 2015 [84]).

Collection vehicles logistics optimisation

Optimising the movement of waste collection vehicles can be achieved through the planning of more efficient collection routes. This can be enabled through GPS tracking on collection vehicles and the information collected on their location and speed. Sevenoaks in Kent has been working with municipal services provider Verdant Group Plc to install GPS trackers in 200 refuse and recycling vehicles [85]. However, this technology has not been widely implemented in London and presents an opportunity in the market.

Automated Waste Collection Systems

Automated Waste Collection Systems (AWCS) transport waste from each floor of a building, or public realm areas, to a central waste collection station through a network of pipes. Such a system was implemented in London for the first time at Wembley City in 2008 [86]. By tracking the weight of each type of waste, easier control over the most suitable time to empty

the system is enabled. There are currently several global providers, such as Envac Group, that supply the system but there are no UK suppliers yet.

7.7 Barriers to adopting digital solutions

The existing opportunities on the Smart Waste Management market could be fully utilised if certain barriers to innovation and entry to market are overcome.

Lack of knowledge

Since smart waste management solutions have only recently entered the market, local authorities are not always aware of the latest smart technologies in waste, or about the benefits that they can bring. Concerns around the robustness of sensors can also be attributed to lack of knowledge about how to use smart systems in a safe manner. Arup's report for BIS has shown:

> "There is an insufficient understanding of how smart technologies could be fully deployed in the waste sector. There is a lack of funding for research, innovation development, and large scale trialling of innovation." [56]

Lack of data harvesting and sharing

There is currently a lack of capturing, harvesting and sharing of data from, for example, intelligent asset monitoring system that could otherwise enhance and prolong the life of assets. It is essential that intelligent assets monitoring systems are being used to their full potential. The data should also be used in a collaborative manner between clients, architects, designers, constructors and operators to optimise the whole life-cycle of assets.

Lack of incentive

Waste contractors in London, as in the rest of the UK, hold long-term contracts with local authorities. The length of these contracts, usually 10-25 years, provides little incentive for waste companies to innovate in order to become more efficient, for example, by optimising refuse collection routes. As a result of such long contracts, it is also difficult to predict what challenges and solutions would have emerged by the end of this period. In addition, in order to win a contract, waste contractors do not necessarily need to demonstrate usage of smart technology as part of their services.

Consumer resistance

Smart technologies, which track the types of waste disposed, could earn smart waste technologies an unfavourable reputation amongst consumers. People might become more resistant to what they see as surveillance of their waste. Consumer awareness campaigns are needed to address such concerns. More consideration might need to also be given to the types of data collected and used through smart waste technologies, such as Radio-Frequency Identification (RFID) tagging, which allows the identification and tracking of waste items.

Funding gaps

There is limited resources available to local authorities and waste management companies for deploying smart waste technologies. As for any new technology, it would be difficult to build a business case without trialling the solution first. Therefore, innovation funding needs to be available to incentivise the testing and uptake of new smart waste technologies.

7.8 Recommendations

In order to break the above barriers down all stakeholders, including the GLA, boroughs and waste contractors, could undertake several measures.

Drive innovation through renewed waste contracts

The London Waste Map shows that waste and recycling collection contracts of nearly 40% of London boroughs are coming to an end within the next 5 years [87]. This presents a great opportunity to improve performance indicators and try new things, for example trial innovative uses of technology and data to optimise vehicle routes. Such changes could incentivise waste management companies to achieve greater operational efficiencies and maximise resources. Waste recovery rates could be improved by developing waste treatment and recycling infrastructure, including smart waste separation and RFID tagging.

Provide support to boroughs

An increased understanding about the benefits of smart technologies can allow innovations to penetrate the market. In light of the EU's Waste Framework Directive, boroughs need advice and guidance on how to meet both the national and international requirements and still remain at the forefront of waste management. An overarching strategic authority such as the GLA might be instrumental in providing such support. The GLA already acts as a convener of all London boroughs. This position allows it to act as a coordinator and source of knowledge about how smart technology could improve waste management in London.

Release waste data

Similarly to the water sector, data has not played a big role in sparking innovation in the waste sector. Renewing waste contracts gives boroughs the opportunity to gather more data from contractors. GIS-based tool Waste Atlas displays waste management data from around the world and visualises available infrastructure and its performance, while the London Datastore publishes open waste data from boroughs. The London Waste & Recycling Board could also make its databases live. If boroughs and waste contractors could unleash the potential of the data which they collect or could start collecting, a new market for waste services could be created.

Besides these measures that could be taken in the short- to medium-term, there are some long-term changes that require some consideration as well, for example the 'pay-as-you-throw' approach. This approach allows users to pay for their waste collection depending on the amount of waste they generate, instead of paying a flat-rate or municipal tax. This is controlled through a measuring cell at the back of the truck which weighs the waste. London's borough and waste contractors could consider this mechanism in order to ensure that consumers are conscious of the amount of waste they produce and thus decrease the pressure on the collection and recycling services.

8 Smart Transport

London's growing population requires a transport system that will allow passengers to travel efficiently, safely and with minimal impact on the environment. Moving Londoners as well as London's working commuters and visitors is at the core of maintaining the city's economy. The Mayor of London's Transport Strategy stresses that "the provision of reliable and efficient transport, with the capacity and connectivity to accommodate [London's] growth sustainably, is crucial to the continued success of the London and UK economies" [88].

This chapter explores the following questions specifically in regards to London:

- What are 'smart' solutions in the Transport sector?
- How large is the market for smart transport solutions?
- Who are the key stakeholders in the sector?
- What are some global and London-specific challenges related to transport and mobility?
- What drives innovation and deployment of smart transport solutions?
- What are London's strengths in this sector?
- What are the market opportunities for smart solutions?
- What barriers need to be overcome in order for businesses to access the opportunities on the market?
- What do the key stakeholders need to do in order to overcome these barriers?

8.1 Smart transport market size

Smart Transport solutions are estimated to comprise 9% of London's total smart city market opportunities by 2020, which is equivalent to **$1.2bn**, as our projections in Chapter 3 show.

Smart transport solutions are seen as a means to enabling improvements which reduce congestion and make travelling easier for commuters. A smart transport system enables not only transport to be organised better but also allows people to make better choices about how they would like to travel and manage their time better. This is enabled through "intelligent and automated systems that manage, communicate with, and integrate into different types of intelligent infrastructure, such as transportation networks." (Frost & Sullivan)

8.2 Key stakeholders

London's key transport player is Transport for London (TfL), responsible for the city's public transport network, road system and infrastructure plans. This includes managing London's buses, the Underground network, Docklands Light Railway, Overground and Tram as well as Santander Cycles bike hire, London River Services, and Emirates Air Line. TfL also regulates London's taxis and private hire vehicles, the Congestion Charge scheme as well as the 580km network of main roads, including the city's 6,000 traffic lights. TfL works closely with the Mayor of London and the GLA to align on wider transport objectives, outlined in the Mayor's Transport Strategy (MTS). [89]

8.3 Sector challenges

The efficient and clean delivery of transport services is affected by several challenges, as outlined below.

Growing population

The latest figures from TfL show that in 2014/15 London Underground had a record 1.3 billion passenger journeys; 2.4 billion passenger journeys on buses – over half of all bus journeys made in England; journeys on the Docklands Light Railway (DLR) increased from 100 million to 110 million from 2013/14; the Overground network experienced five million more passenger journeys than last year, reaching nearly 140 million passenger journeys [5]. These numbers are due to increase in light of the projections for London's growing population, which is estimated to increase from 8.5 million in 2014 to 9 million in 2020 and 10 million by 2030. This will increase discomfort and capacity issues on the public transport network.

Cost of traffic congestion

According to new data from Inrix, a traffic analysis company, the typical commuters in the city's main commuter zone spent 96 hours in traffic last year, 14 hours more than the previous year. As shown earlier, the annual gridlock cost in London is estimated to rise to $14.5bn by 2030 [4]. A TfL report shows that in this timeframe traffic in central London will increase by 60% [90]. Therefore, optimising the road network and encouraging a reduction of the number of cars on the roads is essential not only to decrease the economic costs of congestion but also to increase London passengers' comfort and wellbeing.

Air pollution

The GLA recognises the importance of "[maximising] the opportunities to promote the health of Londoners through the transport system" [91]. As the following chapter will explain, air pollution is primarily caused by traffic and road vehicles, with transport causing 60% of London's nitrogen dioxide pollution. Air pollution has shown to contribute to 7% of all adult deaths in London [92]. Shifting to sustainable and cleaner modes of transport is therefore crucial.

8.4 Drivers for digital innovation

The challenges outlined above have a direct impact on Londoners' health and wellbeing. Therefore, it is the GLA's and TfL's priority to ensure that the transport network operates in a safe and comfortable way. The Mayor's Transport Strategy is a key driver for implementing change throughout London's transport network. Its key pillars are outlined below:

- Support economic development and population growth,
- Enhance the quality of life for all Londoners,
- Improve the safety and security of all Londoners,
- Improve transport opportunities for all Londoners,
- Tackle deprivation and support growth,
- Reduce contribution to climate change and improve resilience [93].

With these priorities in mind, digital technology can be at the forefront of offering innovative solutions to respond to the needs of a modern, future-proof transport network in London.

8.5 London's strengths

In addition to the political will to instigate change, the conditions in London are right for fostering innovation in transport solutions. Dr Mike Short, Vice President for Innovation at Telefonica, believes that the UK is already a leader in intelligent transport systems (ITS) and transport solutions:

> "In Transport, the UK's already a leader, particularly because of the Open Data Initiative. […] Also the Data Observatory that was announced at Imperial College is a great initiative because it doesn't talk about the data *per se* but about how you observe and act on the results in a big data world – that is absolutely vital from transport's point of view. So we've got the skills, we've got the open data, and we've got the visualisation techniques – so I think in transport we're way ahead of most countries." [94]

Some of London's strengths in particular are outlined below:

Open data

Thanks to the wealth of open data that TfL shares on London's open data platform – London Datastore – it is now possible to create online services and apps that provide personalised travel information. As well as a strength, open data presents opportunities for emerging businesses as well. These will be discussed in more detail in Section 8.6.

TfL traffic management

TfL already uses innovative technology to manage traffic flow. SITS – Surface Intelligent Transport Systems – is a network of intelligent sensors that have been introduced throughout London's road network to help manage road space in real time by unlocking additional road capacity [95].

Predictive analytics

Predictive analytics is also gaining momentum in TfL's planning and decision making processes. The increase in computing power now allows for more granular level of data analysis, which enables query runs on individual and anonymised travel patterns and capturing data to analyse and plan better services [96]. Analysis is enabled through the smart ticketing system on London's transport network, allowing Oyster and contactless payments as well as cashless buses. This is coupled with traffic information, bus location data, asset data, and social media to produce more in-depth analysis.

Research & Education

London is the home of world-leading research and education institutions in transport-related fields. University of Westminster has been recognised as a global leader in the field of urban logistics [56]. UCL Transport Institute explores areas such as safety and security, accessibility, and environment. Its Transport Lab in addition carries out more technical transport research: advanced equipment, innovative use of data, etc. [97]

The Centre for Transport Studies (CTS) at Imperial College London is a world-leading multidisciplinary transport centre, with expertise in engineering, economics and mathematics. Principal areas of research include ITS, transport and the environment, travel demand modelling, transport safety, logistics, and urban engineering systems, amongst others. [98] With the KPMG Data Observatory set up at Imperial College, transport data analysis will be one of the outputs of the Observatory's work. For example, analysis can show how

Underground line closures, or strike action, can affect the rest of the network and thus plan better for such scenarios [99].

Finally, Transport for London carries out research projects and trials aimed at improving transport in the city. For example, the London Underground's Technology and Innovation Team have carried out trials on how intelligent infrastructure could interact with visually impaired customers to improve their experience on the Underground. A trial at Euston Underground guided visually impaired participants from the station entrance to the platform via audio directions from a prototype smartphone app.

8.6 Market opportunities

Evidence gathered for this report suggests that transport is the most advanced sector of the five in using digital technology and also the one which presents the biggest number of opportunities for new businesses. Julie Alexander, Director for Urban Development at Siemens, explains that the growth in the sector is a result of the data that comes from connected devices and infrastructure. This results in "a huge shift in how people interact with the transport system through the use of tech". Julie goes on to explain that data coming from infrastructure not only helps derive insights but can also be "made available to people to use in really creative ways". Transport already sees "huge amount of growth around the use of data" and there is even further opportunity to expand on this [100]. For instance, Network Rail's Digital Railway programme aims to accelerate the digital modernisation of British railway in the next 15 years [101]. The different opportunities that transport presents specifically in London are summarised below:

- Open data
- Data analytics
- Customer experience
- Internet of Things
- Traffic optimisation

Open data

TfL shares its transport data both on its website's open data portal and on the London Datastore. The data's popular use has led to the creation of hundreds of transport apps that are currently serving millions of active users. Over 6,000 developers have registered for TfL's open data, consisting of around 200 open application programme interface (API) elements focussed on enabling provision of high-quality travel applications, tools and services [102]. Apps such as Citymapper and Moovit help provide personal travel options and ease commuters' journeys.

Lauren Sager Weinstein, Head of Analytics, Customer Experience at TfL, shares that there are already 460 apps powered by TfL's open data:

> "This provides a huge opportunity to look at transport data, and combine with other data sets. In addition, TfL is also sponsoring hackathons to encourage people to think differently about using data in new ways to provide insights from data and technology." [96]

There is therefore an opportunity for businesses to present TfL with smarter solutions for analysing and visualising data.

Data analytics

Besides releasing a large amount of open data, TfL are also using data for internal analytics to enhance customer experience and inform better service planning, for example by combining data from the ticketing system alongside bus location data to better understand how customers travel across the entire transport network. This data tool has been used for a range of applications: redesigning bus routes in New Addington to better serve customer needs, and predicting the impact of the emergency closure of Putney Bridge in order to develop appropriate measures to minimise customer impact.

There are potential opportunities in the future to partner with businesses to develop smart solutions to help customers. For example, the use of data gathered through third party apps, potentially including smartphone location data, may give a better picture of what is happening on the transport network. Valuable insights could also be generated from data produced by other transport services providers such as CityMapper, Zipcar, etc. These companies' data, provided on an anonymised basis, could help inform a wider picture of London's transport landscape.

Lauren Sager Weinstein sees opportunities arising for new ways of visualising data as well as new tools and techniques for data analysis and presenting its insights, through TfL's open data release and potential partnership collaborations. In contemplating data business opportunities, Lauren advises companies to "focus on the business questions and be practical-minded, […] demonstrate a value and a return for the organisation. Ultimately, in order to deliver a public good in a smart way, the goal is to use technology for a practical benefit." [96]

Customer experience

As a city with growing population and ageing infrastructure, London needs to find innovative solutions to manage traffic flows and ensure reliable passenger journey – by tube, bus, bike, boat, or car. In order to achieve these goals TfL has already made advances in improving the travel networks on the road and underground. Using data and smart solutions has been key to such enhancements. In order to meet the challenges of the future TfL has several key aims that present market opportunities for innovative smart businesses within Customer Experience:

- Integrating ticketing, bus, traffic congestion, and incident data for better performance of the bus and road networks,
- Developing further personalised services for those customers who want tailored information,
- Predicting platform and train congestion at stations,
- Using new data mining tools and geo-spatial visualisations to bring data to life [103].

Internet of Things

Some applications of the Internet of Things are already present on the London network but its capabilities have not been fully explored yet. An example is the Smart Parking system implemented in the City of Westminster. The installation presents a series of SmartEye battery-powered wireless infrared sensors in parking spaces connected to a central data platform. Through an app, drivers can see where the available parking spaces are. This saves

up to 12 minutes of circling in search for a space, alleviating congestion and pollution. Evaluations of the scheme have already shown an increase of paid-for parking occupancy rates by 2%. Following the review of the scheme, sensors will be rolled out to 10,000 parking bays in the borough over three years [104]. Replicating this scheme in other boroughs will present wider opportunities for businesses.

Traffic optimisation

"Maximising traffic flow through innovative technology" is one of the TfL key priorities, as outlined in the 2014 Business Plan. Technologies such as SCOOT can allow to respond to real-time traffic conditions by optimising signals and traffic flow. SCOOT – Split Cycle Offset Optimisation Technique – intelligently detects groups of people waiting at pedestrian crossings and adjusts the green man time accordingly. TfL plans to equip 1,500 traffic signals across London with SCOOT technology, taking into account pedestrian and cyclist demand [95]. The TfL's adoption of innovative technologies to manage and ease traffic flows signifies the growing need for such solutions.

8.7 Barriers to adopting digital solutions

Even though innovation and deployment of smart solutions is on the rise in the transport sector, there are still a few barriers that could be addressed in order to maximise the budding opportunities in the sector.

Regulatory constraints

Osborne Clarke's report "Smart cities in Europe: The future of urban mobility" identifies legal and regulatory issues as the major barriers to innovation in transport [105]. Regulation is especially crucial for the roll-out of autonomous vehicles and data collection via connected cars. The UK currently allows the testing of driverless vehicles on public roads and the Government has committed to "review and amend domestic regulations by summer 2017 to accommodate driverless vehicle technology" [106]. Further considerations need to be given to the insurance of autonomous vehicles and how data will be collected, stored and used by autonomous vehicles and manufacturers. These national and international constraints will influence London as well; therefore, strong lobby at a local level is needed to drive this agenda forward.

Funding gaps

Arup's report for BIS has found that gaps in funding and standardisation of the market deter deployment of Intelligent Transport Systems for local authorities across the UK. In addition, it has also proven challenging to scale up solutions after being piloted in London, e.g. through the Future Streets Incubator Fund. It is essential to develop funding mechanisms and business models that can ensure that innovative solutions are rolled out across the capital.

8.8 Recommendations

The following recommendations suggest ways in which the transport sector could achieve even higher efficiencies in delivering services.

Smart parking

Only a few boroughs in London have implemented a smart parking scheme to ease finding parking spots and thus ease congestion from vehicles circling to find a parking spot.

Boroughs need to therefore more proactively seek opportunities to partner with private sector companies in order to roll out such schemes uniformly across London. Cross-borough collaboration on the standards and interoperability of these initiatives could help make them more compatible and easier to use by drivers.

Collect data from apps

Transport open data has led to the creation of hundreds of apps. Data generated from these apps however is not uniformly collected back. It would be beneficial for GLA and TfL to investigate how they can collaborate with other transport service providers in order to improve modelling and data analytics. Ongoing research at Imperial College analyses the value that could be unlocked from data that is produced by app users. Such data is not only produced by travel apps, such as Citymapper, but by emerging smart parking and car sharing schemes, including Zipcar and BMW's DriveNow. Collating all such sources of data could help both GLA and TfL make further improvements to the analytics and planning of the transport system, especially in light of future changes such as the appearance of autonomous vehicles on London's roads.

9 Health and Assisted Living

The health of citizens is a major priority for cities not only because it underpins the central mission of aspiring to a higher quality of life for all, but because it is essential for a productive economy, an affordable healthcare system and a reduced state benefits bill, to name but a few. In addition, some early interventions can avoid considerable and long-term health problems in the future. According to the "Better Health for London" report,

> "London aspires to be the world's healthiest major global city. That means a city that helps its people to make healthier choices; it means a city that focuses on improving the health of the most vulnerable; it means providing consistently excellent care for people when they need it; and it means a city that enables its health enterprise to prosper and to flourish to the benefit of all its citizens." [92]

London is facing many of the health challenges that other cities around the world are facing, such as an increase in the occurrence of obesity, dementia and long-term chronic health conditions, amongst others. With world-class hospitals, research institutions, global companies and initiatives like MedCity, the city offers digital innovators a great place to develop world-class solutions to address these challenges.

This chapter explores the following questions specifically in regards to London:

- What are 'smart' solutions in the Health sector?
- How large is the market for smart solutions in health and assisted living?
- Who are the key stakeholders in the sector?
- What are some global and London-specific challenges related to adopting smart health solutions?
- What drives innovation and deployment of smart solutions in the sector?
- What are London's strengths in this sector?
- What are the market opportunities for smart solutions?
- What barriers need to be overcome in order for businesses to access the opportunities on the market?
- What do the key stakeholders need to do in order to overcome these barriers?

9.1 Health and Assisted Living market size

The projections outlined in Chapter 3 show that the size of the healthcare sector is due to reach **$2bn** by 2020, which is a 15% share of London's total market for smart city solutions and services.

Smart solutions in healthcare include any electronic and mobile health systems as well as programmes or apps that help citizens monitor their own health. Assisted living technologies in addition can help the elderly live independently for longer by allowing them to live at home instead of relying on health and social care services. (BIS report)

In December 2014, the Government announced the Primary Care Transformation Fund, a £1bn four-year investment programme, which will allow the NHS to provide funds to general practices to invest in both premises and technology [107]. The Transforming Primary Care in London framework outlines specifically opportunities that will arise for technology solutions. These will be explored in further detail below (Section 9.6).

9.2 Key stakeholders

The UK healthcare system presents a complex landscape. The National Health Service (NHS) is made of a variety of organisations specialising in the provision of different types of services. The NHS is therefore the biggest buyer of healthcare-related solutions. In addition, local authorities and clinical commissioning groups are responsible for coming together to set local health and care priorities [108].

The GLA is focusing on the following priority areas: maintaining a healthy local environment, maximising the positive and reducing the negative impacts of transport on health, promoting healthy workplaces, health in schools, better mental health, reducing alcohol consumption, and HIV and sexual health [109]. The GLA is also supporting the development, testing and implementation of digital health innovation through the creation of DigitalHealth.London, set up by MedCity and London's three Academic Health Science Networks (AHSNs): Imperial College Health Partners, UCL Partners and the Health Innovation Network.

The major players within the private sector include insurance and private healthcare providers (e.g. AXA, Bupa), large suppliers (e.g. Tunstall, Philips) and manufacturers (e.g. GSK). In addition to the stakeholders within the supply chain, there are industry players that actively engage with the emerging entrepreneurs and start-ups. Merck Sharp & Dohme Limited (MSD) and Wayra Open Future, Telefonica's digital start-up accelerator, have launched an accelerator programme called Velocity Health that challenges the "digital start-up community to create solutions that re-imagine how healthcare can be delivered in the United Kingdom to help improve patient outcomes" [110]. In addition, investors such as Angels in MedCity provide early stage seed funding to health start-ups.

9.3 Sector challenges

London's population faces a number of health challenges that digital solutions are currently aiming to address.

Increasing number of people with long-term health conditions

London's population is not only growing bigger but also older, which is driving up the number of people with multiple long-term conditions. Life expectancy for males has increased from 75 in 2003 to between 77.5-82 years in 2013, and from 80 to 82-86 years for females [111]. These demographical changes and the increased burden of chronic diseases are "increasing demand on already stretched social care and NHS services," according to Dr. John Woolham, Senior Research Fellow at the Centre for Communities and Social Justice at Coventry University. He goes on to say that this also requires solutions that "support independence and delay the need for long-term care". [112]

Air quality

As with many densely populated cities with a vibrant economy, air pollution has been identified as an issue that affects the health of citizens. For example, transport is the primary cause of London's nitrogen dioxide pollution [92]. However, in the period 2008-2013 some improvements have been detected, with measurements showing reductions of 7.5% in nitrous oxide (NOx), 12.6% in nitrogen dioxide (NO_2), and 13.2% in fine particulate matter (PM2.5) [113]. Plans to introduce the Ultra Low Emission Zone (ULEZ) will help address this issue by "halving nitrogen oxide road transport emissions in central London by 2020." [114]

Obesity

The "Better Health for London" report states that more than 3.8 million Londoners are obese or overweight. This poses serious risks to developing health conditions such as diabetes, heart disease, stroke and cancer as well as mental health. The report further explains that London has "the highest rate of childhood obesity of any peer global city, and the highest proportion of obese children in all the regions of England," especially in minority communities [92].

Dementia

The number of people living with dementia in London is rapidly increasing, from nearly 65,000 in 2008 to just over 72,000 in 2014. In the UK as a whole, it is expected that the number of people who will have developed dementia will rise from 850,000 in 2015 to over a million by 2021 [115]. Amongst an array of solutions proposed to tackle this issue are a number of digital solutions developed in London such as Grouple, "a secure, private online social network helping people share the responsibilities of caring for someone with dementia." [116]

Mental health

The London Mental Health Report states that 1 in 4 individuals experience a mental health condition in any given year. This is estimated to result in around £26bn in total economic and social costs to London [117]. The Mental Health Network has produced a study on the benefits of digital technology on mental health:

> "We believe in the potential for digital technology to transform the way people look after their mental health, and transform the way the NHS designs and delivers mental health services." [118]

9.4 Drivers for digital innovation

The London Health Commission's report "Better Health for London" was published in 2014 pulling together a response to the current health challenges faced by the city, including the main ones outlined in the section above. The aspiration set out in the report is to make London "the world's healthiest major global city" [92] and resulted in a number of priority activities being identified to move the agenda forward. These can be summarised in the Mayor of London's seven priority areas within Health:

Healthy environment: ensuring that the local environment improves the health and well-being of Londoners.

Transport and health: reducing the negative impacts of transport on health and increasing the positive ones.

Health Workplace Charter: promoting and recognising healthy workplaces.

Healthy Schools London: ensuring the city's schools provide a healthy environment for children and promote healthy lifestyles.

Better mental health: addressing mental health issues to improve the wellbeing of Londoners.

Alcohol: reducing alcohol consumption and its harmful effects.

HIV and sexual health: raising awareness about HIV and sexual health. [109]

These priority areas act as the key drivers for instigating change in the way London addresses its health challenges.

9.5 London's strengths

Innovation ecosystem

London has a strong ecosystem that supports innovative digital health SMEs both through incubation programmes and finance. Technology experts and digital practitioners can offer skills and expertise in coding, games, animation, user experience capability, and user engagement.

A new addition to London's health sector ecosystem is MedCity, established in 2014 by the Mayor of London and the capital's three Academic Health Science Centres – Imperial College Academic Health Science Centre, King's Health Partners, and UCL Partners. The collaboration was launched with the purpose of promoting London's life science strengths and helping entrepreneurs do business in the South East of England. This includes building a community of angel investors, as well as advancing digital health entrepreneurship through support mechanisms such as helping understanding the route to market, finding accommodation, matching partners and publicising expertise [119].

In September 2013, the Mayor of London established the London Health Commission with the purpose to act as a bridge between the Mayor of London and the NHS, the local government and the wider public. The Commission's mission was to examine how to improve London's health and healthcare [120]. From the recommendation in the "Better Health for London" report, DigitalHealth.London was set up to advance the development and uptake of digital health solutions. A collaboration between MedCity and London's three Academic Health Science Networks (AHSNs): Imperial College Health Partners, UCL Partners and the Health Innovation Network, DigitalHealth.London provides a pan-London response to bridging the gap between patients, clinicians and entrepreneurs. [121]

World-leading research

London has world-leading universities which provide cutting edge health research and higher education. The range and quality of research is extensive and could form a whole report in itself; however a flavour of the programmes of most interest to the digital community is given in this section.

The King's College London Division of Health & Social Care Research and Institute of Urban Population Health and Care carry out research, design and evaluate interventions to inform local, national and international population health policy. [122] University College London (UCL) Institute for Global Health collaborates across disciplines to find solutions to global health problems and produces research which can be directly applied by policy makers around the world. [123] Similarly, the newly established Wellcome Trust-Imperial College Centre for Global Health Research aims at improving global health research. [124] London School of Economics Health and Social Care (LSEHSC) is a research centre which informs the international and national policy community, while also collaborating with a number of organisations globally. LSE Health is a World Health Organisation (WHO) Collaborating Centre for Health Policy and Pharmaceutical Economics and a founding member of the European Observatory on Health Systems and Policies, supporting health policy-making across Europe. [125]

This extensive body of research carried out in London does not only benefit the capital and the UK but also the international community.

9.6 Market opportunities

In the past two decades, healthcare and social care have been highly impacted by the rapid development of technology. Devices, like sensors, work around the person in their home environment and can send an alarm signal automatically to request immediate responses to fires, floods, falls, or gas escape. This has been "particularly useful in supporting the independence of people with cognitive impairments like dementia by managing risk and helping people to stay safe," explains Dr. Woolham. [112]

More recently, smartphones, tablets and wearable devices are allowing even further capabilities to support different activities such as digital fitness, monitoring own health, and competing with peers. The proliferation of health apps has led to the creation of websites like MyHealthApps that review such apps and rate them.

These trends are also reflected in London and have given rise to a number of opportunities, some of which are of particular interest to the city:

- Telecare solutions
- Solutions addressing ethnic diversity
- Accessibility apps
- Improving Londoners' health and fitness

These opportunities will be further enhanced by the Transformative Primary Care in London programme. The Strategic Commissioning Framework documents stresses the importance of technology in delivering modern healthcare services that make processes smoother and better tailored to patients [126].

Telecare solutions

Remote care devices allow the elderly and those with disabilities and mental health problems to remain at home while receiving professional care. This includes electronic assistive technology devices that collect, store and transmit information to a remote source, usually requiring a particular type of response. Telehealth devices also relay diagnostic information to clinical staff to support the treatment of long-term conditions [112]. An example is London-based SpeakSet, as already mentioned earlier, which allows patients to connect with a health professional through their TV set.

Solutions empowering diversity

Technology can empower people from diverse cultures and backgrounds monitor their health and communicate with their doctors. 42% of Londoners are from Black, Asian, and minority ethnic (BAME) groups, from 90 different ethnic groups and speak 300 languages. It is a major challenge to access and provide healthcare to some of these communities and therefore presents an opportunity for digital solutions to help overcome these barriers.

Accessibility apps

Certain health solutions need to be designed in a way that is tailored to those with special needs, e.g. with hearing problems, slower perception, dementia, or visual impairment. Solutions that facilitate accessibility technology present an opportunity for businesses. The Future Cities Catapult has a joint project with Microsoft and Guide Dogs called "Cities

Unlocked". It is researching how blind people can navigate the city better and have developed a headset that allows a smartphone app to provide the wearer with 3D-soundscapes, augmenting reality to provide a richer understanding of their surroundings. [127]

Improving Londoners' health and fitness

Obesity and physical inactivity pose serious risks to developing health conditions such as diabetes, heart disease, stroke and cancer as well as mental health. Therefore, getting London fitter is becoming ever more important, both by encouraging healthier eating and more physical exercise. There are a number of initiatives addressing this issue across the capital. The GLA have made London's schools a priority, since only 55% of London's children are physically active. [92]

Recent years have seen an increase in the use of devices that monitor one's health and provide tips on healthy eating, sleep and exercise. London-based digital health start-up Big Health, for example, has developed digital sleep improvement program Sleepio, which attracted $3.3 million funding from Index Ventures and Forward Partners in April 2014 [128].

Digital tools also help people manage their own mental health. Big White Wall is an anonymous on-line service available 24 hours a day that supports those experiencing common mental health problems, such as depression and anxiety, and is available to the majority of London residents who need it.

9.7 Barriers to adopting digital solutions

In order for London to be able to realise the opportunities outlined above there are certain barriers that need to be overcome.

Scaling solutions

Our research has shown that companies are struggling to scale up their solutions after a pilot stage in this area. The "Better Health for London" report attributes this both to difficulties accessing capital and adopting innovation within the NHS:

> "London remains a difficult market in which to launch digital health products, particularly for small and medium sized business. It is too hard to access capital, to access clinical input, and to get products purchased and adopted by the NHS." [92]

It is a catch-22 situation, not unique to healthcare. Since solutions are not scaled up and, therefore, cannot provide an evidence base of their benefits, investment for growth is harder to secure. Also, the very nature of the healthcare sector means that there is often a need to use sensitive personal data and this, coupled with the ever-changing sector landscape, can make it less appealing for digital innovators compared with other sectors.

Julie Bretland, CEO of Our Mobile Health, sees the core of the problem in that there is not a clear pathway to market. As a result, when start-ups are at the stage of seeking investment, they can often go to the US. She goes on to explain, in her experience, investors in London and the rest of the UK would be more willing to invest in companies if there were a clearer pathway to market and access to the NHS. [129]

These issues have received attention in London and DigitalHealth.London has been set up to address these barriers and provide further support to the sector [130]. Its aim is to help

London to pioneer the development, commercialisation and adoption of digital health innovation to improve health outcomes, specifically targeting SMEs. DigitalHealth.London Accelerator is a programme which will provide business support to SMEs, helping them to access the market and support further growth.

Access to NHS data

Open data helps stimulate digital innovation and create economic value. As a result of the sensitivity of health data and legal constraints, the NHS is cautious about releasing data without due consideration and so is the British public. [131] Privacy and security issues are not unique to the UK and are undoubtedly key concerns that need to be addressed in order to move forward.

However, the benefits of sharing non-sensitive data about the NHS processes could be given more consideration. Nigel Shadbolt, chairman of the Open Data Institute (ODI), explains that basic data sets, such as trusts' opening times, consultant lists and details of services, are "all fragmented and fractured" but making them available in machine-readable format for apps to use can "improve patient care in the NHS and save hundreds of millions of pounds a year". [132]

Healthcare data is no longer just the domain of the clinical practitioner with an increasing number of people monitoring their health and fitness through personal digital devices (or 'wearable tech') such as fitness bands and smart watches. [133] Data harvested from these devices could be shared with health practitioners in order to give a more holistic view of the individual and to act as early warning for certain conditions.

Financial constraints to health and social care

Local authorities have seen a reduction in central funding from national government over recent years which has led to them having to find savings across all of their services including social care. Estimates show that this will result in a funding gap of between £2.8bn and £3.5bn by 2020. [134] Local councils will remain responsible for raising revenue to support such services, and the reduced pot of money makes it less available to fund innovation. On the other hand, this means that councils are embracing innovations to deliver more for less and digital has a key role to play in this.

9.8 Recommendations

Drawing on our research, including the interviews with health experts, a number of recommendations were suggested:

Set up co-location space for digital health companies

A digital health incubator and co-working space can bring innovative start-ups and larger companies together to spur collaboration and relationships. According to Julie Bretland, this can "help build trust and help small companies attract investment through their newly established network, just like Google Campus helps start-ups grow." [129] The GLA could play a role in advancing this idea by working with the private sector to understand the needs for and benefits from such as space. However, industry should ultimately lead the setting up of such an incubator and co-working facility.

Create a pathway to market / access to NHS

As already discussed, the current route to market, and specifically access to the NHS, is challenging for small companies developing innovative solutions and seeking investment. The Better Health for London report has already recommended the following:

> "Given London's intrinsic strengths, it should be the place where digital health innovations are created and tested. More support can be provided for innovators to undertake local development with patients and clinicians, helping to demonstrate the impact of their products." [92]

Through DigitalHealth.London, the GLA is already starting to address these issues and take actions to help digital entrepreneurs scale their solutions and access the NHS.

Examining the opportunity from a different angle, the NHS has launched the NHS Healthy New Towns programme, aiming to "establish up to five ambitious, long-term partnerships with local areas through which to develop healthier neighbourhoods and towns" and have pinpointed digital innovation as a key enabler [135]. The programme received applications from 114 developments from across the country and a number from London, which demonstrated a real demand for understanding how new developments affect health. After a selection process 10 sites have been shortlisted, with two sites from in and around London: Barking Riverside with 10,800 residential units on London's largest brownfield site, and Ebbsfleet Garden City, Kent, with up to 15,000 new homes. [136] It is the ambition of the programme to enable new digital solutions to be trialled and scaled across these developments.

Cautiously use telecare to enhance social care

Even though digital technology can provide many benefits to patients and practitioners alike, it is important to balance such solutions with traditional methods. Dr. Woolham cautions that:

> "Telecare can compound social isolation and loneliness particularly amongst older recipients and though it might save on the local authority community care budget, there may be much larger savings - though not cashable ones - to be made by reducing demand for residential care and need for non-elective hospital admission. This would require a high level of strategic co-ordination." [112]

Whilst telecare has been identified as one of the solutions for coping with the increasing demands on healthcare provision, there are still lessons to be learnt about the best way to deploy such technologies at scale to maximise value and avoid dis-benefits as highlighted by Dr. Woolham.

10 London is the Place for Smart City Businesses

Digital technology companies bring economic value to London, with employment and turnover growing year on year. The number is growing rapidly: an increase of 12,000 from 2010 to 2015, bringing the total number of businesses to approximately 40,000. Oxford Economics have estimated that London businesses can unlock £48.5bn of growth by harnessing digital technology:

> "London is a digital city. The majority of firms now provide digital content, and their collective digitally-driven revenue growth was £38.1bn [in 2015]. London represents 31% of total UK growth and leads all other regions and countries. Undoubtedly, digital will become more and more important. The capital could see a further £48.5bn of annual benefit if it reaches its full potential." [137]

The city's entrepreneurial environment has already created an agglomeration effect. It has emerged from our desk research and interviews with 12 industry experts that the right conditions are present for smart city businesses to flourish in London. These include:

- Existing innovation ecosystem of digital practitioners and support networks
- World-class research and leaders in education
- Infrastructure megaprojects
- Open data
- City-as-a-system initiatives that cut across silos

10.1 Existing ecosystem of digital practitioners and support networks

London has a world-class innovation ecosystem including a wide range of practitioners related to the digital industries and associated support services. This makes it an excellent environment for digital innovators to find the talent they need to thrive.

The city has been named No.1 city for digital entrepreneurship in Europe by the European Digital City Index 2015 [138]. A number of support networks and accelerator programmes have been launched to help London tech companies set up, grow and export:

- **TechCityUK** is a central government funded non-profit team set up to support the growth of UK's tech companies [139].
- **London Tech Advocates** is a private sector led coalition of over 2,100 expert individuals. Their role is to support London's tech start-ups and high-growth businesses in finding new investment and new talent [140].
- **L39 Cognicity Hub** is a hub for the discovery, development and deployment of smart city technologies. It was set up following the Cognicity Challenge, which enabled six smart city companies to grow their businesses over 12 weeks [141].
- **DigitalHealth .London** was set up in response to a recommendation in the London Health Commission's report "Better Health for London", aiming to make London a global centre for the development and up-take of digital health technologies and to create a marketplace for such technologies. DigitalHealth.London is co-funded by the

European Regional Development Fund (ERDF) and led by London's three Academic Health Science Networks, working with the Mayor of London and MedCity[8] [142].

- **The Scale-Up Institute**: Set up in 2015, the Institute is the first organisation in the world to focus solely on providing support to growing companies to step up to the next level. It will bring public and private sector members together to help increase the number of businesses that have developed beyond start-up mode in the UK [143].
- Two **Smart London Innovation Networks (SLINs)**, formed in 2014 and 2015, connect innovators with organisations delivering London's regeneration projects. The networks provide an opportunity for solutions to be applied on large-scale projects and thus scale up. The Smart London Districts Network enables collaboration between public and private development organisations delivering London's largest development districts. The Smart London Infrastructure Network provides a platform to utilities delivering London's infrastructure services to share best practice and bring innovation to market [144].
- The **Smart London Export Programme** has been set up with the aim to support at least 100 SMEs export their solutions globally by 2016.

Accelerator programmes, incubators and co-working spaces for innovative start-ups are also offering entrepreneurs incentives to take their ideas forward:

- **Digital Greenwich Accelerator** is a free business support programme for digital small and medium-sized enterprises (SMEs) in smart cities, giving them opportunities to develop and test new products in the Royal Borough of Greenwich [145]. Greenwich published its smart city strategy in October 2015, focusing on transforming four key areas through smart solutions: Neighbourhoods and Communities, Infrastructure, Public Services, and the Greenwich Economy [146]. The Royal Borough of Greenwich will also host demonstrations of innovative technologies as part of a €25m European Smart Cities and Communities Lighthouse programme [147].
- **Velocity Health** is a programme launched by MSD and Wayra Open Future, Telefonica's digital start up accelerator, to invest in digital innovation in healthcare. As part of the programme, a selected number of start-ups will receive up to £64k of investment in total, including access to a network of mentors, coaches and investors [110].

At the heart of this support system, London also has to offer a strong financial sector. In the first nine months of 2015, for example, £1bn of venture funding was raised [148]. Investor networks, such as Angels in MedCity [149] in the healthcare sector, introduce businesses to investors. This ecosystem is further enabled through London's wealth of digital practitioners.

[8] "MedCity is a collaboration between the Mayor of London and the capital's three Academic Health Science Centres - Imperial College Academic Health Science Centre, King's Health Partners, and UCL Partners Launched in April 2014 to promote and grow the world-leading life sciences cluster of England's greater south east, it is promoting life sciences investment, entrepreneurship and industry in the region." [119]

Julie Alexander, Director of Urban Development at Siemens, sees London as a "great place for these 'new kids on the block'", going on to explain:

> "We've got Tech City, incubators popping up all over the place – so oversubscribed that we can't provide enough space for these new companies – we've got London Tech Advocates… all these groups and networks are there to support new businesses so I think there's a really big support system in place. [London has] great minds, great energy and creativity, [and] an open business network that promotes growth." [100]

10.2 World-class research and leaders in education

As part of its ecosystem, the city also offers a wealth of world-class research institutions. London has been recognised as a research and education leader, with four of the top 50 universities in the world, according to the Times Higher Education World University Rankings [150]. Institutions such as University College London (UCL) and Imperial College London also host leading research centres on smart cities and data analytics. In November 2015, KPMG opened their Data Observatory at the Imperial College Data Science Institute (DSI). Part of the company's £20m investment into Imperial's DSI [99], the Observatory offers a 310-degree visualisation space, data science studios, conference facilities; providing an immersive data environment to allow for academics and businesses to come together and work on solving challenges [151]. In addition, the Alan Turing Institute, a world leader in data science research and its applications, enables knowledge and predictions to be extracted from large-scale and diverse digital data. To support smart cities research and education, UCL has launched a Master of Science degree in Smart Cities & Urban Analytics. Besides these academic institutions, organisations such as Nesta, Centre for Cities and Centre for London provide valuable cities research. [152]

In addition to those bodies carrying out smart city research, the Government has established a series of Catapults that undertake projects both to help cities and businesses develop their smart city ideas. The Future Cities Catapult, for example, has launched the Cities Unlocked project to find ways to help blind people navigate the city [151]. The Digital Economy Catapult is advancing Internet of Things (IoT) projects and businesses through their programme IoTUK. The programme will link research activities with potential users, connect SMEs with businesses and the public sector as well as demonstrate and incubate new IoT activities across the UK [104]. London will host 17 large-scale IoT experiments by the newly launched Internet of Things Research Hub. Part of IoTUK, the £23m programme will bring nine UK universities together to explore critical issues in privacy, ethics, trust, reliability, acceptability, and security [153].

While carrying out projects focusing on developing solutions for the future, there are existing systems such as big-scale infrastructure projects that also present opportunities for deploying digital solutions, as the next section outlines.

10.3 Infrastructure megaprojects

London is home to large-scale infrastructure projects which are increasingly turning to digital solutions to improve their functional efficiency both throughout the construction and operational phases. If infrastructure megaprojects are not future-proofed, there is a risk that functional problems will emerge in the future. Such projects exist in a wide range of industries including rail, water, housing, and energy.

Rail: Large rail projects such as Crossrail and England's second high speed rail project, HS2, are investing in digital solutions to help them deliver services more efficiently and improve customer experience. For example, Crossrail is connecting London and the South East of England by rail, building 10 new stations and refurbishing 30 existing ones. It claims to be "the first organisation to develop a strategy and process for managing innovation in mega projects" through their innovation programme Innovate18. The programme has already invested over £350,000 in innovative solutions [154]. One of the pillars of the programme is to develop digital capability through innovative sensors and data analytics solutions. The Digital Economy Catapult's event Crossrail Pit Stop aims to connect small and medium-sized businesses to Crossrail through a focused open innovation activity. The aim is to "investigate how sensor systems and data analytics can help find innovative ways of increasing efficiencies during the delivery of the Crossrail project." [155] Such engagement opens up opportunities for SMEs to connect with market leaders and have a clear pathway to participating in London's infrastructure megaprojects.

Water: Tideway, the organisation delivering the Thames Tideway Tunnel, is building a 25-kilometre sewer tunnel to prevent an average 20 million tonnes each year of untreated sewage discharging into the tidal River Thames in London [156]. The project is expected to be delivered over seven years, starting in 2016, at a cost of £4.2 billion [157]. Even though the project does not have a dedicated innovation programme similar to Crossrail's, it still presents opportunities for innovative digital businesses to offer their solutions. Further opportunities in the water sector are outlined in Chapter 6.

Housing: The volume of projects that have received planning permission to accommodate London's growing population is currently at 260,000 homes [158]. The Old Oak and Park Royal Development Corporation (OPDC) is one of the largest regeneration projects in London, with over 25,000 homes being built over 30 years. OPDC have committed to developing a smart city strategy for the area, which will create opportunities for trialling and implementing innovative solutions on a large scale.

Energy: London hosted one of the UK's largest smart grid trials in 2011-2014. The UK Power Networks' innovation project Low Carbon London trialled low carbon energy technologies over four years. Smart solutions which were tested included Demand Side Response & Distributed Generation as well as dynamic Time of Use tariffs. The results and insights from this project have been summarised in 27 reports, which present a wealth of resources to help understand how the electricity network can contribute to London's low carbon future. The results can also inform businesses in the supply chain of what opportunities there are in London's energy sector. These are explored in more detail in Chapter 5.

10.4 Open Data

London Datastore: Launched in 2010, the London Datastore was one of the first online platforms to make public data open. Over 850 datasets are currently available with APIs covering 16 themes from employment and skills to transparency and health services. Today the Datastore receives over 30,000 visits a month. The objective 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.

Releasing London's data has resulted in businesses emerging at each stage of the information value chain. IT companies help city governments to set up open data platforms; smaller

companies then analyse and package the raw open data into an easier format for web and app developers, such as Transport API which acts as an aggregator of open data. Towards the end of the chain, investors and start-up incubators are helping developers to commercialise their products and services. To-date, over 460 transport apps have been created using data from the London Datastore, creating a vibrant "information marketplace" for the sector. Besides the success of transport applications, the Datastore is helping home movers through the MyLondon interactive and personalised dashboard, which helps home seekers find areas that suit their needs [159].

Open Data Institute: Open data activities are further supported in London by the Open Data Institute (ODI). As an independent, non-profit company, it aims to "train, nurture and collaborate with individuals around the world to promote innovation through open data". It does this through open data training, research, events, art work and other activities [160]. The Open Data Institute has estimated that £33.4m has been unlocked in direct investments, from competition funding, direct contracts, partnerships and income that ODI Nodes and Start-ups have generated [161]. An ODI study has identified and analysed 270 open data companies that "use, produce or invest in open data as part of their business" – over half of these (51%) are based in London [162].

10.5 City as a System

The Smart Cities Council has identified a set of key enablers that allow cities to function in a 'smart' way through technology and human capabilities. Technology enablers are the digital underpinnings of a smart city, while human enablers are those relating to people, such as citizen engagement [163]. Implementation of initiatives with cross-functional capability are

A city systems approach

Cities are complicated and messy systems. Urban problems are the result of multiple factors with far-reaching impacts involving complex feedback loops. Traffic congestion, for example, could be the result of increasing population, decreasing household size, expensive public transport, a lack of parking or the city's layout. In turn, congestion can lead to poor air quality and high noise levels, increased health risks, less enjoyable public spaces, reduced productivity and fewer tourists in the city. Each urban problem is part of an intricate system of interactions.

Given the complexity of urban problems, the most effective approach to resolving them considers a city's multiple systems simultaneously, rather than focusing on how to fix a particular element. A **city systems approach** is just this; it considers the city as a system and designs solutions to have maximum positive impacts, while minimising negative unintended consequences.

Adopting a city systems approach is challenging as it requires a new integrated way of working. Firstly, designers must work beyond single disciplines to develop a sufficient understanding of the urban system. Secondly, diverse stakeholders need to be involved to implement these designs. The structure of city governments tends to be based on 19th or 20th century institutional models, with separate departments for distinct city functions such as transport, energy and education. To solve 21st century problems these silos need to be broken down and a more integrated approach to city management and governance is required.

Source: Future Cities Catapult and Arup (2014) "Future Cities: UK Capabilities for Urban Innovation", available on: http://publications.arup.com/~/media/Publications/Files/Publications/F/Future_Cities.ashx

those that allow the city to operate as an integrated system. In London, the GLA has set up the Smart London Board in order to enable the capital to act as a 'city as a system'. However, in order to fully unlock this capability, vital resources (both human and budgetary) are needed to stay remain competitive with global smart cities such as New York and Singapore.

Conclusion

London is a large and vibrant city that has many strengths to offer the rapidly expanding smart city market. Our research confirms many of the strengths that are often cited for London, such as world-class research and academic institutions and a vibrant tech start-up community.

While London is recognised as being at the forefront of smart city innovation today, other cities are starting to advance ahead of the pack. These cities are starting to deploy smart initiatives at scale, to update their legal or regulatory systems, and to facilitate greater public participation using digital technology. London has a choice to build on its strengths in order to keep pace with these innovative cities or to continue as-is.

This report identifies areas of opportunity for London to pursue if it wants to stay ahead. The global smart cities market is large, and London has the capability of capturing a substantial part of it.

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Appendix 1: List of interviewees

Sector	Arup Experts	External Experts
Energy	**Thomas Briault** Associate, Energy Consulting	
Transport	**Tim Gammons** Director, Intelligent Transport Solutions	**Lauren Sager Weinstein** Head of Analytics, Customer Experience, TfL
Waste	**Allan Barton** Director, Energy & Resources	
	Rainer Zimmann Associate Director, Resource & Waste Management	
Water	**Martin Shouler** Associate Director, Environmental Services, Energy & Resources	**Alex Nickson** Policy and Programmes, GLA
Health & Assisted Living	**Pam Turpin** Senior Research Analyst, Health & Wellbeing	**Mike Short** Vice President for Innovation, Telefonica
		Julie Bretland CEO of Our Mobile Health
		Dr. John Woolham Senior Research Fellow Centre for Communities and Social Justice Coventry University
Cross-sectoral		**Julie Alexander** Director, Urban Development, Siemens
		Corin Wilson Head of Smart Cities – Technology Team, UKTI

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