MAYOR OF LONDON

LONDON INFRASTRUCTURE PLAN 2050 A CONSULTATION

Mayor's Foreword

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London Infrastructure Plan 2050 – A Consultation

Since I became Mayor in 2008, we have led huge infrastructure projects to improve the lives of Londoners – like securing Crossrail, creating a thriving new East London district with Queen Elizabeth Olympic Park and its fantastic transport links, and the Northern line extension.

Last year, we published two important documents on London's future - the independent London Finance Commission's report and my own 2020 Vision. Both were a rallying call for London to have its own long-term infrastructure plan. Today, I am pleased to announce we are now consulting on this plan.

Together, these three documents set out an intense agenda for London. In the 2020 Vision, I explain how London can extend its lead as the financial, commercial, cultural, artistic, media, and scientific capital of the world. The London Finance Commission report argued that for London to achieve these ambitions, it needs greater financial independence. This would help the city to plot its own course and make London's government more accountable to Londoners. Now, in this Infrastructure Plan, we set out what physical changes our rapidly growing city will require over the next half century.

Throughout these documents runs a golden thread: to sustain any Mayor's vision, London government needs more financial powers to invest in London's infrastructure and support its growth. So this plan is not a lobbying, manifesto or detailed planning document. It is our first ever strategic attempt to state exactly what infrastructure London needs, roughly how much it will cost, and how we can do it in the best possible way.

London's needs are stark. In order for Londoners to get the homes, water, energy, schools, transport, digital connectivity and better quality of life they require and expect, our city must have continued investment.

By its very nature, infrastructure underpins everything else. We all use it every day. That is why I am consulting with Londoners, businesses, the boroughs, national government, the wider South East and beyond. We all have a stake in improving London's infrastructure, so I want as many people as possible to tell me their views.

Boris Johnson
Mayor of London

This is a consultation about London's growth and how we can make the city better for everyone. Infrastructure is fundamental to every Londoner, every day, from turning on the taps in the morning to switching off the lights at night. Even though we have shown we can deliver world-class infrastructure, such as for the Olympics or HS1 and with Crossrail well underway, we know we can plan and deliver it better. We are determined to build world-class infrastructure systems to support the homes London needs, bolster our growing economy and improve quality of life for everyone. This consultation is a major milestone for London in reaching agreement about what we need, how much it will cost and how we can fund and deliver it.

Section A of the report describes how London is projected to reach over 11 million inhabitants by mid-century, a 37 per cent increase from 2011. Within months from now the population will surpass its previous peak of 8.6 million (set in 1939); combined with a backlog of investment, an historically low level of capital investment in the UK compared with other countries, rising expectations and challenging climate change obligations, the demand for infrastructure is going to increase significantly as we enter this unprecedented era of growth. Our aim in this project has been to assess the broad magnitude of London's infrastructure needs (in transport, utilities and green infrastructure), its costs and how to pay for it, where it might be needed and how to deliver it better.

Section B anticipates new technologies and innovations that will change both how we will conceive infrastructure in the future and how we will provide it. It describes how the city can better embrace existing leading technology (including building information modelling and using big data to plan and make infrastructure work more efficiently), how it needs to prepare for technological change already underway and be open yet realistic about the potential of future technology to transform the way that infrastructure works. Finally, it proposes ways we will attempt to hardwire innovation into our approach to the city's development.

Section C sets out how London could deliver its infrastructure in a more integrated and efficient way to lead to provision ahead of demand. It proposes an Infrastructure Delivery Board to bring together the various actors in different sectors as a first step in overcoming the otherwise inherently disjointed arrangements in place. It lobbies for statutory recognition of the growth projections contained within the Mayor's own statutory planning document, the London Plan, by all infrastructure providers and their regulators, and calls for reforms to regulatory frameworks, in energy and water in particular.

Section D sets out the infrastructure we believe will meet demand over the short, medium and long term (up to 2050). It demonstrates the following.

Transport. Transport is vital to London's economy; it will help serve a growing population and make London more liveable. Chapter 14 sets out our plans to provide a projected 70 per cent increase in rail and tube capacity serving London's economic heart, serve 1.5 million new homes, improve the capital's international connectivity and dramatically improve transport's contribution to Londoners' quality of life. Among the programmes and projects described in this chapter are a new four-runway hub airport to the east of London; delivery of up to 36 trains per hour on certain tube lines; Crossrail 2 by 2030; extending the Bakerloo line; new East-London river crossings; four-tracking the West Anglia lines; a South London Metro; an inner orbital road tunnel; improvements to double the number of passengers on London's rail network; and 200km of new cycle highways.

Green infrastructure. Chapter 15 sets out how the Mayor will champion a network of green infrastructure to provide flood protection, shade, biodiversity, cleaner air, a greener environment visually, pedestrian and cycling routes and space for recreation. It discusses how the GLA will deliver specific projects, develop the evidence base of the benefits of green infrastructure and service a dedicated 'taskforce' to investigate the future design and management of this infrastructure, including the options for its governance and funding.

Digital connectivity. Our aim is for fast, ubiquitous access to the internet from mobile and fixed devices. Chapter 16 discusses how we will develop a map of London's connectivity, which will be used for connectivity ratings of individual properties and to identify where networks need to be improved. It sets out how we will support an economically viable mix of technologies including fibre broadband, mobile broadband and future methods of wireless internet delivery. It also discusses how we will work with Ofcom to ensure sufficient radio spectrum is identified to address the capacity crunch in the short term as well as aiming to make London the first capital city in the world to deploy 5G in the 2020s.

Energy. To avoid a looming energy crisis and decarbonise our energy supply, we rely on national government to double investment to supply sufficient zero-carbon electricity to the grid, with up to a 20 per cent increase in demand in the capital by 2050. Chapter 17 shows how the GLA will encourage new

suppliers to the market and develop its £300m existing pipeline of local energy projects, including in heat recovery, as well as continuing to retrofit existing property to improve energy efficiency and reduce demand.

Water. To meet a projected gap between water supply and demand (reaching 10 per cent by 2025), Chapter 18 discusses how we will support Thames Water to introduce new technologies to repair leaks, roll out water meters combined with more sophisticated tariffs, implement water efficiency measures and, in the longer term, encourage waste water reuse. We support the Thames Tideway Tunnel but want to see better long-term drainage management across the city, with 25 year plans for drainage and flood risk management as well as water supply.

Waste. By 2050, our aim is that very little waste will require disposal, the economic benefits of which will include savings of up to £5bn, a growing economic sector with new employment opportunities, reduced exposure to volatile global commodity prices and less toxic waste. Chapter 19 discusses how enabling this so-called circular-economy approach will require investment in around 40 new facilities, in addition to London's existing capacity, for the reuse, repair and remanufacture of materials.

Section E discusses where London's growth may be accommodated and what impact spatial decisions, such as how investment in a four-runway hub airport in the east will help shape London and the Thames Estuary, will have on infrastructure in the city. It sets out how the Mayor will encourage development in Opportunity Areas and Intensification Areas, confirming his determination to retain London's current green belt boundaries for the foreseeable future, given the large reservoir of brownfield land within the capital that will accommodate growth at least until 2025. It discusses scenarios that assist in thinking about where, within and beyond the capital further growth could occur, as a precursor to the next full revision of the London Plan after 2016.

Section F summarises the full costs of delivering and maintaining the infrastructure that London needs, based on a bottom-up assessment of all of our stated requirements. These include the costs of enhancements, renewals, operating and maintenance. Our estimate is that the costs of delivering our aspirations in Section D would be nearly twice current expenditure levels by 2025. Compared to current levels of funding, there is likely to be a significant public sector funding gap. This section discusses ways in which this gap may be

eliminated - through better integration, asset management, procurement and more certain forward planning.

Section F also reinforces the call for fiscal devolution set out by the London Finance Commission, in order to incentivise growth, provide a revenue stream to support that growth and enable London government as a whole to manage and integrate infrastructure investments. It sets out other potential funding sources to close any residual gap between demand and current funding levels that may exist even after the above approaches to managing costs are exhausted.

Section G sets out our consultation questions and discusses how practically we will approach the next stage of the work. Our aim is to complete the plan by the Winter of 2014/15. We are very grateful to many people and organisations that have been involved in the development of our work so far. Annex 2 attempts to set out a comprehensive list of those with whom we have already discussed the plan. It has been written by a core team working with colleagues in the Greater London Authority (GLA), Transport for London (TfL), the London Waste and Recycling Board, Arup and in many key stakeholder organisations. The consultation period affords the opportunity to extend our contacts further so that together we can plan to support a successful city – for generations to come.

Supplementary documents on transport, other infrastructure and the costs and funding of all London's infrastructure needs are published alongside this report on our webpage.

Comments and questions on the plan should be addressed in the first instance to the core team:

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In this section of the report we explain why the plan has been commissioned. We focus on the pressure that the rapid population growth that is forecast for London will exert on the capital's infrastructure, and consider why infrastructure is vital to the city's competitiveness. We also discuss other recent policy documents that have informed our work. Finally, we set out the scope of our work and how we have approached it in theoretical and practical terms.

Chapter 1
Introduction

The first of its kind, the Mayor commissioned the London Infrastructure Plan in Summer 2013, to ensure that London has the infrastructure it needs to remain one of the best cities in the world in which to live, work and do business.

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. The aim of this plan is to prepare better for this growth over the long term, to ensure London becomes a better city in which to live, not just a bigger one. This plan examines what needs to happen so we can overcome current problems, and introduces fresh thinking about how to deliver the amounts of infrastructure the city needs over the long term.

A clear economic rationale underpins the need for this Infrastructure Plan. Growth in income per head depends on increased productivity, which itself depends on infrastructure, but such infrastructure can only be delivered, improved and maintained through sustained, targeted and planned investment. Recent rates of infrastructure investment in London do not appear to have been sufficient for the long-term needs of London's economy, particularly when viewed in the international context.

Chapter 2
Growth and infrastructure demand

Our assessment of London's infrastructure requirements has been underpinned by our expectation of growth, in particular population growth. While London has been growing continuously for thirty years, the rate of growth has increased in the last decade. Our central projection is a 37 per cent increase in population from 2011 to 2050, with a resident population of 11.3 million by mid-century. As London will surpass its previous 1939 population peak of 8.6 million at some time in 2015, the city will enter an unprecedented phase of growth.

This growth alone will increase demand, both for existing and for new infrastructure. Combined with a backlog of capital investment, historically low levels of investment compared to other countries, relatively poor perception and performance of our infrastructure in comparison with our international city peer group of world-class cities and continually growing and changing expectations, we believe that infrastructure requirements over the next thirty years will be substantial.

Growth projections

The GLA Intelligence Unit has produced projections for London's population and jobs to 2050. Clearly, a great deal of uncertainty is associated with projections so far in the future and for this reason we look at three different sets: a central projection provides the baseline for our analysis, while high and low projections show alternative possibilities for growth.[1]

Between 2011 and 2050, overall population growth in London is projected at 3.1 million or 37 per cent. This puts London's population at 11.27 million at 2050, with a high estimate of 13.39 million and a low estimate of 9.51 million.

Projections suggest an even split between the populations of Inner and Outer London, with each increasing by 1.5 million people. Under this central scenario, the proportion of the total population resident in Inner London[2] is projected to rise from 40 to 42 per cent.

[1] A separate paper published alongside this report on our webpage sets out the results in more detail and the methodology behind them.

[2] Inner London is defined as the 14 local authorities of Camden, Kensington & Chelsea, Westminster, the City of London, Hackney, Hammersmith & Fulham, Haringey, Islington, Lambeth, Lewisham, Newham, Southwark, Tower Hamlets and Wandsworth. Outer London is defined as the remaining 19 authorities of Barking & Dagenham, Barnet, Bexley, Brent, Bromley, Croydon, Ealing, Enfield, Greenwich, Harrow, Havering, Hillingdon, Hounslow, Kingston upon Thames, Merton, Redbridge, Richmond upon Thames, Sutton and Waltham Forest.

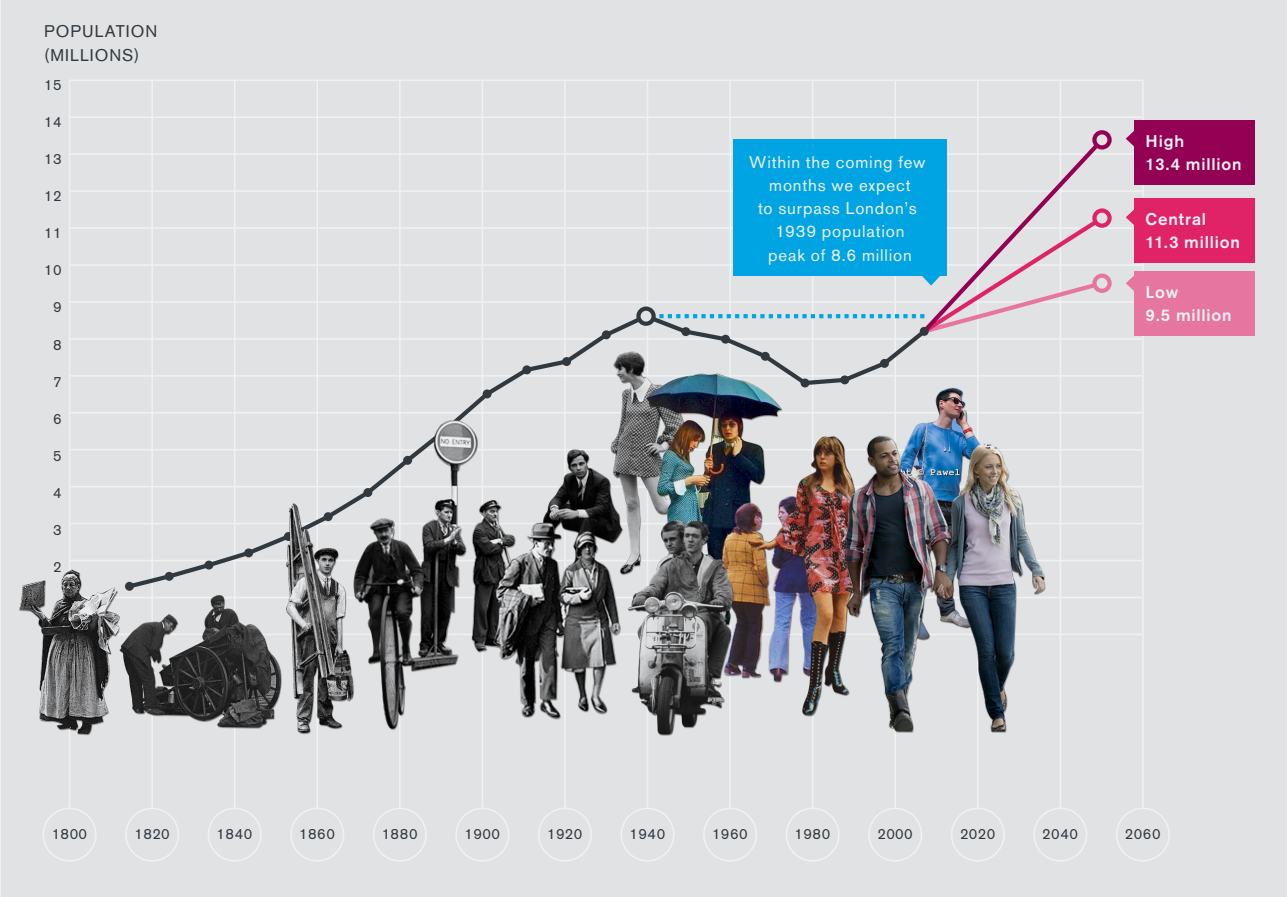

FIGURE 1
LONDON'S HISTORIC AND EXPECTED FUTURE GROWTH
Source: GLA Intelligence Unit

Workforce jobs in London (that is, jobs located in London whether or not they are taken by Londoners) are projected to increase to 6.3 million by 2050, from 4.9 million in 2011. This equates to a per annum growth rate of 0.71 per cent[3].

In 2012, there were 15 million international visitors to London. This number is forecast to increase to around 21 million by 2022.

[3] *If trends continue, the professional, real estate, scientific and technical activities sectors are expected to see the largest increase in employment over this period (nearly doubling to 1.4 million). Two thirds of the total increase in jobs are expected to occur in the Inner-London boroughs.*

Implications for demand

We have developed a core scenario based on the central population projection above and a number of key assumptions within each of the main infrastructure sectors.

The headline impacts on infrastructure demand are set out below.

— Demand for public transport is likely to increase by 50 per cent[4]. Given the limited scope for London's roads to provide additional capacity, demand on the Underground and rail is likely to go up by 60 and 80 per cent respectively.

— The city and the country need new hub capacity in a location that ties in with our wider social and economic objectives including maintaining London's leading position in the global economy. London's hub airport capacity is already at bursting point, with Heathrow routinely operating at 98.5 per cent utilisation.

— Londoners increasingly want ubiquitous and fast digital connectivity.

— The total energy demand is expected to increase moderately (up by 20 per cent by 2050). If we are to meet our climate change targets there will need to be a significant shift away from domestic gas consumption (down by 60-70 per cent) to electricity (up by 140-200 per cent). More local energy production will be needed to provide greater resilience[5].

— From as early as 2016, demand for water is predicted to exceed vital supply. Thames Water projects a 10 per cent deficit in London by 2025 rising to 21 per cent by 2040. A variety of demand and supply-side measures will be required, alongside the greening of the urban environment, as a counter balance to the city's increasing development.

— Green infrastructure needs to be regarded as infrastructure in its own right, assisting with flood protection, water storage and recycling, and providing shade, new pedestrian and cycling routes as well as space for recreation and biodiversity.

[4] Based on TfL analysis of the impact of the central population scenario.

[5] The Mayor's Climate Change and Mitigation Strategy sets out a number of policies and programmes aimed at reducing energy consumption and encouraging local supply of energy within London. The Strategy states that energy supply should be low carbon, in line with the supply contribution to the Mayor's target to reduce CO_2 emissions from all targeted sources by 60 per cent on 1990 levels by 2025 and that 25 per cent of London's energy supply should come from local production.

In addition, we anticipate the following developments.

— There will be a move towards a circular economy where materials are reused or recycled rather than thrown away, which could result in significant environmental and economic benefits. Ensuring the correct incentives and facilities are in place will be essential.

— Provision must be made for an increasing school age population, equivalent to over 600 new schools and colleges.

— We need to build 49,000 new homes a year if we are to meet the growing demand for housing and the existing backlog.

Chapter 3
Infrastructure and competitiveness

London has many competitive strengths, which for businesses include access to qualified staff, access to markets and a competitive business environment – as well as the agglomeration benefits that occur as a result of London's dense clustering of businesses[6]. People are attracted to London by the variety of career opportunities it offers[7], its diversity and openness to different cultures and its leisure and cultural activities.

All these 'higher-level' competitive strengths depend on effective infrastructure. While London regularly tops the rankings of global cities in terms of competiveness (with London and New York generally vying for first and second place[8]), the UK's and London's infrastructure is not best in class, as a number of evidence-based reports testify:

— In the World Economic Forum Global Competitiveness 2013-2014 report[9] the UK was ranked only 28th on perceptions of 'quality of overall infrastructure'.

— Another relatively recent survey[10] found that 'historic levels of underinvestment' have placed UK businesses at a disadvantage. OECD figures indicate that the UK's public investment since the millennium has been consistently below that of the majority of OECD countries'[11]. This finding is based on UK businesses' perception of the UK infrastructure performance.

[6] A concentration of businesses and people increases productivity both by putting upward pressure on the price of land, thus driving businesses to become more productive and people to become more skilled, and also through the agglomeration benefits to which the close proximity of firms gives rise. Valuable agglomeration economies, which help to sustain London's prominent global position, are crucially dependent on effective infrastructure.

[7] Indeed, investment in infrastructure alone provides job, skills and training opportunities for Londoners.

[8] The Economist Intelligence Unit 2013 ranks New York as the most and London as the second most competitive world city; Site Selection magazine and IBM Global Business Services 2013 rank London as the number one city and New York as the second in terms of competitiveness.

[9] The Global Competitiveness Report 2013-14, World Economic Forum 2013. The infrastructure ranking is based on a range of data sources and the WEF's own annual Executive Opinion Survey.

[10] CBI/KPMG infrastructure survey September 2013 (based on a survey of 526 business leaders)

[11] CBI/KPMG infrastructure survey September 2013 - analysis based on OECD statistics

A number of recent studies looking at the UK as a whole conclude that without greater investment in infrastructure economic growth will be hindered:

— The ICE State of the Nation 2014[12] report recognises that more needs to be done to ensure that the UK possesses world-class infrastructure, particularly around energy, flood management and local transport.

— PwC[13] concluded that investment in critical infrastructure will need to increase significantly with spending on transport doubling and power generation nearly tripling up to 2025.

— The City Growth Commission's 'Connected Cities: the link to growth' report concluded that although infrastructure and connectivity are vital for economic growth, the UK has underinvested in infrastructure for decades. The Commission has called for a number of changes at national level to allow better working at the city level, including more flexibilities around funding.

[12] *'State of the Nation: Infrastructure 2014' Institute of Civil Engineers. July 2014*

[13] *'Capital project and infrastructure spending: Outlook to 2025.' June 2014*

Chapter 4
Infrastructure and competitiveness

The London Infrastructure Plan has been commissioned in the wake of a number of recent policy reports, which in different ways make the case for better infrastructure provision in London and reflect the case made above about the importance of infrastructure in London.

— The **Mayor's 2020 Vision** document sets out his ambitions to make London the best place in which to work, live, play, study, invest and do business. World-class infrastructure provision that meets the city's needs forms a critical element of the vision. The Mayor's vision identifies the shortage of housing as the gravest crisis London currently faces. Although housing delivery is increasing, it is still far short of the 49,000 net new homes that are needed every year to house the growing population and meet the backlog of need.

— The **London Housing Strategy** therefore sets out a range of proposals to increase housing delivery across all tenures and improve the housing offer for working Londoners. It includes proposals to provide the long-term stable funding necessary to deliver new homes; to bring land forward for development; and to reinvigorate the housing market by attracting new players (including smaller house builders) to better meet the needs of a growing city.

— The independent **London Finance Commission**[14] argues for the full devolution of property taxes to London government with associated increases in borrowing levels (within prudential rules) to enable London government to increase investment in its own infrastructure, which it identifies as a priority for the future success of the city. The Mayor and the Chair of London Councils endorsed the recommendations of the London Finance Commission and recognised the value in London's metropolitan government playing a more central – and natural - role in planning for its infrastructure provision. It is obvious that as the city grows and develops, the need for more sophisticated governance and planning will grow with it.

[14] *Raising the capital. London Finance Commission, May 2013*

— The **Further Alterations to the London Plan (FALP)** document sets out the scale of the housing challenge to 2036 and recommends planning policies to address it, including identified housing capacity to 2025 and a range of other proposals about infrastructure and the environment, to ensure good-quality, sustainable development. The FALP document makes it clear that the London Plan will have to be reviewed once the effects of the recent recession are better understood and there is greater certainty about London's economic and demographic future. The London Infrastructure Plan will significantly inform this review.

— The **London First Infrastructure Commission**[15] examines the challenges the capital faces because of a growing population and workforce, ageing infrastructure and demanding fiscal context, and looks at solutions to planning, delivery and financing for the future. It specifically calls for stronger city-wide strategic infrastructure planning for London with greater coordination across sectors.

— The **Smart London Plan**, published in December 2013, invites a closer look at how the capital as a whole functions as a result of the interplay between its 'systems' - from local government to education, healthcare, transportation and utilities – and how digital technology can be used to integrate different systems and enable efficiencies for the benefit of London residents and businesses. It also sets out how the Mayor can harness London's expertise in science and technology, its research base and innovative milieu, to take advantage of this market opportunity – through better articulating opportunities to business, attracting investment, demonstrating new approaches to technology, exporting innovations globally and enabling the growth of our already strong tech-firm base.

[15] *World Class Infrastructure for a World City' London First 2010.*

Chapter 5
Approach

We have approached the work in a number of stages.

— We began with a literature review to understand what lessons could be learned from other cities. A number of cities are undertaking long-term infrastructure planning but it seems London is unique in looking across infrastructure types, assessing costs and including plans for funding and financing. It is also the first time London has attempted to develop such an integrated plan.

— We commissioned work from the GLA Intelligence Unit to forecast employment and population growth to 2050 as a prerequisite for assessing London's infrastructure needs. Combining the population data with various long-term policies and making reasonable assumptions and forecasts, we developed a baseline proposition for London's infrastructure requirements.

— Taking this baseline, we assessed the magnitude of costs and the funding options required to deliver these costs. Given the wide range of technical expertise required, we procured the services of Arup to develop a comprehensive cost model. The model can be flexed to reflect different assumptions and choices. It includes the costs of operating and maintenance, renewals and enhancements (i.e. new infrastructure) across the main infrastructure types.

— We then developed an approach to take account of the inevitable impact of new technology and innovation.

— We assessed where future growth is likely to occur by considering scenarios that involve the interaction between land-use planning and transport investment. We have assumed that these decisions will largely determine the location of growth, and in practice we have found that much infrastructure is quite locally oriented or is necessary regardless of the shape of the London's growth (such as upgrading the Tube).

— We considered major alternative scenarios for London's development to 2050, such as the consequences for London's infrastructure needs should Heathrow be relocated to a new site on the eastern side of London, as well the impact of HS2 and other place-changing infrastructure.

— As well as setting out the long-term systems of infrastructure London requires, we continue to identify London's shorter-term needs.

— As far as possible we have attempted to develop the plan in partnership with the London Enterprise Panel (LEP), London Councils and local authorities in the rest of the South East.

— We have consulted widely including with industry, businesses and their representatives, investors and national government. Alongside more informal discussions, we held an event in December 2013 for around 200 stakeholders to consider our early thinking. We tested this thinking further in March 2014 at the London First Infrastructure Summit, which coincided with the publication of our Progress Report. This consultation period allows us to extend our understanding and discuss the plan further with a wider audience.

— Throughout the process we have also been seeking to identify the main ways to improve delivery.

An external group has been meeting periodically since Autumn 2013 to advise on the progress of the work. Chaired by Isabel Dedring, Deputy Mayor for Transport, members include Harvey McGrath, Deputy Chair of the LEP, and representatives from London First, London Councils, TfL, academia, business and Infrastructure UK.

Scope

Our chief aim has been to focus on material matters given the totality of London's infrastructure needs. We have not attempted to identify every single infrastructure item or type. That task will be undertaken through more detailed planning at the city and local levels.

The Infrastructure Plan therefore sets out London's strategic infrastructure requirements to 2050 across the main aspects of infrastructure, as set out below.

— **Transport**
Railways and stations (Underground, Overground, light rail and national rail including high speed), roads (bus, car, cycling, pedestrian, street lighting) and global connections with a new four-runway hub airport.

— **Green Infrastructure**
London's network of parks, green spaces, trees and other features such as green roofs.

— **Energy**
Electricity, gas and renewable, nationally and locally produced.

— **Water**
Water supply, drainage (rain and waste water), wastewater and flood risk management.

— **Resource Management**
Recycling, re-use and disposal facilities.

— **Digital Infrastructure**
Given the rate of change in this category of infrastructure, we have only examined related infrastructure requirements up to 2020. This decision reflects our approach to innovation which, as outlined in Section D, takes the pragmatic approach of making the most of existing technologies and being ready to act as new technologies become available. However, we have taken a longer-term view for assessing the magnitude of costs involved, in particular operating and maintenance.

For the purposes of assessing the total bill London will face, we have included an assessment of the overall need and cost for **housing** and **schools**, which will compete for the limited funds available for investment. We have not looked specifically at delivery of housing and schools but a key driver for this work is the potential for infrastructure, especially transport, to unlock the housing potential across the capital.

We have excluded NHS infrastructure for the reasons set out below.

— There is a great deal of uncertainty about the mix of healthcare infrastructure investment needed in the near future, let alone to 2050.

— Methods of improving London's health and healthcare are under examination by the London Health Commission.

— The NHS is nationally funded and organised and is likely to remain so for the foreseeable future, with a funding settlement that may continue to be ring fenced.

However, throughout the process we have been aware of the potential for the city to enhance or harm the health of its people through its infrastructure, and we have sought to seek out and choose the options that enhance health, particularly for the poorest. This includes encouraging physical activity through the transport system, encouraging mental wellbeing through access to green space, using new technologies to empower Londoners to take control of their health and disease, and reducing the health impact of extreme weather through energy and waste management.

We have also omitted other forms of social infrastructure at this stage, mainly to avoid spending limited GLA resources on spurious levels of accuracy and detail.

The horizon – to 2050 – exceeds the timeframes of existing plans (the FALP, for example, will look to 2036), and may appear deceptively remote. However, given its long-term nature, many infrastructure investments will remain active well beyond 2050, so it is a realistic window for good forward planning. It also affords today's stakeholders sufficient distance to be more objective about the city's long-term investment needs.

In this section of the report we expose the tension that exists between our certainty that technological advances will have profound impacts on infrastructure provision, and our uncertainty about the nature of all of these advances – and discuss how this will affect our approach to forward planning.

Chapter 6
Existing and new technologies

London already relies on infrastructure from previous eras (many of which were revolutionary in their own time), including early bridges over the Thames, Victorian sewers and early twentieth-century Tube lines, which emphasises the strong link between urban economic growth and major technological advances. There is no doubt that innovation and new technology will continue to play a vital enabling role in modernising and transforming London's infrastructure.

Our approach to innovation therefore needs to be cognisant of the importance of innovation in the past and alive to it in the future. As set out in this chapter, it will be a combination of:

— making better use of existing technology and innovative practices now

— adopting new standards coming on stream

— testing radical new alternatives

— hardwiring innovation into our approach.

Making better use of existing technology and innovative practices now

As a first step, we must be certain to make more widespread use of existing advanced technology that has already been tried and tested, for example Building Information Modelling, which is used to enable the virtual design and planning of infrastructure in great detail, and the interrogation of big data generated by infrastructure systems, often assisted by open-data platforms. Only a few years ago, such innovations would have been considered exceptional.

These case studies demonstrate how innovation is already improving infrastructure delivery.

1. Construction companies such as Balfour Beatty are using innovations such as King Sheet Piling retaining wall systems, which use up to 40 per cent less steel than standard cantilever walls. Benefits include:

    - typical savings of 35 to 40 per cent of the steel normally used in a sheet pile wall
    - linear installation speed increased by two to four times
    - substantially simplified installation
    - marked environmental and sustainability benefits.

    It has been successfully used in the widening of the M25, which contributed to the project finishing ahead of time and under budget. It is also being used in the design phase for the Crossrail South-East Spur.

2. Smart meters are empowering consumers to monitor and reduce their energy and water bills. New entrants to the energy market are further developing this technology in ways that allow consumers to reduce their peak load energy usage. Smart-meter infrastructure will evolve beyond just meter reading to support applications for smart homes and buildings.

    For example, TEMPUS Energy is a new energy supply business for London that will work with energy users to optimise their energy use. This optimisation will lead to lower peak demand on London's electricity networks and enable increased utilisation of existing infrastructure, reducing infrastructure costs for new developments and energy bills for Londoners.

3. Low-carbon concrete brings all the benefits of standard concrete (such as fire resistance and noise insulation) and is also more environmentally friendly, stronger and more durable than normal concrete.

    It has already been used throughout the Olympic Park development and in the construction of Crossrail, where all the concrete used is low carbon.

4. We expect technology to open up opportunities for more effective monitoring and management of infrastructure. During the Olympics TfL actively managed all aspects of the road network, using CCTV to monitor activity and so being able to immediately respond to accidents, burst water mains, etc. Alongside travel demand management, this successfully kept the city moving. While it was particularly labour intensive, technology may make it a realistic approach to adopt for everyday traffic management.

Adopting new standards

We must be aware of technological advances that are already well in train, and be ready to adopt them more swiftly. Examples include the following.

- 5G is likely to become the next mobile global standard, allowing everyone to communicate everything they want to.

- The technology for autonomous vehicles already exists. Adopted more widely as standard, car safety would improve dramatically, and in the longer run autonomous vehicles offer the potential for making better use of road space, reducing costs and increasing the efficiency of goods distribution.

Data as a utility

In many ways, data can be considered a new utility that is flowing through the city's 'pipes'. It is fast becoming a key element of planning and operating cities (the 'glue' that integrates transport, energy, health, waste and housing) and it is an intrinsic part of modern living. It is important to recognise the vital enabling role and transformational aspects of data collection, data release and powerful analytics in modernising London's infrastructure and in delivering important upgrades such as smart grid services.

This year the Mayor will be launching the second generation of the London Datastore (LDS II). More than just a catalogue, we want the LDS II to be a place where a range of actors – academics, our mature and active developer community and the private and third sectors – can collaborate around projects that deliver social, economic and environmental benefits. To this end, LDS II will incorporate the ability for individuals, organisations and businesses to request access to data sets that are held across London. City Hall will manage these requests and seek to identify where datasets are held

and whether or not they can be released to a high open data standard. As part of this process we will identify and prioritise which data are needed to address London's growth and infrastructure challenges.

Further, the GLA will be working in partnership with the London boroughs and other members of the GLA Group[16] on a London Open Data Partnership to identify and showcase how open data can be used to solve city challenges that cross administrative boundaries and that will ultimately improve services and make London a better place to live and work.

The GLA will adopt an Open Data Charter and we will extend our ambition to boroughs and other parts of the London public sector so that it can become the London Open Data Charter. Its purpose will be to encourage the release of London's local-level data and to create the necessary standards around its release and use so that we can realise the full potential of our city data.

In pursuit of these aims London will collaborate with bodies such as the Open Data Institute, the Technology Strategy Board, the Connected Digital Economy Catapult and the Future Cities Catapult to lead on the key issues of data privacy, transparency, and sharing of data, to ensure the protection of civil liberties is balanced with commercial interests.

[16] The GLA Group comprises the GLA, TfL, the Mayor's Office for Policing and Crime, the London Fire and Emergency Planning Authority and the London Legacy Development Corporation.

Chapter 7
Open to radical change

We must also be sure to keep an open mind about future technology that could radically alter the world. The World Wide Web was only invented in 1989, and the emergence of something just as revolutionary is possible – yet impossible to foresee.

One example of a radical change that one day may be considered ordinary is the 'solar digital road'. If successful, this technology could do away with the need for solar farms, transform roads into digital as well as physical arteries and replace all manner of other highway accoutrements, including road markings, traffic lights, gritting and snow ploughs.

At this stage, however, it is too early to know how far this kind of idea will go - and we need to remain grounded in reality. While we do not want to be left behind, it is important not to move too quickly and be left with costly mistakes and redundant infrastructure.

It will therefore be necessary to carefully consider the costs, risks and benefits of possible new technologies as and when they become available. An obvious approach is to allow more widespread piloting of new technologies at small cost and scale to test radical new ideas, working with our universities and private sector companies.

In transport, the following new technologies may characterise the future.

- Integrated systems, for example use of bank card for all travel (which is already starting to be rolled out on key services).
- Smart assets such as parking sensor technology, solar highways, kinetic pavements, cooled tubes and communicating vehicles and infrastructure as well as in the installation, maintenance and renewal of the city's utility assets e.g. more subterranean mapping, 'keyhole surgery'.
- New materials, technologies and techniques to enable cheaper, less disruptive construction of bridges, tunnels and other infrastructure.
- Major changes in logistics models, through extensive networks of convenient collection points, 'drone lorries' and 3D printing.
- New longer range narrow-bodied aircraft and sophisticated yield management systems meaning fewer, larger hub airports with wider and longer reach.
- Autonomous connected vehicles.

Chapter 8
Hardwiring innovation

There have been a number of attempts to help systematise the adoption of innovation and new technology in London's development. The best example is probably the Crossrail Innovation Platform, which provides a range of tools and forums deliberately designed to coax and record innovation in construction design, processes, materials manufacturing and we would expect in later years, service delivery.

Crossrail Innovation Portal

Innovation is an integral part of most mega projects - the Queen Elizabeth Olympic Park, the London Olympics 2012, and of course, Crossrail are all obvious examples. Yet because of the informal nature of much innovation, lessons that could be applied to future projects are often lost.

Innovation is crucial to Crossrail because it provides new ways of unlocking cost reductions, helps raise the bar across business processes and improves delivery certainty. As such it is now launching an innovation strategy, which identifies a process for managing innovation in mega projects. A core element of this strategy is the introduction of a new system, the Innovation Portal, which will make it easier to identify, develop and implement ideas.

The Innovation Portal provides an online platform that enables people with an idea (however large, small, simple or radical) to capture and submit it to Crossrail's Innovation Team for consideration. In return Crossrail will provide those with the best ideas access to the social and financial resources required to transform the idea from an initial thought to full-scale implementation, or simply spread the word.

Indeed, innovation is central to London's economy. It is home to world-leading experts in technology, it has more universities in the global top 40 than any other city and 21 per cent of employees in London work in science and technology companies (the employee count has grown by 14 per cent in the last ten years).

Therefore, in order to ensure that lessons are learned from exemplar projects like the Crossrail Innovation Platform and that the knowledge of London's experts is fully exploited, the London Infrastructure Delivery Board (see Section C) will work closely with the Smart London Board and the LEP.

Innovation goes beyond technology and may, for example, help improve procurement methods. The next section sets out how we intend to bring about innovative ways of providing leadership across the city and across infrastructure types.

In this section of the report we analyse systemic barriers to successful infrastructure provision, such as organisational siloes and unhelpful regulations, and propose ways to reconcile the disjointed arrangements in place and to introduce more coordinated and strategic approaches.

Chapter 9
Creating the right conditions for delivery

The UK is home to world-class infrastructure providers, developers, engineers and architects, which are at the forefront of delivering large-scale innovative infrastructure projects both overseas and at home. In London, the Olympic Park was delivered on time and within budget, and Crossrail is well on its way to successful delivery.

Yet, while we know that we can successfully develop and deliver infrastructure, it often takes an incredibly long time - the idea for Crossrail was first put forward in the 1940s, but over sixty years elapsed until construction finally began. Decisions about infrastructure can be plagued by political uncertainty and when projects do get the go ahead, delivery is not always coordinated across sectors. These factors all add to both the time and costs of delivery.

We must therefore bring out the very best in infrastructure delivery to create a more conducive environment where:

- the infrastructure industry has the certainty it needs to make investments
- the regulatory and policy frameworks support development
- the industry is involved in planning for infrastructure from the beginning
- mechanisms are in place to bring infrastructure providers together to integrate plans and jointly develop cost-effective solutions.

This process will take a concerted effort on behalf of the Mayor, the London boroughs, national government, the regulators and industry. Ensuring all parties work together will be vital for the successful delivery of London's infrastructure requirements.

To start the process, the Mayor will:

a) Consult with the borough leaders, the London Assembly and Infrastructure UK on the co-ordination process and future interactions related to the Infrastructure Plan. This exercise will help gain cross-party support and commitment to London's major infrastructure requirements.

b) Convene a London Infrastructure Delivery Board composed of senior representatives from all the main infrastructure deliverers in London. The members of the Board will work to better join up delivery, forge links across sectors and share expertise on best-practice delivery (see Chapter 11).

Chapter 10
Political leadership

We want to make sure that strong political support exists to push projects through from the beginning - we have seen the power that political consensus can have in the 2012 Olympics.

Yet because the infrastructure planning cycle invariably spans elections, infrastructure can fall victim to political attack - and long-term plans are less convincing when they can be easily rejected by political opponents.

If cross-party support across London and at national level were achieved for major projects, the increased certainty it would bring about could have a real impact on costs and delivery time.

As set out above, to gain consensus around the proposals in this report, the Mayor will formally consult with the borough leaders, the London Assembly and Infrastructure UK before the final iteration of this report is published. Existing mechanisms such as the London Congress, which brings together the Mayor and the leaders of London's local authorities, will be used for ongoing decisions regarding London's infrastructure requirements and we will also seek to involve national government and local authorities outside London in decisions of national or regional importance.

Public support is obviously closely linked to political consensus. During the consultation period, we will seek to better understand the factors at play in achieving public support, in particular by looking at projects that have proved popular and those that have not.

Chapter 11
Integrated best-practice delivery

Infrastructure delivery works best when delivery is integrated across sectors and industry is involved from the early stages – it is industry, after all, that possesses the expertise in best practice delivery. We want to benefit from this expertise and to ensure integrated delivery across all sectors.

Integrated delivery has proven economic benefits, as demonstrated by the analysis carried out by Frontier Economics for Infrastructure UK of successfully delivered infrastructure projects. Its findings include the following.

- Opportunities are conservatively assessed over a five-year period to be in the region of £150-450 million from well-targeted interventions to encourage more efficient street works in key cities.

- Potential savings of 16-26 per cent could be achieved where existing infrastructure is used to roll out broadband.

Unfortunately, the current arrangements do not support integrated delivery, and governance is varied between and sometimes within sectors.

- In transport, the Mayor is responsible for TfL, Network Rail has responsibility for national rail while the Department for Transport specifies services. Governance for the road network is shared between TfL and the boroughs.

- Airports policy is a national government responsibility, although some of the surface access is provided by TfL and regulation is managed by the Civil Aviation Authority.

- The energy sector is made up of private companies, regulated by Ofgem.

- Water is supplied by four monopoly suppliers[17], which are regulated by Ofwat.

- Telecoms are provided by private companies, which are regulated by Ofcom. However, within this model, there is an effective monopoly controlled by BT Openreach.

- Private companies collect and dispose waste under contract to local authorities in London.

[17] Thames Water, Affinity Water, Essex and Suffolk Water and Sutton & East Surrey Water, with one sewer undertaker, Thames Water.

- No single body or set of bodies manages London's green space from a network perspective. The boroughs and the Royal Parks manage many public parks and open spaces, and much of London's green infrastructure is managed by a variety of other organisations.

- While the GLA's statutory planning document, the London Plan, sets out growth forecasts for London, many of the bodies above who actually shape and deliver infrastructure do not need to plan on the same basis and are subject to a range of different drivers and planning frameworks.

These arrangements lead to siloed delivery across sectors and are not producing optimal outcomes. For example, and the capacity of green space to reduce flood risk is rarely factored into the planning or design of parks.

London's infrastructure needs to be delivered in a more integrated way – as it was so successfully for the Olympics. While the Games were a special case, they provided us with important lessons to learn about political commitment and effective cross-sector working that can be taken forward on a pan-London basis, optimising the development of new Opportunity Areas.

London Infrastructure Delivery Board

We believe the desire to better coordinate (and so reduce costs and risks) exists in the industry. The technology is also there to identify the potential for joined-up delivery. We therefore want to provide the leadership that is currently lacking to unite London's infrastructure providers.

The Mayor is establishing a London Infrastructure Delivery Board composed of senior representatives from all the main infrastructure providers in London to create links across sectors and to utilise their expertise on best-practice delivery.

The Board will be established in Autumn 2014 and will include important stakeholders (including the regulators, Infrastructure UK, land owners, developers, utility providers, TfL and Network Rail). We envisage that they will meet on a regular basis to drive forward London's development. More detail on the Board's roles and membership can be found in the accompanying paper on infrastructure delivery published on our website.

We view the establishment of the Board as a significant step towards creating a system where infrastructure projects are as a matter of course, designed and delivered as a single project where all aspects are planned from the beginning and interdependencies are identified at the outset. Action beyond London will be needed to make this vision a reality, as well as from Government departments and the regulators, bodies that all too often do not coordinate their actions.

Chapter 12
Strategic planning

To enable even greater levels of joint working and planning, we want to see planning undertaken by bodies such as the regulators and utility companies to be more joined up with London's infrastructure planning.

Such coordination can be achieved through greater consultation on both sides. We propose that the utility companies and the regulators should be involved in formulating the London Plan and in return expect these bodies to consult the Mayor on their plans. The Delivery Board will facilitate this process.

We are also considering the need for a formal arrangement whereby the Mayor has a statutory duty to consult the utility companies and regulators and the utility companies and regulators also have a statutory duty to consult the Mayor.

With such duties in place we would expect utility companies and regulators to then have due regard to the growth projections and infrastructure commitments in the London Plan.

Additionally, there is scope for national and London planning to be better aligned, with the London Plan and the National Infrastructure Plan having due regard to each other.

Chapter 13
Regulatory changes

Much of our infrastructure provision - water, energy, telecoms and broadband - is in the hands of the regulated utilities.

The regulatory frameworks determine how companies in these sectors invest in infrastructure and deliver services to consumers. The regulators' main interest is in protecting consumer interests, in particular against unnecessary price rises, and given that the UK enjoys some of the lowest prices in Europe, their work has been successful and we would not argue

with the underlying principles they have adopted. However, as with any market intervention, there have been unintended consequences.

- There are few incentives for utility companies to help consumers reduce their demand for scarce resources.
- There are only limited incentives to reduce the disruption caused by works at busy times.
- Large investments with a guaranteed rate of return can be favoured over cost-saving measures.
- While greater use of broadband is to be encouraged, there is no universal service requirement or incentive to roll out fibre to some parts of London that are currently unserved.

In addition, the regulatory structures treat all parts of the country in the same way with no differentiation made between small towns and rural areas and the UK's largest and growing cities.

The difficulties this situation raises for London are covered in Section D and include:

- a lack of possibilities for investment ahead of need in electricity infrastructure, which delays developments and increases associated costs
- the water companies having greater incentives to invest in significant new resources (e.g. a new reservoir) rather than in maintaining existing infrastructure (such as ageing pipes)
- parts of London with poor broadband connections – or none at all.

To overcome these matters the Mayor will continue to work with national government, the regulators and the utility companies to ensure that where necessary there is scope within the regulatory system to treat London and other growth areas of the UK differently to the rest of the country.

Separate regulators for each sector bring expertise and focus but without greater joint working, they also create an uncoordinated environment and make joined-up infrastructure delivery all the more difficult. The Mayor calls on the regulators to join up their planning and procedures. The UK Regulators Network, established earlier this year to bring the regulators together to ensure effective cooperation, is a significant

step forward and we welcome the inclusion of cross-sector infrastructure considerations in its work programme for 2014/15.

These matters are explored in more detail in this report and accompanying documents, but in summary regulatory change across sectors will enable:

- greater flexibilities – so different parts of the country can be treated differently to reflect local circumstances
- introduction of incentives to cut costs and reduce demand
- joined-up planning.

In this section of the report we set out in broad terms the infrastructure that will be required to meet demand in the capital over the short, medium and long-term up to 2050, and what the Mayor will do in partnership with other stakeholders in the more immediate future, as a first step to meeting projected demand.

Chapter 14
Transport – a better-connected city

Transport is fundamental to cities and for centuries it has played a huge role in shaping London. From the construction of London Bridge, which established our city in ancient times, to the development of Crossrail today, London's growth has been predicated on and in turn, shaped by its transport infrastructure.

London has one of the best transport systems in the world, boasting aviation connections with global reach and a vast network of railways, Tube lines, highways, local roads, bus routes, pedestrian and cycle links, trams and light railways. Mostly these work well, and significant investment has been made in recent years. However, every Londoner and London business has experienced the frustration and economic costs when they do not - and there is certainly room for improvement, including through increased reliability and reduced crowding. London's growth also poses additional challenges; extensions will be needed to reach new or expanding neighbourhoods, and improved accessibility will be required to cater for more people, old and young.

For this plan, we have set three overarching objectives for long-term strategic transport investments for the capital, to:

- support London and the UK's economy
- serve a growing population
- make London more liveable.

Supporting the London and UK economy

Over a third of the jobs in London - and the majority of the most productive ones that help drive employment in the rest of the economy - are located in its relatively small centre (the Central Activities Zone, CAZ, which makes up just 2 per cent of Greater London's area). Around 1.17 million people travel into this zone each working day, swelling its daytime population by over 500 per cent.

A critical assumption of this plan is that the importance of this central agglomeration of jobs is likely to continue, despite the growth in mobile and remote working enabled by technology. Indeed, the physical clustering of jobs appears to be as important to the economy as ever before – as it is in other knowledge-rich economies such as Silicon Valley in California. Thus sustaining the growth of the centre - and good access to it - remains a strategic economic priority for London's foreseeable future. This can occur through densification of business districts in the CAZ, through developing new areas on the fringes of the CAZ (such as King's Cross and Vauxhall Nine Elms Battersea), and also through the development of a few very well connected locations beyond the fringes of the CAZ, including Canary Wharf, Stratford and potentially Old Oak Common.

In all these cases investment in high-capacity radial public transport will be vital and, given delivery timescales, we need to plan now for future investments to keep up with the growth projected to 2050.

Rail freight also plays an important role in London's economy bringing products to London such as aggregates and removing waste such as Crossrail spoil.

- **Making the most of our existing Tube network** to deliver the best possible service. This can be done by increasing train frequencies from a current maximum of 34 to up to 36 trains per hour across the Jubilee, Piccadilly and Northern Lines by 2035. These changes will increase the peak capacity of these lines by 20-50 per cent, and brand new, air-conditioned, walk-through trains will also add capacity and improve passenger comfort.

- **Extending the Bakerloo Line** south from Elephant and Castle through Southwark, into Lewisham and beyond, which will transform the connectivity of this area of South London.

- **Further Crossrail projects** – starting with Crossrail 2 by 2030 and increasing the frequency of Crossrail 1 trains. This investment would add 10 per cent to overall rail network capacity and introduce Tube-style frequencies to many parts of Outer London.

- **Transforming the national rail network within London** to provide equivalent capacity to a second Underground network, as well as continuing to enable longer distances and other services. Working in cooperation with Network Rail, and providing more trains per hour and more carriages, this will open up the potential to carry twice the number of

passengers than at present, reduce crowding and improve the customer experience. It will also complement the role of the national rail network in providing business and leisure links with other cities and facilitate freight movements - all of which is beneficial to London. Network Rail plays an essential role in developing, planning and operating the national rail network to make best use of its overall capacity for these different activities.

- **Modernising key central London stations** with new ticket halls, escalators, lifts and interchanges to enhance capacity and create a catalyst for the growth and development of the surrounding area, including Holborn, Victoria, Waterloo and Euston.

- **Supporting the expansion of London's core beyond its traditional borders** – including Old Oak Common where we have the opportunity to create a new mini-city and a second Canary Wharf. Around 90,000 jobs and 20,000 new homes are possible, catalysed through HS2, Crossrail and Overground connections.

- **A 24-hour transport system** – from 2015, certain sections of the Tube will run all night at weekends, complementing the existing 24-hour night bus network. This will be accompanied by night-time running of the rail network and out-of-hours freight deliveries and servicing to ensure we have a transport system to support a 24/7 city.

- **Faster and higher capacity links to an expanding labour market beyond** London and its traditional commuter belt, for example to Northampton, Hastings, Ebbsfleet and Peterborough through upgraded links to HS1, which would capitalise on capacity released by HS2 and enhancements to the national rail network.

The road network caters for 80 per cent of people's journeys and 90 per cent of freight journeys; it is vital for the continued economic success and functioning of the city. The investment programme set out by the Roads Task Force would deliver a step change in this network, rendering it fit for the future, with more extensive tunnelling and world-leading traffic management ensuring efficient journeys for essential users. An increasing proportion of other journeys would be made by sustainable modes of transport, with the streets above ground in many areas transformed for walking, cycling and public transport.

Delivering such a network would include the following interventions.

- **A congestion-busting programme**, with world-leading signal technology, predictive traffic management and the redesign of London's major junctions and pinchpoints.

- **An enhanced bus network**, including increased priority, new links to growth areas, and expanded capacity to serve the growing population.

- **A series of new river crossings in East London** beyond the proposed Silvertown tunnel to overcome the major barrier effect which constrains travel between Thamesmead, Belvedere, Barking Riverside and Rainham.

- **A new inner orbital tolled road tunnel** that could reduce congestion by 20 per cent in central London and help ensure a world-class environment in the city centre and around the Inner Ring Road, alongside a series of mini-tunnels and/or decking over of roads to overcome severance and transform places across the city.

London's economy is highly internationally orientated and hosts a set of high-value 'world-city' functions that depend on first-class aviation connections with global reach. Heathrow can no longer meet these needs, which is why the Mayor has argued consistently for a new four-runway airport to the east of London.

With the freedom to operate at any hour without disturbing local residents, a new hub airport will provide critical support to London's economy, as well as facilitating growth in services to new and emerging economies in countries and regions such as China and South America. It would also provide the international freight connectivity to support the UK's advanced manufacturing economy and grant UK businesses access to vital global supply chains.

Properly integrated with new rail freight capacity to the rest of the country, a new hub airport has the potential to drive high-tech and advanced manufacturing industry sectors not just in the South East but throughout the country.

The following schemes will support improved connections with the rest of the world.

- **A new world class four-runway hub airport** to open by 2029 and make London and the UK the best-connected city and country in the world.

- **A new/improved network of direct rail connections to support access to airports including:**

  - **a high speed rail link** serving a new Thames Estuary airport to multiple destinations in Central London and beyond, a Crossrail extension from Abbey Wood through Ebbsfleet to the airport and strategic road improvements to serve the new airport

  - **improved connectivity and integration with existing airports**, including four-tracking of the West Anglia Main Line to improve access to Stansted.

- **An extended network of direct rail connections to mainland Europe** for passengers and freight, including a fit-for-purpose link between HS1 and HS2 along with provision of additional cross-Channel rail crossings.

Serving a growing population

As London's population grows, so too does the need to deliver housing across the city and beyond its borders. Transport is a vital enabling ingredient, helping to ensure that new housing is viable, sustainable and successful.

Some areas of the capital are already rapidly evolving into new city quarters and with additional investment, many more could support major housing development. It is imperative that we maximise the potential of these reservoirs of land within the city – and under the Mayor's current powers, we are able to plan transport and housing together. To this end we propose a comprehensive package of transport investment to integrate these existing growth areas into the wider transport networks, alongside a broader programme of local place-making, which will help to support an extra 350,000 homes. We also need to look at emerging opportunities associated with new infrastructure, for example along the route of Crossrail 2. Examples include the following.

- **Extensions to the existing network to connect to areas with major development potential.** A Bakerloo Line extension could regenerate areas such as Old Kent Road and Catford, as well as supporting development in Outer London locations. The extension of the Gospel Oak to Barking line to Barking Riverside would open up development of a major new quarter with 11,500 new homes. A further

extension across the river to Thamesmead and Abbey Wood would open up major regeneration and housing development potential in South East London.

- **Network improvements to cater for increased demand and address the cumulative impacts of developments**, for example four-tracking the West Anglia lines through the Upper Lee Valley, tripling services on this corridor, and a programme of road corridor and junction improvements (for example, the A13, North Circular, A40, A23).

- **New and improved stations to act as focal points for development**, whether on existing routes such as at Cricklewood to serve a Brent Cross, Beam Park in East London or on new routes such as Angel Road on Crossrail 2 to serve the Upper Lea Valley .

The comprehensive package of road and rail links that would accompany a new hub airport also has an important part to play. As a major infrastructure intervention, the airport is without parallel; the facility itself will create a significant economic pole on the eastern side of the city that will generate large amounts of sustainable employment, while the new transport connections that accompany it will make those employment opportunities accessible throughout the growth areas of East London and the Thames Gateway. This development would create the potential for a rebalancing of London's economic shape and could play a key role in supporting the success of identified development opportunities such as in Barking and Ebbsfleet.

While radial capacity and links are vital, not all Londoners work in the centre and the realities of travel in the capital are complex and diverse. Transport infrastructure needs to support the growth and densification of London's multiplicity of existing neighbourhoods and help Londoners access jobs and services right across the city. We have identified a broad programme of improvements that, together, would underpin the delivery of over a million more homes, thriving town centres and sustainable, successful communities. As such, we propose the following interventions.

- **Further devolution of suburban rail routes into London** to enable the Mayor to improve services and fully integrate journey planning and ticketing systems that serve the majority of the travelling population, following the success of partial rail devolution, which has already helped triple the ridership of the London Overground. Close working with Network Rail will be essential to ensure that network benefits and efficiency are maintained for the benefit of all rail services and users.

- **A South London Metro** to ensure that no area of London is without fast, frequent and high quality metro-style services. By 2030, around three quarters of rail stations in the capital should offer a service running at least every ten minutes during peak hours.

- **Enhancements in public transport accessibility and the embedding of more sustainable travel options** to support the densification of existing suburbs. The kind of enhancements required would include further bus priority and capacity, a major expansion of cycling and walking infrastructure and capacity enhancements to existing rail services such as an upgrade of the Overground to six cars, as well as new high-capacity connections including tram and light rail extensions and additional orbital rail connections in outer London where these are feasible.

- **A programme of targeted investments to help town centres adapt** to their changing role as locations for city living, including improved stations, gyratory removal, over a hundred new or improved public spaces in town centres and high streets, enhanced bus services, transformed walking environments and 'mini-Holland' cycling areas rolled out to cover at least half of London's main centres.

A more liveable city

We need to ensure that London becomes not only a bigger city but a better city, offering a high quality of life to its residents and a high-quality experience to its visitors. London's population is becoming increasingly diverse and the expectations for its transport system are growing. The competitiveness of cities like London is also increasingly linked to the quality of the lifestyle choices on offer and even the urban fabric itself. With roads making up 80 per cent of public space there is huge potential for transformation.

One of the most recent and pronounced trends has been the growth in cycling and walking - a return to more 'human-centred' modes of travel - providing smart but low-tech solutions to some of the challenges we face. Meanwhile, new technology is already helping provide a more cost-effective customised service and more stations are accessible than ever before. We should therefore now be in a position to set a more ambitious vision for the future of London's transport networks, and we propose the following.

- **Enhanced accessibility programmes** to meet the needs of older and younger people, with two thirds of public transport journeys to be step free by 2050.

- **A comprehensive network of cycle routes** for all types of journey and cyclist, including 200 kilometres of new Dutch-style cycle highways, at least five new major pedestrian, cycle or green bridges and inter-regional cycle corridors connecting London to towns outside such as Cambridge.

- **Pollution-free transport system** - an Ultra-Low Emission Zone established by 2020 should alone reduce air pollutant emissions in central London by half, while strengthening the existing London Low Emission Zone will deliver further benefits across the capital. We will complement these regulatory incentives by supporting the uptake of ultra-low emission vehicles, based on electricity, hydrogen and other technologies and greening the Tube.

- **A series of iconic place-changing schemes**, such as the Garden Bridge in the shorter term, key locations on the Inner Ring Road including Vauxhall Cross, Old Street, Euston Road / King's Cross) in the medium term and the Westway in the longer term.

- **'Minimal impact freight'**, including out of hours, consolidation, last mile bike freight and zero-emission vehicles as the norm.

- At least **an 80 per cent reduction in fatal and serious accidents** on London's road network by 2040, moving towards the elimination of all such accidents.

These developments are all part of a trend towards the development of a more liveable and greener urban environment that is affecting the delivery of infrastructure more generally, as discussed in the next section.

Chapter 15
A strategic network of green infrastructure

London is widely regarded as a green city. Its parks, gardens and canopy of trees provide a vital recreation and amenity resource, which are known to provide health and well-being benefits and also make London an attractive place in which to live, work and invest. This situation is a consequence of a land-use planning framework that has sought to protect London's

diversity of green spaces over many decades, an objective reaffirmed in the current London Plan.

It is important Londoners have access to high-quality green spaces even as the city increases in density in the future. Simply to keep pace with the projected population increase, we will need to create the equivalent of an additional 9000 ha of accessible green space to meet existing standards.

Although the existing parks and green-space network has functioned well for the purposes of amenity and recreation, in future it should be better planned, designed and managed to deliver a range of additional benefits, including mitigating flooding, improving air quality, cooling the urban environment and enhancing biodiversity and ecological resilience.

Conceived and delivered as a more integrated green infrastructure, it should be regarded as vital to the capital's economy, affording benefits that cannot be provided by other infrastructure and services that can be delivered more efficiently and more sustainably. The concept of a green infrastructure has been set out in the current London Plan and the policy framework provided by the All London Green Grid.

The Government-appointed Natural Capital Committee is developing metrics to measure the services provided by the natural environment and is identifying the long-term plans needed to ensure its effective and efficient management. These findings will be important as we develop London's approach to green infrastructure.

Evidencing the benefits of green infrastructure

Many cities around the world are beginning to make significant investments in new green infrastructure (rather than simply relying on the benefits provided by default by existing parks and green spaces) because of the proven benefits and growing evidence base that green infrastructure can:

- reduce costs for local authorities by minimising the management of negative externalities (such as storm water and air pollution).

- diversify funding opportunities for the provision of public goods (for example, health and wellbeing and ecological resilience), including investment from the private sector.

A growing evidence base on the benefits of green infrastructure

- The new neighbourhoods[18] being created in and around the Olympic Park are demonstrating how good planning and design of urban regeneration can ensure the services and benefits of green infrastructure are realised. The design and construction of the parklands sought to install sustainable drainage, encourage active lifestyles, enhance ecology and blur the distinction between parkland and urban form, and these objectives are now being transposed into the development of new housing and social infrastructure.

- The city of Chicago has estimated that investment in 'greening' only a small percentage of the city's rooftops has significantly reduced air pollution. Converting 10 per cent of Chicago's rooftops removed 17,400 mg of nitrogen dioxide each year, and Chicago estimates that this investment could result in avoided public health costs of approximately 17m to £65m annually.[19]

- In 2011 the city of Philadelphia created the Green City, Clean Waters programme, a 25-year plan of approximately £1.47bn to protect and enhance the city's watersheds by managing stormwater with innovative green infrastructure. The city estimates that the use of green infrastructure in lieu of traditional approaches will save around £4.7bn over the life of the programme. This bold initiative is a paradigm shift in approach that treats urban water resources as a key pathway to a sustainable future for the city.

- Copenhagen has recently published a Cloudburst Management Plan[20] which aims to significantly reduce serious surface water flooding resulting from extreme rainfall events through green infrastructure interventions (alongside other measures). Implementation costs are likely to reach around £410m – far cheaper than the cost to the city of around £600m incurred as a result of just one extreme downpour event in 2011.

[18] *http://queenelizabetholympicpark.co.uk/the-park/homes-and-living*

[19] *Clark. C et al., Green Roof Valuation: A Probabilistic Economic Analysis of Environmental Benefits, January 2012.*

[20] *http://en.klimatilpasning.dk/media/665626/cph_-_cloudburst_management_plan.pdf*

Learning from these examples, we will aim to accelerate the implementation of green infrastructure in London, especially in those parts of the city subject to the most rapid regeneration and change. To this end, the Mayor will ensure that:

- development projects led by the GLA or TfL will embed the concept of green infrastructure at project inception

- new standards are developed that will ensure that, in those parts of the city that are subject to increased densification, there will be a minimum 10 per cent increase in the amount of green cover.

We recognise that further evidence is required to demonstrate the amount and type of green infrastructure we will need to deliver some of our key outcomes. Consequently, in order to optimise the capability of green infrastructure to mitigate the impacts of surface-water flooding and the urban heat island effect, we will quantify the green infrastructure required to increase London's resilience to extreme weather events by:

- modelling and mapping the potential for retrofitting sustainable drainage across London, including green roofs, modified green spaces and increased tree canopy cover

- modelling the likely impact of increased development on the urban heat island effect and identifying the green infrastructure interventions required to avoid increased ambient temperatures.

Securing the benefits of green infrastructure

Establishing integrated green infrastructure that delivers a wide range of benefits by design, rather than a limited set of benefits by default, requires a paradigm shift in the way we plan, design and integrate the management of the existing resources and new components.

As such, a number of key challenges must be addressed in the medium and long term, as follows.

- The existing resource is underutilised and underfunded because it is not properly understood in terms of the functions and benefits it already provides and the additional services it could provide.

- It needs to be upgraded and repurposed to improve its performance in the delivery of these additional services.

- New ways are needed to fund future investment and management. There is no statutory duty or effective market mechanism to provide for the maintenance of existing parks and green spaces, let alone a green infrastructure.

- New institutional and governance arrangements are needed to instigate a shift from an approach based on the provision of amenity and recreation to one which can help deliver the full range of green infrastructure benefits and services.

In order to address these more fundamental barriers, the Mayor is establishing a Green Infrastructure Task Force to advise on the future design and management of London's green infrastructure and the options for governance and funding. It will report in 2015.[21]

Chapter 16
Digital connectivity

Broadband is now considered the fourth utility. Internet access not only affects the productivity of businesses and proves essential to the future growth of many firms, it is also vital for many residents to take part in modern society (as more services move online), and now serves as a major factor influencing homebuyers[22].

As such, the Mayor wants to see greater action taken to raise the UK and London's connectivity to world-class levels. Meanwhile he will work with:

- the telecoms industry to develop property connectivity ratings

- central government and London's local authorities to ensure that strategic communication networks are enabled rather than inhibited by the planning and other regulatory systems (whilst ensuring the utility works themselves are properly managed).

[21] Made up of experts and individuals representing user interests, the Task Force will be established in Autumn 2014 and will meet regularly in 2015 to consider the key issues and challenges facing London's green infrastructure in the medium and long term. It will be supported by the GLA and will commission research and analysis as necessary. By the end of 2015 it will report on its findings, including recommendations for the governance and funding arrangements required for planning, co-ordinating and investing in green infrastructure programmes and strategic projects.

[22] Fast broadband now considered vital by increasing numbers of homebuyers, The Observer, Sunday 2 March 2014 http://www.theguardian.com/technology/2014/mar/02/fast-broadband-vital-to-homebuyers?CMP=twt_gu

Fast, ubiquitous, affordable connectivity

London has a number of areas that have no or poor internet connectivity, many of which, left to market forces, may well remain unconnected. We need to think differently about providing high-speed[23] access to the internet via a combination of technologies.

This chapter discusses 'connectivity' rather than 'broadband' (which refers to a limited range of technologies) as we recognise that fibre broadband is not the only solution to providing internet access.

We need to strategically assess the needs of areas without fibre broadband and look at the many ways these needs can be met. Such an approach could turn areas of market failure in fibre broadband provision into areas of market opportunities for alternative providers, partnerships and alternative technologies. In addition, we need to challenge developers and investors for new kinds of provision where fibre broadband does not meet long-term needs.

The future may hold technologies that can deliver levels of connectivity that cannot be envisioned today (see Section B). We must act with the technologies we have available and ensure that a flexible framework is in place to allow for the speedy adoption of new communication technologies. This balance between immediacy and long-term planning underpins the proposals in this section.

A recurring theme in this report, it will be vital to ensure that a coordinated approach is adopted across London so that every Londoner and London business can access the connectivity they need. To this end, the Mayor will establish a Connectivity Advisory Group, comprising the GLA, the London Boroughs, representatives of business and residents, internet providers and other relevant stakeholders.

[23] *We deliberately use, and avoid defining, the term 'high speed' in this document given the rapid evolution of technologies and expectations in this arena. As a minimum, though, we would expect 30 megabits per second (mb/s) at all times.*

The Connectivity Advisory Group will work in conjunction with the London Infrastructure Delivery Board, with the following objectives:

- to take forward a city-wide mapping exercise (including underground) to ascertain existing levels of high speed connectivity accessibility, and the barriers to provision in 'not-spots', and identify the strategic priorities in areas to access whether the levels of connectivity required now and in the future will be met
- to consider ways to monitor levels and available methods of connectivity on an ongoing basis
- to develop a profile of business and consumer communities and their potential communication infrastructure needs, consider ways to aggregate demand and explore ways to encourage the take up high-speed internet access
- to advise on and assist with the delivery of the Mayor's Digital Inclusion Plan, due to be published in Autumn 2014
- to develop a strategy for better utilising existing infrastructure to deliver improved availability and connection speeds[24]
- to devise a process for the GLA and local authorities to build in connectivity requirements when developing strategic priorities for an area, considering a range of solutions, technologies and potential providers and partnerships to meet those needs.

[24] Transport for London has an extensive range of assets which it uses to support physical connectivity in London. The Connectivity Advisory Group will work with TfL to look at how these assets may be used to support connectivity. The group will also support local authorities in utilising their networks, building on projects such as using CCTV networks to improve fibre broadband provision, as the London Borough of Hammersmith and Fulham has done.

Connectivity ratings

The city-wide mapping exercise will be used to develop a connectivity ratings map, introducing an accurate and responsive rating system for individual properties both to assist consumers and providers and to encourage developers and property owners to improve the connectivity of their properties.

The ratings approach may be developed along similar lines to Right Move's 'Check Broadband Speed' which is now included in its property listings, or to Energy Performance Certificates.[25]

We will also work with estate agents and surveyors to develop ways of assessing properties for their connectivity and to ensure that such assessments become part and parcel of building surveys in future, given their importance to consumers and businesses.

Supportive regulatory environment

While London's communications requirements have evolved rapidly, the planning system that regulates infrastructure has not kept up and regulations intended to improve city government sometimes erect unintended barriers to provision.

A clear opportunity exists for the Advisory Group and the Mayor, who has overall strategic responsibility for planning in London and a track record of effective partnership working, to improve conditions for the roll out of faster broadband across the city – through the following measures:

- using powers set out in the London Plan to facilitate the development of a London-wide connectivity network, including an economically viable mix of fibre broadband, mobile broadband and future methods of wireless internet delivery
- investigating the use of more effective methods of installing connectivity infrastructure, such as microtrenching for cables, and the methods required for new technologies
- opening up access points across (for example bus stops, street lights and other street furniture) across the city in order to develop city wide coverage, and working with property owners to provide them with opportunities to easily partner with communications providers to improve coverage

[25] *Properties would be rated based on the levels of connectivity available, where A would denote a high level of connectivity and G would denote a low level. It could be produced using standard measuring methods so properties could be easily compared, and could include recommendations to improve the connectivity rating of a building. Depending on the quality of the information developed in preparing the map, it would be relatively cheap to implement.*

- lobbying to bring planning applications for communications infrastructure within the Mayor's strategic responsibility, with the ability to take them over for his own determination as a means of last resort

- working with Ofcom to ensure sufficient radio spectrum is identified to address the capacity crunch in short term, as well as helping London become potentially the first capital city in the world to deploy 5G (by 2020)

- ensuring the London Permit Scheme can fulfil its worthy objectives of allowing local authorities to reduce congestion by controlling when and how utility companies can carry out works, without placing unnecessary burdens on broadband providers

The Mayor will also work to ensure high-quality communication networks are installed in new developments, particularly in Opportunity Areas, following the example of the Queen Elizabeth Olympic Park[26].

Innovative solutions on new developments

The Opportunity Areas represent the ideal occasion to build in high-quality communication networks to provide high-speed internet access.

The London Infrastructure Delivery Board will investigate opportunities for partnership in meeting the strategic communications needs of opportunity areas, and involve communication providers, developers and others in the early planning and delivery of the Opportunity Areas. They will be well placed to ensure high-speed connectivity capability is designed into new builds and refurbishment schemes.

[26] *Forward planning and stakeholder engagement for the Queen Elizabeth Olympic Park ensured successful delivery in the first instance, and the London Legacy Development Corporation has developed a long-term plan that ensures high-speed provision across the Queen Elizabeth Olympic Park, and provides a path for the assets to be subsequently sold to and managed by the private market in the most cost-effective way.*

Chapter 17
Secure, affordable and sustainable energy supply

While at present Londoners enjoy an uninterrupted supply of energy over 99.99 per cent of the time, London may be facing an energy crisis in the very near future, as demand begins to outstrip supply[27], which is largely a legacy of under investment in national energy supply to the grid.

However, within London there is also the problem of increasing development putting more pressure on an already stressed distribution network (40 per cent of London's substations are already under stress). The pressure that London's networks are under can be witnessed in blackouts in the West End; the Vauxhall-Nine Elms–Battersea development is at severe risk of delay because of the lack of available electricity infrastructure to carry the power that it requires; and the potential for spiralling energy costs poses a risk to London's future competitiveness and reputation.

In order to ensure that capacity is available to meet the needs of a sustainably growing city and to allow connections for major redevelopments, it is essential that an effective energy strategy is in place to ensure the effective balancing of three interconnected objectives:

- security and reliability of supply
- affordability and cost-competitiveness of energy
- 80 per cent reduction of CO_2 emissions by 2050 in line with Mayoral and national government policy.

It is clear that we will rely on a mix of nationally and locally produced energy, which together demonstrate promising potential to meet London's energy needs. A diversity of national sources of energy supply will improve security, affordability and sustainability of our energy supply; and the efficient production of locally produced energy incorporating a diverse range of energy sources, from gas through to large scale heat pumps utilising waste heat will also have a significant role to play in reducing our carbon output and making London's energy more secure and resilient.

[27] *The UK is within just two years of an energy-capacity headroom (i.e. the difference between demand and supply at peak times) of just 2 per cent.*

Electricity investments ahead of demand

Significant new investment is urgently needed in substations and wires to keep up with demand and to accommodate the step change in the rate of house building required in London.

The investment required to meet new demand in the short term is estimated to be around £210m over eight to nine substations. Substation renewal is also necessary, as one in five substations only have 7 per cent spare capacity. In the more constrained boroughs, such as Westminster, almost no spare capacity exists.

The regulatory regime rightly protects consumers from unnecessary investments that have an impact on their bills, but in many other ways the system is in need of improvement, for example to avoid unnecessary delays and costs for developers[28]. The current system is estimated to be blocking over £200m in electricity infrastructure investment that could unlock new development areas.

In order to ensure that the regulatory framework works better for London, we are working with No.10 and other Government departments, developers, Ofgem, UK Power Networks and other major cities in the UK to find a solution to the regulatory system that allows investment ahead of need, but in a way that does not have a material impact on business or consumer bills. The solution will be based on the following principles.

- More investment ahead of need could be permitted if the developers that stand to benefit from forward investment bear the risks of new infrastructure being left substantially unused and stranded.

- In the event that the predicted rate of use of the additional new infrastructure installed turns out to be overly optimistic, developers bear the excess cost. If the cost to developers is excessive, then consideration will be given to involving the interested local authorities in contributing to the balance of unrecovered cost.

We believe that regulatory change is a critical component to maintaining London's energy supply, housing its growing population and supporting economic growth. We will be working with UK Power Networks, developers, the London boroughs, Ofgem and the Government to ensure a solution is agreed and enacted. Future iterations of the London Infrastructure Plan will assess the extent to which the new arrangements are working.

[28] *Currently, when new unplanned-for connection requests are made by a number of parties in an area of insufficient capacity and/or where new capacity is not in the business plan, the full costs are recovered from the party that makes the request for the connection, often the developer responsible for regeneration of a site or a new development. This arrangement is leading to unacceptable delays, adding to developers' cash and opportunity costs and causing great uncertainty. It is also out of step with the rates of demand growth and network stress in key areas of London.*

Energy produced in London for a resilient low-carbon energy source

We use more energy in heating our buildings than we do for transport or electricity generation. Faced with Mayoral and national polices for an 80 per cent reduction in CO_2 emissions by 2050, building heating will have to become electrified (using new nuclear and wind sources and carbon capture and storage) - at significant investment cost. Local energy production will help to reduce the national investment requirement and keep energy costs down for consumers.

Many types of energy production have the potential to be used in London including solar, wind, combined heat and power and ground source, along with the application of heat networks. We are committed to ensuring that energy is produced locally within London to develop a more sustainable, secure, cost-effective energy supply in the capital.

Indeed, the Mayor has set a challenging target to supply a quarter of London's energy from locally produced sources by 2025; in order to meet this objective, significant changes to incentives, policies and funding will be required. While investment is available for large-scale local energy projects, there are a number of challenges to realising them, including a lack of development capacity, knowledge and coordination across the range of stakeholders involved in planning local energy projects and mitigating the significant commercial risk.

To enable the development an effective market in locally produced energy, the GLA will continue to develop the pipeline of projects it already supports through its decentralised energy programme, which will provide a further 74MW electrical capacity. We will also ensure that further large-scale local projects to generate energy locally continue, by working with TfL (the capital's largest energy consumer) and other public and private-sector partners.

In order to extend regulatory reform to allow newer market entrants to access the local electricity market and to realise the benefits of Smart Grid approaches, the GLA will:

- lead the move for greater market access for local energy generators by becoming the first active Licence Lite holding energy supplier

- work with Government and interested parties to secure wider access to anonymised smart-meter data

- use the LEP, low-carbon innovation prizes and demonstration projects to promote and demonstrate new market models that can realise value within London.

To exploit London's waste heat resource, the GLA will:

- continue to demonstrate and facilitate local energy projects using secondary heat sources, and use this information to inform future energy and planning policies

- work with the Government to consider how to broaden the support for heat.

These proposals will be supported by a detailed Energy Infrastructure Plan for London that will map out London's requirements and costs and supply decarbonisation and distribution capacity over time.

Further regulatory reforms will be required to support innovative forms of local energy production and new technologies. Reforms are likely to include:

- the establishment of a set of technical, commercial and consumer standards and a regulatory framework that allows the nascent heat network market to fulfil its commercial potential

- changes to reduce cash-flow risk, regulatory cost and simpler customer acquisition for new smaller market participants.

These issues will be kept under review and will be considered jointly with Ofgem.

Reducing our energy demands

Rather than just increasing supply to meet our ever-increasing demand for energy, we need to reduce the energy consumed by every Londoner, every business and every building.

This reduction will require a combination of retrofitting London's ageing building stock, smart metering and controls, and actively reducing peak demand. If these actions are coordinated across the city they can have a real impact on the parts of London most likely to be affected by substations reaching or exceeding capacity. The Energy Infrastructure Plan for London will consider this matter.

Insulating London's housing stock, some of the most inefficient in Europe, will reduce heat demand, increase affordability and reduce CO_2 emissions. The GLA is calling on Government to focus post-2017 energy-company obligations on solid-walled properties, particularly flats, social housing and private rented properties. It is also recommended that Government gradually increases minimum energy-efficiency standards for private rented and owner occupier properties.

Smart controls and other innovations will also help to reduce heat and electricity demand. In homes, smart metering and associated apps and technologies are supporting reductions in total energy use and increasing awareness of patterns of energy use. This change can help shift demand away from peak times. Smart controls also have a significant role to play in commercial and public sector buildings, with programmes such as RE:FIT supporting their roll out.

These actions will have a significant impact on our energy demands. However, given the level of population and economic growth we expect London to experience, we still expect up to a 20 per cent increase in overall energy demand in the city. With an expected shift away from gas towards electricity, this is likely to mean a doubling of demand for electricity by 2050.

Chapter 18
Resilient, secure water

Simply to meet current demand for water, we are already abstracting too much from the environment, a problem that will grow worse as London's population grows larger. We must therefore work to ensure we use the water at our disposal more wisely and that sustainable water resources are developed.

In parallel, the performance of many of our drainage and sewerage systems and flood defences may fall below standard against the triple challenges of population growth, new development and climate change. However, taking a more integrated approach to water management and breaking down organisational siloes will help improve the situation and introduce multiple benefits at a lower cost.

Improving the security and sustainability of water supply

From as early as 2016, demand for water is predicted to exceed supply. Thames Water projects a 10 per cent deficit by 2025, rising to 26 per cent by 2050. To meet the gap, a variety of demand and supply-side measures will be required, including the following:

- improving the water efficiency of existing development by retrofitting water efficient devices
- incentivising people to become more water efficient by raising awareness
- developing innovative tariffs and smart tariffs
- including better water efficiency standards in new developments
- encouraging innovative leakage detection and fixing, including through technology and regulation.

The London Infrastructure Delivery Board will be asked to consider how water companies can improve the security and sustainability of London's water supply on new developments.

New technology will play an important role in ensuring we get the most out of our current infrastructure, and will help to determine what new infrastructure we need and when. Thames Water is already investing in cheaper, less disruptive and more innovative solutions to improve leakage detection and fixing. It has produced a model that determines where the most cost-effective leakage reductions can be made, incorporating information on the state of the pipes, the surrounding soil conditions and the vulnerability of local premises to flooding (if the mains break), and it drives sensors through the pipes to detect the condition they are in. To help inform the model, Thames Water is investing in re-lining technologies and is implementing many thousands of smart meters to help narrow down where the leakages are greatest as well as to help customers manage their water use.

In order to improve water sustainability, the Mayor will encourage and support the following changes in London's water companies:

- actively investigating and investing in new technologies and approaches to using the water we have more wisely,

particularly with regard to metering flats, raising consumer awareness of the economic benefits of water efficiency and cutting the costs of reducing leakage

- investing more in maintaining their existing assets, supported by regulators taking a longer-term perspective

- taking a resilience-based approach to assessing the options for their long-term water resource management plans for London, such as applying the 'flexible adaptive pathways' approach developed by the Environment Agency for the Thames Estuary 2100 project.

The Government also needs to take action. The Mayor urges the Government to include greater encouragement for a more integrated approach to water management in its proposed water supply National Policy Statement; in particular it must enable the strategic water supply infrastructure London requires.

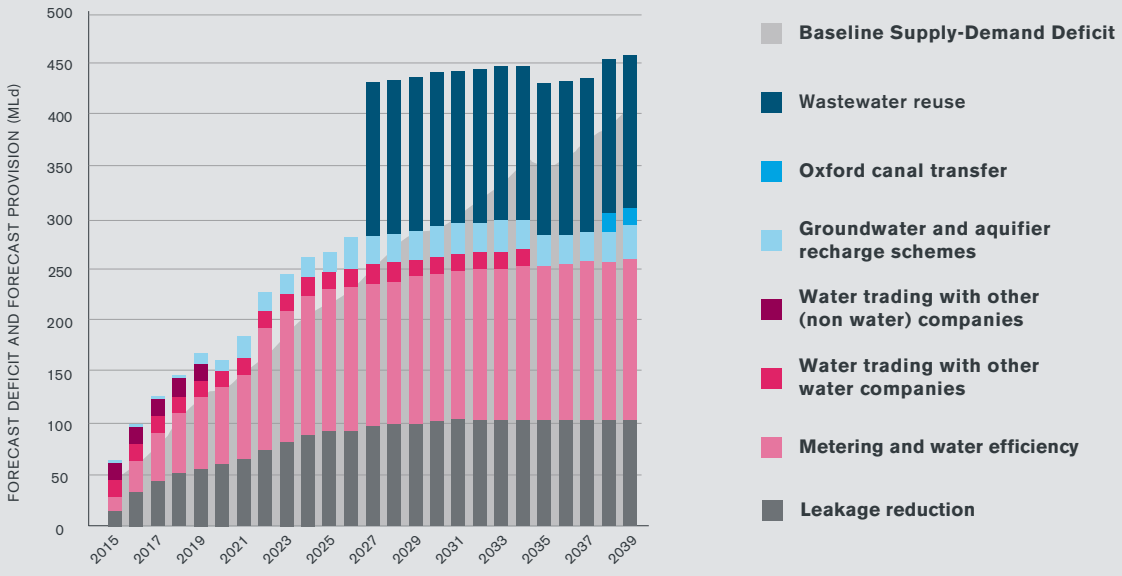

FIGURE 2
THAMES WATER'S PROPOSED MEASURES TO 2020 AND BEYOND TO BALANCE SUPPLY AND DEMAND (IN MILLION LITRES PER DAY)
Source: Thames Water, 2014

Sustainable drainage for London

Our current drainage capacity (drains and sewers) is insufficient for future challenges, highlighted by the fact that as little as 2mm of rain can cause overflows from the combined sewer into the Thames. As the population increases, it is likely that more sewage will flow into a drainage network that is already at capacity[29], which will increase the risk of sewer flooding of properties.

The Mayor will therefore lead on developing a sustainable drainage action plan for London. It will model and map the potential for retrofitting sustainable drainage across London (including through green infrastructure); establish incentives to encourage landowners to capture more rainwater on new and existing development, open and green and spaces; and make proposals to manage the risk of surface water and sewer flooding.[30]

Again, the water companies will play an important role. The Mayor will encourage Thames Water to develop 25-year plans for wastewater and drainage, which should include how they plan to use sustainable drainage to extend the life of the Thames Tideway Tunnel. The Mayor will lobby the Government to make these plans a legal requirement.

Managing London's flood risk

We want to do all we can to reduce London's flood risk. The recent floods in London and across the country have shown the damage flooding can do to people's homes and livelihoods[31] and also to other infrastructure, such as the transport network. 1.25m already people live and work in areas of tidal and river flood risk and 1.4m live in areas at risk of surface water flooding. Furthermore, flood risk will increase due to a combination of climate change, ageing flood defences, more impermeable surfaces from new development and more people and assets in areas at risk.

The Mayor will work with the Environment Agency, London Boroughs and other stakeholders to develop a prioritised 25-year flood risk management and investment plan for each catchment area in London, covering all flood sources. The Environment Agency will work through seven strategic Flood Risk Partnerships in London to develop and monitor the long-term plan. This will combine the actions identified in borough, water companies and GLA flood risk and water management plans.

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[29] It should be noted that by using less water we will create less sewage, which will help to relieve some of the pressure on our sewers.

[30] This document will be published in late 2014 for consultation, with a final plan in place in by the middle of 2015.

[31] In some parts of London flood risk is preventing house building, which implies that improved flood management could help bring more land into use for development, in turn helping to meet London's broader infrastructure challenges.

Maintaining flood risk at an acceptable level will require significant investment. To ensure that we have the funding and finance in place to deliver improvements in the standards of our flood protection, London needs to receive a (risk-based) 'share' of the national flood budget. The Mayor will raise this matter in discussions with Government.

It will also be necessary for the Environment Agency to work with the Mayor, boroughs, water companies and other stakeholders to identify alternative, complementary means of funding and financing to ensure the required level of flood defence expenditure for London is secured.

In order to raise awareness amongst local politicians and communities at risk, the Mayor will work with:

- the Thames Regional Flood and Coastal Committee members to ensure that flood risk is recognised and prioritised at a political level

- the Environment Agency and London Boroughs to raise awareness of flood risk with communities and business at risk – and communities should be included in the development of Local Flood Risk Strategies.

Chapter 19
Moving from waste to reuse

The current waste management system in London, as in the rest of the UK, is designed to manage the 'take-make-dispose' economy – but we are moving towards a future where goods are designed to be reused and recycled[32] in the so-called circular economy. In this system, waste is designed out of products, which are made to be disassembled and reused with the minimum of effort and energy.

[32] Many large companies have been adversely affected by higher resource prices and supply disruptions. Globalisation and high global growth rates are increasing the competition for scarce resources, and the indications are that raw material prices will continue to increase.

Many of the world's largest companies have already started to make the shift to circular-economy thinking – including Cisco, H&M, Kingfisher, Philips, Renault, Ricoh, Unilever and Vodafone.

Renault's remanufacturing plant in Choisy-le-Roi near Paris, which employs 325 people, re-engineers different mechanical sub-assemblies, from water pumps to engines, to be sold at 50 to 70 per cent of their original price. The remanufacturing operation generates revenues of around £160 million annually.

The company also redesigns components (such as gearboxes) to increase the reuse ratio and facilitate sorting by standardising components. While more labour is required for remanufacturing than making new parts, the process still results in a net profit because of reduced capital, cutting and machining expenses.

Renault has achieved reductions of 80 per cent for energy, 88 per cent for water and 77 per cent for waste from this remanufacturing process[32].

By 2050 it is our aim that very little waste will require disposal, the estimated economic benefits of accelerating London's move to a circular economy include:

- reduced costs of up to £5billion from 2016 to 2050
- a new economic sector bringing new employment opportunities and sparking innovation
- the increased ability of industry to hedge its exposure to global commodity price volatility and supply disruption by reusing waste materials
- reduced toxic waste
- reduced wider impacts, for example on transport (currently there are over 50 different contractors removing waste from Bond Street alone).

With a move to the system described above, London is likely to require much less waste disposal infrastructure by 2050 – likely to be around 40 new facilities, in addition to London's existing capacity. Most of them will be required to help reuse and recycle materials, predominantly repair workshops, disassembly lines and recycling and reprocessing facilities.

[32] *Source: Ellen MacArthur Foundation, 'Towards the Circular Economy: Accelerating the scale up across global supply chains', 2014*

Accelerating a market-driven move to a circular economy

The move towards a circular economy is already underway, with many companies already prospering as a result of it. While the move will be private-sector led, the Mayor will examine what can be done to accelerate proceedings.

It is clear that in order for companies to reuse resource inputs to the maximum degree, they need to increase the rate at which their products are collected and subsequently reused and their components and materials recuperated.

As a first step, London's waste authorities, with assistance from the London Waste and Recycling Board, will need to introduce more consistent collection and recycling services that will help to increase the capture of materials from individuals and businesses. Improved waste collection is needed, both under the current system and to support the circular economy. A recent report by the Circular Economy Taskforce[33], a business-led group, estimates that a more consistent approach could result in a saving per household of £61 per year.

There may be further interventions that could accelerate London's move to a circular economy in a cost-effective way. To start the process of assessing what interventions may be necessary and how to most effectively support the move, the London Waste and Recycling Board will work with the private sector to understand how the regulatory and fiscal environment would need to change. It will develop a route map to the re-generative economy for London, which will identify partners, actions and opportunities.

Additionally, the GLA Group will lead by example by examining its use of procurement and material handling and by mapping leakages out of the current linear set up. Applying the GLA Group's buying power will help to encourage suppliers to move towards more circular systems.

[33] *Benton & Hazell, Wasted Opportunities: Smarter Systems for Resource Recovery: A Report for the Circular Economy Taskforce, July 2014*

In Section E we discuss where London's growth may be accommodated and the impact spatial decisions will have on infrastructure. We consider alternative scenarios for how a growing population can be accommodated in London, including in the Opportunity Area and through town-centre densification, and in places surrounding the city, and we analyse the consequences spatial decisions will have on infrastructure requirements.

Chapter 20
Possibilities for growth across the city

The London Plan has identified 33 Opportunity Areas in the capital. These areas are London's major reservoirs of brownfield land with significant capacity to accommodate new housing, commercial and other developments, linked to existing or possible future improvements to public transport accessibility. They represent significant housing potential, but the lack of infrastructure in some cases represents a challenge. While the measures set out in this document will help maximise the potential of these areas, as we approach 2050 it will be necessary to exploit additional development capacity elsewhere.

The London Plan also emphasises the importance of what it terms 'Intensification Areas' as further sources of development capacity. These are typically built-up areas with good existing or potential public transport accessibility which can support redevelopment at higher densities. They offer significant capacity for new jobs and homes but at a lower level than in the Opportunity Areas.

The projected drop in the rate of growth of demand for retail space can help provide additional capacity to deliver good-quality housing intensification in town centres. The Further Alterations to the London Plan (FALP) encourages high density, residential-led, mixed-use redevelopment, particularly in centres with a surplus of retail and office floorspace[34].

There are a number of reasons why town centres are attractive places for increasing development.

- They often already have good public transport connections and include important services nearby, including health, education and civic facilities together with a retail offering.
- They provide an opportunity for sustainable development including car-free or 'car-lite' development.

[34] There is likely to be more potential medium-sized town centres, and it is thought that they will be most adversely affected by changing shopping habits.

- An increased resident population will also help support the retail sector.

- High-density development will enable the provision of a range of different housing including private rented, housing for older people, housing for smaller households and other specialist housing.

Our analysis suggests that town centre intensification could allow London to accommodate a population of 11.21 million at 2050, while the greater number of town centres in Outer London implies its population would grow by 16 per cent by 2050, compared to growth of 11 per cent in Inner London.

However, the impact on infrastructure requirements relating to town-centre development will be minimal given the range of existing infrastructure in town centres.

Increasing densities in areas with good transport links

The London Plan encourages higher-density housing provision in locations with good public-transport accessibility, whilst taking account of local context and character.

Public Transport Accessibility Levels (PTALs) are used as a consistent measure of accessibility to the public transport network, taking into account walk-access time and service availability[35]. The higher the PTAL, the higher the density of development that is permitted in an area. Our analysis show that increasing the permitted densities in areas with particularly good transport links (defined here as areas with a PTAL of 4 or above), could enable house building to accommodate a population of 11.24 million, largely contained in Inner London.

As above, given the level of existing infrastructure, the impact on London's overall major infrastructure requirements of further densification would be minimal.

[35] PTAL ratings range from grades 1–6 (including sub-divisions 1a, 1b, 6a and 6b), where a PTAL of 1a indicates extremely poor access to the location by public transport, and a PTAL of 6b indicates excellent access by public transport.

Renewal of suburban housing

Although Outer London is relatively densely populated compared to other global cites, it is less densely populated than Inner London and can often be characterised by under-occupancy[36].

Previous work has explored the potential for densification in Outer London. The Supurbia project[37] calculated that if just 10 per cent of semi-detached housing in Outer London was fully occupied rather than part occupied, it could accommodate an additional 100,000 people. Furthermore, if 10 per cent of semi-detaching housing was redeveloped at twice its existing density it would accommodate a total of 400,000 new homes, which would remain within the London Plan sustainable residential quality density matrix.

Densification of the suburbs may help accommodate more residents as well as stimulating economic activity, improving service provision and enhancing property value.

Further transport improvements would be required to support large scale population growth in Outer London, particularly in terms of improving orbital movement. Without improvements in public transport and provision for active travel, increased congestion on key sections of the highway network would be likely. Yet if London is to accommodate a large proportion of its growth within its borders, it will be necessary to increase densities in Outer London, at least to some extent.

Chapter 21
Impact on the wider South East

Independently of the impacts of a new airport to the east of London, outside London we are likely to see planned new developments or additional densification of existing town centres. These developments would most likely occur on existing or planned transport corridors, where growth could most sensibly be accommodated, and it may occur naturally as people chose to move out of London.

We have analysed the potential for increased densities in urban areas in the South East where current residential densities are low, even near public transport or in established town centres, particularly focusing on more deprived areas. We have also considered the role that new towns and urban extensions can play in areas beyond the Green Belt, particularly in areas where there is scope to increase rail commuting. HS2 in particular

[36] *Our analysis (GLA, City of Villages, 2006) has focused on houses built between 1930 and 1939 – a category of houses that is likely to be vulnerable to potential decline. Increasing densities in the lowest density areas (fewer than 30 dwellings per hectare) by 25 per cent would enable London to accommodate a total population of 11.3 million.*

[37] *HTA Design (2014) Supurbia – A study of urban intensification in Outer London*

will relieve existing main lines to the north of London, allowing commuter services on these lines to be intensified.

By increasing densities in such areas to 100 dwellings per hectare, our initial analysis demonstrates the potential for a population increase of around one million in the areas surrounding London.

Figure 3 below shows the impact this spatial distribution would have on rail requirements.

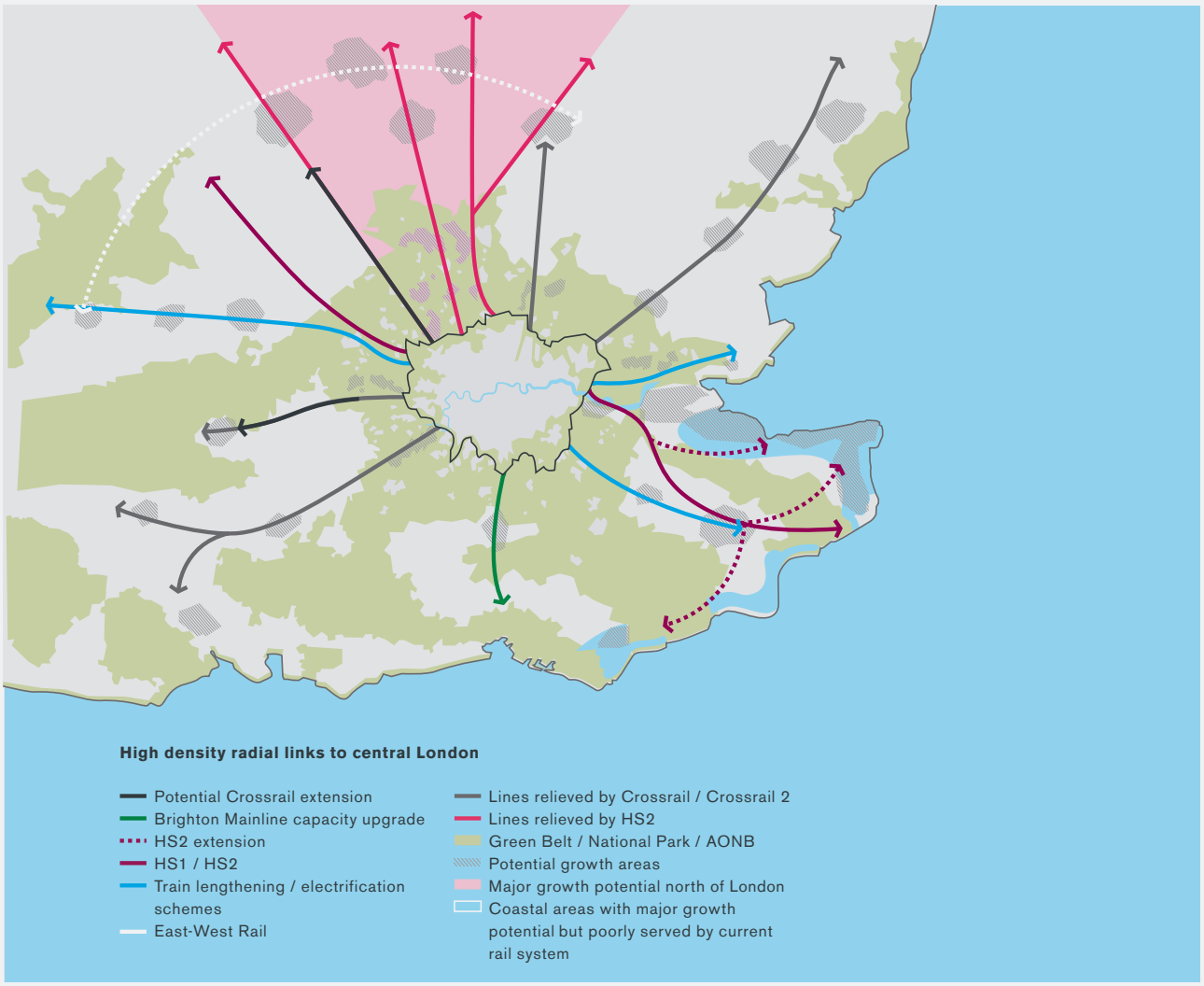

FIGURE 3
THE IMPACT OF SPATIAL DISTRIBUTION ON RAIL REQUIREMENTS

Providing better rail connections to some existing locations could support the regeneration, for example, of seaside towns on the south coast, with Central London commuters generating local demand for services and local employment just as they do in London. While there are significant numbers of medium and long-distance commuters in locations served by fast inter-city routes to the north and west of London (from places like Peterborough, Swindon and Rugby), many areas to the south and south east that are a similar distance from London have fewer such commuters because of relatively poor rail connections.

Impact of a new hub airport

A new hub airport in the Thames Estuary together, along with the supporting road and rail infrastructure it would require, could bring about a rebalancing of the city and wider region by encouraging more development in areas to the east of the city, and in the Thames Estuary, where there is both development capacity and a need for regeneration. This could help make a major contribution towards accommodating London's growing population. For example, in the case of a new hub airport on the Isle of Grain, supporting infrastructure would have a significant upward effect in terms of land and development values, enhancing viability of large scale projects and stimulating housing markets. The transport implications are shown in Figure 4.

It would also enable a Heathrow Regional Opportunity Zone with the potential to accommodate housing for around 200,000 people and 90,000 jobs.

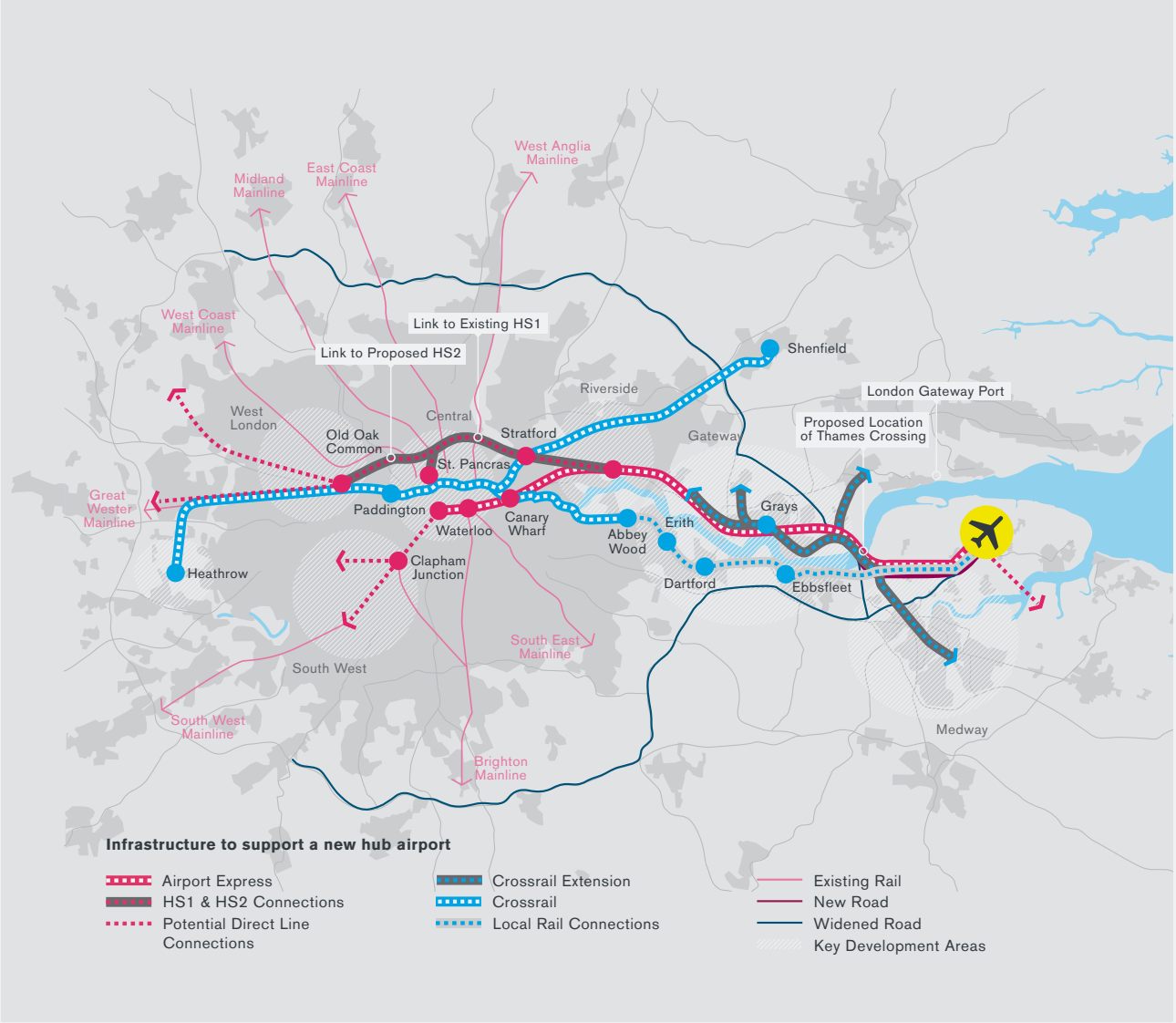

FIGURE 4

THE IMPACT OF A NEW HUB AIRPORT ON TRANSPORT CONNECTIONS

Overall potential for housing London's increasing population

The above analysis takes a 'what-if' approach when considering the potential for increasing densities across London and in surrounding areas. The likely outcome will be a mixture of all the scenarios considered and we are not identifying a preferred scenario, although growth outside London is generally less sustainable. Instead we conclude that the additional projected population increase can be accommodated within London and that there is also capacity within the surrounding areas to increase densities.

Overall, the analyses suggest that the overall scale of investment required will be the same in all scenarios with variations in the exact requirements according to particular patterns of development. With regard to the Green Belt, the Mayor has concluded that the large reservoirs of brownfield land within the capital will enable London to accommodate its growth at least until 2025 within the existing boundaries. The analyses above nevertheless assist in thinking about where, within and beyond the capital, further growth could occur, and can be seen as a precursor to the next full revision of the London Plan after 2016. We will continue to work with the London boroughs and local authorities surrounding London to ensure our growing populations are strategically planned for.

In this section of the report we summarise the full costs of delivering and maintaining the infrastructure that London needs. As it would result in a sharp rise in costs and a probable public sector funding gap, we consider other ways in which costs could be managed in order to deliver requirements.

Chapter 22
Costs

The analysis in this chapter is based on the work we commissioned from Arup to develop a detailed cost model to provide high-level estimates of London's complete infrastructure bill, in real terms and as a proportion of the economy.

The costs include capital costs (defined here as enhancements and renewals) as well as operating and maintenance costs[38]. The analysis attempts for the first time to understand the magnitude of the full costs of our future infrastructure needs, including maintaining most of the existing asset base[39]. We did not attempt to value all the existing infrastructure asset base in the capital (which would involve developing a complete asset register across all sectors) because of the wide variety of organisations that own them (see section C) and very disparate sources of information.

Capital costs

The headline figure from the Arup report is that the total investment in London's infrastructure between 2016 and 2050 will reach £1.3 trillion[40], within a range of £1 trillion and £1.7 trillion. Given the level of uncertainty inherent in the timeframe at hand and the number of assumptions made, the range of costs takes into account different measures for construction industry inflation, the high and low population estimates in Section A and the potential for efficiencies.[41]

The analysis also demonstrates the following.

- Total infrastructure costs will rise steeply over the next ten years to double what they were in the baseline period (2011-2015) in real terms, from an annual average of £16 billion in 2011-15 to £38 billion in 2016-50.
- As a proportion of the economy, costs will almost double over the next decade but in later periods (after 2030), costs are projected to decline as a percentage of the overall economy.

[38] For further information regarding definitions, and for more detail on costs, see the separate report from Arup 'The cost of London's long-term infrastructure' published alongside this document.

[39] It is conceivable in future that a more comprehensive approach to asset valuation and management across sectors could be adopted in future, but the current governance arrangements make this impracticable at present and of questionable value.

[40] Cumulative figure for all capital investments estimated to 2050, expressed in 2014 real terms.

[41] That said, while uncertainty is inherent, the findings of Arup's report align with other studies of the nation's infrastructure requirements. For instance, spending on power and transport infrastructure will rise from £70 billion in 2014 to £106 billion by 2025, according to research carried out by PwC and Oxford Economics (PwC and Oxford Economics [2014]; Capital project and infrastructure spending: Outlook to 2025).

However, these projections do not fully take into account the wealth creation brought about by implementing the plan and ignore the likelihood of completely new infrastructure being planned and delivered in future decades.

The figures above relate to the total bill across all infrastructure types for the period to 2050[42]. Points to note on the breakdown of costs include the following.

- Housing and transport make up 77 per cent of the total costs, followed by energy, which makes up 11 per cent.
- ICT infrastructure may form a very modest 1 per cent of overall costs, which is remarkably low considering the high-value benefits of digital infrastructure[43].

Figure 5 and Table 1 below provide more information about projected capital costs. Figure 5 provides a summary of the outputs from the cost model. It shows the total costs in real terms in five-year blocks from 2011-2050, where 2011-15 is a baseline figure (including both historic data and 2014 and 2015 budgets), while the remaining five-year blocks are projections based on high-level assumptions.

These projections are based on the following assumptions:.

- Construction cost inflation is at 2 per cent (over and above RPI).
- We meet our existing key policies, delivering on housing and school needs and achieving targets for decarbonisation of the system and locally produced energy targets.
- In terms of projects, the estimates include the full cost of a Thames Estuary Airport[44], Crossrail 2 and 3, implementation of the Roads Task Force and an estimate of London's contribution to High Speed 2. They also include a London share of energy investment (on the basis that London consumers will pay for their share) and the Thames Tideway Tunnel.
- Population and employment projections are as per the London Plan to 2036, and assume a 2.5 per cent employment growth per annum thereafter.
- The comparison with the size of the economy in Figure 5 below assumes 3.5 per cent GVA growth – on the basis that infrastructure investment should yield higher economic growth.

[42] While we have constructed a cost range to highlight uncertainty, we focus in the next pages on our best cost estimate to concentrate our analysis.

[43] Benefits include increased business productivity and individuals being enabled to access services and information as well as work from home. Environmental benefits may occur from reduced commuting and business travel.

[44] The construction of a New Estuary Airport, including surface access costs, would make up around 5 per cent of the total capital costs.

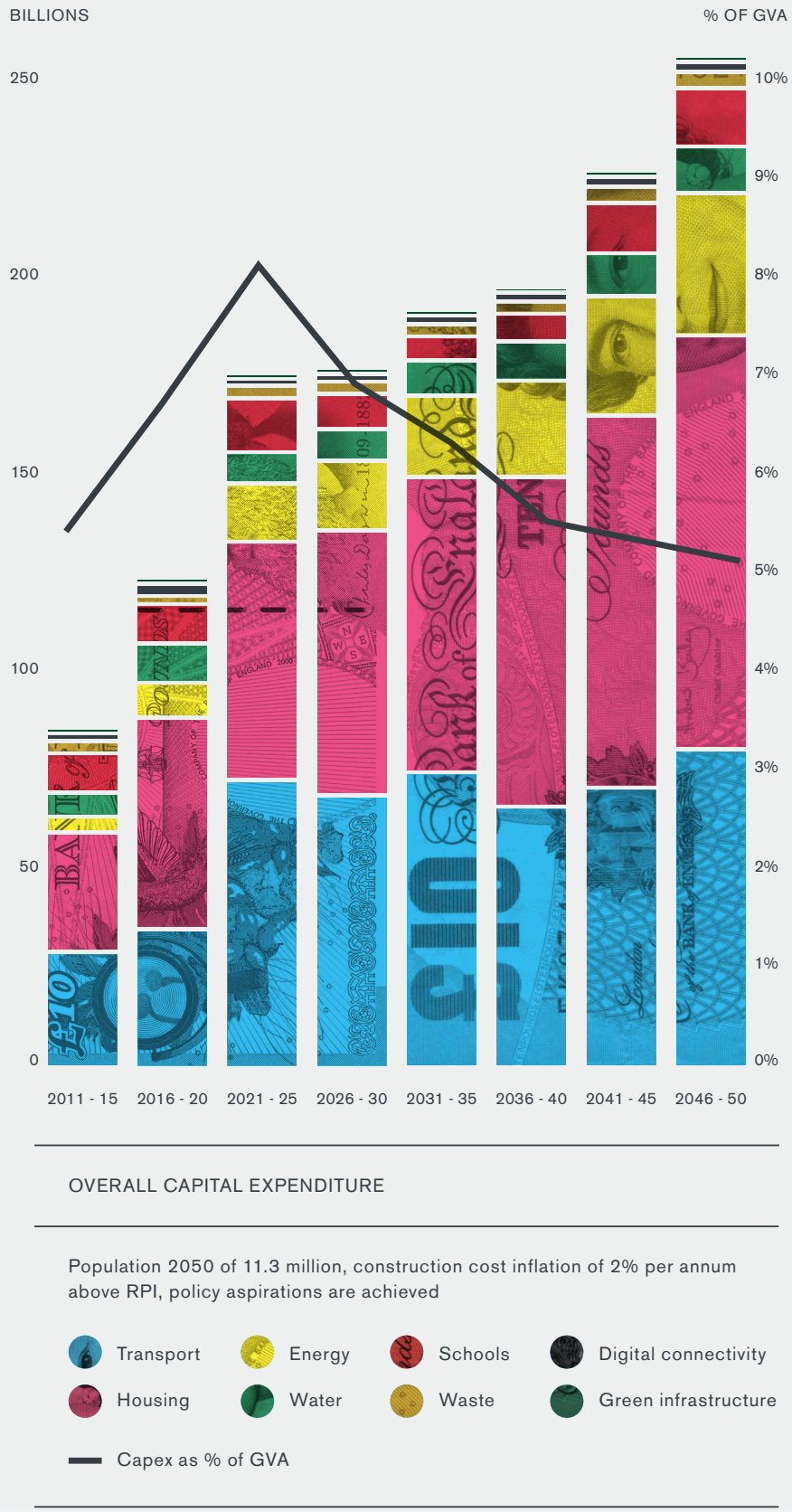

FIGURE 5

PROJECTED CAPITAL EXPENDITURE REQUIRED BY FIVE-YEAR PERIOD, 2016-2050, AND PROJECTED CAPITAL ENHANCEMENT REQUIREMENTS AS A PERCENTAGE OF GVA

Sector	Capital expenditure (billion)...	...as % of total costs	Capital expenditure (billion), annual average	Capital expenditure, per capita annual average
Housing	£547	42%	£16	£1,416
Transport	£466	35%	£13	£1,150
Energy	£148	11%	£4	£354
Schools	£68	5%	£2	£177
Water	£46	4%	£1.3	£115
Green	£22	2%	£0.6	£53
Waste	£14	1%	£0.4	£35
ICT	£8	1%	£0.2	£18
Total	£1,324	100%	£38	£3,363

TABLE 1
PROJECTED CAPITAL EXPENDITURE FOR THE WORKING ESTIMATE, 2016-2050 (2014 PRICES, BILLION)

Notes:

- Housing includes affordable (52 per cent of total new housing units) and market-rate housing (48 per cent of total new housing units).
- Transport includes TfL's responsibilities (£269 billion), aviation (£134 billion, of which £46 billion for a New Estuary Airport[45]), London's share of national rail projects (£63 billion), and Highways Agency and local authority responsibilities (£9 billion).
- The energy estimate assumes over 50 per cent of London's energy is produced locally by 2050.
- The water estimate includes the Thames Tideway Tunnel and assumes no new reservoir.

[45] *This figure does not include the 2 per cent construction industry cost uplift per annum. Arup has used initial estimates put forward by the Davies Commission however more recent work by TfL has revised the costs to £44 billion.*

- Green infrastructure includes parks and open spaces for recreation, flood management, walking and cycling routes. In order to more accurately reflect projected investment requirements associated with London's green infrastructure, portions of capital expenditure projected in transport (£8.5 billion) and water (£11.8 billion) have been allocated to the green sector in this summary chart (these figures are re-allocated to the transport and water sectors in the funding discussion).

- Waste figures assume that 20 per cent of resources are being reused and remanufactured in 2050.

- The ICT estimate includes fibre broadband, cyber security, 4G, 5G and potential costs post 5G rollout.

Investing in infrastructure delivers huge economic and social benefits. It is not within the scope of the report to quantify all the benefits across all sectors, but we highlight some below.

- Transport benefits range from increased capacity, congestion relief on London's public transport system, better access to the capital and additional employment opportunities. The benefits of Crossrail, for example, are estimated to reach at least £42 billion in current prices, a return of approximately £4 to every £1 spent[46].

- Recent analysis of broadband infrastructure investment has found returns far exceeding those evident in other sectors, estimating a net return of £20 for every £1 spent in the coming decade. These economic impacts are additional to the social benefits derived from bridging the 'digital divide' and the environmental benefits associated with reduced commuter journeys and other lifestyle adjustments made as a result of broadband use[47].

- Investing in green infrastructure can lead to more sustainable drainage, improved air quality, more active lifestyles and enhanced ecology. Harder to quantify, there is a growing evidence base on the benefits of green infrastructure. For example, Chicago saves up to £65m annually in public health costs reducing air pollution by greening the city's rooftops (see Chapter 15).

[46] *Crossrail. Wider Economic Benefits. available: http://www.crossrail.co.uk/benefits/wider-economic-benefits/*

[47] *Department for Culture, Media and Sport. The Benefits of Broadband, 14 November 2013, available: https://www.gov.uk/government/news/the-benefits-of-broadband*

Chapter 23
Funding gap

The cost model has enabled us to extract the likely costs to the public sector in London (under a 'business as usual' scenario, i.e. that the existing funding arrangements continue[48]), estimating the gap between future costs compared to existing levels of funding.

Overall, the estimates suggest that the current level of funding (particularly for infrastructure provided by the public sector) will not meet London's growth. More specifically, the following average annual funding gaps in infrastructure currently funded by the public sector can be expected.

- **Housing:** £1.3 billion per annum (or 8 per cent of total new housing investment over the period)
- **Transport:** £2.5 billion per annum (19 per cent)
- **Education:** £0.6 billion per annum (33 per cent)
- **Green infrastructure:** £46 million per annum[49] (8 per cent);
- **Waste:** no expected funding gap; if we successfully transition to an economy where we recycle more and reuse our materials, bills could be 28 per cent lower than they are today by 2050.

[48] London operates under the current centralised framework, with approximately 70 per cent of its income coming from Central Government.

[49] Assumes green infrastructure related to transport and water will be covered by each respective sector.

Sector	Projected funding gap (billion), total 2016-2050	% of total costs	Projected funding gap (billion), annual average	Projected funding gap, per capita annual average
Transport	£89	19%	£2.5	£225
Housing	£46	8%	£1.3	£116
Schools	£22	33%	£0.6	£56
Green Infrastructure	£16	8%	£0.046	£4

TABLE 2
PROJECTED FUNDING GAP ACROSS SECTORS
Note: the housing funding gap is for affordable units.

We have also estimated the likely impact on consumer bills for those sectors that will remain outside the public sector (again, assuming 'business as usual'[50]), and have concluded that the costs to the consumer will most likely increase somewhat in water and energy.

- **Water:** bills are not expected to increase for water supply, but the Thames Tideway Tunnel sewerage system is likely to increase bills by 0.5 per cent per annum, as already announced.

- **Energy:** if we achieve our targets for locally produced energy, bills are expected to increase by 2.4 per cent per annum in real terms – but this figure would increase by an additional 0.3 per cent under the current system of nationally supplied energy. The increase in prices will mostly occur as a result of national and international decarbonisation targets.

[50] *Consumers pay through bills for water, energy and broadband.*

Chapter 24
Funding and financing options

While our cost model is inevitably an imperfect approximation of what will actually happen, the rise in costs compared to existing funding is stark and needs to be addressed. In our discussions and assessments, we have concluded that there is no single answer to this dilemma; action on a combination of fronts is required - but 'business as usual' will no longer be an option.

However, we do know that achieving results in practice will require a great deal of political will and determination amongst all stakeholders to act in Londoners' best interest.

Fiscal devolution

One of the original hypotheses behind this work was that fiscal devolution would enable London to make additional self-determined investments in its infrastructure to support growth, which is broadly confirmed by our analysis, although the gains from fiscal devolution are likely to be modest, at least initially.

Crucially though, fiscal devolution will enable the city to have greater financial control over its own transport, housing and other infrastructure investments; it will provide a fiscal base against which to borrow prudently; and it will at the margin enable us to make additional investments in other infrastructure, such as digital connectivity. Devolution alone of the remaining fifty percent of the business-rate tax base might yield £18bn over 35 years (though this income would build up gradually over time), but overall it would also enable us to make choices between different infrastructure investment types and encourage greater integration, force greater accountability and incentivise efficiency. Alongside the governance reforms proposed in Section C, fiscal devolution is vital to enable us to plan the city's future.

Other cities around the world do far more to capture the property value uplift generated by infrastructure, and London could do much more. Analysis for the London First Cross Rail 2 Taskforce[51] suggests the net present value of additional property tax revenues (stamp duty, council tax and business rates) attributable to the impact of Crossrail 1 could reach some £2.4 billion (approximately 15 per cent of the total investment for Crossrail 1); almost all of these revenues will accrue to the Treasury and were not explicitly taken into account in the funding package for Crossrail 1. While the effect on property values will differ for each project, we have made here a crude assumption of a similar impact from all other new transport

[51] *'Funding Cross Rail 2 Report from London First's Task Force'. 2014*

investments to illustrate the potential of this contribution to funding. Taken prudently as only 5 per cent of total new transport investments, £23 billion could contribute to the funding package for London infrastructure – but only if property taxes were devolved.

More efficient delivery

Better governance, as outlined in Section C, should enable improved coordination, integration and understanding of the project pipeline. In addition, a more joined-up and simplified planning system, better procurement, and more widespread adoption of the innovative approaches set out in Section B and the regenerative economy approaches in Section D should all contribute to reducing the funding gap. Planning for the whole lifecycle and adopting a more standardised design approach will also be beneficial.

Public sector land and other assets could be utilised much more intensively. Local authorities are already working hard to generate greater returns from their fixed assets, often through the regeneration and densification of whole neighbourhoods – creating funds to meet their service obligations in the process as well as providing affordable housing. Some schools have been shrewd in raising additional income from their existing assets (such as the Durand Academy in Lambeth, which established a health club, swimming pool and residential property to bring in additional income).

Infrastructure UK[52] and Arup estimate that a combination of many of the efficiency measures alluded to above could reduce capital costs by 10 to 15 per cent, which could mean a reduction in costs between £100 to £150 billion over the period for infrastructure currently in the hands of the public sector, though it is probable that beneficial effects would only be felt in the medium term.

Other Options

We have also considered other options that could reduce costs or provide additional funding.

- Technology and innovation are likely to yield significant savings in future. Given the uncertainty, we have not attempted to quantify these savings, which will vary by infrastructure type and may turn out to have the most significant impact on costs.

[52] *Infrastructure UK. Infrastructure Cost Review. 2010*

- Distinguishing all beneficiaries, which may be particularly significant in the case of green infrastructure (for example it should be possible to charge other parts of the public sector and the private sector that benefit from green investments).

- Greater use of private sector sponsorship could yield additional income.

If the impact of the above is not enough to eliminate the funding gap, it may be necessary to prioritise or delay some infrastructure projects. We may also need to re-think the policies that are driving particular aspects of infrastructure demand.

However, good progress on most if not all these fronts should enable London to deliver the infrastructure that the city requires to remain in the top tier of global cities.

Further devolution

While we have focused above on reducing the funding gap by exploring better, more innovative and more efficient ways of running the system, new local funding sources may also be required[53]. Table 3 shows a menu of options that could play a role – the examples below are for illustrative purposes and none are recommended at this stage.

Further analysis and evaluation would obviously precede any implementation, but they serve to highlight the range of levers that could be pulled if necessary. It is also important to note that these options could either be additional to current taxes or could be introduced with associated reductions elsewhere in the taxation system.

[53] *The CLG Select Committee has recently called the transfer of a range of tax raising powers to local authorities, including business rates, stamp duty, council tax and other smaller taxes and charges, along with greater flexibility to borrow for investment. See 'Devolution in England: the case for local government'*

Option	Potential amount raised to 2050 (2014 real terms)
Regional income tax potential	£56 billion (Our illustrative model takes 2 per cent of the marginal tax rate for each income band, i.e. a 0.4 percentage point of the 20p income tax band, 0.8 of the 40p band, and 0.9 of the 45p band).
London-only income tax potential	£33 billion (As above but for London only).
'Motoring duty'	£48 billion (Assuming a London share of replacements for vehicle excise duty and fuel duty, which currently raise approximately 0.5bn and £1.7bn per annum).
Hotel bedroom tax	£6 billion (Assuming £2 per person per night).
Business Rates Supplement (after Crossrail 1 is paid for)	£3 billion (Raised after 2037 carrying forward the Crossrail business rate supplement assumptions).

TABLE 3
MENU OF POSSIBLE OPTIONS FOR ADDITIONAL FUNDING SOURCES

Financing

So far in this chapter we have looked at different options that could help meet the funding gap and different revenues that contribute towards the funding of a project on an ongoing basis. For the purposes of clarity, we define funding in this report as the ultimate payment for the service, for example revenue streams such as taxes, user charges, fees and savings that cover costs over time. Those revenues are then used to support different financing options. Financing comprises the different tools such as debt and equity that allow for upfront payments.

In this chapter, we consider how the upfront costs for the investments we need might be financed.

Central government, the GLA Group and private owners of infrastructure use different financing methods to pay for investments upfront. In terms of borrowing, the Government and private owners primarily depend on the debt capital markets to finance their requirements. The GLA Group is also a regular issuer, but it also relies on the Public Works Loan Board for borrowing activities. Seeking equity participations on projects is another method that has been used by a number of different actors.

Given the anticipated level of investment needed in London's infrastructure, it is safe to assume that it will not be possible for every project to sit on the public sector's balance sheet. It is also clear that scope exists for more private sector investment in selected infrastructure projects. We should not let negative experiences in the past deter us from exploring more private and public sector collaboration.

Indeed, the public sector must still play a role in delivering critical infrastructure projects, government intervention of some kind will always be required in large-scale infrastructure projects in order to protect investors from the risks of the construction phase of projects, and we should expect government intervention to ensure the best deal for Londoners. In the words of Dr. Pippa Malmgren, 'foreign investors can't run away with our tracks and tunnels, so let them invest'.

Certainly, conversations with institutional investors confirm an appetite to invest, and there are deep pockets of money in the UK and internationally that could contribute to London's growth, either through debt or equity options. We have illustrated below different ways in which recent infrastructure projects have been or will soon be funded and financed.

Structure: Private sector owned, Regulated industry, Needs Government Guarantee	
Thames Tideway Tunnel (estimated cost £4 billion)	Funding Consumer bills Financing A separate company that owns the tunnel has been set up. This company will be owned by institutional investors (pension and sovereign funds) which will be responsible for raising debt and overseeing procurement for the project. A government guarantee is in place to overcome construction risk.
Structure: Private sector owned, Regulated industry	
Capital investments for water	Funding Consumer Bills Financing The regulated utilities have ready access to capital as the regulatory system provides certainty of returns from the income-generating assets and ensures risks are kept to a minimum by passing costs to consumers (under the Regulated Asset Base model). This model gives certainty to investors and ensures the asset is financed via long-term borrowing (which matches the life of the assets). The stability of the regulatory system is key to ensure the system functions properly.

Structure: Public sector	
Northern Line Extension (estimated cost £1 billion)	Funding Tax gains from developer contributions and business rates (under a Tax Increment Financing model) Financing The GLA will do the borrowing from a variety of sources to ensure best deal is achieved for the public sector (the mix is yet to be decided).
Structure: Public sector	
Crossrail 1 (estimated cost £15.9 billion)	Funding Grant from central Government; contributions from beneficiaries (City of London Corporation, Heathrow, Canary Wharf Group, Berkeley homes); users through fares; and businesses through the business rate supplement. Financing Borrowing is done by the GLA and TfL backed by the business rate supplement and user fares.

TABLE 4
EXAMPLE INFRASTRUCTURE FUNDING AND FINANCE METHODS

The examples above illustrate the fact that most of the time projects require a joint effort between the public and private sector. More can be done to ensure these collaborations can deliver the best outcomes for Londoners.

The public sector can use private capital to raise debt for the assets it owns and operates; the GLA and TfL could make more use of their sound credit history to increasingly look at private capital to raise finance. Borrowing freedoms without artificially imposed caps by Government, as highlighted by the London Finance Commission, would also allow more flexibility in managing the funding gap – and placing greater borrowing powers in the hands of London government would enable us to finance on the capital markets in London's best interest.

Another option is to give assets to the private sector to operate and finance, though support in the form of guarantees would be required to overcome construction risk. Regulation has already generated transparency in privately-owned infrastructure industries and helped with financing, while ensuring consumers get a fair deal in terms of prices.

While investors are keen to invest, a number of outstanding issues still need to be addressed, and certainty of projects and clarity of public sector processes rank high on that list. This consultation begins the process of achieving such certainty and clarity.

Chapter 25
Consultation questions

We encourage all readers to respond to this document. We are particularly interested in hearing your views on the following questions:

1. Do you agree with the need for an infrastructure plan for the capital? Do you support our approach? If not, why?

2. Is any of the infrastructure identified unnecessary – if so why? What (if any) infrastructure do you think London will need in addition to what we have identified? Why?

3. We have identified a significant funding gap with regard to the infrastructure that we think London will need. We have also set out a menu of options to help close the gap. Which of these should we pursue and why? Which not and why? Are there other options we haven't considered which you think need to be addressed?

4. Will the London Infrastructure Delivery Board be enough to ensure best-practice joined-up delivery of infrastructure in London? What more could the Mayor do?

5. Where do you think London's growth would be best accommodated (please explain why)? Are there alternative spatial scenarios we need to analyse?

6. Do you agree that incentives on utility providers should be amended to enable investment costs for growth to be shared more widely? How practically can this be achieved? If not, why?

7. Regarding technological change, do you agree with the proposed approach? What technological advances should London be taking account of or be leading?

8. How can we change behaviours to reduce demand for key infrastructure? To what extent could demand side changes affect, for example, our energy needs or over-crowding on London's transport?

We are also interested in hearing your thoughts on any or all of the following more specific questions:

Housing

9. Do you have other suggestions for how we could more effectively unlock housing sites with the help of infrastructure?

Transport

10. Are there any other strategic projects we have not considered?

11. Given funding constraints, what projects do you think we need to prioritise?

12. Which transport innovations do you think will have the most impact and why? How can we encourage their development?

13. How clear is our approach to tackling road congestion? How significant do you think promoting walking and cycling could be as part of the solution?

14. What do you think of the vision for increasing step-free access on public transport?

Green infrastructure

15. Are there strategic green infrastructure objectives that should be prioritised? If so, are there any specific initiatives needed?

16. What are the key issues that the proposed Green Infrastructure Task Force need to consider?

Digital

17. What else can we do to ensure we achieve universal digital connectivity?

18. Are you able to suggest examples of alternative ways of providing digital connectivity to local areas with poor or no broadband provision?

Energy

19. Do you agree with our approach in stimulating locally produced energy? If not, why?

20. What else should we consider to ensure London's energy supply is affordable, sustainable and secure?

Water

21. Have we identified the correct water management challenges? How do you feel they rank against the other issues in the London Infrastructure Plan 2050?

22. How do you think water supply and demand should be balanced?

23. Do you think enough is being done to protect London from flooding?

Waste

24. Do you think the name 'circular economy' is best to describe the approach or will it confuse consumers and businesses? Can you suggest other names?

25. Do you agree with our proposed approach? If not, why?

26. How can we incentive businesses and households to reuse and recycle more?

Chapter 26
Next steps and timing

The consultation period will last for three months and responses are requested by 31 October 2014. You can respond through the consultation page at London.gov.

We will consider all submissions. Extracts may be cited in our report and submissions may be published on the GLA website unless they are marked as confidential or there is a legal reason for non-publication.

It would be helpful if your submission could be no more than 2000 words in length.

We plan to publish a final report in early 2015.

Annex 1
Glossary

5G (5th generation mobile networks) refers to the next major phase of mobile telecommunications standards beyond the current 4G standards. No official specification yet exists for 5G, but it is widely considered that it will give the impression of instant unlimited access to the internet.

Agglomeration describes the clustering of individuals and businesses in the same geographical location.

Autonomous vehicles, also known as driverless cars, are capable of sensing their surroundings and navigating without the need for human involvement. Related benefits include increased safety and velocity.

Capital expenditure comprises investments in new infrastructure and renewals of existing infrastructure.

Circular economy is an industrial system that is restorative in nature and where materials are reused and remanufactured rather than disposed of.

Climate change is the significant and lasting change in the distribution of weather patterns including temperature, wind patterns and rainfall.

Finance is the act of raising funds to upfront costs of infrastructure; could take different forms, such as debt and equity, and come from different sources, such as the Public Works Loan Board, the European Investment Bank, private investors.

Fiscal devolution is the transferal to a sub region of powers and responsibilities for revenue raising (e.g. tax-raising powers) and expenditure.

Funding represents the different revenue streams from a given source (e.g. taxes, user charges and fees) which are usually used to service financing obligations.

GVA (gross value added) is a measure in economics of the value of goods and services produced in an area, industry or sector of an economy. Like Gross Domestic Product (GDP), it is a measure of output. The relationship is defined as: GVA + taxes on products - subsidies on products = GDP. GDP is the measure used for the UK, whereas GVA is the measure used for the regions.

Microtrenching is an installation method in which a narrow and relatively shallow channel is cut, typically on one side of a roadway, causing minimal disruption to roads.

Operational expenditure comprises ongoing, routine maintenance of infrastructure assets.

Procurement is the acquisition of goods or services from an external body.

Projections are an estimate of a future situation based on present and past trends. Projections differ from forecasts, which attempt to predict and factor in future events.

Quality of life refers to the general well-being of individuals and society, generally defined in terms of health and happiness rather than wealth.

Regulation refers to laws designed to govern conduct, for instance the protection of consumers from the monopoly powers of the utility companies.

Regulators are the bodies responsible for enforcing and overseeing regulation, such as Ofwat, Ofgem and Ofcom.

Annex 2
Stakeholders

We are grateful to the following for their time and expertise.

AECOM
Argent
Arup
Atkins
Association for Consultancy and Engineering
Balfour Beatty
Ballymore Group
BAM Nuttall
Battersea Power Station Development Company
Beyond Green
British Property Federation
Cabinet Office
Carillion
Cathedral Group
Central
Central London Forward
Centre for Cities
City of London
Civil Engineering Contractors Association
Cleshar
Confederation of British Industry
Construction Products Association
Costain
Crossrail
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Deloitte
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EC Harris
EY
Environment Agency
Farrells
Federation of Small Businesses
Foresight
Forestry Commission
Foster + Partners
Future Cities Catapult
Gerald Eve
Hawkins Brown
HM Treasury
Hochtief
iBUILD
Infrastructure Studies Institute
Infrastructure UK
Institute for Civil Engineers

Institute for Sustainability
Institute of Directors
InVenta Partners
Interserve
J.P. Morgan Asset Management
Lagan
Lafarge Tarmac
London and Partners
London Boroughs
London Chamber of Commerce and Industry
London Councils
London Business Advisory Council
London Finance Advisory Committee
London First
London Sustainable Development Commission
London Wildlife Trust
Macquarie
Mishcon de Reya
Morgan Sindall
National Trust
Natural England
Network Rail
Ofcom
Ofgem
Ofwat
Optimity
Osborne
PwC
Peter Neal
Professor Brian Collins
Professor Rahim Tafazolli
Rothschild
Royal Academy of Engineering
Sir Alan Wilson
Sir John Armitt
Skanska
South East England Councils
Sustrans
TheCityUK
Total Flow
UCL
UK Power Networks
Urban Land Institute
Vinci
VolkerFitzpatrick