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# **The cost of London's infrastructure requirements to 2041 and the funding gap**

Technical report

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Ove Arup & Partners Limited  
19 July 2019

## **CONTENTS**

|  |           |
|--|-----------|
| <b>Executive Summary</b>   | <b>4</b>  |
| <b>1. Introduction</b>   | <b>8</b>  |
| <b>2. Headline Findings</b>  | <b>10</b> |
| <b>3. Transport</b>  | <b>14</b> |
| <b>4. Affordable Housing</b>   | <b>21</b> |
| <b>5. Energy</b>   | <b>25</b> |
| <b>6. Water</b>  | <b>29</b> |
| <b>7. Green Infrastructure</b>   | <b>34</b> |
| <b>8. Waste</b>  | <b>37</b> |
| <b>9. Digital</b>  | <b>40</b> |
| <b>10. Fire, Police and Mayoral Development Corporations (Capex only)</b>  | <b>43</b> |
| <b>11. Conclusions</b>   | <b>45</b> |
| <b>Annex A: Reconciliation with the GLA Capital Strategy</b>               | <b>48</b> |
| <b>Annex B: Reconciliation with the National Infrastructure Assessment</b> | <b>50</b> |

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## Executive Summary

London has huge infrastructure investment needs. The city's transport system is the most congested in the UK and struggles to meet increasing demand. Severe housing shortages affect living standards and constrain the economy. Digital infrastructure networks fail to meet the needs of many businesses. And a transformation in the capital's energy networks is needed to reduce carbon emissions and combat climate change.

London government and the civic leaders of all the core cities have argued that the UK economy is being held back by a lack of investment in cities, a point echoed by the National Infrastructure Commission (NIC). This technical report summarises analysis by consultants Arup, modelling the level of investment needed in London's infrastructure to 2041.

The consultants estimate the total capital and operating expenditure requirements to be in the region of £968bn (in 2018 prices) over this period. This includes expenditure by the public and private sectors across a range of infrastructure types. Almost 80% of the costs relate to London's transport and affordable housing needs. While the scale of investment required is substantial, the deep economic links between the capital and the rest of the UK mean the benefits would extend far beyond London's boundaries<sup>1</sup>.

Cost estimates made over a time horizon of more than twenty years are inevitably subject to considerable uncertainty. The modelling relies on a number of working assumptions detailed throughout the report. Infrastructure projects are often highly complex with many technical challenges to overcome at the planning and construction phases. Costs are typically adjusted for risk and optimism bias and contingencies made for overruns. However, even with these allowances it is not uncommon for budgets for major infrastructure projects in the UK and internationally to increase over time. History suggests that the cost estimates in the report should therefore be considered a lower bound.

The cost estimates for the infrastructure sectors in scope are summarised in the table below and include the following:

- **Transport** costs cover investments to deliver the Mayor's Transport Strategy, including major schemes like Crossrail 2 and line extensions, as well as policies to encourage more people to walk, cycle and reduce their car use.
- **Affordable housing** costs reflect the need to deliver 32,500 affordable homes per annum in accordance with the draft London Plan.

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<sup>1</sup> Mayor of London (2019) '[London and the UK: A Declaration of Interdependence](#)'.

- **Energy sector** costs include those required to support London's transition to a net zero carbon city by 2050, including measures to improve the energy efficiency of buildings and investment in new forms of low carbon energy infrastructure.
- **Green infrastructure** costs include those for new green cover, the renewal of existing green spaces, as well as Sustainable Urban Drainage solutions which manage the flow of rainwater into the combined sewer system.
- **Water infrastructure** costs include investment to improve London's resilience to flooding, and in the water supply network to cope with additional demand and reduce leakages.
- **Digital infrastructure** costs reflect the roll-out of full fibre broadband technologies and a 5G mobile network across London.
- **Waste** costs include those to manage the waste generated by a growing population, more of which needs to be recycled and re-used.

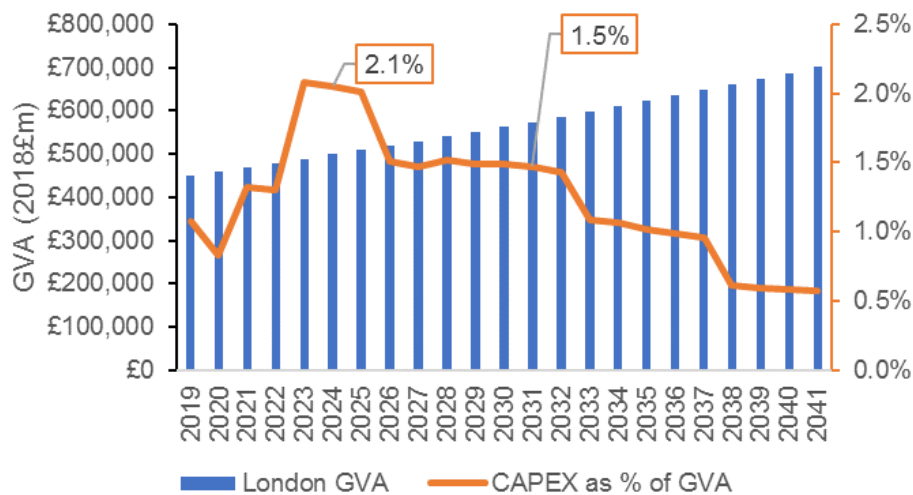
**Figure 1: Projected Capital (Capex) and Operational (Opex) Expenditure Requirements 2019-2041 (2018£bn)**

|  | Projected capital expenditures, 2019-41 (2018£bn) | % Capex total | Projected operational expenditures, 2019-41 (2018£bn) | % Opex total |
|--|---|---------------|---|--------------|
| <b>Transport</b>   | 150   | 28%           | 295   | 69%          |
| <b>Housing</b>   | 263   | 49%           | 47  | 11%          |
| <b>Energy</b>  | 65  | 12%           | 41  | 10%          |
| <b>Waste</b>   | 0.2   | 0%            | 19  | 5%           |
| <b>Digital</b>   | 9   | 2%            | 1   | 0%           |
| <b>Green</b>   | 30  | 6%            | 8   | 2%           |
| <b>Water</b>   | 19  | 3%            | 16%   | 4%           |
| <b>Fire &amp; Police / Mayoral Development Corporations (capex only)</b> | 5   | 1%            | N/A   | N/A          |
| <b>Total</b>   | <b>541</b>  | <b>100%</b>   | <b>427</b>  | <b>100%</b>  |

Source: Arup

To put these large sums in context, the National Infrastructure Commission (NIC) was given a fiscal remit by Government that capped its spending recommendations for national infrastructure at 1.2% of UK GDP. On a like-for-like basis<sup>2</sup>, the analysis in this report implies capital expenditure by the public sector on infrastructure in London which averages 1.2% of the city's economic output (Gross Value Added) over the period. This peaks in the 2020s at around 2.1% of London's GVA. The higher proportion of spending in the 2020s reflects capital expenditure on major projects like Crossrail 2, and is consistent with the NIC's profiling of investment in the National Infrastructure Assessment.

**Figure 2: Public sector capital expenditure requirement as a % of London's GVA**

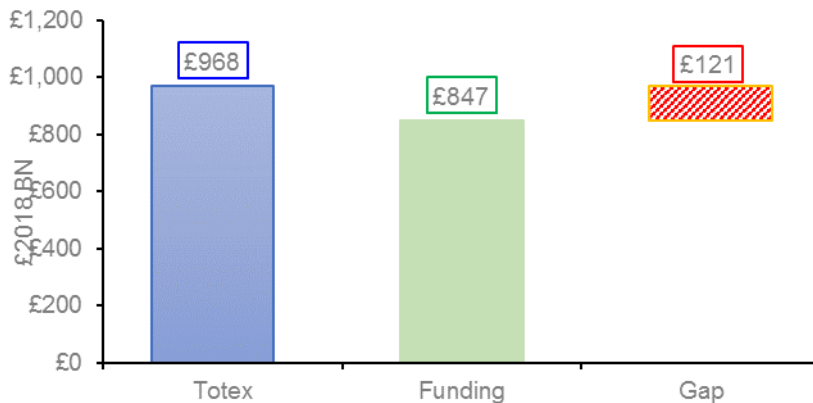


Source: Arup

A variety of different funding sources will be needed to meet the costs identified in the report. The research identified existing public and private sector funding streams that could reasonably be expected to continue and rolled them forward to derive the public sector funding gap. Most of this funding is outside the Mayor's control and cannot be guaranteed. If it were to continue at similar levels, the analysis estimates a funding gap of £121bn over the period, however should any of these funding streams fall away, the gap would increase.

<sup>2</sup> The definition of infrastructure adopted by the NIC in the National Infrastructure Assessment (NIA) is narrower than that in this report as it excludes affordable housing, green infrastructure, fire and police. It also covers capital expenditure only and not operating expenditure.

**Figure 3: Public sector funding gap 2019-2041 (2018£bn)**



Source: Arup

The clear conclusion of the analysis is that current funding mechanisms are insufficient to pay for London's long-term infrastructure needs. Closing the gap will require a range of measures including better use of existing assets, deriving greater commercial income from the infrastructure asset base, and cost savings in future projects.

However, even with these efficiency measures, new funding mechanisms will need to be considered. One is the tax uplift anticipated from some of the major housing and transport investments in the Mayor's strategies. In addition, there may be a need to introduce additional marginal local taxation or new fees and charges to fund the infrastructure London needs to grow sustainably. The Mayor has argued that London and the core cities need greater autonomy and long-term certainty over funding for infrastructure, as recommended by both the London Finance Commission<sup>3</sup> and the National Infrastructure Commission<sup>4</sup>.

<sup>3</sup> London Finance Commission (2017) '[Devolution: a capital idea](#)'.

<sup>4</sup> National Infrastructure Commission (2018) '[National Infrastructure Assessment](#)', Chapter 4.

# 1. Introduction

The GLA commissioned consultants Arup in Summer 2018 to develop a model estimating the scale of investment needed in London's infrastructure to 2041 and the size of the public sector funding gap. The work builds upon previous modelling for the [London Infrastructure Plan 2050](#) (2014 and updated in 2015) and [London's Strategic Infrastructure Requirements to 2030](#) (2017)<sup>5</sup>. An update of the cost and funding estimates in these documents was needed to reflect the current Mayor's vision for London and the policy objectives set out in his published strategies and plans<sup>6</sup>.

The key research questions for this assignment were:

- i. What are London's long-term strategic infrastructure requirements (within the scope identified) and their costs?
- ii. What are the existing funding streams available to deliver these requirements?
- iii. What is the size of the public sector funding gap?

This technical report summarises the main findings from Arup's analysis and explains the underpinning assumptions in the model. A Steering Group comprised of senior officers from the GLA and TfL oversaw development of the model. Contributions were also sought from external stakeholders where necessary. The following infrastructure sectors were agreed by the Steering Group to be in scope:

- Transport (excluding aviation)
- Affordable housing
- Energy
- Water supply, flooding and drainage
- Green infrastructure
- Waste management
- Digital connectivity (fixed and mobile)

In addition, to reflect the Mayor's statutory responsibilities and to align with the GLA Group Capital Strategy, capital expenditure for police and fire services as well as the London Legacy Development Corporation (LLDC) and the Old Oak Park Royal Development Corporation (OPDC) were also profiled in the model<sup>7</sup>.

The research drew heavily on existing models and analysis of costs and funding sources, including:

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<sup>5</sup> The figures quoted in this report cannot be directly compared with those in the London Infrastructure Plan 2050 as the methodology has been updated to reflect new objectives and information.

<sup>6</sup> The Mayor's priorities for infrastructure are primarily set out in his Transport, Housing, Environment and Economic Development strategies and in the draft London Plan.

<sup>7</sup> The potential for overlap between capital investment requirements for Mayoral Development Corporations and those in the main infrastructure sectors is acknowledged but not deemed to be significant.



- Cost estimates developed by Transport for London (TfL) for the Mayor's Transport Strategy and the National Infrastructure Commission (NIC).
- Modelling of London's affordable housing funding requirements by the GLA with partners in the sector<sup>8</sup>.
- Modelling of the infrastructure requirements and costs of the transition to London becoming a net zero carbon city<sup>9</sup>.
- The GLA's waste forecasting model and Waste and Resources Action Programme (WRAP).
- Evidence from the Environment Agency on flood risk mitigation requirements and costs, and from Thames Water on London's water infrastructure needs.
- Modelling undertaken previously for the London Infrastructure Plan 2050.
- The GLA's Capital Strategy published as part of the GLA Group Budget<sup>10</sup>.

The analysis gives a sense of the order of magnitude of the funding challenge in London. Over a time horizon of more than 20 years, there is inevitably significant uncertainty over many of the inputs and assumptions used in the model. This includes uncertainty about future population growth, economic growth, the pace of climate change, technological change, future government policy and funding, as well as public attitudes and behaviours.

These, and many other factors, will affect the types of infrastructure required and the eventual costs. The modelling inevitably relies on a number of working assumptions which are made in good faith and draw on the expertise of Arup, GLA officers and stakeholders. All figures in the report are subject to ongoing review and revision as new information comes to light. **Where assumptions have been made about existing funding sources, these represent working assumptions for the purposes of the modelling and do not represent funding commitments.**

This report presents the central estimates of the costs and funding requirements for each of the main infrastructure sectors. The key assumptions which underpin these calculations can be adjusted in the model to examine different scenarios and perform sensitivity tests. All figures presented are expressed in undiscounted 2018 prices. Nominal inputs were adjusted to 2018 prices using the Bank of England target inflation rate of 2% per annum.

The costs reported do not assume any additional efficiency or real cost increases over and above what has been assumed in other GLA models. Efficiency and inefficiency sensitivities for capital and operational expenditure can be tested in the model. The model reports figures over the period from 2019 to 2041 (in calendar years), annually and five-yearly.

The rest of this report is structured as follows. Chapter 2 provides a summary of the headline findings from the modelling. Chapters 3-10 provide more detail on the costs and funding gaps in each of the main infrastructure sectors within scope. Chapter 11 draws conclusions from the analysis.

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<sup>8</sup> Mayor of London (2019) '[The 2022-2032 Affordable Housing Funding Requirement for London: Technical Report](#)'

<sup>9</sup> See Mayor of London (2018) '[Zero carbon London: 1.5°C compatible plan](#)'

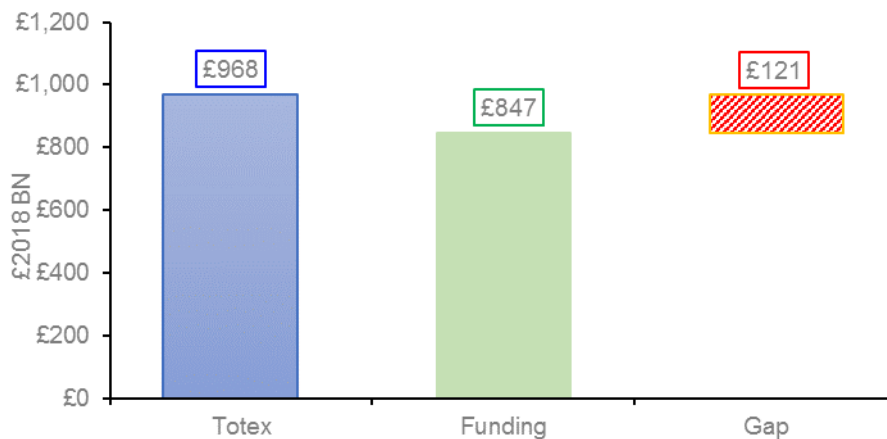
<sup>10</sup> See Annex A for an explanation of the differences between this report and the GLA Group Capital Strategy.

## 2. Headline Findings

The model estimates that London's long-term infrastructure requirements will exceed £541 billion in capital expenditure and £427m in operating expenditure over the period 2019-2041 (2018 prices). This equates to total expenditure of £968bn in the period.

The projected level of funding over the period is £847bn based on best estimates of the currently available public and private funding sources rolled forward. This leaves a total estimated public sector funding gap of £121bn over the period in the central scenario.

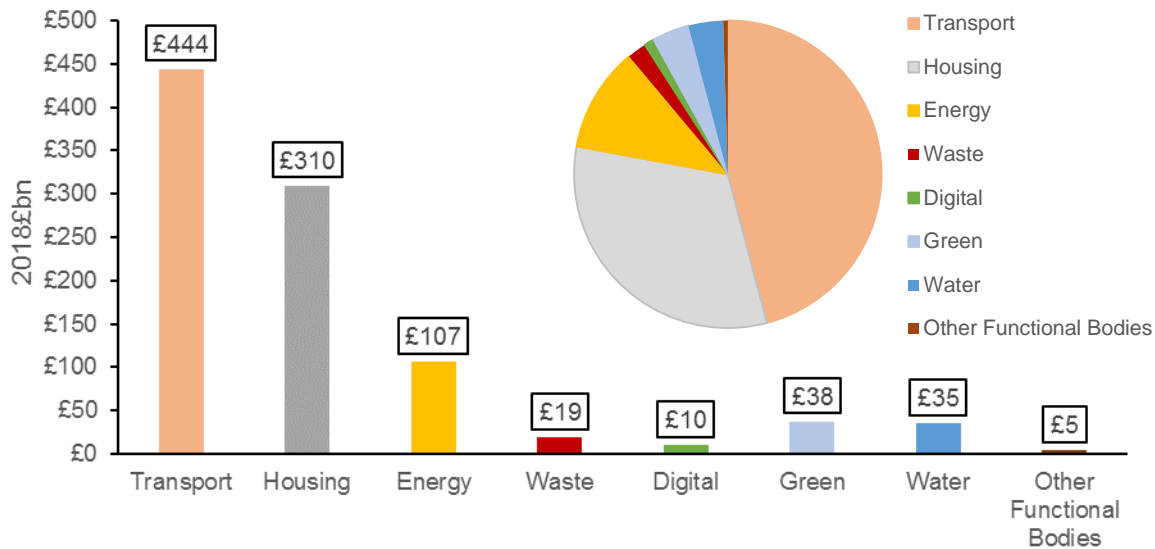
**Figure 4: London's Infrastructure Funding Gap – All Sectors 2019-2041**



Source: Arup

Examining total expenditure requirements by sector (Figure 5) reveals that almost 80% of costs are in the affordable housing and transport sectors. However, the projected total costs for energy, waste, water, green, and digital infrastructure also each run into the tens of billions.

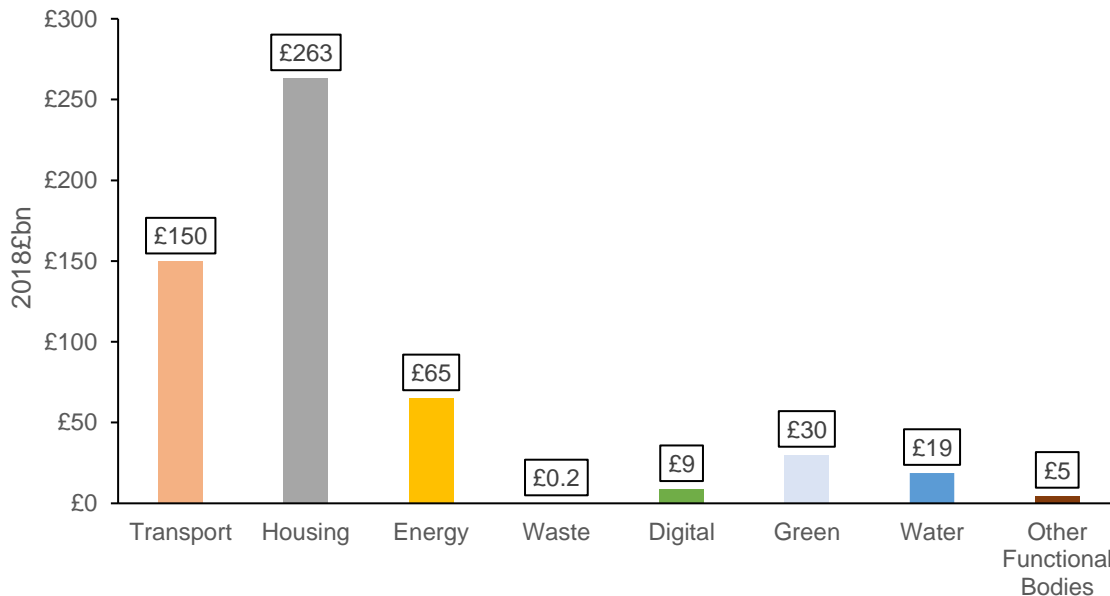
**Figure 5: Total Expenditure by sector 2019-2041**



Source: Arup

Looking only at capital expenditure requirements, costs are also highest in the affordable housing sector (£263bn) and in transport (£150bn).

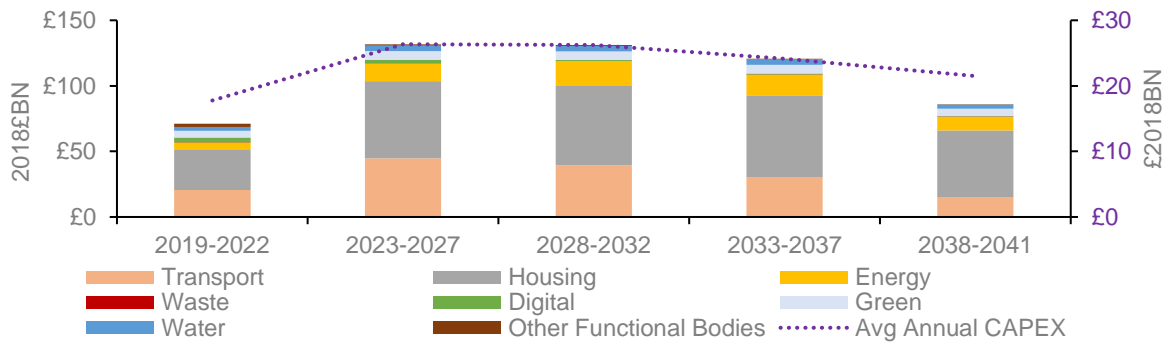
**Figure 6: Capital expenditure requirements by sector 2019-2041**



Examining the profile of capital expenditure requirements over time (Figure 7), there are higher average annual requirements in the mid to late-2020s/early 2030s when transport capital expenditure requirements are highest (see Chapter 3). Capital spending requirements for housing remain reasonably consistent over time reflecting the delivery of the draft London Plan annual affordable housing target (see Chapter 4). It should be noted that capital spending in the period up to 2022/23 is constrained in the model by current

levels of funding and largely reflects current spending plans<sup>11</sup>. Beyond 2022/23, the model reflects capital spending ambitions to achieve Mayoral policy and strategy objectives.

**Figure 7: Capital expenditure requirements over time and by sector (2018£bn)**



Source: Arup

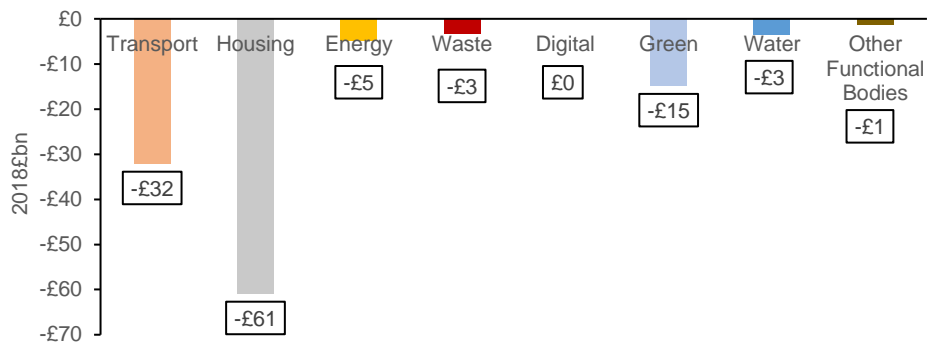
Figure 8 shows the public sector funding gap across all sectors and totals an estimated £121bn over the period. The biggest gaps in public funding are in affordable housing (£61bn) and transport (£32bn).

As discussed later in the report, the model makes some key assumptions about the expected level of private sector funding which means the funding gap in some sectors appears relatively small compared to housing and transport (although nonetheless still challenging). There is a risk that private sector funding is not forthcoming or does not bring about the scale, pace and type of change in infrastructure provision that is consistent with the Mayor's strategic objectives. Financial incentives funded by the public sector may also be required meaning these estimates should be considered a lower bound.

Moreover, where existing levels of public funding for infrastructure have been assumed to roll forward for modelling purposes, they are in practice is subject to considerable uncertainty.

<sup>11</sup> Financial years have been converted to calendar years in the modelling.

**Figure 8: The public sector funding gap by sector (£bn) 2019-41**



*Source: Arup*

The chapters below provide further detail on the infrastructure needs in each sector together with the projected costs and funding requirements.

### 3. Transport

The projected increase in London's population will create significant pressures on already crowded and congested transport networks. The Mayor's Transport Strategy (MTS)<sup>12</sup> sets out his vision and objectives for the transport network in London to 2041. The overarching aim of the MTS is to shift more trips to sustainable modes of travel in order to reduce carbon emissions, improve air quality and health outcomes. This will be achieved through a variety of different policies notably the Healthy Streets Approach (encouraging active forms of travel), and through investment in the public transport network to increase capacity and frequency of services. New public transport links and extensions are also needed to unlock sites for development.

To keep the scope of the modelling manageable, cost estimates have been limited to the spending items listed in the table below. These are principally the costs identified by Transport for London to deliver the MTS along with some additional items including a proportion of High Speed 2 to be delivered in London, spending on the maintenance of non-Transport for London Road Network (TLRN) roads, and investment by Network Rail and the Train Operating Companies.

It is acknowledged that there may be other expenditures on the transport network by boroughs, central government and the private sector which are additional to the costs included here.

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<sup>12</sup> Mayor of London (2018) '[Mayor's Transport Strategy](#)'

**Figure 9: Transport items included in the cost estimates**

| Cost Category             | Cost type                | Cost items   |
|---------------------------|--------------------------|--|
| Transport for London      | Capital expenditures     | Crossrail 1 & 2<br>Line extensions<br>Line upgrades<br>Enhancements<br>Renewals  |
|                           | Operational expenditures | Public transport costs<br>Non-public transport costs   |
| Non-TLRN roads            | Operational expenditures | Maintenance costs  |
| High speed rail           | Capital expenditures     | 50% HS2 phase 1<br>HS2 Euston & Old Oak Common   |
|                           | Operational expenditures | 5% cumulative capex HS2<br>50% HS1   |
| Network Rail              | Capital expenditures     | 30% (assumed share of operations in London based on Arup analysis) of Network Rail Capex from Business Plan CP6        |
|                           | Operational expenditures | 30% (assumed share of operations in London based on Arup analysis) of Network Rail Opex from Business Plan CP6         |
| Train Operating Companies | Operational expenditures | 30% (estimated share of operations in London based on Arup analysis of TOCs route km operating in London) of TOCs Opex |

With reference to the table above:

- Line Extensions include the Northern Line Extension, Bakerloo Line Extension and Upgrade, Elizabeth line extension, Overground, DLR and Tram network extensions.
- Line Upgrades include Four Lines Modernisation (Circle, District, Hammersmith & City and Metropolitan lines), Deep Tube Upgrade (the Piccadilly, Central and Waterloo & City lines), World Class Capacity (service capacity increases on the Victoria, Jubilee and Northern London Underground Lines), Docklands Light Railway new rolling stock and increasing the frequency of the Elizabeth line.
- Enhancements includes the balance of TfL's new capital investment expenditure across all parts of TfL
- Renewals expenditure is necessary to ensure the continued safe operation of transport services

Aviation costs have been excluded from the analysis owing to ongoing uncertainty about how London's airport capacity requirements will be met and the Mayor's objections to the

current plans for expansion of Heathrow. Transport investments to service aviation facilities are included in TfL's capital expenditures, but exclude the potential impact of a third runway at Heathrow.

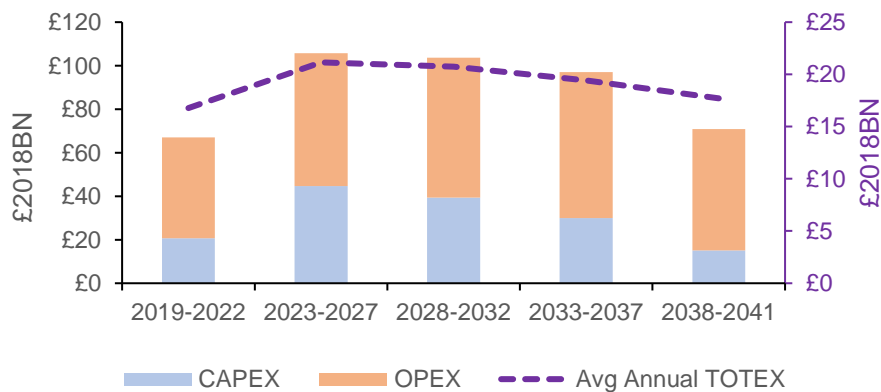
Where non-TfL spending is across several regions, a "London share" has been estimated based on the geographical spread of the asset and its users. This includes an estimate of Network Rail and Train Operating Companies' expenditures apportioned to London as well as high speed rail.

### Estimated costs of London's transport requirements to 2041

The total expenditure requirement for transport is estimated to be £444bn (2018 prices). Projected capital expenditure requirements are £150bn and projected operational expenditure requirements are £295bn over the period 2019-41.

The profile of these costs is shown in Figure 10 below. In the period to 2022/23, costs are based on TfL's Business Plan and expenditure within the constraints of current levels of funding. Beyond April 2023, expenditure is based on the aspirations identified in the MTS including the need to fund major schemes. Capital expenditure requirements are expected to be highest during the mid-2020s to early-2030s largely as a result of the investment required for Crossrail 2 and line extensions.

**Figure 10: Transport capital and operating expenditure 2019-2041 (2018£bn)**



Source: Arup

The projected costs by transport category are summarised in Figure 11 and discussed in further detail below.



**Figure 11: Summary of capital and operating expenditures by cost category 2019-41**

|                      | Capital expenditure<br>(2018£m) | Operating expenditure<br>(2018£m) |
|----------------------|---------------------------------|-----------------------------------|
| Transport for London | £96,406                         | £165,342                          |
| High speed rail      | £14,342                         | £11,476                           |
| Network Rail & TOCs  | £40,159                         | £105,139                          |
| Non-TLRN roads       | -                               | £12,627                           |
| <b>Totals</b>        | <b>£150,908</b>                 | <b>£294,584</b>                   |

Source: Arup

#### *Transport for London*

TfL's capital expenditures were sourced from the Mayor's approved Capital Strategy. Figure 12 provides a summary of these capital costs in 2018 prices, which total £96bn over the period 2019-2041.

**Figure 12: TfL Capital requirements 2019 to 2041 (2018£m)**

|                                      |                |
|--------------------------------------|----------------|
| Crossrail 1 & 2                      | £33,711        |
| Line extensions                      | £16,102        |
| Line upgrades                        | £14,045        |
| Enhancements                         | £15,644        |
| Renewals                             | £16,904        |
| <b>Total TfL capital expenditure</b> | <b>£96,406</b> |

Source: Arup

The Capital Strategy provides spending estimates up to 2037/2038, therefore the annual expenditures in the period from 2038 to 2041 for line upgrades, enhancements and renewals were extrapolated from the period 2033/34 to 2037/2038 to extend the analysis to 2041. Costings for Crossrail 2 are in line with the Independent Affordability Review. Financing costs are excluded from the analysis.

TfL's Business Plan for 2019/20-2023/24 holds operating expenditure effectively flat in constant prices despite the additional operating costs of the Elizabeth line, Ultra Low Emission Zone, Tube/ Rail timetable improvements, the Northern Line Extension and Barking Riverside extension. The aim is for this to be achieved by delivering significant operating efficiencies. Future operational expenditures beyond the Business Plan period were estimated based on a split between public transport costs (assumed to rise in real terms to reflect the introduction of new services) and non-public transport costs (assumed to remain at the same level in real terms).

### *High speed rail*

The capital construction cost of High Speed 2 (HS2) phase one London to West Midlands is estimated to be £24.3billion (2011 prices, sourced from HS2 2015 Spending Review Settlement<sup>13</sup>). HS2 is a national infrastructure project but an assumption has been made that 50% of the cost for phase one is attributable to London which is consistent with the London Infrastructure Plan 2050. Renewals for HS2 have been calculated based on the HS2 business case. In the case of HS1, capital renewals were based on available information from Control Period (CP2) outlook accounts, also in line with the London Infrastructure Plan 2050.

HS2 operational and maintenance costs are based on a benchmarking of other sectors. HS1 operational and maintenance costs were sourced from CP2 outlook accounts and extrapolated to cover future years.

### *Network Rail and Train Operating Companies*

Network Rail Capital costs consisting of enhancements and renewals have been included based on information obtained from the Network Rail CP6 Business Plan. According to this, Network Rail will spend £28.6bn in capital expenditure over this control period. A working assumption has been made that the expected share of costs affecting London is approximately 30% (based on Arup analysis of route km). These costs have been extrapolated to cover the period up to 2041. 30% of operating expenditures for both Network Rail and Train Operating Companies are also attributed to London. At this stage, no shift of operating costs from Train Operating Companies or Network Rail to TfL has been assumed in relation to the further devolution of rail services or infrastructure.

Some costs not included in the Network Rail Business Plan have been added to cover the costs of 'Metroisation' (a London suburban metro, offering improved frequencies, journey times and interchange opportunities). These are schemes in the TfL Capital Strategy where it is assumed that TfL would cover a portion of the full costs.

### *Non-TLRN roads*

For borough roads, capital improvements are included in TfL's investment plans for the Mayor's Transport Strategy, but the costs associated with their maintenance are not. A separate estimate for operational expenditures associated with borough roads was

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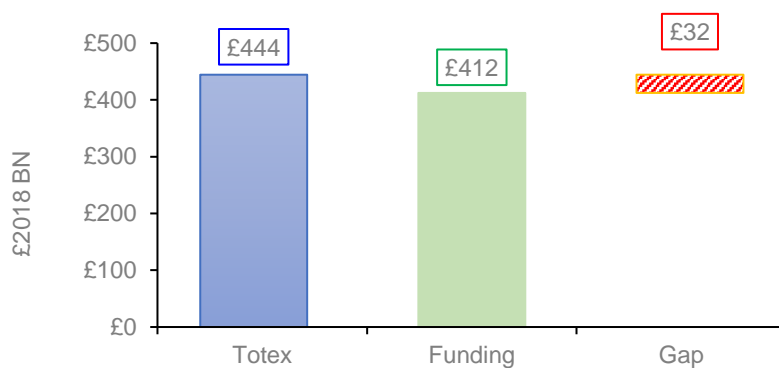
<sup>13</sup> In September 2019, the Government announced that HS2 is expected to exceed the original budget and subject to a review.

therefore added. The same benchmarks used in the London Infrastructure Plan 2050 were adopted. For the Strategic Road Network (Highways England roads; the M11; M4 and M1), maintenance based on a per mile rate was also added.

### The transport funding gap

As is normal, not all the funding for future transport infrastructure schemes has yet been identified. Funding packages for major schemes will continue to be developed by scheme promoters. Estimates of likely funding against the expenditure items identified in Figure 9 were made to derive the public sector funding gap. As shown in Figure 13, this is estimated to be £32bn for the period 2019-2041 (2018 prices).

**Figure 13: Transport public sector funding gap 2019-2041 (2018£bn)**



Source: Arup

Transport for London capital funding assumptions were sourced from the Mayor's approved Capital Strategy. Funding sources assumed in the model include: retained business rates, capital receipts, capital grants, revenue contributions (operating surpluses), and Crossrail funding sources.

With respect to Crossrail 2, an assumption has been made that the Department for Transport will fund 50% of the cost and that the Mayoral Community Infrastructure Levy (MCIL2) and the Business Rate Supplement (BRS2) will continue. Further information can be found in the GLA Group Budget 2019/20.

TfL is increasingly covering its operating costs from fares and other income and has set the financial objective of breaking-even on the cost of day-to-day operations, which includes renewing and maintaining the network and covering the cost of financing by 2022/23. It is therefore assumed that all operating expenditures are covered by operating revenues. From 2022/23, it is assumed that all renewals will also be covered by operating revenues, in line with TfL's Capital Strategy.

Costs relating to Network Rail, HS2 and the Strategic Roads Network in London are assumed to be met from central government funding sources.

Borough funding for highways and transport, and from relevant capital receipts are included at the 2018 level reflecting their 'Capital Expenditure and Receipts' reporting. These are extrapolated and maintained at the same level in real terms throughout the model period.

A large proportion of total transport costs identified are operating expenditures which are assumed in the study to be fully funded by operating income. Of the capital expenditure requirements, those funded by central government (for high speed rail, Network Rail and the Strategic Road Network) are also assumed to be fully funded. The remaining funding gap therefore relates almost entirely to TfL capital expenditure for which future funding is unclear.

## 4. Affordable Housing

The Mayor's draft London Plan has identified capacity for 65,000 net new homes a year in the capital<sup>14</sup> and sets a strategic target for 50% of all new homes delivered to be genuinely affordable<sup>15</sup>. The model provides an estimate of:

- The cost to build and maintain 32,500 affordable homes a year over the period to 2041.
- Expected levels of future funding - from developer contributions, registered providers' borrowing against future revenues, cross-subsidy from private sales, and a continuation of current Affordable Homes Programme grant funding.
- The funding gap - the difference between the total estimated costs to build 32,5000 affordable homes and the expected funding streams.

These estimates are based on a separate model developed by the GLA Housing and Land Directorate together with industry stakeholders in the affordable housing sector and the consultants Beacon Partnership LLP. Further detail can be found in 'The 2022-2032 Affordable Housing Funding Requirement for London' Technical Report<sup>16</sup>. As the affordable housing model covers the period 2022-2032, cost and funding estimates were adjusted to cover the study period 2019-2041. Expenditure and borrowing requirements by local authorities are included alongside other registered providers of affordable housing.

The infrastructure requirements associated with this affordable housing, such as transport, utilities, green, or digital infrastructure to service sites, are not included in this section. Some of these requirements are captured in the costings for other infrastructure sectors in this report, but it is unlikely that all are. Other costs associated with affordable housing such as land remediation, land assembly or for the regeneration of local areas are also excluded.

### Estimated costs of London's affordable housing requirements

The total costs of the modelled housing requirements over the period 2019-2041 are estimated to be £310bn (2018 prices). These costs include capital expenditure requirements for affordable housing and their maintenance costs. The total capital expenditure requirement is £263bn while operating expenditure requirements are £47bn over the period. The profile of the required capital and operating expenditure is set out below.

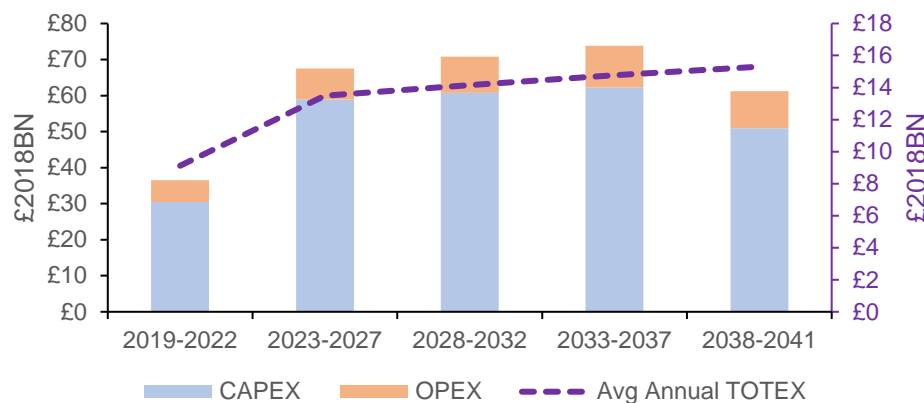
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<sup>14</sup> GLA, Draft New London Plan, [Chapter 4: Housing](#)

<sup>15</sup> Ibid.

<sup>16</sup> Mayor of London (2019) ['The 2022-2032 Affordable Housing Funding Requirement for London: Technical Report'](#)

**Figure 14: Affordable Housing Capex and Opex requirements (2018£bn)**



Source: Arup

It should be noted that spending prior to 2023 is based on the expected rate of delivery that can be achieved from the current Affordable Homes Programme grant settlement, rather than the targeted rate of delivery. Beyond 2023, the model is based on the capital expenditure needed to deliver the target of 32,5000 homes per annum.

The affordable housing capital expenditure estimates are sourced from the GLA Housing and Land/ Beacon Partnership LLP model, which drew upon the expertise of a working group of affordable housing providers. Maintenance costs are sourced and updated from the London Infrastructure Plan 2050 model which used benchmark data from the Building Cost Information Service (BCIS).

### The affordable housing funding gap

The funding sources for affordable housing capital expenditure included in the model are:

- Borrowing secured by Registered Providers against the income streams from new affordable homes and sales receipts from intermediate (shared ownership) homes.
- Developer contributions from private sector led developments (Section 106 agreements).
- Cross-subsidy generated from the sales of market homes built by affordable housing providers.
- Government grant from the 2016-21 Affordable Homes Programme (assumed to continue until 2041).

The total funding and funding gap for capital expenditures over the period is shown in the table below.

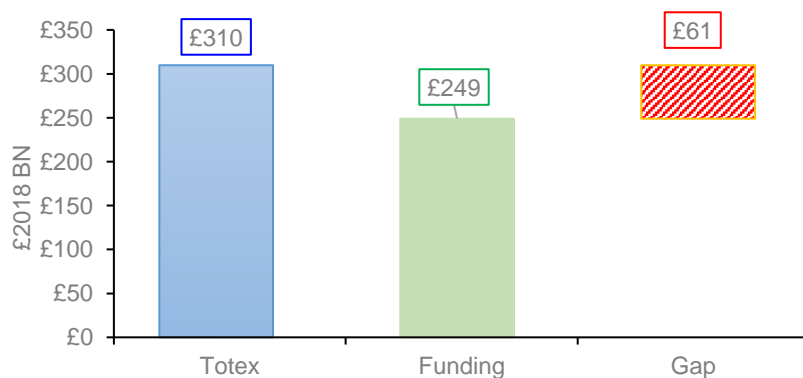
**Figure 15: Summary of housing capital funding and the funding gap 2019 to 2041 (2018£m)**

| Funding source   | Estimated funding 2019-2041 (2018£m) |
|--|--------------------------------------|
| Borrowing against revenue, and first tranche sales receipt (2023-2041) | £116,700                             |
| Developer contributions (2023-2041)                                    | £36,000                              |
| Affordable housing providers' cross-subsidy (2023-2041)                | £6,100                               |
| Affordable Homes Programme   | £16,800                              |
| Funding assumed 2019-2023 (non-Affordable Homes Programme)             | £26,700                              |
| <b>Total capital funding</b>   | <b>£202,300</b>                      |
| <b>Total capital expenditures</b>                                      | <b>£263,200</b>                      |
| <b>Capital funding gap</b>   | <b>£60,900</b>                       |

Source: Arup

Operational expenditures relating to affordable housing are assumed to be entirely covered by rents and service charges received by providers from the new affordable housing. Over the draft London Plan period, the model predicts a funding gap of approximately £61bn as shown below.

**Figure 16: Affordable housing funding gap 2019 to 2041 (2018£m)**



Source: Arup

The primary public sector funding source for affordable housing is the Affordable Homes Programme, which has been agreed with central government for the period up to March 2022. Although there is no funding certainty beyond this date, the model assumes that as a minimum baseline the current average level of government grant funding (£689 million per annum) will continue. This is consistent with the GLA Capital Strategy.

The GLA also has access to several smaller public sector funding programmes that support new housing supply. These include the Housing Infrastructure Fund, and the Mayor's Land Fund. These capital grant funds enable new housing delivery (both private and affordable) through investment in land assembly and infrastructure, in order to correct market failures that constrain residential development within London. These funds have been excluded from the funding gap calculations to keep the project's scope manageable. However, funding to support land assembly and enabling infrastructure will continue to be required after March 2022. Any future calculations regarding funding gaps for land assembly and/or enabling infrastructure therefore should be added to the Affordable Homes Programme funding gap detailed within this analysis to give an overall housing funding gap.



## 5. Energy

The Mayor has some of the most ambitious plans to tackle climate change in the world. The London Environment Strategy (LES) was one of the first plans of any city to be compatible with the highest ambition of the Paris Agreement, which aims to limit the global average temperature rise to 1.5C above pre-industrial levels. It commits London to becoming a net zero carbon city by 2050. Achieving this will require a mix of policy, regulatory and legislative changes as well as significant investment.

To understand how the zero-carbon target can be met, the GLA commissioned Element Energy to model different future buildings and energy systems to assess the impact of different policy scenarios and their costs<sup>17</sup>. The four scenarios modelled were:

1. Decentralised energy – focused on heat networks.
2. High electrification – focused on heat pumps powered by a renewable electricity grid.
3. Decarbonised gas – focused on hydrogen replacing gas in the gas grid and carbon capture and storage enabling hydrogen to be made from natural gas,
4. Patchwork - a combination of heat pumps, heat networks and a partial hydrogen network

All of the pathways to zero carbon rely on a high level of energy efficiency building retrofits by 2030. Only 35% of homes currently achieve adequate energy efficiency performance (EPC C or above) and many will still be in use by 2050. At least 70% of London's buildings need to reach EPC C by 2030.

The costs associated with the four scenarios above, including the necessary energy efficiency retrofits, have been incorporated into the model. Those described below relate to the Patchwork scenario and are sub-divided into building-level costs and infrastructure costs as outlined below.

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<sup>17</sup> For more information on the four scenarios see Mayor of London (2018) '[Zero Carbon London: A 1.5°C compatible plan](#)'.

**Figure 17: Energy costs included in the model (patchwork scenario)**

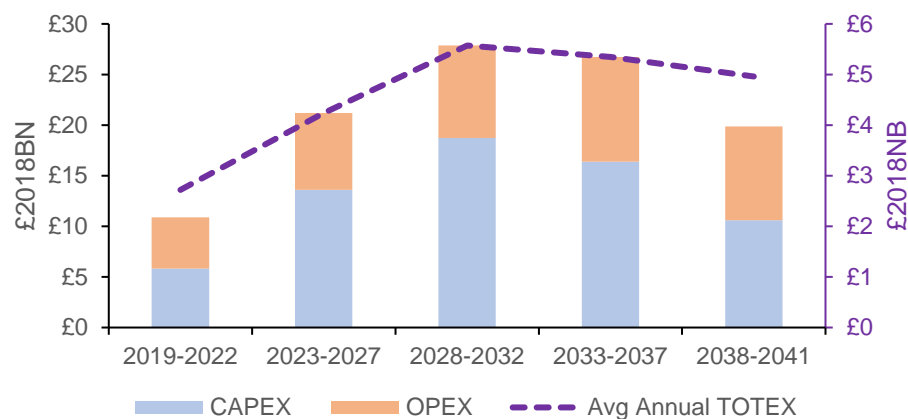
| Building level costs       | Infrastructure                          |
|----------------------------|---|
| Energy efficiency          | Electricity grid upgrades               |
| District heating           | Network storage & additional generation |
| Heat pumps                 | District heating                        |
| Solar thermal              | Hydrogen grid                           |
| Hydrogen Boilers           | Electric Vehicle (EV) charging          |
| Gas Boilers                | Hydrogen refuelling                     |
| Electric heating           |   |
| Photovoltaics              |   |
| Smart installation         |   |
| Electricity storage        |   |
| Additional thermal storage |   |

The Element Energy model looks at peak demand and assumed increases in peak demand above a substation's capacity that would result in upgrade requirements. It does not consider the network's ongoing maintenance and replacement programme or upgrades required for reasons other than peak demand increases. Therefore, an allowance has been made for non-load related operation and maintenance costs associated with the current electricity and gas networks.

### Estimated costs of London's energy requirements

The total expenditure requirement in the energy sector in the central 'patchwork' scenario is estimated to be £107bn over the period 2019-2041 (2018 prices). Capital expenditure requirements over this period are estimated to be £65.1bn, of which 89% are building-level costs mainly associated with energy efficiency retrofits and heat pumps.

**Figure 18: Energy capital and operational expenditure requirements (2018£bn)**



Source: Arup

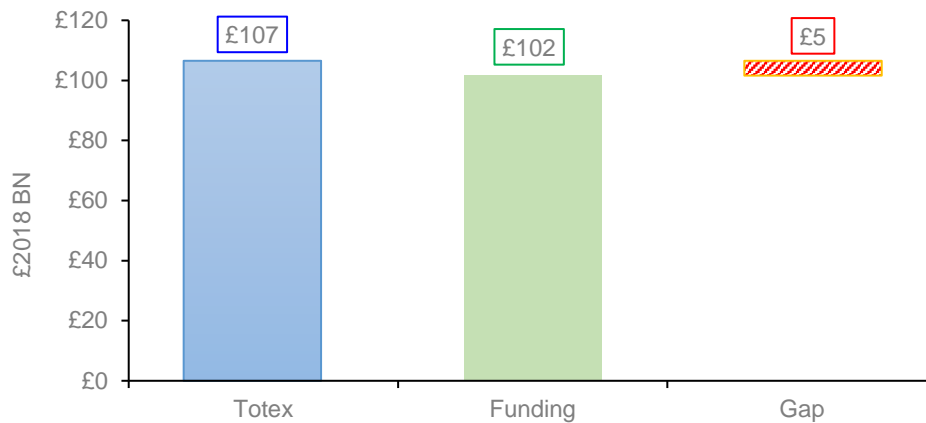
It should be noted that these costs do not include those associated with climate change adaptation. In other words, those costs needed to manage the impact of higher temperatures in London such as future cooling needs. Nor do they include operational expenditures associated with infrastructure-level capital investments. However, the allowance made for ongoing operation and maintenance of the existing electricity and gas networks would be expected to diminish over time and shift to maintaining low-carbon forms of energy infrastructure.

Energy efficiency costs (which account for 22% of total Capex) are derived using a measures-based approach which assumes a combination of insulation, glazing and draught proofing which are sufficient for buildings to reach an acceptable energy performance standard (EPC C). However, a more comprehensive retrofit (e.g. damp correction/proofing) may be required for some London properties, meaning the costs quoted in this report are likely to be a lower bound. There is also uncertainty about how properties with an EPC C rating will be fitted with a heat pump or connected to district heating. The costs associated with these retrofits and the necessary electricity grid upgrades based on the usage of heat pumps and Electric Vehicles remain uncertain and draw on data from a small number of trials.

### The estimated public sector funding gap in the energy sector

The public sector funding gap in the energy sector is estimated to be £5bn over the period 2019-2041 under the patchwork scenario.

**Figure 19: Estimated funding gap in the energy sector in the ‘patchwork’ scenario.**



*Source: Arup*

The public funding gap in the energy sector appears relatively small compared to housing and transport because it is assumed that the private sector will pay for a large proportion of the necessary infrastructure. This includes private households, commercial property owners/occupiers and also utilities providers through the Regulated Asset Base (RAB) via customer bills. The potential future costs associated with incentivising private sector investment have not been included as it is assumed this will be achieved through regulatory or legislative changes. However, financial incentives (with a cost to the public sector) may also be required to achieve the scale and pace of change required to meet the zero-carbon target. Some of the costs assumed to be privately funded may also require public sector support to finance them.

Building level costs are allocated to the public and private sector based on tenure breakdown of London's housing stock. Grid upgrades, additional generation, and operating and maintenance costs associated with electricity and gas networks are assumed to be recovered through customer bills. All other infrastructure related costs are assumed to be covered by the private sector. The public sector costs therefore relate mainly to the cost of retrofitting social housing with energy efficiency improvements and heat pumps. This is consistent with the approach taken in the National Infrastructure Assessment.

Infrastructure-level costs are assumed to be almost entirely funded by the private sector. Electricity grid upgrades, network storage and generation, and operation and maintenance costs are all assumed to be paid for by utilities companies (from the RAB/customer bills). District heating and Electric Vehicle charging are assumed to be paid for mainly by the private sector. Hydrogen refuelling is assumed to be funded by a mix of private sector, RAB and other capital grants.

Some existing public sector capital grants are assumed to continue for homes energy efficiency and commercial and public sector energy efficiency. However, at current levels of funding these only amount to £8.09m over the period.

## 6. Water

Climate change is expected to mean hotter, drier summers and more frequent extreme weather events. London and the wider South East are already classed by the Environment Agency as ‘seriously water stressed’. Thames Water predicts that without action, the combination of climate change and population growth in London, will lead to a shortfall between the amount of water available and the amount needed of 864 million litres per day by 2100.

Climate change is also expected to increase the frequency of intense precipitation events that lead to flash surface and fluvial flooding. Significant investment is therefore needed to ensure London has sufficient water supply and to mitigate flood risk. This includes investment in Sustainable Urban Drainage Systems (SuDS) which reduce the amount of water entering the combined sewerage and drainage network.

To estimate the costs of London’s water infrastructure requirements, four key capital expenditure categories were modelled as set out below. Operational expenditures were also modelled following the same categories.

**Figure 20: Water cost categories included in the model**

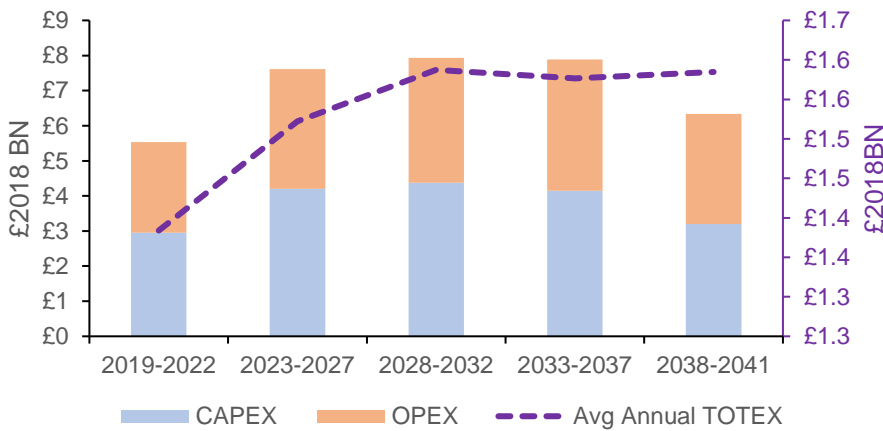
|   |   |
|---|---|
| <b>1. The London Water Resource Zone</b>    | <p><b>Water supply</b><br/>Including leakage prevention, pipe maintenance, reducing supply interruptions/improving resilience, customer and new property connections, reducing per capita consumption.</p> <p><b>Waste Water</b><br/>Including upgrades to treatment facilities, reducing internal sewer flooding and improving resilience to flooding.</p> <p><b>Retail (e.g. IT systems)</b></p> <p><b>Bioresources</b><br/>Including sludge treatment/logistics, renewable energy production.</p> <p><b>Strategic resilience</b><br/>Including new treatment/pre-treatment facilities, pumping stations, storage and connectivity.</p> |
| <b>2. Flood and Coastal Risk Management</b> | <p><b>Fluvial flood risk alleviation</b><br/><b>Surface water management</b><br/><b>Other Flood and Coastal Erosion Risk Management (FCRM)</b></p>  |

|  |  |
|--|--|
| 3. Major projects                            | <b>Thames Estuary 2100 programme</b><br><b>Thames Tideway Tunnel Reservoir</b><br><b>Potable reuse (Deephams)</b><br><b>Groundwater schemes</b><br><b>Oxford canal</b>   |
| 4. Sustainable Urban Drainage Systems (SuDS) | <b>‘Grey’ solutions</b> (e.g. rain collection barrels, artificial ponds and similar measures)<br><b>‘Green’ solutions</b> (e.g. Green roofs). Note: These costs are included in the Green Infrastructure section and excluded here to avoid double counting. |

**Estimated costs of London’s water infrastructure requirements**

The total expenditure requirement in the water sector is estimated to be £35bn between 2019-2041 (£2018 prices) as profiled below.

**Figure 21: Capital and Operating Expenditure requirements in the water sector, 2019-2041 (2018£bn)**



Source: Arup

The capital expenditure requirement over this period is estimated to be £18.9billion. The breakdown of these costs by category is summarised in the table below.

**Figure 22: Capital expenditure requirements in the water sector by category**

|  | <b>Capital expenditure (£2018m)</b> |
|--|-------------------------------------|
| London Water Resource Zone                         | £13,385                             |
| Flood risk   | £1,359                              |
| Major projects                                     | £4,063                              |
| Sustainable Urban Drainage ('grey' solutions only) | £503                                |
| <b>Total</b>                                       | <b>£18,869</b>                      |

Source: Arup

There are a number of assumptions that underpin the estimated costs in the model as set out below.

#### *London Water Resource Zone (WRZ)*

The Greater London population is served by four water companies: Thames Water, Affinity Water, Essex and Suffolk Water and Sutton and East Surrey Water. For the purposes of the modelling, costs have been extrapolated using Thames Water's Water Resources Management Plan (WRMP) and the Business Plan for Asset Management Period 7 (AMP7) 2020-2025. The WRMP covers the entire Thames Water region which is not analogous to the London WRZ. However, since Thames Water is by far the largest water supplier in the region (serving roughly 75% of London's population), these costs have been used as the basis for costing the London area. Unit costs associated with each category were derived and applied to key drivers of growth, principally projections of population growth and the number of properties in London.

The modelling is based on the October 2018 version of the Thames Water Business Plan which is currently under review by Ofwat and subject to revision. It should be noted that these plans do not currently reflect the full ambitions of the Mayor and costings will therefore need to be updated in future iterations of the model.

#### *Flood and Coastal Risk Management (FCRM)*

Figures were obtained from the Environment Agency (EA) on the value of the current Flood and Coastal Risk Management Programme in London and used as a proxy for the costs of flood and coastal risk management. This includes river flooding, surface water management and other flood and coastal risk management. A projected cost of £591m for FCRM was estimated for the ten-year period (2018-2027) and extrapolated by Arup to cover the study period to 2041. The EA has stressed its figures are based on the currently

available information and subject to significant uncertainty. The extrapolation of these figures is based strictly on Arup assumptions and calculations for the purposes of this modelling exercise. Partnership funding will need to play a role in delivering FCRM schemes as Government Grant in Aid funding will often not completely fund a scheme.

### *Major projects*

Thames Estuary 2100 (TE2100) programme costs in the model cover the entire Estuary (not just London) reflecting the need for an integrated programme of investment. The FCRM Programme discussed above includes part of the TE2100 Plan costs but this overlap is not considered to be material to the estimates. While the TE2100 programme identifies the need to improve or replace the Thames Barrier in future, this is currently expected to be in phase 3 of the programme (2050-2100) which is outside the study period, and there are other potential options being explored. Regardless of the decision on a new Barrier, current projections indicate a need for improvements along the network of tidal walls and embankments by around 2040. However, a projection of these costs in London, over and above the previous costings for the entire TE2100 Plan, is not currently available.

The Environment Agency will in due course be reviewing the Thames Estuary 2100 Plan and testing whether the costs and assumptions need to be updated. It should be noted that costs may vary if planned infrastructure projects require works to be brought forward. Projected costs are for tidal flood defence works only and further assessment is required to analyse the gap between the current standard of protection of fluvial flood risk and an acceptable future standard of protection for fluvial flood risk.

### *Sustainable Urban Drainage*

To mitigate flood risk, more of London's surface water needs to drain to Sustainable Urban Drainage Systems (SuDS) rather than into London's combined waste water and sewerage network. Thames Water's emerging London 2100 plan currently estimates that 30% of the impermeable surfaces in London need to drain to SuDS by 2100 to mitigate the effects of climate change. This figure is used as a benchmark requirement but will require updating as the work on London 2100 develops. In order to achieve this target, the model assumes a linear increase in the amount of impermeable surfaces draining to SuDS to arrive at a requirement by 2041.

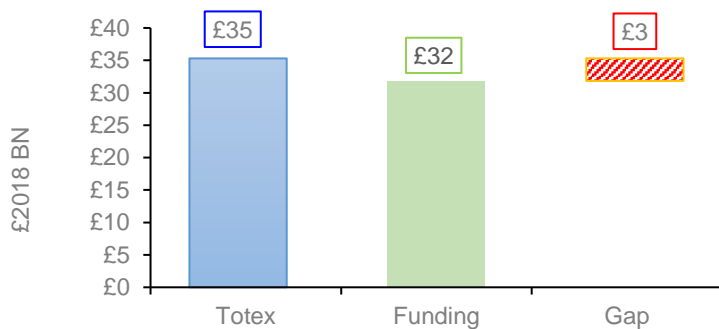
A working assumption has been made that 70% of the SuDS requirement will be met through green infrastructure solutions, which is included in the costs for green infrastructure reported in the following chapter. The remainder will be through 'Grey SuDS' solutions which include rain collection barrels, artificial ponds and similar measures. The cost per square metre of SuDS is estimated based on Arup's experience of similar projects but inevitably subject to variation. All of the above assumptions can be varied in the model.



## The estimated funding gap in the water sector

The estimated funding gap in the water sector is £3.5bn for the period 2019-2041 (2018 prices). The majority of costs in the water sector are expected to be covered through private water companies. However, there is significant uncertainty about future funding for major projects, flood risk management as well as sustainable urban drainage.

**Figure 23: Estimated funding gap in the water sector, 2019-2041 (2018£bn)**



Source: Arup

This funding gap is calculated based on a number of working assumptions about funding across the different cost categories identified above:

- *London Water Resource Zone* - All capex and opex is assumed to be met through the private water companies and user charges. Thames Water currently forecasts no impact on bills in real terms (see TW Business Plan 2020-2025).
- *Major projects* – In the absence of information about future funding, the TE2100 programme is assumed to be unfunded. The Tideway Tunnel is assumed to be 100% funded by the water companies/customer bills. A working assumption was made by Arup that a new reservoir might be 50% funded by the water companies leaving 50% unfunded. All other projects are assumed to be funded by the water companies.
- *FCRM* – Arup assumed that 50% of Capex is funded from Environment Agency grants and additional sources of funding, while 25% is assumed to be fulfilled through private sector partnerships including developers, NGOs, community groups etc. The remaining 25% is considered to be the funding gap. These are all working assumptions made strictly by Arup for modelling purposes only and do not represent funding commitments.
- *SuDS* - It is assumed there is no existing funding in place for grey Sustainable Urban Drainage Systems and there would be an additional public sector funding requirement for these measures.

## 7. Green Infrastructure

There is growing recognition of the importance of London's natural capital (its green spaces, parks, trees and rivers) for their environmental, health and productivity benefits. Together with greener buildings (e.g. buildings with green roofs and walls) and drainage systems that allow rainwater to flow back to rivers and streams more naturally, these assets can be thought of and managed as green infrastructure.

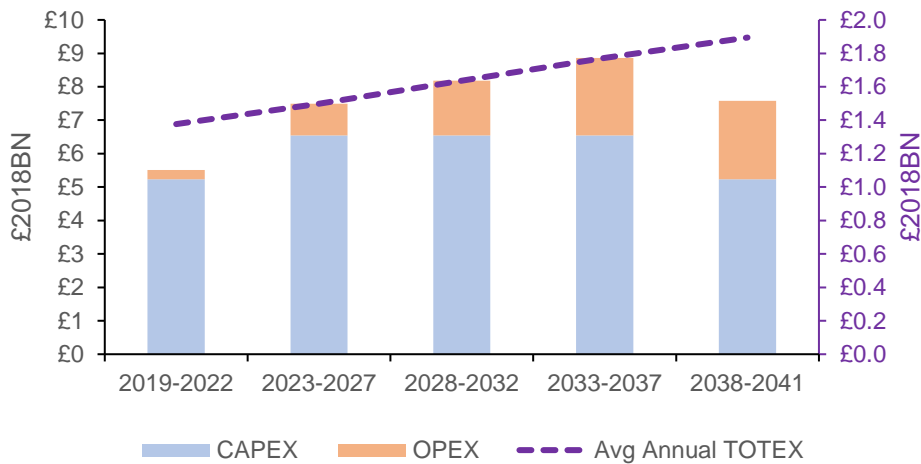
The modelling focused on the cost of meeting the Mayoral target of achieving over 50% green cover across London by 2050. This will require implementing new green cover at a rate that outpaces any losses in green cover. The modelling also includes a capital cost for renewing 10% of existing public sector-owned green cover such as parks. In addition, it is assumed that meeting this green cover target will also mean provision of 'green' Sustainable Urban Drainage Systems (SuDs) such as green roofs.

Operating expenditure in the green infrastructure sector is highly variable as there are a multitude of different operational models from local community trusts to private sector agreements and public-sector management. For the purposes of the modelling, only the public sector costs for operation and maintenance of new green infrastructure delivered during this period is considered. It is assumed that all green cover delivered through the private sector will be operated and maintained through non-public revenue streams and this has therefore not been estimated in the model.

### Estimated costs of London's green infrastructure requirements

The total costs of London's green infrastructure requirements are estimated to be £37.6bn of which £30.1bn is capital expenditure. Of this capital expenditure, the provision of new green infrastructure accounts for an estimated £23.4bn of costs and the renewal of existing green cover for £6.7bn.

**Figure 24: Green infrastructure capital and operating expenditure requirements 2019-2041 (2018£bn)**



Source: Arup

The estimated costs of new green cover provision are based on a number of working assumptions as set out below.

The London land area is estimated to be 160,000 hectares and the lower bound estimate of existing green cover in London of 48% is used as a baseline, sourced from the report 'How Green is London?' published in January 2019. To achieve the Mayoral target, the model assumes the required increase in green cover in London by 2050 to be 3% or 4,700 hectares, increasing linearly over the period.

To account for the expected loss in existing green cover in London associated with development, a working assumption has been made that an additional 2,300 hectares of green cover will be required by 2041 (3% of existing green cover). This assumption has not been validated as data on the loss of greenspace is not available.

A working assumption has been made that 90% of new green cover provision will be delivered through the land-use planning process (e.g. through regeneration and development of former brownfield land). The remaining 10% is assumed to be delivered through enhancement of existing public realm and buildings through investment by local authorities, utilities and infrastructure providers.

In terms of the types of green cover to be provided, the following breakdown has been used for modelling purposes:

- 50% green roofs or walls.
- 30% pocket parks, green links and street trees.
- 20% new amenity green space.

These assumptions can be varied in the model. Benchmark costs per square metre for each of these categories have been sourced from previous projects to calculate overall

costs. Costs are assumed to remain constant in real terms over the period through to 2041.

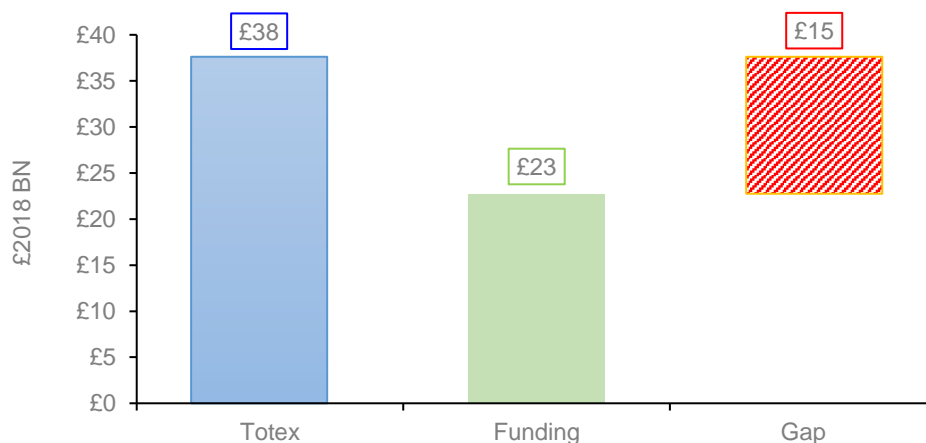
### The estimated funding gap in the green infrastructure sector

Green infrastructure will need to be paid for by a combination of public and private sector funding. The model assumes that 90% of the additional green cover needed to meet the Mayor's target will be funded through the private sector from developer contributions. In contrast, it is assumed that 90% of the costs for renewing existing green cover in public ownership will need to be paid for by the public sector with 10% of funding from private sector contributions, including Section 106. These are assumptions that can be adjusted in the model.

To estimate the funding gap for publicly delivered green infrastructure, a review of existing funding sources in London was undertaken. Key funding streams identified included the GLA Greener City Fund, Borough Open Spaces Funding and Borough Capital Receipts. Based on a review of projects supported through the GLA Good Growth Fund, 10% of this funding was attributed to green infrastructure. It is assumed that all funding sources continue at the same level in real terms throughout the model period. All of the existing public funding for green infrastructure is subject to considerable uncertainty and assumptions about its continuation are made for modelling purposes only.

Based on these assumptions, the public sector funding gap for green infrastructure is estimated to be £15bn.

**Figure 25: Public sector funding gap for green infrastructure**



Source: Arup

## 8. Waste

Around seven million tonnes of waste are produced from London's homes, public buildings and businesses each year. Local authorities deal with about half of this waste and the rest is dealt with by the private sector. Two-thirds of Local Authority Collected Waste (LACW) is either incinerated or sent to landfill. Both are undesirable, costly and an inefficient use of resources. London needs to reduce, reuse and recycle more waste to minimise the potential harmful impacts on the environment. The London Environment Strategy set a target for 65% of municipal waste to be recycled by 2030 from the current rate of 52%. A separate 50% LACW recycling target has been set for waste authorities.

Achieving this target will require a significant improvement in both the household and non-household components of municipal waste recycling. In addition, London's businesses and residents need to be encouraged to adopt a 'circular approach' to the use of resources, ensuring that materials stay in use as long as possible, reducing the amount of virgin materials required.

The costs presented in this chapter draw on the GLA's waste forecasting model developed by consultants SRL. This considers municipal waste only, interpreted in its broadest sense to include household, commercial, and industrial waste (excluding construction waste). The SRL model provides forecasts of waste arisings, current waste management capacity, future waste management infrastructure needs and the associated costs. Given the uncertainty over waste arisings and future rates of recycling and reuse, the GLA waste model considers a number of different scenarios, all of which have been built into Arup's model.

The costs presented below are based on the scenario used to inform the draft London Plan. In this scenario, a municipal waste<sup>18</sup> recycling rate of 65% is assumed to be achieved by 2030 with a household recycling rate of 42% by 2022 and 50% by 2030.

### Estimated costs of London's waste infrastructure requirements

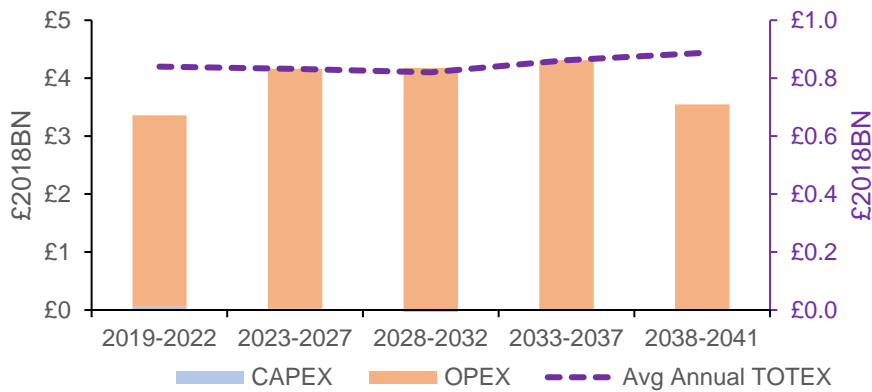
The total costs of London's waste infrastructure requirements in this scenario are estimated to be £19bn for the period to 2041.

Of these costs, over 90% are operating expenditures by London boroughs. Capital expenditures are modest because the focus is on supporting front-end collection of waste and recycling for onward management. Higher rates of recycling and the re-use of materials should mean no new incinerators/energy from waste facilities are required.

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<sup>18</sup> Based on the EU definition of municipal waste being household waste and other waste similar in composition to household waste. This includes local authority collected waste and waste collected by the private sector.

**Figure 26: Capital and Operational Expenditure requirements in the waste sector, 2019-2041 (2018£bn)**



Source: Arup

The main cost categories within the modelling are:

#### *London Borough expenditures*

The GLA municipal waste strategy model includes baseline data sourced from London boroughs. This includes cost information by borough and service area. This data is used to estimate baseline cost per tonne in the following waste management service areas:

- Street cleaning
- Waste collection
- Waste disposal
- Trade waste
- Recycling
- Waste minimisation

These make up the majority of future costs and are estimated to total £18.4bn over the period 2019-2041 in the GLA Strategy scenario.

#### *Capital and operational expenditures for new facilities*

To identify additional infrastructure needs, the waste management capacity gap was calculated. For a given management route (e.g. energy from waste), this is calculated as the required tonnage to be managed to reach targets, less existing capacity.

#### *Capital renewal costs associated with new facilities*

A level of 5% of cumulative capital expenditures has been assumed to estimate requirements for renewals expenditures.

### Costs associated with better recycling services

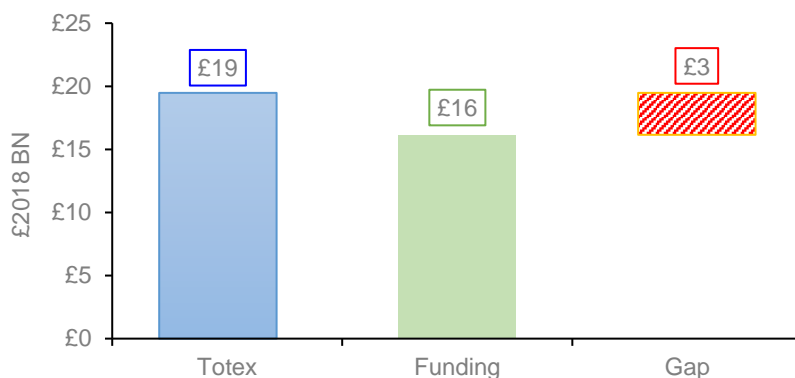
The Waste and Resources Action Programme (WRAP) modelled scenarios for how London's household recycling rate can be improved. The modelling looked at a combination of individual services that would achieve a household recycling rate of 42%, e.g. weekly separate food waste collections and improved kerbside collections. Based on this modelling, the GLA has a £320 million minimum ask of Government for measures to achieve the recycling target.

### Estimated funding gap in the waste infrastructure sector

Waste management is primarily paid for by London boroughs. For the purposes of the modelling, current borough capital and revenue expenditure on waste management has been used as a proxy for funding and rolled forward with population projections. This funding is subject to significant uncertainty and assumptions about its continuation are made for modelling purposes only.

Based on the assumptions above, the funding gap for waste in the GLA Strategy scenario is estimated to be £3bn over the period 2019-2041 (2018 prices).

**Figure 27: Public sector funding gap in the waste sector (2018£bn) 2019-2041**



Source: Arup

## 9. Digital

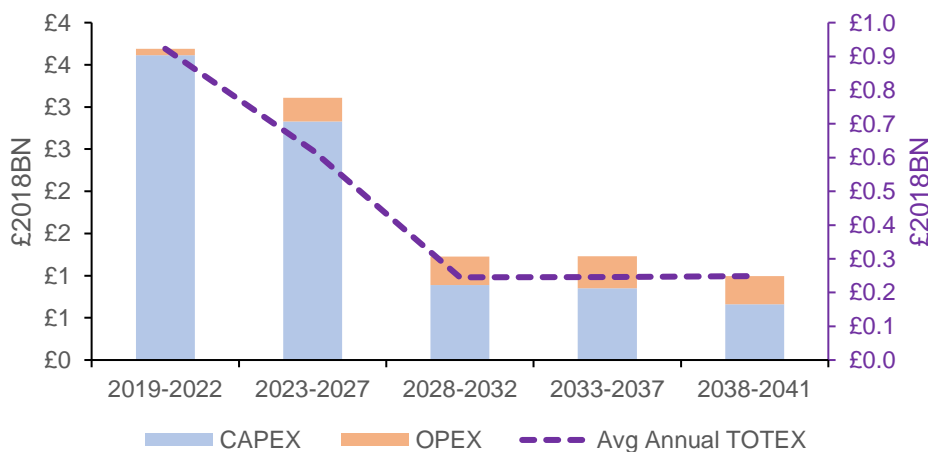
The capacity and speed of London's fixed and mobile broadband networks need to keep pace with the demands of a modern economy. Full fibre to the premises is needed to increase the speed, reliability and capacity of London's broadband networks. Moreover, London's infrastructure and transport services (including driverless cars) will need fast and reliable mobile internet connections in the future. 5G mobile broadband is needed to support this transition and to serve London's businesses and residents. The two technologies are intrinsically interconnected as 5G technology is reliant on full fibre backhaul connections.

The focus of this section is on costing the complete implementation of full fibre broadband and 5G across London. In addition, an allowance has been made for ongoing capital and operational expenditure on future, currently unknown, technologies given the pattern of continuous technological change.

### Estimated costs of London's digital infrastructure requirements

The total cost of London's digital infrastructure requirements to 2041 is estimated to be £10.4bn of which £8.9bn is capital expenditure.

**Figure 28: Capital and operational expenditure requirements in the digital sector (2018£bn)**



Source: Arup

Of the capital expenditure, 5G rollout is expected to cost £4.7bn while full fibre rollout is estimated to cost £2.2bn. An allowance of £2bn is made for future enhancements. The assumptions underpinning these estimates are set out below.



### *Full fibre broadband*

The roll out of full fibre has already begun across London and is expected to accelerate over the coming years according to industry leaders. According to data from the Ofcom Connected Nations 2018 report, 11.7% of London premises were already connected to full fibre as of January 2018. The costs of connecting the remaining properties are estimated in the model. According to industry experts this is expected to be largely complete by 2028. The Future Telecoms Infrastructure Review published by the Department for Digital, Culture, Media and Sport sets a goal for universal full fibre broadband coverage by 2033. However, there are a number of potential barriers to deployment including access to properties (wayleave agreements) and the 'hold-up' problem whereby monopoly incumbent copper cable providers have little incentive to invest in full fibre.

To estimate the potential capital costs of rolling out full fibre across London, the model draws on assumptions from the Future Telecoms Infrastructure Review (FTIR). The estimated cost to connect a new premise to fibre is £575 according to the FTIR. £400 of this cost is to run the fibre backhaul past the premises with the remaining £175 dedicated for connection costs at each premise. According to a 2017 Ofcom report 60% of these combined costs are related to the costs of civils works (including ducts, polls and other physical infrastructure).

### *5G*

Industry stakeholders expect the rollout of 5G technology across London to pick up pace substantially in the early 2020s. The high density and productivity levels in London mean London will be a leader in the implementation of this technology nationally with full implementation being largely complete by 2025.

To understand the potential costs, the model uses costs from a 2017 report on UK digital communications costs commissioned by the National Infrastructure Commission produced by Tactis / Prism and an ONS working paper on cell tower density in London that uses OpenCelliD data. There are uncertainties about these estimates as discussions are ongoing about the approach to deployment.

### *Future enhancements*

The model assumes that continued investment in digital infrastructure will be needed beyond the rollout of 5G and full fibre. While there remains a high level of uncertainty around future technologies, the model assumes that the cost of digital infrastructure will remain largely in line with current levels of investment.

The model takes a straightforward approach to calculating the future operational expenditure requirements of the digital sector. Relying on evidence from the National Infrastructure Commission report in 2017 on digital connectivity in the UK as well as expertise of industry stakeholders, operational expenditure is assumed to be between 0.75% and 1% annually of cumulative capital spending in each sub category. It is important to note that this only considers the costs of operating new capital infrastructure

and not incorporating the cost of maintaining and operating London's existing digital infrastructure.

### The estimated funding gap in the digital sector

Beyond some small public-sector grants, digital infrastructure is primarily funded by the private sector. A review of public sector funding identified some relatively modest sources including the DCMS voucher scheme and one-off grants to be spent by 2019. It is assumed these funding sources will not continue. Therefore, for the purposes of the modelling, the public sector funding gap is assumed to be zero.

While there is strong private sector interest and investment in full fibre broadband and 5G in London, there are barriers that could slow deployment and increase costs, necessitating public intervention and/or public investment. Additional public-sector funding could therefore help to expedite the rollout of 5G and full fibre throughout London.

## 10. Fire, Police and Mayoral Development Corporations (Capex only)

The definition of infrastructure has been extended to include Fire and Police reflecting the Mayor's responsibilities for the London Fire Commissioner (LFC) and the Mayor's Office for Policing and Crime (MOPAC). In addition, the model includes capital expenditure requirements specific to the two Mayoral Development Corporations – the London Legacy Development Corporation (LLDC) and Old Oak Park Royal Development Corporation (OPDC).

Figures on future capital expenditure and expected funding are sourced directly from the GLA Group Capital Strategy converted to 2018 prices for consistency with the rest of the model:

- For 2018/19 to 2022/23 inclusive, estimates of individual yearly spend for each Functional Body are sourced from their respective Capital Spending Plans.
- For 2023/24 to 2037/38 inclusive, estimates are taken from the five-yearly data on likely spending need in the Capital Strategy.
- The Capital Strategy provides estimates up to 2037/38, so for 2038/39 to 2041 inclusive, it is assumed that the expenditure will remain at the same level in real terms as the 2033/34 to 2037/38 period.

It is acknowledged that that capital expenditure by LLDC and OPDC creates a risk of double counting with other sectors but is not thought to be material. Capital expenditure and expected funding for the functional bodies above is summarised in Figure 29.

**Figure 29: Total capital expenditure and expected funding 2018-2041 (2018£bn)**

|              | Capital Expenditure | Likely funding | Funding gap |
|--------------|---------------------|----------------|-------------|
| MOPAC        | 2.84                | 1.89           | 0.95        |
| LFC          | 0.49                | 0.12           | 0.37        |
| LLDC         | 0.68                | 0.68           | 0           |
| OPDC         | 0.73                | 0.73           | 0           |
| <b>Total</b> | <b>4.73</b>         | <b>3.41</b>    | <b>1.32</b> |

Source: Arup

The funding gaps identified above are discussed in further detail in the GLA Group Capital Strategy. MOPAC's shortfall between spending need and likely level of resource is almost £1bn (2018 prices) over the period 2018-2041. This principally results from the need to continue to invest and maintain assets such as the Met's estate, IT and fleet, together with the National Counter Terrorism Policing Network Headquarters. This figure allows for assumed levels of capital receipts and capital grants but assumes no borrowing.

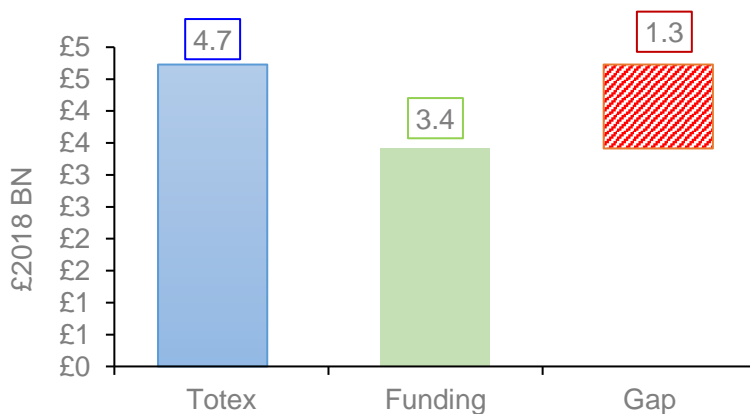
LFC's shortfall between spending need and likely level of resource is £370m (2018 prices). This principally results from the need to continue to invest and maintain assets, such as the LFC's estate, IT and fleet. This figure allows for assumed levels of borrowing.

There is no assumed gap between OPDC's spending need and likely level of resources from 2023/24 as it is expected that private sector investment will meet necessary costs once Housing Infrastructure Fund investment (HIF) is made.

LLDC has no shortfall between its spending need and likely level of resource over the period from 2022-23. This is because, after allowing for the GLA direct capital grants to LLDC, it is anticipated that capital receipts will be received to repay the GLA's investment in LLDC, including the maximum borrowing of £520 million.

Figure 30 summarises the funding gap for MOPAC, LFC, LLDC and OPDC combined which amounts to £1.3bn over the period in 2018 prices.

**Figure 30: Fire, Police and Mayoral Development Corporations Funding Gap 2018-2041 (2018£bn)**



Source: Arup

## 11. Conclusions

This report has presented estimates of the cost and funding requirements for London's infrastructure over the period 2019-2041 based on economic modelling undertaken by consultants Arup. The modelling relies on a range of assumptions about London's future infrastructure requirements, the likely costs and the availability of funding, all of which are subject to considerable uncertainty and ongoing revision. The report presents estimates from the modelling for each of the infrastructure sectors in scope. From these estimates the following conclusions can be drawn:

### **The scale of the investment needed in London's infrastructure is considerable**

Between 2019 and 2041, the level of total expenditure needed for London's infrastructure is estimated to be £968bn. This includes £541bn of capital expenditure and £427 in operating expenditure.

Transport (£444bn) and affordable housing (£310bn) together account for almost 80% of the total expenditure requirement. However, the total costs of London's energy (£107bn), green (£38bn), water (£35bn), waste (£19bn) and digital (£10bn) infrastructure requirements are also considerable.

### **As a proportion of London's economic output, the level of public expenditure required over the period is broadly consistent with the National Infrastructure Commission's fiscal remit**

While the costs set out in this report are substantial, as a proportion of London's economic output they are broadly consistent with the fiscal remit given to the National Infrastructure Commission by Government, which capped their recommended capital spending on infrastructure at 1.2% of UK GDP. On a like-for-like basis with the National Infrastructure Assessment (i.e. excluding affordable housing, green infrastructure, fire and police), the model suggests London's public sector capital expenditure requirements average 1.2% of London's GVA over the period 2019-2041. This peaks in the 2020s at 2.1% of GVA when key transport capital projects like Crossrail 2 need to be delivered. This is consistent with the National Infrastructure Assessment which also profiles investment in London transport schemes in this period.

### **There is a significant public sector funding gap**

Approximately 88% of the total expenditure requirements identified can be funded through existing sources including user charges, developer contributions and currently available public funding sources like council tax, business rates and central government grants. However, given the scale of the infrastructure delivery challenge in London, the 12% which is unfunded still amounts to an estimated £121bn over the period 2019-2041.

This estimate is considered to be a lower bound given that assumed investment by the private sector may also require financial incentives with a cost implication for the public sector. For example, a major energy efficiency retrofit of private sector housing is required and assumed to be funded by private households but could require fiscal incentives.

Some of the key items where further public funding needs to be identified include:

- Affordable housing
- Major transport schemes
- Energy efficiency retrofitting of social housing
- Flood risk mitigation including Sustainable Urban Drainage Systems
- A major new water resource (reservoir)
- New green cover and the renewal of existing green cover
- Waste management services (opex)

### Measures to close the gap

The clear conclusion from the modelling is that current funding mechanisms are insufficient to pay for London's long-term infrastructure needs, as costed in this report (which excludes some material items beyond the remit of this study such as aviation). Closing the gap will require a range of measures including better use of existing assets, deriving greater commercial income from the infrastructure asset base and cost savings in future projects. However, even with these efficiency measures, new or reformed funding mechanisms will need to be considered.

One such mechanism is the tax uplift anticipated from some of the major housing and transport investments in the Mayor's strategies<sup>19</sup>. In addition, there may be a need to introduce additional marginal local taxation or new fees and charges to fund the infrastructure Londoners need. A variety of mechanisms exist in theory, each with various challenges. The list below sets out many of the options that have been raised in the past, but it must be stressed that none of these are Mayoral policy, except two asterisked (\*):

- \*Property tax reform – including devolution and reforms to Council Tax, Business Rates and Stamp Duty as discussed in the report of the London Finance Commission<sup>20</sup>.
- Road user charging – next generation road user charging extending the existing mechanisms in London<sup>21</sup>.
- Transport Premium Charge – charges levied on commercial and residential properties within a certain radius of transport projects, as discussed in Transport for London's Land Value capture report<sup>22</sup>.
- Local income tax – a surtax on the basic rate band, or a flat-rate surtax across all bands, as suggested by the Institute for Fiscal Studies<sup>23</sup>.

<sup>19</sup> Greenwood Strategic Advisors (2018) 'Mind the Gap: Funding and Financing City Investments in the 21<sup>st</sup> Century'

<sup>20</sup> London Finance Commission (2017) 'Devolution: a capital idea'.

<sup>21</sup> For a discussion, see Centre for London (2019) 'Gren Light: Next generation road user charging for a healthier, more liveable, London'.

<sup>22</sup> Transport for London (2017) 'Land Value Capture'

<sup>23</sup> Institute for Fiscal Studies (2019) 'Taking control: which taxes could be devolved to English local government?'

- Workplace parking levy – a levy on workplace parking spaces used by commuters<sup>24</sup>.
- Extended producer requirements – industry fees linked to ease of reusing or recycling packaging<sup>25</sup>.
- Mayoral Community Infrastructure Levy – an additional rate of MCIL hypothecated to infrastructure projects<sup>26</sup>.
- Local payroll tax – a tax on employees/employers working in London<sup>27</sup>.
- Tourism levy – a per night/per person charge on accommodation<sup>28</sup>.
- \*Vehicle Excise Duty – devolution of London’s share of vehicle tax to pay for the maintenance of London’s road network<sup>29</sup>.
- User charge supplements – such as the surcharge on Londoners’ water bills which contributed to the funding of the Thames Tideway Tunnel.

In addition to support from the Mayor, many would require the permission of central government and/or legislation (primary and/or secondary). The level of revenue that could be generated by these reforms would depend on a range of different factors most importantly the tax rate, the taxbase and the behavioural response to the tax. All would need to be fully appraised against the principles of good taxation and assessed for their distributional impacts. Moreover, additional revenues generated by some of the proposals would be needed to fund other public services and activities.

Finally, it may be possible to agree with Government an ‘investment deal’, whereby the city and Government come to an agreement on the investment needs of the city, the growth and additional tax that it should generate and therefore the level of funding (and potentially financing) to support investment in housing, transport and other forms of infrastructure. The Mayor has argued that additional funding should be delivered through fiscal devolution to the capital as set out in the London Finance Commission’s report *‘Devolution: a capital idea’*<sup>30</sup>. For all of these options, and the many combinations thereof, this report provides a supporting evidence base, a fully costed assessment of London’s infrastructure needs as set out in the Mayor’s statutory strategies.

<sup>24</sup> See the London Assembly (2017) [‘London stalling: reducing traffic congestion in London’](#).

<sup>25</sup> See Defra (2019) [‘Consultation on reforming the UK packaging producer responsibility system’](#).

<sup>26</sup> See the [Mayor of London website](#) for information on MCIL2.

<sup>27</sup> See the London Finance Commission (2017) [‘Devolution: a capital idea’](#) supporting evidence GLA Economics (2017) [‘Devolving other national taxes to London’](#).

<sup>28</sup> See the London Finance Commission (2017) [‘Devolution: a capital idea’](#) and supporting evidence GLA Economics (2017) [‘Options for a tourism levy for London’](#).

<sup>29</sup> As advocated for in the [Mayor’s Transport Strategy](#), p.291

<sup>30</sup> London Finance Commission (2017) [‘Devolution: a capital idea’](#).

## Annex A: Reconciliation with the GLA Capital Strategy

The GLA Group Capital Strategy provided a key input to the model notably Transport for London's future capital spending plans. This Annex provides further information on how Capital Strategy inputs were incorporated into the model. There are a number of important differences between the Capital Strategy and the model which mean care must be taken when comparing the headline expenditure requirements in each. They are different exercises as the Capital Strategy is intended to set out the GLA Group's long-term capital ambitions while the Arup model presented in this report provides cost estimates for London's long-term infrastructure needs.

The key differences are as follows:

### Price base:

The Capital Strategy is reported in 'outturn' or nominal prices.

The model reports in constant 2018 prices as is standard for economic modelling of this type (although it is also capable of reporting in nominal terms).

### Time period

The Capital Strategy provides capex requirements to the financial year 2037/38.

The model time period is to 2041 to align with the draft London Plan.

### Scope

The Capital Strategy includes anticipated capital expenditure by the *GLA Group only* whereas the model includes *London-wide capital and operating* expenditure requirements on infrastructure, which are far broader in scope. To summarise:

- **Transport:** TfL capex is taken directly from the Capital Strategy but converted to real prices and extrapolated to 2041. Financial year inputs from the Capital Strategy were assumed to correlate with calendar years in the model (e.g. 2019-20 was assumed to be 2019). In addition, the model includes a proportion of HS2 capex, non-TLRN roads, Network Rail and TOC capex.
- **Housing:** For the period up to 2022, the model estimates the total capital costs of the homes expected to be built under the current Affordable Homes programme grant agreement. Funding is based on the Affordable Homes programme and consistent with the Capital Strategy. From 2022 onwards, the model uses modelling by the GLA Housing and Land Directorate analysing the costs of delivering the



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Affordable Homes target over the period 2022-2032 extrapolated to 2041. As the GLA is a commissioner of new affordable housing, not a manager or owner of affordable housing, costs of new affordable housing are primarily covered by housing providers and developers, with the GLA allocating Government grant funding to fill any funding gaps.

- **Digital:** The model includes all the capital costs of deploying full fibre broadband and 5G which will almost exclusively be in the form of investment by telecommunications providers. TfL will, however, be partnering with industry to support this transition by providing a new fibre backbone through its tunnels, which will also support next generation mobile coverage. In the process this will generate revenue to reinvest in the transport network.
- **Water:** The majority of capex and funding for London's long-term water infrastructure requirements (supply, drainage and flood risk mitigation) will be by the water companies, the private sector, and Government rather than the GLA Group.
- **Energy:** The model includes all the capital costs for London to transition to a net zero carbon city by 2050, only a fraction of which is capex funded by the GLA Group.
- **Waste:** The model includes capital expenditure on waste management facilities and equipment which will be expenditure by boroughs and the private sector not the GLA Group.
- **Green infrastructure:** The model includes the costs of achieving 50% green cover, 90% of which is expected to be provided through private development. A small proportion of the GLA Good Growth Fund has been assumed to contribute to green infrastructure. However, most of the capital expenditure on regeneration through funds such as the Good Growth Fund is not within scope of the model.

## **Annex B: Reconciliation with the National Infrastructure Assessment**

The National Infrastructure Commission (NIC) was established in 2015 to advise Government on the long-term infrastructure challenges facing the UK. It produces a National Infrastructure Assessment every five years, the aim of which is to “set out a clear, long term strategy for the UK’s economic infrastructure from 2020 to 2050, providing long term clarity for industry and the supply chain”.

The NIC published its first National Infrastructure Assessment (NIA) in July 2018. This identifies cities as the engines of UK economic growth and as being important for quality of life. The NIA highlights the infrastructure constraints facing cities and the need to prioritise urban transport, also advocating “investment in regional cities which is in addition to, rather than instead of, investment in London”. In terms of the policy priorities, there is a good degree of crossover between the recommendations in the NIA and those of the Mayor of London. Headline recommendations in the NIA include:

- Digital - nationwide full fibre by 2033 and a national broadband plan.
- Energy - half of the UK’s power provided by renewables by 2030.
- Electric Vehicles - preparing for 100% electric vehicle sales by 2030, including a core network of charging points subsidised where the market won’t provide.
- Waste - three quarters of plastic packaging recycled by 2030 and 65% of all municipal waste.
- Water - resilience to extreme drought, and a national standard of flood resilience for all communities by 2050.
- Design - design champion and design panels for nationally significant infrastructure; National infrastructure design group.

The NIC was given a fiscal remit by Government capped at 1.2% of GDP, i.e. an envelope within which its recommendations for public expenditure on infrastructure should not exceed. This includes existing commitments like HS2. Currently public expenditure on infrastructure is c. 0.8% of GDP so this represents an uplift on previous expenditure but there remain questions as to whether even 1.2% of GDP is sufficient.

The recommendations in the NIA are costed and the profile of expenditure is set out in Table 7.1 of the report (reproduced below)

**Figure 31: NIC spending recommendations (Table 7.1 The Fiscal Remit of the NIA)**

| Average annual expenditure (£ million, 2018/19 prices) | 2020-2025     | 2025-2030     | 2030-2035     | 2035-2040     | 2040-2045     | 2045-2050     |
|--|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>Transport</b>                                       |               |               |               |               |               |               |
| HS2  | 4,500         | 3,900         | 900           |               |               |               |
| Crossrail 2  | 200           | 2,200         | 2,900         |               |               |               |
| Northern Powerhouse Rail                               | 200           | 1,100         | 1,700         | 1,800         |               |               |
| Network Rail   | 6,100         | 6,100         |               |               |               |               |
| Highways England                                       | 4,300         | 3,200         |               |               |               |               |
| Strategic Transport*                                   |               |               | 10,500        | 11,400        | 11,200        | 11,600        |
| Devolved Cities  | 3,300         | 3,600         | 4,600         | 5,400         | 6,100         | 6,800         |
| Transport for London                                   | 2,600         | 2,900         | 2,200         | 2,000         | 2,200         | 2,400         |
| Urban Major Projects                                   | 500           | 400           | 2,400         | 3,100         | 3,500         | 3,900         |
| Non-urban local transport                              | 2,700         | 2,900         | 3,400         | 3,800         | 4,200         | 4,700         |
| Local Roads Backlog                                    |               | 500           | 500           |               |               |               |
| Housing Infrastructure Fund                            | 500           | 200           | 200           | 200           | 200           | 200           |
| <b>Energy</b>  |               |               |               |               |               |               |
| Energy efficiency                                      | 100           | 300           | 300           | 100           |               |               |
| EV Charging  | 2**           |               |               |               |               |               |
| <b>Digital</b>   |               |               |               |               |               |               |
| Rural fibre  | 400           | 300           | 100           |               |               |               |
| <b>Waste</b>   | 600           | 500           | 500           | 500           | 500           | 500           |
| <b>Flood Resilience</b>                                | 600           | 700           | 900           | 1,300         | 1,300         | 1,300         |
| <b>Studies Contingency</b>                             | 300           | 400           | 400           | 400           | 400           | 400           |
| <b>Total expenditure</b>                               | <b>26,900</b> | <b>29,200</b> | <b>31,500</b> | <b>30,000</b> | <b>29,600</b> | <b>31,800</b> |
| <b>As a % of UK GDP</b>                                | <b>1.20%</b>  | <b>1.20%</b>  | <b>1.20%</b>  | <b>1.00%</b>  | <b>0.90%</b>  | <b>0.80%</b>  |

\*combined allocation for road and rail.

\*\*£10m funding in 2020/21

A comparison of the relevant public expenditure recommendations in the table above with those in this report is provided below. It should be noted that the NIA time period is 2020-2050 and the Arup model time period is 2019-2041 so relevant adjustments have been made.

#### Crossrail 2

- The NIA identifies an indicative budget of £27.7bn for Crossrail 2.
- In Arup's model, the cost included for Crossrail 2 is consistent with the Independent Affordability Review.
- Both the NIA and the model assume half of the project will need to be funded by London.

#### Transport for London

- In the NIA, total recommended public capital expenditure for Transport for London (the organisation) is equivalent to £50.7bn over the period 2020-2041.

- Total capital spending in the Arup model for TfL over the same period is £63.9bn (excluding Crossrail 2).
- While the cost figure in the Arup model is higher than the recommended spending by the NIA it also includes some TfL corporate investments such as technologies and commercial development that would not have been included in the NIC's calculations as they do not meet the definition of transport infrastructure investment.

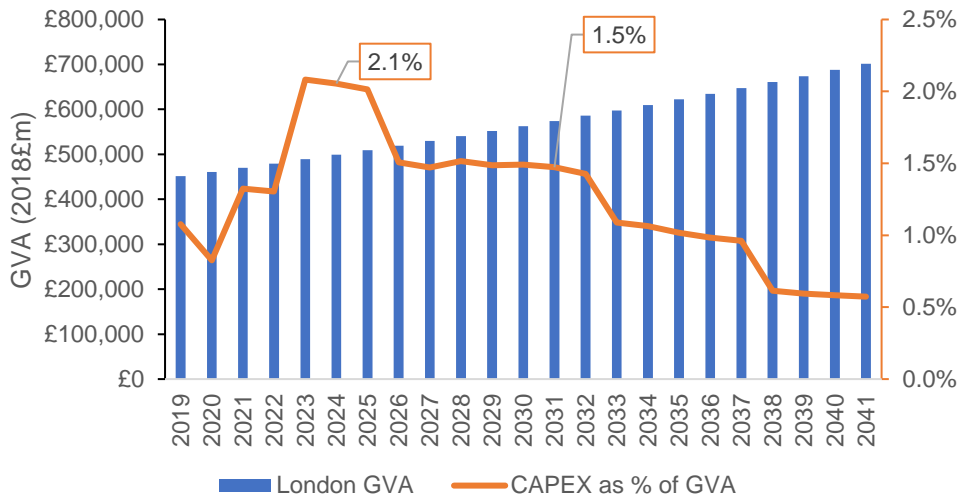
Other relevant spending lines from the NIA Table above include:

- HS2 - Arup's model uses the same cost figures for HS2 as the NIA (sourced from the 2015 Spending Review) and assumes half the costs of phase 1 are in London. These figures are under review.
- Network Rail, Highways England (from 2030 'Strategic transport') – a proportion of spending would be on projects in London.
- Devolved cities – some spending in this category could be available to London boroughs.
- Local roads backlog – the NIC notes this is for local Highways Authorities which in theory would include London authorities.
- Housing Infrastructure Fund – the NIA rolls this fund this into 'Devolved Cities' funding and the spending recommendations for this line apply to rural areas only. HIF spending is excluded from the Affordable Housing funding estimates in the Arup model.
- Energy efficiency – public spending recommendations in the NIA are limited to social housing and the same assumption is made in the Arup model.
- Waste – a proportion of recommended NIA spending would be in London.
- Flood resilience – a proportion of recommended NIA spending would be in London.

The NIC's spending recommendations are within their fiscal remit of 1.2% of GDP. As can be seen in the table above (Figure 31), the NIC's recommended spending in London is higher in the earlier half of the period during 2020-2035 reflecting their profiling of expenditure on Crossrail 2 and other transport capital investments in London during this period.

Using the same infrastructure sectors as the NIA and looking at public capital spending only, the Arup model suggests capex averages 1.2% of London's GVA over the period. Public capital expenditure peaks in the mid-2020s at 2.1% of London's GVA reflecting capital expenditure requirements for Crossrail 2 and other public transport projects in London.

**Figure 32: Public sector capex requirement as % of London's GVA**



Note: in the absence of long-term forecasts, London's GVA is assumed to grow at a long-term rate of 2% per annum in real terms.